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A Hybrid DEMATEL-Grey System for Analyzing Slow Disbursement Causes in Public Infrastructure Projects

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ABSTRACT

Project stakeholders and the local economy are negatively impacted when state budget funds are not allocated on time, which causes delays in the capital disbursement of public investments, especially in transportation infrastructure projects in Vietnam. Introducing a hybrid approach that combines the Decision Making Trial and Evaluation Laboratory (DEMATEL) method with Grey System Theory (GST), which is effective in handling uncertainty and inadequate data, this research examines the complex relationships between several factors that contribute to disbursement delays. The findings of this study identify eight critical factors, with slow land clearance as the most significant cause influencing these delays. Detailed results reveal that bureaucratic inefficiencies and compensation disputes during the land clearance process are primary contributors to these delays. The results provide policymakers and project managers with practical insights, emphasizing the necessity of focused interventions in land clearance procedures to speed up cash release and improve project delivery schedules. A strong framework for tackling comparable problems in various regional contexts is provided by the study's innovative methodology and empirical findings.

1. INTRODUCTION

Worldwide, particularly in Vietnam, infrastructure projects are essential for the development of socioeconomic growth and sustainable development. In order to provide essential services that improve people's quality of life and boost economic growth, these projects are essential [1, 2]. However, the execution of such projects often encounters significant barriers due to slow disbursement processes of public funds. This delay not only behinds project schedule but also leads to cost overruns. The challenge is especially acute in the realm of public transport infrastructure, where complex financial management issues abound.

It is critical to identify and remove bottlenecks in grant disbursement processes given the growing demand for infrastructure amidst limited public fiscal resources. This paper presents these critical bottlenecks and offers pragmatic solutions based on the findings from a hybrid DEMATEL analysis. This research significantly enriches the ongoing conversation on enhancing project delivery within the public sector. By conducting a thorough investigation of Vietnam's case study and soliciting expert opinions, this study delves into the complexities of funding delays in public infrastructure projects. It provides a detailed understanding of the factors at play, thereby offering valuable insights for policymakers, project managers, and other stakeholders involved in the planning and execution of such projects. The outcomes of this research furnish these professionals with vital tools to forecast potential delays and develop effective countermeasures.

Previous studies have primarily focused on isolated aspects of the disbursement process, often overlooking the multifaceted nature of these delays and the uncertainties inherent in the data. This research aims to fill this gap by employing a hybrid methodology that integrates the Decision Making Trial and Evaluation Laboratory (DEMATEL) with Grey System Theory (GST), forming the hybrid G-DEMATEL method. This methodology enables a systematic examination and visualization of the complex causal relationships influencing project fund disbursement. The G-DEMATEL method transforms interconnected issues into a clear cause-effect framework, thus allowing for the identification and prioritization of key variables. By focusing on the case of Vietnam, this study not only seeks to identify the most critical factors affecting disbursement delays but also to provide actionable insights that can inform policy reforms and improve project management practices. In summary, this study addresses the pressing need for a systematic examination of the factors influencing public infrastructure project disbursements in Vietnam, offering a novel methodological approach that enhances our understanding of these challenges and proposes targeted solutions. Next, this paper was structured with the presentation of a literature review in section 2, followed by methodology in section 3. Empirical findings were described and discussed in section 4 and section 5 concluded the research paper.

2. BACKGROUND

Public investment is the state's deployment of capital to industries that promote the general welfare rather than being driven by profit [3-5]. Furthermore, public projects—financed either wholly or partly by the government or through voluntary contributions of money or labor by citizens—are designed to meet various needs that benefit the community. According to Vietnam's Public Investment Law, public investment projects are classified based on their nature and importance. Projects that include construction elements are categorized as new investments, renovations, upgrades, or expansions of existing investments, including asset and equipment acquisitions. Conversely, projects lacking construction components encompass asset acquisitions, land use rights transfers, and the purchase, repair, or upgrade of equipment and machinery. Based on their significance and scale, public investment projects are further divided into national priority projects, and Group A, B, and C projects.

