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Analyzing barriers in peri-urban land development for informed policymaking

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ABSTRACT

BACKGROUND AND OBJECTIVES: Peri-urban land development is crucial to achieving the UN Sustainable Development Goal of equitable and sustainable urban areas. Fair land, infrastructure, and resource management improves land management services and reduces social and economic inequities. However, the peri-urban land management system has contributed to unequal rapid urbanization in neighboring regions. This study examines the complex relationships between peri-urban land development barriers in India. The goal is to understand how these barriers induce unequal urbanization transcending the city, resulting in uncontrolled growth, urban sprawl, and inadequate services in peri-urban areas. The main goal is to improve decision-making and promote fair peri-urban growth in Indian cities using a multi-criteria decision-making tool. This application gives experts a new perspective on peri-urban issues.

METHODS: A questionnaire-based survey was conducted by 122 planners and academicians from north Indian cities using snowball sampling techniques. The study collects expert perspectives to create a causal map, using the DEMATEL ISM method, classifying these barriers as "determinants or causes," "dependent barriers," "independent barriers," and "effects," presenting a new perspective on peri-urban development complexity. that depicts these roadblocks and highlights the most significant drivers impeding peri-urban land development.

FINDINGS: Findings revealed four interdependent challenges as the leading 'causes' based on DEMATEL Weight; Imprecise spatial policies with 0.10119, undemarcated land boundaries with 0.10082, weak institutions with 0.10003, and absence of planning regulations with 0.09945 weight. Within these barriers, addressing the governance capability and spatial policies would have a beneficial cascading effect on catering to other challenges. Findings have valuable insights for policymakers, aiding in the formulation and prioritization of effective policies and resource allocation.

CONCLUSION: This study extensive analysis of causal linkages among Indian city peri-urban land development challenges. Beyond identifying barriers, it explains their causes, interdependencies, and hierarchical links. This study's holistic approach to peri-urban development issues and inventive barrier categorization and prioritization make it distinctive.

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INTRODUCTION

Rapid urbanization has extended cities beyond their traditional borders, creating vast built-up areas and transforming agricultural land. These changes, caused by real estate market dynamics and regulatory interventions like Special Economic Zones (SEZ) and new townships, stress natural resources and risk conflict (Narain, 2009; Ahani and Dadashpoor, 2021b). Peri-urban regions, straddling urban and rural areas, are characterized by agricultural activities, informal settlements, and rapid urban growth (López-Goyburu and García-Montero, 2018; Ahani and Dadashpoor, 2021b; Cattivelli, 2021). Peri-urban areas may be the epicenter of global urbanization, with the greatest prospects and concerns (Allen, 2003). Over time, peri-urban areas have evolved from an intangible idea to a broadened region that competes for land. Although perI-urban areas can provide infrastructural needs, relieving urban centers of the effects of fast expansion, it results in disorganized and fragmented development, urban sprawl, and inadequate critical services (Wolff, Mdemu, and Lakes, 2021). Therefore, the conflicting development is harming the region's socio-environmental framework. Additionally, peri-urban land development is critical for attaining equitable development as outlined in the United Nations Sustainable Development Goal 11. It emphasizes effective land management practices to ensure equitable access to land, infrastructure, and resources, which address social and economic imbalances within communities (Follmann, Hartmann, and Dannenberg, 2018). Many studies have identified urban phases characterized by variable intensity of growth patterns and reflecting distinct socioeconomic contexts with inherent variability in development (Ma *et al.*, 2018). The peri-urban land development process in Indian cities is crucial for several reasons. Metropolitan and significant urban agglomerations in India are projected to add 416 million people by 2050 and built-up area growth is far its peri-urban hinterlands than in municipalities (Cattivelli, 2021). Inefficient peri-urban land management has produced an imbalance in preventing city expansion into outlying areas (Dutta, 2012). Due to legislative issues, Urban Local Bodies (ULBs) cannot integrate regional and master plans for peri-urban expansion and analyze transformation (Aijaz, 2019). The top-down administrative approach also limits land intervention frameworks due to a lack of knowledge of the urban-rural split and its fluid planning process (Aijaz, 2019; Follmann *et al.*, 2023). The numerous barriers impeding land development, especially in the uncertain boundaries of periphery or peri-urban areas, are exacerbated by the ever-changing characteristics of the land, which undergoes transitions from rural to urban environments due to several factors (Dadashpoor and Malekzadeh, 2020). The issues encompass a wide range, such as ambiguous demarcation of peri-urban regions (Mortoja, Yigitcanlar and Mayere, 2020), the existence of numerous overlapping institutions (Marshall and Dolley, 2019), disputes over land ownership, non-compliant land development methods, lack of territorial planning tools (Wolff, Mdemu and Lakes, 2021), informality of land ownership, influences from neo-liberal forces, and the phenomenon of gentrification (Akaateba, 2019), lack of unified data, the disregard for decision sciences for land allocation (Žlender, 2021), the absence of explicit regulations and guidelines for transitioning territories, and a planning intervention that frequently disregards regional and local contexts (Nuhu, 2019), adhering to a standardized approach in all peripheral regions. These barriers collectively lead to a fragmented, disorganized, and unsustainable peri-urban landscape. Resolving these issues becomes imperative to achieve a coordinated, equitable, and environmentally sustainable urban expansion. The objective further aligns with the broader goals of fostering resilient and effective urban management practices. Therefore, peri-urban regions in Indian cities suffer an array of land development barriers, and there is a substantial dearth of understanding about the causal-effect links between these barriers (Follmann *et al.*, 2023). The complexity of peri-urban communities, frequently disregarded in urban-rural classifications, presents several problems and hurdles to equitable and sustainable development. Cities need land for homes, jobs, and economic activities, requiring efficient land management to maximize resource use (Adam, 2014). One must comprehend local government regulations, legislation, and institutional competence to identify and handle peri-urban regions most vulnerable to uncontrolled growth. Urban planning standards, efficient laws, and inclusive governance are needed to monitor India's

