Civil and Sustainable Urban Engineering

Research Article
Volume 6(1), 2026, 199−207
https://doi.org/10.53623/csue.v6i1.1031

Infrastructure Development Strategy in an Industrial Zone: A Case Study in the Sei Lekop Industrial Area, Indonesia

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SUBMITTED: 2 February 2026; REVISED: 18 March 2026; ACCEPTED: 25 March 2026

ABSTRACT: Infrastructure is vital for boosting firm performance and competitiveness in industrial zones, especially amid Industry 4.0 demands for seamless efficiency and connectivity. This study analyzes development strategies at a manufacturing firm (anonymized here for confidentiality) in Batam's Sei Lekop Industrial Area, Indonesia. We anonymized the firm throughout for confidentiality. A single-case study gathered data via in-depth interviews, site observations, and document reviews; descriptive qualitative analysis drew rigor from quantified SWOT and gap methods. Results exposed clear shortfalls—roads, power, water, digital links—versus benchmarks. SWOT scores land the firm in a growth quadrant, demanding bold upgrades fueled by public-private partnerships. This work enriches infrastructure strategy literature with a firm-level lens on industrial zones, weaving in physical and digital dimensions. On the practical side, it lays out phased upgrades, digital integration, and sustainability-focused tactics to lock in lasting competitiveness.

KEYWORDS: Infrastructure development; industrial zone; SWOT analysis; gap analysis.

1. Introduction

Industrial zones propel national economic growth by grouping production, logistics, and distribution into efficient, focused hubs. In developing economies like Indonesia, their success is directly tied to the quality and reach of supporting infrastructure. Roads, energy networks, water supply, and digital connectivity are no longer seen merely as supporting facilities but as key enablers of productivity and competitiveness [1–3]. When infrastructure provision is inadequate, industrial operations tend to suffer from higher costs, delays, and lower efficiency, which eventually weaken firms' competitive positions [4, 5].

The Sei Lekop Industrial Area in Batam represents one of the rapidly developing industrial clusters due to its proximity to ports and major transportation corridors [6, 7]. Yet, its prime location does not eliminate persistent infrastructure challenges. PT X, one of the companies operating in this area, faces practical constraints related to road capacity, energy supply, clean water availability, and the reliability of digital infrastructure. These limitations directly affect logistics performance, production continuity, and operational costs [8, 9].

Recent studies frame infrastructure beyond just physical assets, embedding it within a broader ecosystem of institutions and technology [10, 11]. Green and sustainable planning has gained traction, especially for industrial and urban zones [12, 13]. Social infrastructure also plays a role in shaping regional growth patterns and economic output [14]. Manufacturing firms must now align their strategies with digital transformation and Industry 4.0 [15, 16]. Tools such as prescriptive analytics, digital twins, and integrated digital systems enhance efficiency and competitiveness in infrastructure operations [17–20]; however, cybersecurity threats remain a significant concern in smart systems. Nevertheless, much of the existing research focuses on national or regional infrastructure, with limited attention to firm-level decision-making in specific industrial zones [21]. Recent studies have explored practical tools such as BIM–GIS integration and planning support systems, but coverage remains limited for industrial areas in developing countries [22, 23].

SWOT and gap analysis are widely applied across transport, energy, and infrastructure sectors to support strategic decision-making [24–27]. These approaches are particularly useful for identifying mismatches between existing conditions and desired performance targets, as well as for formulating prioritized development strategies. Another important issue concerns infrastructure financing and governance. Public–private partnerships (PPP) have been increasingly promoted as viable mechanisms to accelerate infrastructure provision and improve project performance [28–31]. Nevertheless, empirical evidence indicates that private participation in infrastructure projects is not without risks and failures, particularly in complex institutional and regulatory environments [32, 33].

This study contributes by focusing on firm-level infrastructure strategy within a specific industrial zone, integrating physical and digital infrastructure assessments through SWOT and gap analysis. It moves beyond general strategic discussions by providing a grounded and practical perspective on infrastructure planning. Thus, this study aims to evaluate PT X's infrastructure strategy in the Sei Lekop Industrial Area by mapping current conditions, identifying gaps, and formulating targeted strategies to enhance operational performance and ensure long-term competitiveness. The findings are expected to contribute to academic discourse on industrial infrastructure while offering practical insights for companies and policymakers involved in industrial zone development.