The capital for public investment comprises state budget funds and legally sourced revenues from state agencies and public service units, as stipulated by law. The disbursement of public investment funds involves payment control agencies processing advances or payments for completed project stages, as per legal requirements. In cash flow terms, this means that the control agencies transfer funds from the state budget to the accounts of beneficiaries based on requests from project owners. The Public Investment Law permits fund disbursement within a one-year timeframe, with annual public investment capital execution and disbursement concluding by January 31 of the following year. Delays in disbursing public investment capital refer to situations where the payment of allocated funds from the state budget does not meet the planned schedule for each project. Such delays not only harm the project owners and contractors but also impact the economic growth momentum of the locality. While local governments need to compensate for the costs of basic construction and technical infrastructure projects through loans, aid, or bond issuance, the capital lying idle in the State Treasury is not optimally utilized. Additionally, delays in public investment disbursement lead to revenue losses due to the lag in project execution. This inefficiency erodes public trust in the local government machinery and incurs additional costs for most projects, including unfinished work, increased labor and machinery costs, and price escalations of materials.

Next, this section presents comprehensive previous studies that collectively underline the effectiveness of the DEMATEL method and related methods in identifying and analyzing complex interrelationships within various facets of construction and infrastructure project management. In the study by Hatefi and Tamošaitienė [6], an integrated approach using fuzzy DEMATEL and fuzzy ANP models is utilized to evaluate the risk interrelationships in construction projects. This approach addresses the need for a nuanced analysis of how different risk factors influence one another in a construction environment, which is often ignored in traditional risk assessments. By applying the fuzzy-DEMATEL method, the study identifies the directional influence and interdependencies among various risk factors such as time, cost, and safety, and then it uses fuzzy ANP to prioritize these risks based on their relative importance. The integrated model is applied to assess and compare five different construction projects in Isfahan, Iran, revealing that time, cost, and safety risks are the most significant. It provides a more holistic understanding of construction risks by incorporating the complexities of factor interrelationships, thereby enabling managers to make better-informed decisions about project risk management. The DEMATEL method is utilized to analyze the factors contributing to falls from height in construction projects [7]. The author categorizes these factors into organizational, individual, and environmental segments into 15 specific sub-factors. The research results demonstrate that individual factors—specifically motivation, training hours, and age/experience—are the most critical, with substantial influence on accident occurrence. Organizational factors, including management commitment and safety culture, are also highlighted as pivotal. This suggests that enhancing safety training and worker motivation can significantly reduce occupational and psychological stress, thereby decreasing the incidence of falls.

Lin et al. [8] explore the factors influencing construction safety at high-speed railway stations in China, focusing on the Hanghuang railway's Fuyang station. They utilize the DEMATEL and ISM methods to analyze 17 identified risk factors within four categories. These factors are assessed for their interaction and degree of influence on construction safety. This approach results in a multi-level hierarchical model that systematically analyzes the factors impacting the safety of high-speed railway station construction. Their research results show that the critical need for focused management and personnel factors to enhance safety measures and propose several strategic interventions. It provides a robust theoretical framework and practical insights for improving safety management in the construction of high-speed railway stations. In another study, Yang et al. [9] address the complex safety challenges in road tunnel construction in China by utilizing grounded theory and DEMATEL. They identify key factors influencing safety incidents based on examining 30 formal accident investigation reports and deriving a model that categorizes these factors into six levels of influence. It allows for a detailed analysis of the causal relationships among these factors, offering a substantial contribution to strategies aimed at enhancing safety in tunnel construction. Key insights include the identification of security awareness and professionalism as central to reducing accidents.

Akal et al. [10] addresses the challenge of insufficient proliferation of Building Information Modelling (BIM) in developing construction sectors, particularly through a structured implementation roadmap facilitated by the DEMATEL technique. Their study identifies 18 key success factors (KSFs) crucial for BIM implementation within the socio-economic context of developing economies. It investigates the interrelationships among these KSFs by collecting data from ten Egyptian BIM experts through a matrix format-based questionnaire. Utilizing the DEMATEL method, the study effectively categorizes these KSFs into four distinct clusters, each representing a phase in the BIM implementation process. This phased approach aids in establishing a practical roadmap that emphasizes step-by-step implementation, allowing for better prioritization and resource allocation by policymakers. Recently, Wu et al. [11] tackled the adoption challenges of blockchain technology in the construction industry. They employ a fuzzy DEMATEL method integrated with the Technology-Organization-Environment (TOE) framework to systematically identify and analyze barriers. Their paper reveals critical barriers such as policy uncertainties and technology maturity, while emphasizing the causality of technical barriers like interoperability and smart contract security. It not only contributes to understanding blockchain implementation barriers in construction, suggesting strategies from government, industry, and organizational perspectives to facilitate blockchain integration but also provides a comprehensive framework for stakeholders to address and navigate the complexities of adopting blockchain technology in construction projects.