urban expansion and promote fair, ecologically sustainable land usage (Sareen and Haque, 2023a). The expansion of urban limits, frequently with government aid, is complex and connected with land use planning and governance, especially Master Plans. Peri-urban periphery, historically managed by rural authorities, has presented particular issues in India. Peri-urban areas lack governance because water delivery, sanitation, and waste collection are now urban responsibilities (Aijaz, 2019). Peri-urban areas, influenced by urban development, attract industries, SEZs, and IT parks due to location and lower land costs. This prevalent tendency in large Indian cities is seen in increased employment and migration. These transitional areas have significant population increase, while the city core stagnates, indicating the diverse impact of government policy on urban expansion dynamics (Jain and Korzhenevych, 2020). In India, land governance is hierarchical and involves multiple government and administrative levels. The State Government, which sets the policy framework, has complex power relationships with local governments, resulting in ineffective land management in many Indian towns (Jain, 2018). Land governance differences emerged when the focus shifted from urban to peri-urban regions. Municipal corporations and local planning organizations handle urban land-use planning and infrastructure. Peri-urban areas are managed by the revenue department and local panchayats. The limited capability and resources of these agencies sometimes lead to informal development, encroachment, and land usage conflicts (Mondal and Banerjee, 2021). Common land interventions including urban planning schemes, land pooling, and land acquisition lacked strategic planning and often faced local resistance. Despite their widespread use, these interventions have been condemned for their lack of transparency, accountability, and community participation, which has hurt the affected people's livelihoods and rights (Gomes *et al.*, 2023). Without a regulatory framework for transitioning areas, peri-urban land management is still seen as informal and disorganized (Follmann, Hartmann, and Dannenberg, 2018). The lack of a comprehensive national land-use strategy in India leads to a fragmented and unpredictable land-use process, impeding efficient planning and sustainable development (Shaw and Das, 2018). simultaneous existence of multiple land development strategies, prompted by economic, sociological, and technological expectations, complicates land ownership, usage rights, and income and resource distribution (Marshall and Dolley, 2019). The complex situation at hand requires a thorough examination from the viewpoint of urban planning and land resource management, which is lacking in the existing literature. Also, it becomes essential to understand the complex nature of rural-urban transition in the peri-urban landscape from the governance perspective as the government and decision-making bodies exert considerable influence in pre-urban land development, owing to the transitional characteristics of these places. In contrast to firmly established urban environments, peri-urban regions frequently see swift transformations as they transition from rural to urban. In peri-urban regions, where the process of transitioning from rural to urban areas is still in progress, the government assumes a pivotal role in establishing the regulatory structure, guaranteeing adherence to regulations, and providing guidance for the general trajectory of development (Follmann *et al.*, 2023). Decision-making entities play a pivotal role in defining pre-urban land development, encompassing many stakeholders such as urban local bodies, development authorities, and municipal corporations. These organizations are responsible for the formulation of policies, the approval of development plans, and the supervision of project implementation, thereby exerting a substantial influence on the spatial and structural changes occurring in peri-urban areas. In later stages of urban development, the participation of additional players, such as private developers, community groups, or non-governmental organizations, may become increasingly prominent. However, during the earliest phases, a robust regulatory and planning framework is typically necessary. The establishment and implementation of this framework are commonly undertaken by governmental entities and policymakers to facilitate a synchronized and regulated shift from rural to urban environments. To achieve the mentioned objectives, the authors have conducted a questionnaire-based study by circulating on an online Google form during April 2023 to the planning domain experts. Current practices and policy information gap stifles effective planning and decision-making. To overcome the knowledge gap, the study's objectives are to i) thoroughly examine

Table 1: List of barriers

Challenge	Description
B1	Peri-urban area demarcation is ambiguous
B2	Insufficient development of skills and abilities within institutions(Urban local bodies/ Government Authorities)
B3	Overlapping and multiple institutes (Urban local bodies/ Government Authorities) leading to conflict in land intervention
B4	Notable absence of effective spatial policy-making and a comprehensive approach to territorial governance
B5	For the peri-urban area, there are no comprehensive planning regulations or benchmarking
B6	Lack of cadastral data for spatial assessment of Land,
B7	Lack of Limitation on metropolitan overgrowth in the periphery
B8	Insufficient policies, plans, methods, and evaluations to curb unauthorized exploitation of natural and agricultural resources
B9	Lack of studies evaluating the implementation and adherence of plans after their execution
B10	Exhibit high levels of informality in land use and tenure arrangements
Present study	The study will rank the barriers to understanding the relative significance of these above challenges by employing the MCDM technique on experts' responses to inform the policymakers for resource allocation and targeted intervention.

the root causes and linkages among the identified barriers through a structured methodology to gain a full understanding of the intricate factors involved in peri-urban land development and ii) To present the hierarchical structure of the identified barriers and determine the ones with the most influence, providing valuable insights into the areas where interventions can yield the most substantial effects. The current study has been carried out in the cities of north Indian states using a questionnaire-based survey sent through an online Google form in April 2023 to specialists in the field of planning.

Identification of barriers

Literature shortlisting was done systematically using inclusion and exclusion criteria to compile the significant peri-urban land development barriers for the experts to review during April 2023. A total of 167 articles were collected from Web of Science and Scopus databases using keywords: *peri-urbanization* OR *peri-urban development* OR *peri-urban planning*, AND, *land development* OR *land management* OR *intervention* in title, abstract, and keywords of the articles. The research's goal of studying and analyzing peri-urban development was best described by these keywords in conjunction with the associated land intervention with the usage AND/OR with selected words from boolean logic. Additional inclusion criteria were the type of articles published, i.e. only Journal articles published in the *English language were included*. These shortlisted articles were filtered by *publication date.* i.e. articles published during *2013-2023* were included to cater to recent and relevant issues arising in the research domain. The step yielded 71 articles which were further screened based on the analysis of *explicit mention of the challenge or barrier* faced in the study. Based on these criteria, 24 articles were included in the review. The selected papers were further manually analyzed by the authors for the identification of the challenges in Indian cities or similar cities of developing nations. The authors selected 10 challenges which were discussed in the multiple papers as illustrated in Table 1. The experts in the questionnaire further analyze these challenges to understand the relative significance, and further, statistical analysis helps In identifying the cause-effect relationship and hierarchical structure of this complex web of challenges. Further, the selected 24 articles for comprehension of the issues they present are illustrated in Table 2.

Issues in peri-urban land development

Peri-urban development research shows significant social and environmental differences between core cities and peri-urban areas. The lack of land development and urban growth control in local planning is the main cause of this gap (Jain, Korzhenevych, and Sridharan, 2019; Salem, Tsurusaki, and Divigalpitiya, 2020). Decision sciences and methods to prioritize lands (Dutta, 2012; Honeck *et al.*, 2020) and solve inequities in peri-urban regions (Mondal and Banerjee, 2021) are still unclear and have ambiguous approaches. Peri-urban regions lack well-planned and ordered spatial structures, resulting in uncontrolled urban expansion and large city layout modifications (Long *et al.*, 2020). Uncontrolled growth causes disorganized settings, with peri-urban residential complexes covering more space than the city center (Marshall and Dolley, 2019).

Table 2: List of Barriers identified in the literature. (**O**= Observed/Identified)

S.No.	Sources	Barriers									
		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1.	(Adam, 2015)	O	O		O			O		O	O
2.	(Hedblom, Andersson and Borgström, 2017)		O	O		O	O	O	O	O	
3.	(Dutta and Roy, 2017)					O					O
4.	(Arif and Gupta, 2018)	O		O				O			
5.	(Shaw and Das, 2018)				O	O				O	
6.	(Follmann, Hartmann and Dannenberg, 2018)	O	O				O	O	O		
7,	(Jain, Korzhenevych and Sridharan, 2019)			O		O					O
8.	(Nuhu, 2019)		O		O				O	O	
9.	(Marshall and Dolley, 2019)	O					O	O			O
10.	(Aijaz, 2019)			O		O			O	O	
11.	(Jain, 2019)	O		O			O			O	
12.	(Long *et al.*, 2020)		O		O	O		O			
13.	(Mondal and Sen, 2020)	O			O			O			O
14.	(Hussnain et al., 2020)		O					O	O		
	(Wubie, de Vries and Alemie, 2021)			O	O	O				O	O
16.	(Wolff, Mdemu, and Lakes, 2021)		O			O	O		O		
17.	(Ahani and Dadashpoor, 2021a)			O				O		O	
18.	(Chettry, 2022)	O	O		O						O
19.	(Mohammadi-Hamidi *et al.*, 2022)		O		O		O				O
20.	(Kurnia *et al.*, 2022)	O		O		O				O	
21.	(Seifollahi-Aghmiuni *et al.*, 2022)		O				O	O	O	O	O
22.	(Sahana *et al.*, 2023)	O			O	O	O				
23.	(Karakadzai *et al.*, 2023)			O				O		O	O
24.	(Follmann *et al.*, 2023)		O	O		O			O		O

This uncontrolled proliferation shows the scope and complexity of urban transition in peri-urban areas and inefficient decision-making. Land ownership, usage, and value disputes are common, owing to issues such as ambiguous property rights and conflicting land uses (Dutta, 2012). The lack of transparent land governance and participatory decision-making procedures exacerbates these tensions. Complex networks of overlapping urban local bodies make defining peri-urban region boundaries challenging, particularly in the face of fast development(Wubie, de Vries, and Alemie, 2020). In peri-urban regions, a lack of knowledge about cadastral data, land records, taxation, demography, land sub-divisions, and land use changes impedes decision-making (Simon, McGregor, and Thompson, 2006; Dadashpoor and Ahani, 2019). Due to a lack of understanding, the decision-making process for land development in peri-urban regions is frequently insufficient. Existing classifications frequently ignore the intricacies that

exist outside the classic rural-urban distinction (Jain and Korzhenevych, 2020; Gottero, Cassatella, and Larcher, 2021). The master plans of urban local bodies (ULBs) frequently ignore crucial variables such as carrying capacity, available resources, and the preservation of local agriculture and resources, resulting in inequities in the advantages of urbanization(Aijaz, 2019). Furthermore, due to a lack of key tools and capabilities, local self-government organizations, particularly in Indian cities, struggle to adapt to the difficulties of urbanization (Aijaz, 2019; Jain, 2019). Land development regulation in peri-urban settings is hampered by rapid changes in open spaces, which result in environmental deterioration (Imbrenda *et al.*, 2021). This degradation involves an unequal distribution of biological traits, which jeopardizes the region's carrying capacity and land suitability (Imbrenda *et al.*, 2021). As a result, peri-urban landscapes are more valued for their immediate financial rewards rather than their agricultural relevance, resulting in spatial changes resembling informal settlements (Ma *et al.*, 2018). Another problem is territorial governance since the notion that all peri-urban regions are the same has negative effects on spatial management and policy (Gonçalves, Gomes, and Ezequiel, 2017). Without a spatial approach to policymaking, managing peri-urban regions across supra-territorial boundaries becomes difficult (Cattivelli, 2021; Gottero, Cassatella, and Larcher, 2021). In India, model guidelines for the development of peri-urban areas were proposed by the Ministry of Housing and Urban Affairs for selected 20 cities across the nation in 2018. However, the guidelines mention the process for the phases-wise development, but approval, management, and planning are in the jurisdiction of the urban local body and do not give insights into dealing with the development. Additionally, spatial perspective is frequently ignored, resulting in plans that fail to recognize the multifunctionality of peri-urban interfaces and their links to neighboring urban and rural regions (Mondal and Sen, 2020). Research gaps in peri-urban land development are discussed in the following Table 3. Furthermore, the existing practices and lack of policy information hinder the ability to plan and make effective decisions. The study aims to address the lack of knowledge by conducting a comprehensive analysis of the underlying causes and connections between the identified challenges using a systematic approach. This will enable a thorough understanding of the complex factors associated with peri-urban land development. Additionally, the study seeks to present the hierarchical arrangement of the identified barriers and identify the ones with the greatest impact, thereby offering valuable insights into the areas where interventions can have the most significant outcomes.

Table 3: Identified research gaps

Sources	Key Research Gap(s)
(Sareen and Haque, 2023b)	In developing cities with no conventional planning regulations, peri-urban gentrification, and land management are understudied, hindering evidence-based decision-making.
(Wubie, de Vries and Alemie, 2021)	Need for a well-designed framework for intervening in peri-urban land areas and precise institutional arrangements. Validating and refining the peri-urban land management approach requires empirical effort.
(Owino *et al.*, 2021)	A limited number of studies thoroughly examine the processes of land use change and spatial arrangements in peri-urban areas.
(Gottero, Cassatella and Larcher, 2021)	Emphasis on developing strategic spatial planning at the local level, considering local concerns and variables.
(Ahani and Dadashpoor, 2021b)	Need to study the implementation of strategic measures in developing countries empirically.
(Arif and Gupta, 2018; Jain and Korzhenevych, 2020)	Lack of understanding regarding the efficacy of land interventions in peri-urban areas in India.
(Jones *et al.*, 2019)	Significance of examining not only the institutional framework governing land access but also motivations and perspectives of individuals towards governance systems.
(Nuhu, 2019)	Additional research is needed to explore the connection between rising insecurity and land conflict in peri-urban regions.
(Owino *et al.*, 2021)	A limited number of studies thoroughly examine the processes of land use change and the spatial arrangements in peri-urban areas.

MATERIALS AND METHODS

The study seeks to understand the governance challenges that hinder peri-urban development, as it is crucial to consider the opinions of sector workers to inform decision-making by addressing peri-urban land development concerns like policy-making, planning strategies, implementation, geographic scale issues, etc. A multi-criteria decision-making (MCDM) tool is essential for solving complicated problems since it evaluates numerous criteria at once. MCDM tools provide a structured framework for assessing and solving complex issues with multiple aspects and barriers. Systematic methods help decompose complicated issues into manageable parts, supporting a disciplined approach to prioritizing peri-urban growth challenges. MCDM technologies also reduce subjectivity, promoting objective decision-making. These techniques ensure that issues are addressed based on their impact and importance rather than subjective impressions by giving a quantitative foundation. The authors used DEMATEL ISM (Decision-Making Trial and Evaluation Laboratory and Interpretive Structural Modelling) to analyze data from their questionnaire-based study on Indian city peri-urban land development challenges. We chose DEMATEL ISM because of its outstanding MCDM approaches for peri-urban land development in Indian towns. Unlike alternative methods, DEMATEL ISM excels in its ability to analyze and visualize casual correlations between criteria or factors, in this case, barriers, offering a comprehensive view of the interdependencies and cause-and-effect relationships in prioritizing obstacles based on their impact, enhancing the decision-making efficacy (Chuang *et al.*, 2013). This provides a complete view of peri-urban development issues' interdependencies and cause-and-effect relationships. The hierarchical perspective provided with this approach helps policymakers prioritize for maximum impact (Chuang *et al.*, 2013). Also, the generated causal maps are easy to interpret, enabling the translation of study findings into policy ideas and, thus, improving real-world decision-making. DEMATEL ISM helps prioritize urgent issues when used in barrier identification studies (Tayebi *et al.*, 2023).