Rostamzadeh et al. [12] apply an integrated approach using DEMATEL and ANP to study factors influencing fall accidents in construction. Analyzing data from 135 fall accidents across 15 residential construction projects, the authors identify and prioritize various risk factors based on expert opinions. It finds that organizational factors have the most significant influence, acting as causal factors in accidents, while individual and environmental factors tend to be the effects of these causes. Their study underscores the necessity of systematic strategies focusing on organizational factors to mitigate unsafe conditions and improve safety in construction projects. In another study, Dehdasht et al. [13] explore key drivers necessary for the successful adoption of the lean construction paradigm in the Malaysian construction industry. The study innovatively integrates DEMATEL with Social Network Analysis (SNA) to examine the complex interrelations among these drivers (DSNA). The authors identify critical factors such as optimization, continuous improvement, and company culture as pivotal for fostering Sustainable and Successful Lean Construction (SSLC). Their study also emphasizes how other important drivers are greatly impacted by elements like stronger teamwork, less disagreement among leaders, and a better workplace culture. It highlights the necessity for targeted interventions in these areas to advance sustainability in the construction industry, guiding policy makers in addition to shedding light on the causal and effective links between the major factors.

Shi and Wu [14] employ Knowledge Graph (KG), DEMATEL, Interpretative Structural Modeling (ISM), and MICMAC methods to conduct a data-driven analysis of elevator accidents. This approach allows for the identification and classification of risk factors without heavy reliance on expert input. It provides valuable insights into preventative measures for elevator safety, significantly contributing to risk management literature by enhancing the robustness and accuracy of risk assessments in safety-critical systems. Furthermore, Yu and Ma [15] examines the risk factors in the mega infrastructure construction supply chain (MICSC) within EPC projects, focusing on identifying risk incidents and evaluating their importance and causality using a combined fuzzy Analytic Hierarchy Process (FAHP) and fuzzy DEMATEL model. It identifies 12 primary and 36 secondary risk factors by reviewing 178 literature sources and consulting with five professionals. Their research results show that political situation, social security, and management mode are significant risk factors, with the first two acting as cause factors and the last as an effect factor. This research offers substantial contributions by embedding all phases of the project lifecycle and various stakeholders into the risk evaluation framework, providing practical insights for improving risk management strategies in construction supply chains. In their paper, Shi et al. [16] analyze safety risk factors in coal mine construction by applying DEMATEL combined with Interpretative Structural Modeling (ISM). Their study employs text mining to identify risk factors and uses association rules to reveal their interrelations, forming a hierarchical analysis. It categorizes identified risk factors into six levels and highlights unsafe behavior and equipment malfunction as direct causes of accidents. The study's comprehensive approach, focusing on both identification and structural analysis of risk factors, offers significant insights into safety management practices, suggesting strategic interventions for improving safety standards in coal mine construction projects. This work stands out by integrating systematic methodologies to enhance risk evaluation and management in complex construction environments.

The DEMATEL technique has been used in earlier research to examine important variables and how they interact with one another in the management of engineering and technology projects. However, the majority of these studies have not incorporated Grey System Theory (GST), a novel approach that could significantly enhance our understanding of data uncertainty and ambiguity in infrastructure projects. In the following section, this paper introduces an innovative methodology by applying G-DEMATEL. t is expected that this method will provide a more efficient way to examine and assess the important elements causing public infrastructure project funding to move slowly. By using G-DEMATEL, we aim to better handle uncertain data, which is a frequent issue in large-scale infrastructure projects.