Statistics

In DEMATEL's first step, a questionnaire survey is produced using the mentioned barriers in Table 1. The experts used Satty's five-point integer scale to rate each barrier's impact on another in the questionnaire. The acquired data was used in DEMATEL modeling. The DEMATEL shows causal relationships, weights, and rankings by categorizing components into cause-and-effect categories. In the second stage, DEMATEL cause-and-effect linkages are supplied into ISM modeling. The cause-and-effect linkages determined the directions of the relationships between the components that helped convert DEMATEL to ISM. According to their driving and reliant abilities, DEMATEL ISM separated barriers into four groups: cause, dependent, independent, and effects. The analytical procedure involves establishing an initial or average direct relation matrix, normalizing it, calculating the total relation matrix, and filtering out inconsequential values with a threshold. Total relation matrix row-wise and column-wise sums define barrier prominence and interdependency. DEMATEL weights influence barrier significance. Next, ISM creates contextual barriers and Initial and Final Reachability Matrices. Transitivity checks confirm linkages and hierarchical structure exposes barrier interdependencies and causal links. The causal and interpretive structures from DEMATEL and ISM were used to create an integrated DEMATEL-ISM model. The following subsections describe DEMATEL and ISM modeling procedures and stages.

Data collection methods

A survey appraised peri-urban land development barriers using Satty's five-point rating technique (Tayebi et al., 2023) as illustrated in Table 4. To gain a comprehensive understanding of peri-urban development, 122 experts from Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Haryana, Delhi, Rajasthan, and Uttar Pradesh and Bihar, shown in Fig. 1, 83 experts from planning, educational, and research institutes, and 39 planning professionals, including architects, planners, and program managers, were sent a Google form questionnaire with closed-ended questions. We collected data in April 2023. A maximum of 89 of 122 replies were MCDM-analyzed. Incomplete questionnaire responses were removed to maintain data accuracy. Experts from ULBs, such as Development Authorities, Municipal Corporations, and Planning Educational Institutions, were chosen since they make land development decisions. The online poll used Snowball Sampling to select

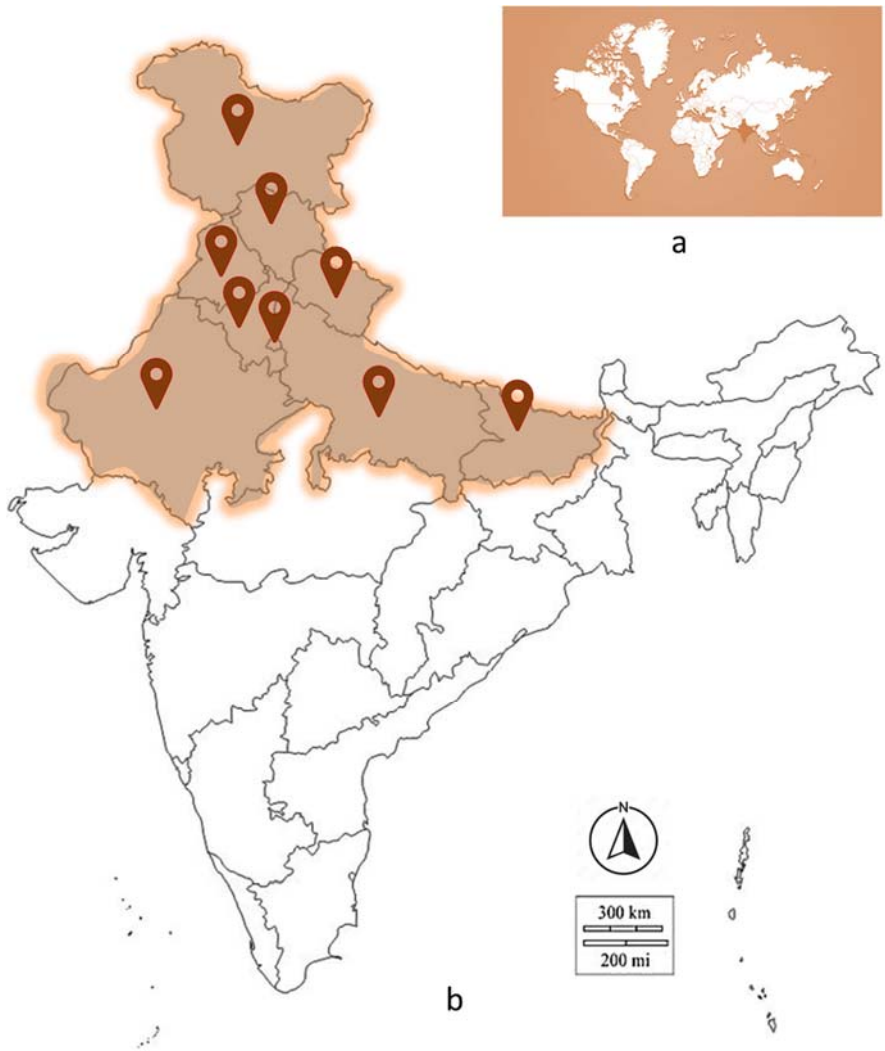

Fig. 1: a. Key map of the World. b.Map showing the states of India from which the experts are selected

Table 4: Lingual term in Salty's scale

Lingual options	Response
Not influential at all	0
Less influential	1
Moderately influential	2
Influential	3
Very influential	4

respondents. Snowball sampling employed peri-urban land development experts' knowledge. These professionals view regional issues holistically. Scholars use snowball sampling to reach specialists not in public databases. Experts participate more, increasing response rates due to their wide professional networks. Snowball sampling accommodates field limits and provides significant data. There is no full

list of peri-urban land development specialists on any portal. Hence, a more rational procedure was needed to choose respondents.

Conventional sampling methods may encounter challenges in clarifying the dynamics of peri-urban land expansion. The preference for cities situated in North India stems from the fact that the difficulties related to land development differ across different regions. To enhance the scope of the study through comparative analysis with other states or cities in the region, a specific focus has been placed on cities located in North India. Geography, culture, and administration pose unique dynamics. The systematic collection of data ensures that the results of the study may be effectively applied to real-world situations

Data reliability

The Cronbach's Alpha coefficient, which gauges the internal consistency of survey data, was used to assess the obtained data for reliability and inconsistencies. The internal consistency of the 89 participants' responses was evaluated using Cronbach's Alpha Value (α) to assess the validity of the information obtained from the questionnaire-based survey employed in this study as discussed using Eq. 1 (Khan *et al.*, 2023).

$$\alpha = \frac{C}{C-1} \times \left(1 - \frac{\sum_{i=1}^{c} \sigma_x^2}{\sigma_y^2} \right) \quad (1)$$

where C denotes the number of challenges (or barriers), σ_x^2 denotes the variance in the scores given to each challenge, σ_y^2 denotes the variance in the total sum of scores given by each participant.The α value obtained in the survey is 0.83 which is greater than 0.7, hence the collected data can be considered reliable for analysis.