3. RESEARCH METHOD

Julong Deng created the grey theory in China in the early 1980s to deal with problems that are characterized by ambiguity and incomplete knowledge [17-22]. It has been widely applied in various fields such as forecasting, system decision-making, control, and management. Concurrently, the DEMATEL method, formulated by the Battelle Memorial Institute in Geneva in the late 1970s, enables the visualization, analysis, and interpretation of complex relationships among elements within a system [23-25]. Integrating these two methodologies, G-DEMATEL harnesses both the DEMATEL method (Decision Making Trial and Evaluation Laboratory) and Grey Systems Theory to effectively tackle problems involving uncertain and incomplete data [26-28].

The G-DEMATEL method was chosen for this study precisely because it is a robust quantitative approach. By employing G-DEMATEL, we are able to systematically analyze and quantify the complex interrelationships among various critical factors that contribute to delays in public infrastructure project disbursements. This method integrates the strengths of Grey System Theory, handling uncertainty and incomplete information, with the DEMATEL technique, constructing a cause-effect relationship among factors. This combination ensures that our analysis is both data-driven and objective, reducing the potential for bias that might arise from qualitative approaches. By relying on this method, we aim to deliver a more reliable analysis that stakeholders can use to make informed decisions in the management of public infrastructure projects.

Step 1: *Initial grey direct-relation matrix construction*

Gather information using a linguistic scale, then convert these assessments into grey numbers that are shown as intervals in Table 1 to account for the uncertainty of expert judgments.

Table 1. Linguistic scales with grey numbers

Linguistic Terms	Grey Numbers
No influence	[0,0]
Very low influence	[0,1]
Low influence	[1,2]
High influence	[2,3]
Very high influence	[3,4]

Then, construct an initial direct-relation matrix using grey numbers.

$$Z^k = \begin{bmatrix} [0,0] & \dots & \otimes z_{12}^k & \dots & \otimes z_{1n}^k \\ \otimes z_{12}^k & \dots & [0,0] & \dots & \otimes z_{2n}^k \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \otimes z_{n1}^k & \dots & \otimes z_{n2}^k & \dots & [0,0] \end{bmatrix} \tag{1}$$

where,

$\otimes z_{ij}^k$ is the grey number for the influence or impact of factor *i* on factor *j* for an expert *k*. For example, they are the lower and upper bounds of the grey interval, indicating the minimum and maximum impact, respectively [29-31].

Step 2: *Normalize the grey direct-relation matrix*

Normalize the initial grey direct-relation through Eqs. (2) and (3).

$$\otimes s = [\underline{s}, \bar{s}] = \frac{1}{\max\limits_{1 \le i \le n} \sum_{j=1}^{n} \otimes z_{ij}} \tag{2}$$

$$\otimes n_{ij} = \left[\underline{s}.\underline{z}_{ij}, \bar{s}.\bar{z}_{ij} \right] \tag{3}$$

where

$\otimes n_{ij}$ is the normalized grey number interval between factor *i* and *j*.

Step 3: *Develop the total relation matrix*

Calculate the total relation matrix by using Eq. (4):

$$T = \sum_{i=1}^{\infty} D^i = D(I-D)^{-1} \tag{4}$$

where,

I represents an *n*x*n* identity matrix; and

D^i is the matrix *D* raised to the power of *i*, capturing the *i*-th order indirect effects.

Step 4: *Analyze the causal influence*

Calculate the degree of prominence (importance) and the net cause-effect (relation) for each factor from the total relation matrix:

$$\otimes r_i = \left[\sum_{j=1}^{n} \otimes t_{ij} \right]_{n \times 1} \tag{5}$$

$$\otimes c_j = \left[\sum_{i=1}^{n} \otimes t_{ij} \right]'_{1 \times n} \tag{6}$$

4. RESULTS AND DISCUSSION

Based on a literature review and in-depth interviews with experts, this study identifies the eight most critical causes of slow disbursement in Vietnam's public infrastructure projects. These causes are (C1) Errors in survey and construction design; (C2) Fiscal budgetary constraints; (C3) Slow land clearance; (C4) Inappropriate audit and settlement processes; (C5) Incomplete legal procedures in investment project management; (C6) Insufficient project preparation; (C7) Limited capabilities of consulting firms and project owners; and (C8) Poor contractor performance.

Table 2 presents the integrated grey direct-relation matrix, developed based on the synthesis of expert evaluations for grey numbers given in Table 1. Next, the normalized grey direct-relation matrix was obtained by using formulas (2) and (3), as shown in Table 3. After obtaining the normalized grey comparison matrix, we calculated the total relation matrix using (4) as shown in Table 4. Finally, the normalized grey weight of these factors to disbursement delays was presented in Table 5.

Table 2. The integrated grey direct-relation matrix

[0.000, 0.000]	[0.667, 1.667]	[0.667, 1.667]	[0.000, 0.667]	[1.000, 2.000]	[2.333, 3.333]	[1.333, 2.333]	[0.333, 1.333]
[2.000, 3.000]	[0.000, 0.000]	[2.333, 3.333]	[2.000, 3.000]	[3.000, 4.000]	[2.000, 3.000]	[0.000, 1.000]	[1.000, 2.000]
[1.333, 2.333]	[2.333, 3.333]	[0.000, 0.000]	[0.667, 1.667]	[2.333, 3.333]	[2.000, 3.000]	[0.667, 1.667]	[0.333, 1.333]
[0.000, 0.333]	[0.000, 1.000]	[2.000, 3.000]	[0.000, 0.000]	[2.000, 3.000]	[2.000, 3.000]	[2.000, 3.000]	[1.000, 2.000]
[1.333, 2.333]	[1.667, 2.667]	[1.667, 2.667]	[1.000, 2.000]	[0.000, 0.000]	[1.000, 2.000]	[0.000, 1.000]	[0.000, 1.000]
[3.000, 4.000]	[0.000, 1.000]	[1.000, 2.000]	[0.000, 1.000]	[1.667, 2.667]	[0.000, 0.000]	[1.667, 2.667]	[0.000, 1.000]
[2.000, 3.000]	[1.000, 2.000]	[1.000, 2.000]	[0.000, 1.000]	[1.000, 2.000]	[1.000, 2.000]	[0.000, 0.000]	[0.000, 1.000]
[2.000, 3.000]	[1.000, 2.000]	[1.000, 2.000]	[0.000, 1.000]	[1.000, 2.000]	[2.000, 3.000]	[1.000, 2.000]	[0.000, 0.000]

Table 3. The normalized grey direct-relation matrix

[0.0000, 0.0000]	[0.0345, 0.0862]	[0.0345, 0.0862]	[0.0000, 0.0345]	[0.0517, 0.1034]	[0.1207, 0.1724]	[0.0690, 0.1207]	[0.0172, 0.0690]
[0.1034, 0.1552]	[0.0000, 0.0000]	[0.1207, 0.1724]	[0.1034, 0.1552]	[0.1552, 0.2069]	[0.1034, 0.1552]	[0.0000, 0.0517]	[0.0517, 0.1034]
[0.0690, 0.1207]	[0.1207, 0.1724]	[0.0000, 0.0000]	[0.0345, 0.0862]	[0.1207, 0.1724]	[0.1034, 0.1552]	[0.0345, 0.0862]	[0.0172, 0.0690]
[0.0000, 0.0172]	[0.0000, 0.0517]	[0.1034, 0.1552]	[0.0000, 0.0000]	[0.1034, 0.1552]	[0.1034, 0.1552]	[0.1034, 0.1552]	[0.0517, 0.1034]
[0.0690, 0.1207]	[0.0862, 0.1379]	[0.0862, 0.1379]	[0.0517, 0.1034]	[0.0000, 0.0000]	[0.0517, 0.1034]	[0.0000, 0.0517]	[0.0000, 0.0517]

[0.1552, 0.2069]	[0.0000, 0.0517]	[0.0517, 0.1034]	[0.0000, 0.0517]	[0.0862, 0.1379]	[0.0000, 0.0000]	[0.0862, 0.1379]	[0.0000, 0.0517]
[0.1034, 0.1552]	[0.0517, 0.1034]	[0.0517, 0.1034]	[0.0000, 0.0517]	[0.0517, 0.1034]	[0.0517, 0.1034]	[0.0000, 0.0000]	[0.0000, 0.0517]
[0.1034, 0.1552]	[0.0517, 0.1034]	[0.0517, 0.1034]	[0.0000, 0.0517]	[0.0517, 0.1034]	[0.1034, 0.1552]	[0.0517, 0.1034]	[0.0000, 0.0000]