Description of the modified DEMATEL ISM analysis procedure

DEMATEL-ISM is a Multi-Criteria Decision Making (MCDM) framework that is used to investigate the cause-effect interrelationship of different criteria. The ISM and DEMATEL have numerous commonalities, including their shared interest in examining the causal relationship between various criteria (Kumar and Dixit, 2018). Since both the ISM and the DEMATEL techniques are potent and useful tools that support the decision-making group, this is the major benefit of the combined approach (Tayebi *et al.*, 2023, Noor *et al.*, 2024).

DEMATEL groups barriers into cause-and-effect categories to identify hierarchically structured solutions. Following are the steps for performing DEMATEL analysis:

Step 1: To incorporate all the responses from n respondents, the initial or average direct relation matrix 'Xij' is developed by using Eq. 2 (Noor *et al.*, 2024):

$$X_{ij}^{*} = \frac{\sum x_{ijk}}{n} \quad (2)$$

where *x* corresponds to the response by participant *k* on the influence of barrier *i* on barrier *j* and *n* is the total number of participants in the survey.

Step 2: This demonstrates the normalization of the average response matrix using Eq. 3 (Noor *et al.*, 2024):

$$X_n = \frac{\mathrm{X}}{max\left(\sum x_{ij}\right)} \quad (3)$$

Step 3: In this step, Total Relation Matrix has been calculated using Eq. 4 (Noor *et al.*, 2024):

$$T = X_n \times \left(I - Xn\right)^{-1} \quad (4)$$

Step 4: Furthermore, to clarify the interrelationship among problems and maintain the problem's complexity manageable, a threshold level 't' was selected to filter out the inconsequential values from matrix 'd' by using Eq. 5 (Noor *et al.*, 2024). The issues that have an impact on the matrix d that exceeds the cutoff value are those that will be subjected to additional analysis

$$t = mean\left(d_i\right) \quad (5)$$

Step 5: The row-wise (D) and column-wise (R) sums of the total relation matrix are used to determine the prominence and interdependency of barriers, as illustrated in Eqs. 6 and 7 (Noor *et al.*, 2024):

$$D = \sum_{i=0}^{n} T_{ij} \quad (6)$$

$$R = \sum_{j=0}^{n} T_{ij} \quad (7)$$

Step 6: The row-wise sum and column-wise sum of the total relation matrix are added to determine the prominence of the barriers, and these same sums are subtracted to determine the relationship value using Eqs. 8 and 9 (Noor *et al.*, 2024):

$$Prominence = D + R \quad (8)$$

$$Relation = D - R \quad (9)$$

Eq. 10 (Noor *et al.*, 2024) has been used to calculate the DEMATEL weight:

$$DEMATEL\,Weight = \frac{(D+R)_i}{\acute{O}(D+R)_i} \quad (10)$$

The ISM technique consists of the following steps as used in previous studies (Chauhan, Singh and Jharkharia, 2018; Khan *et al.*, 2023; Tayebi *et al.*, 2023): In the first step, ten different barriers are considered. In the second step, a contextual relationship between the barriers is generated using DEMATEL, based on the purpose of the research. The average response matrix from DEMATEL analysis is used to create the Initial Reachability Matrix in the third stage, depending on how the barriers "B1" and "B2" interact with one another. In the fourth stage, the Final Reachability Matrix is generated from the Initial Reachability Matrix and checked for transitivity (Tayebi *et al.*, 2023) The ISM's key concept is that the relationships between the barriers are transitive. E.g. if barrier B1 has a strong association with barrier B2, and B2 has a strong association with B3, then B1 is also strongly associated with B3; It implies using Eq. 11 (Noor *et al.*, 2024):

$$if\ IM_{ik} = 1\ \&\ IM_{kj} = 1; then\ FRM_{ij} = IM_{ij} \quad (11)$$

The level of partition is finished in step 5 utilizing the acquired reachability matrix. In step 6, a resultant graph is generated based on the partition level, and transitive linkages are deleted using the transitivity rule. Finally, in step 7, substituting statements for the barriers nodes in the ISM hierarchical structure of the completed digraph.

RESULTS AND DISCUSSION

DEMATEL analysis

Based on the average response matrix and its normalization, a Total Response Matrix, TRM, Table 5. is generated, which provides a visual representation of the interrelationships between the barriers. This further helps to identify the significant barriers that have the greatest impact on the system, analyze the direct and indirect effects of the factors, and discover causal chains within the system. This helps in comprehending the Prominence and Relation of the barriers and deriving DEMATEL Weights of barriers.

The obtained DEMATEL weight of the barriers is illustrated in Table 6. This weight helps in identifying the prominence-relation diagram of the barriers.

The statistical finding using DEMATEL is illustrated in the form of a causal diagram in Fig. 2. The result il-

Table 5: Total response matrix of barriers

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	3.10	3.07	3.08	3.11	3.20	3.12	3.12	3.15	3.02	3.08
B2	3.01	3.05	3.02	3.06	3.15	3.07	3.06	3.10	2.97	3.01
B3	2.98	2.99	3.02	3.02	3.11	3.03	3.03	3.06	2.94	2.98
B4	3.04	3.06	3.06	3.12	3.19	3.10	3.10	3.13	3.00	3.05
B5	3.08	3.09	3.09	3.13	3.25	3.14	3.14	3.18	3.04	3.09
B6	2.89	2.90	2.90	2.93	3.02	2.99	2.94	2.98	2.84	2.90
B7	2.97	2.98	2.98	3.02	3.11	3.03	3.06	3.06	2.93	2.98
B8	2.89	2.90	2.90	2.93	3.02	2.94	2.94	3.01	2.85	2.90
B9	2.97	2.98	2.98	3.01	3.10	3.03	3.01	3.06	2.97	2.98
B10	2.91	2.92	2.91	2.95	3.04	2.97	2.96	3.00	2.87	2.96

Table 6: DEMATEL weight of the barriers

Barriers	Row Wise Sum of TRM	Column-Wise Sum of TRM	Prominence	Relation	Weight
	D	*R*	*D+R*	*D-R*	
B1	31.05	29.85	60.90	1.20	0.10082
B2	30.49	29.93	60.42	0.56	0.10003
B3	30.15	29.93	60.07	0.22	0.09945
B4	30.85	30.27	61.12	0.58	0.10119
B5	31.23	31.20	62.43	0.03	0.10336
B6	29.29	30.42	59.71	-1.13	0.09884
B7	30.11	30.35	60.46	-0.23	0.10009
B8	29.29	30.73	60.02	-1.44	0.09936
B9	30.08	29.42	59.49	0.66	0.09849
B10	29.48	29.93	59.41	-0.45	0.09836

lustrates that the barriers which are in the first quadrant have a characteristic of being high in prominence as well as high relation to the other challenges i.e. (B5) - For the peri-urban area, there are no comprehensive planning regulations or benchmarking, (B4) - Notable absence of effective spatial policy-making and a comprehensive approach to territorial governance, (B1) - Peri-urban area demarcation is ambiguous and (B2) - Insufficient development of skills and abilities within institutions. The significance of these barriers makes them the 'causes' that impede cohesive and strategic peri-urban development. Overcoming these barriers would affect the handling of other barriers as well. In the second quadrant, barriers (B9) - Lack of studies evaluating the implementation and adherence of plans after their execution, (B3) - Overlapping and multiple institutes leading to conflict in land intervention can be found. These barriers are comparatively low in prominence but are still highly related to other barriers in the domain. Therefore, these barriers are termed 'dependent barriers', The barriers which are low in prominence as well as relation is illustrated in the third quadrant. This means that (B10) - *Exhibit high levels of informality in land use and tenure arrangements,* (B6) - *Lack of cadastral data for spatial assessment of Land,* and (B8) - Insufficient policies, plans, methods, and evaluations to curb unauthorized exploitation of natural and agricultural resources can be termed as 'independent' challenge. In the fourth quadrant, the challenge that is illustrated is B7-Lack of Limitations on Metropolitan Overgrowth in the Periphery, which has high prominence but less relation with other barriers. These barriers are therefore termed 'effects'.

Modified DEMATEL ISM analysis

A modified DEMATEL ISM method was used to identify the hierarchical structure of barriers and determine their interrelationships. The researchers categorized the discovered barriers in the peri-urban land development structure according to their perceived relevance and interdependencies, resulting in rank variation in resonance with the expert's opinions. The authors' rationale for prioritizing obstacles is based on their opinion that addressing problems at the highest level would serve as a strategic leverage point, exerting a more significant impact on other barriers. Conversely, the final barriers are classified as dependent barriers in the structural modeling. The presence of these barriers is mostly attributed to the insufficient resolution of the foundational issues, resulting in an extended struggle. The allocation of rank variation functions to underscore the hierarchical character of these obstacles, accentuating their interconnectedness and the possible areas of leverage for more efficient intervention. By ranking and classifying, the authors offer policymakers suggestions on how to focus resources and efforts to maximize influence on the whole peri-urban land development process. The first

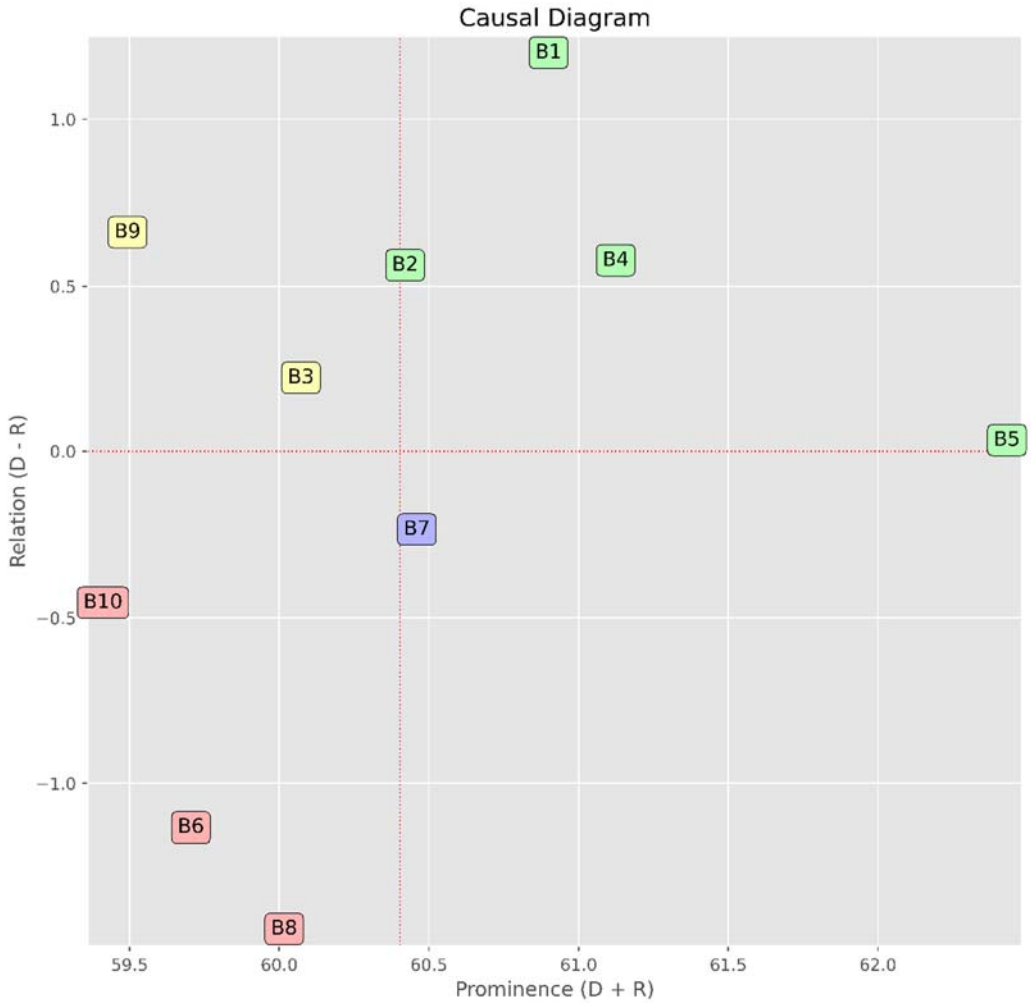

Fig. 2: Causal diagram of response from the experts

step in DEMATEL ISM analysis is to generate the initial reachability matrix (Table 7) based on the average response matrix as analyzed in DEMATEL.

The final reachability matrix (Table 8) was derived by using the rule of transitivity on the initial reachability matrix. In the given table, the Driving Power and Dependence of the barriers are shown, which will help in classifying the barriers into causes, dependent, independent, and effects. The reachability and antecedent set for each challenge are determined using the final reachability matrix. The reachability set comprises the challenge itself and other barriers that may be progressed by its help, whereas the antecedent set includes barriers itself and other barriers that may aid in its progress. The intersection of these sets is then calculated for each challenge. The top-level element in the ISM hierarchy is the one with the same reachability and intersection sets. After identifying the top-level challenge, it is split from the other barriers. The following level of components is then discovered using the same method as illustrated in Tables 9, 10, and 11.

In iteration 1, challenges B3, B6, B7, B8, and B10 are placed at level I as it does not have an impact on other barriers.