Table 4. The normalized grey direct-relation matrix

[0.0524, 0.3666]	[0.0581, 0.3538]	[0.0664, 0.3979]	[0.0131, 0.2428]	[0.0919, 0.4570]	[0.1531, 0.5154]	[0.0906, 0.3761]	[0.0230, 0.2532]
[0.1782, 0.6508]	[0.0541, 0.4025]	[0.1820, 0.6183]	[0.1272, 0.4436]	[0.2299, 0.7097]	[0.1840, 0.6715]	[0.0511, 0.4411]	[0.0673, 0.3728]
[0.1376, 0.5685]	[0.1537, 0.5036]	[0.0593, 0.4144]	[0.0620, 0.3530]	[0.1846, 0.6207]	[0.1649, 0.6062]	[0.0683, 0.4192]	[0.0318, 0.3105]
[0.0686, 0.4435]	[0.0430, 0.3759]	[0.1440, 0.5104]	[0.0175, 0.2441]	[0.1559, 0.5610]	[0.1538, 0.5603]	[0.1312, 0.4489]	[0.0585, 0.3146]
[0.1133, 0.4915]	[0.1121, 0.4208]	[0.1233, 0.4712]	[0.0705, 0.3241]	[0.0565, 0.3994]	[0.1029, 0.4935]	[0.0289, 0.3392]	[0.0135, 0.2589]
[0.1924, 0.5632]	[0.0332, 0.3477]	[0.0828, 0.4330]	[0.0126, 0.2695]	[0.1228, 0.5074]	[0.0492, 0.3941]	[0.1082, 0.4097]	[0.0071, 0.2521]
[0.1410, 0.4987]	[0.0760, 0.3721]	[0.0817, 0.4156]	[0.0154, 0.2607]	[0.0919, 0.4611]	[0.0935, 0.4652]	[0.0226, 0.2688]	[0.0086, 0.2421]
[0.1583, 0.5510]	[0.0816, 0.4075]	[0.0902, 0.4574]	[0.0169, 0.2868]	[0.1031, 0.5088]	[0.1526, 0.5566]	[0.0811, 0.4005]	[0.0094, 0.2172]

Table 5. The normalized grey weights

(C1) Errors in survey and construction design	0.1317
(C2) Fiscal budgetary constraints	0.1392
(C3) Slow land clearance	0.1396
(C4) Inappropriate audit and settlement processes	0.1060
(C5) Incomplete legal procedures in investment project management	0.1377
(C6) Insufficient project preparation	0.1380
(C7) Limited capabilities of consulting firms and project owners	0.1092
(C8) Poor contractor performance	0.0341

The research results show that slow land clearance is the leading cause of delayed disbursement of investment capital for Vietnam's' public infrastructure projects. Firstly, the policy framework's complexity and the drawn-out bureaucratic procedures required make it difficult to implement even after several revisions. The current policies require multiple steps in the land clearance process, including land appraisal, compensation, support, and resettlement. These procedures are often cumbersome and time-consuming, significantly delaying the completion of the project. Secondly, the compensation mechanism for land clearance often becomes a contentious issue leading to disputes. Currently, the state's compensation often does not reflect the current market value, leading to dissatisfaction among those whose land is expropriated. This dissatisfaction can escalate into legal disputes, further delaying project progress. Next, delays in clearing land for infrastructure projects adversely affect the socio-economic landscape. Infrastructure projects such as roads, bridges, and public utilities are essential for economic development and urban expansion. Delays in their deployment can result in missed opportunities. For instance, inadequate transportation infrastructure can hinder the movement of goods and services, impacting local businesses and the broader Vietnamese economy. Lastly, the bureaucratic burden associated with land clearance for public infrastructure projects often leads to a significant allocation of resources that could be better used in other aspects of project development. Therefore, to accelerate the land clearance process and timely resolve issues related to land, the state must ensure adequate compensation policies combined with resettlement plans to stabilize the lives of displaced households.