In iteration 2, barriers B4, B5, and B9, are

Table 7: Initial reachability matrix of barriers

Barriers	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	1	0	1	0	1	1	0	0	0	1
B2	0	1	0	1	1	0	0	0	0	0
B3	0	0	1	0	0	0	0	0	0	0
B4	0	0	0	1	1	0	1	0	0	0
B5	0	0	0	1	1	0	1	1	0	1
B6	0	0	0	0	0	1	0	0	0	0
B7	0	0	0	0	0	0	1	0	0	0
B8	0	0	0	0	0	0	0	1	0	0
B9	0	0	0	0	0	0	0	1	1	0
B10	0	0	0	0	0	0	0	0	0	1

Table 8: Final reachability matrix of barriers

Barriers	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Importance
B1	1	0	1	1	1	1	1	1	0	1	8
B2	0	1	0	1	1	0	1	1	0	1	6
B3	0	0	1	0	0	0	0	0	0	0	1
B4	0	0	0	1	1	0	1	1	0	1	5
B5	0	0	0	1	1	0	1	1	0	1	5
B6	0	0	0	0	0	1	0	0	0	0	1
B7	0	0	0	0	0	0	1	0	0	0	1
B8	0	0	0	0	0	0	0	1	0	0	1
B9	0	0	0	0	0	0	0	1	1	0	2
B10	0	0	0	0	0	0	0	0	0	1	1
Relation	1	1	2	4	4	2	5	6	1	5	23

Table 9: Iteration 1

S.No.	Reachability set	Antecedent set	Intersection set	Level
1.	1,3,4,5,6,7,8,10	1	1	
2.	2,4,5,7,8,10	2	2	
3.	3	1,3	3	
4.	4,5,7,8,10	2,4,5	4,5	
5.	4,5,7,8,10	1,2,4,5	4,5	I
6.	6	1,6	6	
7.	7	1,2,4,5,7	7	
8.	8	1,2,4,5,8,9	8	
9.	8,9	9	9	
10.	10	1,3,4,5,10	10	

Table 10: Iteration 2

S.No.	Reachability set	Antecedent set	Intersection set	Level
1.	1,4,5	1	1	
2.	2,4,5	2	2	
4.	4,5	1,2,4,5	4,5	II
5	4,5,	1,2,4,5	4,5	
9.	9	9	9	

Table 11: Iteration 3

S.No.	Reachability set	Antecedent set	Intersection set	Level
1.	1	1	1	III
2.	2	2	2	

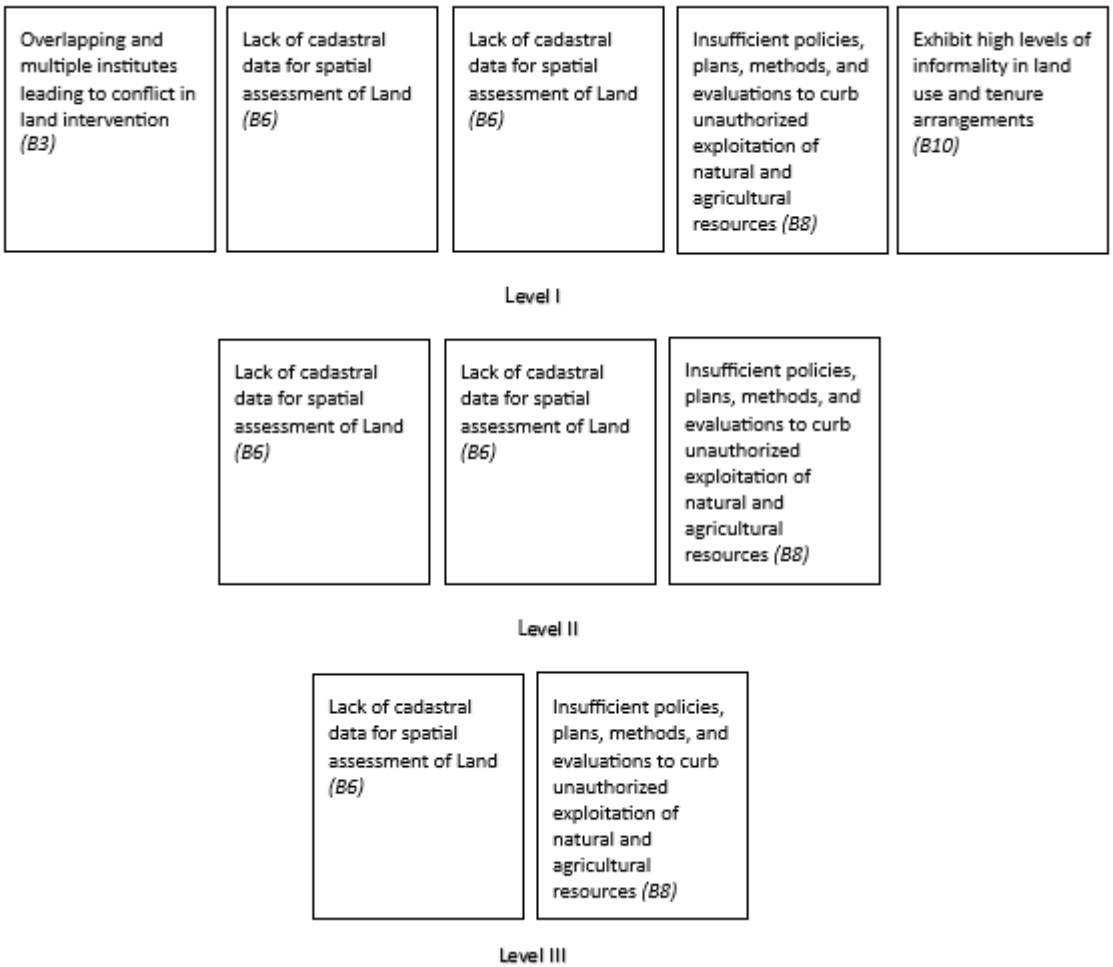

Fig. 3: ISM velopment

eliminated and put in level 2. Furthermore, in iteration 3, the barriers B1 and B2, are kept together in level III, as it has the most impact on the rest of the barriers in the domain.

The findings suggest that the two most significant challenges are B1 and B2. It implies that if the challenge of peri-urban demarcation (B1) and capacity building of urban local bodies (B2) are dealt with, it may be able to help deal with the next level of barriers in the structure as illustrated in Fig. 3. The barriers of not having a comprehensive territorial governance approach and absence of effective spatial policy-making (B4), absence of comprehensive planning and benchmarking for peri-urban areas (B5), and Lack of studies conforming to the planning measures and the post-implementation evaluative mandates (B9) are highly dependent on challenge B1 and B2. Therefore, if these barriers are addressed, it would help the planners to get a hold of the other barriers; B4, B5, and B9. While addressing the issues in the

peri-urban land development process, policymakers should prioritize the above-mentioned barriers as they would have more impact on the overall process. Also, the last structural modeling of barriers; B3, B6, B7, B8, and B10 are more of dependent barriers. They are mostly present because the rest of the barriers are not addressed and act as an extended challenge. Overlapping and Multiplicity of the institutes (B3), Lack of cadastral data for spatial assessment (B6), Lack of control on metropolitan encroachment in the peripheral areas (B7), insufficient and ineffective policies to control unauthorized exploitation of agricultural and other resources (B8), and high informality of land (B10) are the barriers at the least level, their significance is less and their dependency on the other barriers in the structure is high.