The second most important factor is fiscal budgetary constraints. They hinder the timely disbursement of public investment capital. Due to these limitations, scarce financial resources are frequently dispersed too widely among several projects, which delays their completion. Government finance agencies should give priority to projects that have the greatest potential for socioeconomic impact in order to lessen this. Furthermore, public-private partnerships (PPPs) scheme and other alternative financing methods can help diversify funding sources and ease the burden on state budgets.

Next, the third important reason is insufficient project preparation. Some public projects are initiated without adequate pre-feasibility or feasibility studies, risk assessments, or stakeholder consultations, which can result in unforeseen challenges during implementation. To address this, project owners, consultants, and government planning agencies should adopt a comprehensive multi-stage planning process. This process should include thorough pre-feasibility or feasibility studies, detailed risk analysis, and extensive stakeholder consultations. Additionally, benchmarking against successful projects can provide valuable insights and guide preparation efforts.

In addition to insufficient project preparation, incomplete legal procedures in public investment project management can create significant roadblocks in the disbursement of investment funds. Government officials need to ensure that all legal requirements are thoroughly understood and met before project initiation. Providing specialized legal training to project managers can greatly improve compliance with these procedures. Furthermore, establishing dedicated legal support units within project management teams can help navigate complex legal landscapes more efficiently.

Moreover, one of the most critical factors affecting public investment disbursement is the errors in survey and construction design. These errors can lead to significant delays as projects must be halted to correct inaccuracies, often resulting in additional costs and behind schedule. To address this issue, it is essential for stakeholders such as surveyors, design consultants, and project managers to receive comprehensive training on the latest construction standards and technologies. Furthermore, implementing a robust preliminary review process can help identify and rectify potential design flaws before the project commences.

Similarly, the limited capabilities of consulting firms and project owners often lead to inefficiencies in managing public transportation infrastructure projects, causing delays in fund disbursement. To address this, it is crucial to develop certification and training programs that ensure they possess the necessary expertise to manage large-scale public transportation infrastructure projects. Continuous professional development should also be encouraged to keep these stakeholders updated on the latest industry advancements. Next, inappropriate audit and settlement processes can significantly slow down public investment disbursement, leading to financial bottlenecks that behind project schedules. Auditors or financial managers must streamline these processes to ensure efficiency. One way to achieve this is by adopting digital tools that facilitate real-time monitoring and reporting, thereby reducing the time spent on manual checks and balances. Additionally, capacity-building initiatives should be introduced to train auditors and financial managers in the latest audit standards and practices.

Finally, poor contractor performance is a significant factor contributing to delays in public investment disbursement. Contractors who fail to meet deadlines or maintain good quality standards can derail entire projects, leading to extended timelines and increased costs. To mitigate this issue, performance-based contracts should be introduced, where compensation is tied to specific performance metrics such as timely completion and adherence to quality standards. Additionally, establishing a transparent contractor evaluation system can incentivize high performance by making contractor ratings publicly available.

5. CONCLUSIONS

This study has highlighted the pivotal role that slow land clearance plays in the significant delays encountered in the disbursement of funds within public transportation infrastructure projects in Vietnam. By utilizing an innovative hybrid approach that integrates Grey System Theory (GST) and the DEMATEL method, this study has effectively navigated the complexities of uncertain and incomplete data to map out the intricate interdependencies among various factors contributing to these delays. The findings provide compelling evidence that land clearance is the primary bottleneck, suggesting that targeted policy interventions and enhancements in project management practices could substantially mitigate these delays. In addition to adding a new methodological framework to the body of knowledge, this study provides useful information for project managers and policymakers who want to maximize infrastructure development and advance economic progress.

However, this study does have several drawbacks. The study's focus on particular public infrastructure projects in Vietnam is one of its major limitations, which may restrict the applicability of the findings to other situations or nations with distinct sociopolitical and economic conditions. One significant limitation is the scope of the study was limited to specific public infrastructure projects in Vietnam, which may limit the generalizability of the findings to other contexts or countries with different socio-political and economic environments. Future research should focus on testing the effectiveness of these interventions across different regional contexts in other countries with similar challenges, to validate and refine the proposed solutions. By addressing these limitations, it can build on the findings of this study, providing a more nuanced understanding of the dynamics at play in public investment disbursement and offering more tailored solutions for improving efficiency in project implementation.

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