This study sought to identify and characterize peri-urban land development challenges based on their relevance and interconnection. The causal diagram shows four sorts of constraints to peri-urban land development: determinants/causes dependent, independent, and effects. The study statistically maps peri-urban land development restrictions. This structured and visual representation reduces complex barrier links, facilitating analysis and decision-making. The study also discusses the policy implications of prioritizing peri-urban delineation and ULB capacity building to address the other issues of spatial planning policies, comprehensive planning regulations, and post-implementation evaluation studies. Planners and policymakers could also create and prioritize successful policies and resource allocation with stated challenges. Experts recommended explicit peri-urban planning and development laws to address challenges. The guideline should instruct institutes and urban local authorities on spatially executing concepts. Designating peri-urban zones at various dimensions, including communities and continuous clusters on the city's outskirts is also a prospected intervention. The policymakers-focused research addresses complex Indian city peri-urban land development issues. 122 planners and professors add credibility to the study as the practical experiences and viewpoints of these experts complete barrier research and offer authenticity. Unfortunately, time and scope constraints limit the study to North Indian towns, which may limit its applicability to other Indian cities' peri-urban problems due to regional complexities. Developers, communities, and NGOs also affect peri-urban growth dynamics and difficulties. However, their perspectives are not covered in the study. The study suggests several recommendations and inferences, including 'causes' that policy-makers and planners should prioritize. The URDPFI guidelines' delineation and regulatory framework for peri-urban areas are unclear and fail to reflect their dynamic nature. Thus, Metropolitan and District Planning Committees must actively create a phased boundary projection using GIS and decision sciences. Regional and metropolitan strategies sometimes ignore peri-urban fluctuations. To develop practical solutions, a more specialized territorial strategy is needed. This can be done by compiling ideal approaches in various contexts to aid planners in constructing local area plans. Additionally, urban development in surrounding regions necessitates immediate answers. A zonal plan that prioritizes green spaces and agriculture can achieve this. This plan prohibits land use changes and prevents surrounding construction projects from using these sites. This can be done with zonation software, using blue-green infrastructure, and ecosystem services. Capacity-building programs are needed to achieve these goals since governing body professionals must be technically proficient. The study is methodologically sound, supports global sustainability goals, addresses related challenges, and is policy-relevant. It aids Indian city officials in making crucial peri-urban land development decisions. The study can help researchers understand locals, developers, environmental groups, and NGOs. Understanding stakeholder goals helps make peri-urban development more inclusive and sustainable. Another study can explore comprehensive Indian peri-urban case studies to discover their particular difficulties and solutions. The chosen case studies would show how to tackle comparable issues elsewhere.

CONCLUSION

Periurbanization is an inevitable phenomenon occurring globally, leading to urban development and expansion in a haphazard manner. This phenomenon is especially bringing in an inequitable and non-conforming development pattern with unfair distribution of resources to the cities. It has become increasingly important to address the unchecked development and prepare measures to streamline it as prescribed in SDG 11. In this study, the authors

have attempted to comprehend the challenges that lead to this form of fragmented development and understand the relation among the challenges for its effective resolutions. 122 experts from varied Indian cities were surveyed via online Google form during April 2023 to collect their responses on the significance and interrelationship of the multifaceted challenge that persists in the literature and hinders the efficacy of peri-urban land development. The response is analyzed using the MCDM technique of DEMATEL ISM which provides a visualization of the hierarchy of the challenges. This study contributes to the advancement of knowledge on the causal relationships between barriers to peri-urban land development by elucidating the underlying causes, as well as the dependent and independent barriers, and their resultant effects. The study has identified some important variables that impede the expansion of peri-urban areas. Through a thorough review of existing literature, the study has inferred ten key challenges (B1-B10) and aims to evaluate their interconnection and relationships using the DEMATEL ISM approach. The findings indicate that out of the ten barriers identified, the most significant ones hindering peri-urban land development are: (B1) ambiguous peri-urban delineation, (B2) insufficient capacity development of local institutions, (B4) ineffective spatial policy-making and absence of territorial governance approach, and (B5) absence of comprehensive planning regulations for peri-urban areas. These barriers can also be referred to as 'causes' that impede peri-urban land development. Lack of studies evaluating the implementation and adherence of plans after their execution, (B3) - Overlapping and multiple institutes leading to conflict in the land intervention are found to be minor yet strongly related to others in the domain, thus these barriers can be called 'dependent barriers'. The study also identifies low-profile and low-relationship barriers; (B10) - Exhibit high levels of informality in land use and tenure arrangements, (B6) - Lack of cadastral data for spatial assessment of Land, and (B8) - Insufficient policies, plans, methods, and evaluations to curb unauthorized exploitation of natural and agricultural resources, as 'independent' challenge. In the fourth quadrant, B7-Lack of Limitations on Metropolitan Overgrowth in the Periphery is prominent but unrelated to other barriers. Therefore, these barriers are called 'effects'. Furthermore, the study's findings also illustrate the hierarchical organization of these problems by identifying barriers that exert the greatest influence on other barriers. The analysis identifies that the resolution of obstacles B1 and B2 may yield the most advantageous and wide-ranging impact on other barriers, highlighting importance for planners and policymakers to prioritise obstacles B1 and B2. Doing so has the potential to result in positive outcomes and significant impacts in addressing other challenges, such as enhancing the capacity of local institutions, improving spatial policy-making, strengthening territorial governance, facilitating post-implementation evaluation strategies for land interventions, and addressing issues related to the informality of land. The implicit structure of the barriers provides policymakers with valuable insights regarding the efficiency of resource allocation, the execution of targeted policies, and the prioritization of the most significant issues. Thus, it can be concluded that the implications of the findings are relevant to contemporary peri-urban planning and practice, and include a wide range of advantages in planning and policy-making: a) The findings of this study can provide valuable insights for policymakers in formulating comprehensive policies and recommendations; strategically concentrating on addressing the most pressing issue initially, through an in-depth understanding of the cause-and-effect relationships between different barriers. b) Through the process of identifying the primary challenges and their interconnectedness, stakeholders can enhance their resource allocation strategies, prioritizing the root causes that exert the most significant influence on other barriers. c) Capacity building and training initiatives can be informed by the study's findings, enabling policymakers to develop targeted programs that effectively address the highlighted challenges. This will enable institutions to more effectively address barriers to peri-urban development, enhance their capacity for planning, and ensure long-term and equitable outcomes. To advance the study's outcomes, further investigation can be conducted by researchers to explore other challenges or conduct case studies in specific instances, to enhance comprehension and offer solutions that are more tailored to the specific case. Additionally, evaluation of urban planning strategies and land development policies and schemes would enhance the concept of informed decision-making.

AUTHOR CONTRIBUTIONS

S. Sareen conceptualized, analyzed, and prepared the manuscript. M. Haque supervised, reviewed, edited, and formatted the manuscript.

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CONFLICT OF INTEREST

The authors declare that there are no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, were observed by the authors.

ABBREVIATIONS

B	Barriers
DEMATEL	Decision-Making Trial and Evaluation Laboratory
GIS	Geographic information system
ISM	Interpretive Structural Modeling
MCDM	Multi-Criteria Decision Making
NGO	Non-Government Organization
SDG	Sustainable Development Goals
SEZ	Special Economic Zone
ULB	Urban Local Body
URDPFU	Urban and Regional Development Plans Formulation and Implementation
α	*Cronbach's Alpha value*
C	Challenegs
σ	Sigma
x	Response by participant
k	Participant number
n	Total number of participants
Xij	Average direct relation matrix
X	Average response matrix
T	Total Relation Matrix
t	threshold level
d	matrix
D	row-wise sum of the total relation matrix
R	column-wise sum of the total relation matrix
I	Initial Reachability Matrix
FRM	Final Reachability Matrix
TRM	Total Response Matrix

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