2. Materials and Methods

2.1. Research design and case selection.

We used a qualitative single-case study to unpack firm-level infrastructure strategy in an industrial zone setting. This approach fits messy, real-world issues where context can't be untangled from the problem. Our focus: a manufacturer in Batam's Sei Lekop Industrial Area—a fast-growing cluster with solid logistics ties but nagging infrastructure limits. This case study was chosen for three main reasons: the company's active role in production and logistics, its firsthand experience with infrastructure problems, and its willingness to share data. To protect confidentiality and uphold research ethics, the company will be referred to as the "case company" throughout this document.

2.2. Data collection.

Data Collection To ensure a thorough triangulation process, we gathered data from several sources. The main insights came from semi-structured interviews with key individuals. In addition, company documents and industry reports provided important secondary context. We assessed the infrastructure using direct observations in the field. Table 1 provides a summary of the participant profiles. A purposive sampling technique was used to select respondents with direct involvement in infrastructure-related activities.

Table 1. Profile of interview informants.

No	Position	Experience (Years)	Role in Infrastructure
1	Operations Manager	12	Strategic decision-making
2	Logistics Supervisor	8	Distribution management
3	Maintenance Staff	6	Infrastructure maintenance
4	IT Officer	5	Digital infrastructure

2.3. Data analysis.

We took a structured qualitative route for analysis. Thematic coding processed interview transcripts—starting with open coding, then axial, and selective phases—to build themes on infrastructure hurdles, operational fallout, and response tactics. Triangulation cross-checked interviews with site observations and documents to ensure rock-solid reliability. This method builds trust in the analysis by ensuring both credibility and solid reliability.

2.4. SWOT and gap analysis procedure.

We ran SWOT via quantified IFE and EFE matrices, weighting factors (0–1) and rating them (1–4) to yield weighted scores. Gap analysis pitted current conditions against benchmarks from industrial regulations and key studies. The gap percentage was calculated as:

Gap (%) = (Ideal – Existing) / Ideal × 100.

2.5. Research workflow.

Figure 1 maps our step-by-step workflow. It starts with wide-ranging data collection from primary and secondary sources. We followed up with coding and thematic analysis to pull out patterns and main themes from the qualitative data. Those insights went into gap analysis against industry standards to highlight big discrepancies, then fed a SWOT matrix to balance internal and external factors, wrapping up with concrete recommendations for infrastructure upgrades.

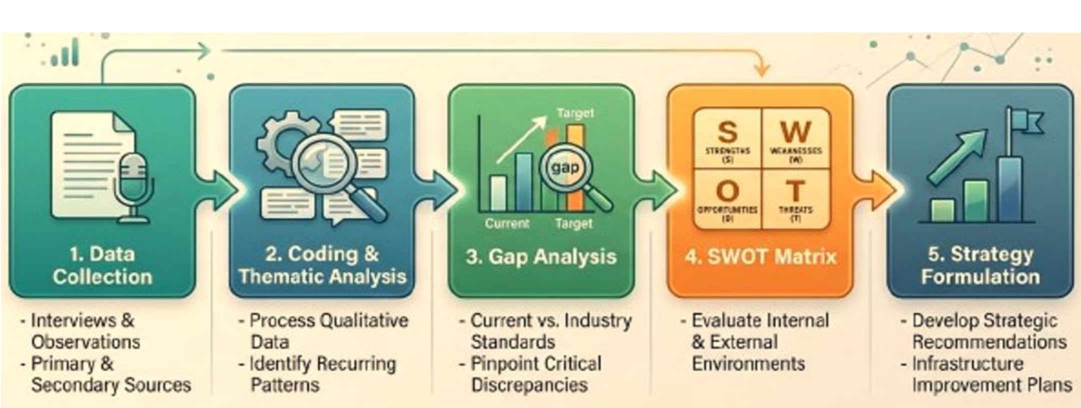

Figure 1. Research workflow.

3. Results and Discussion

3.1. Infrastructure conditions.

PT X grapples with major infrastructure hurdles that drag down operations. Roads stand out as the top issue—too narrow and poorly linked between blocks. Figure 2 shows 72% of respondents pinpointed roads as the top issue, followed by water supply (18%) and digital systems (10%). This matches earlier studies tying transport shortfalls to logistics holdups and output slumps [4, 5]. Road problems lead the pack in fast-growing zones like Sei Lekop, where skimpy capacity stalls shipments. Electricity stays fairly steady but lacks punch, leaning on generators that jack up expenses—echoing dependability woes across industrial clusters [10, 11].

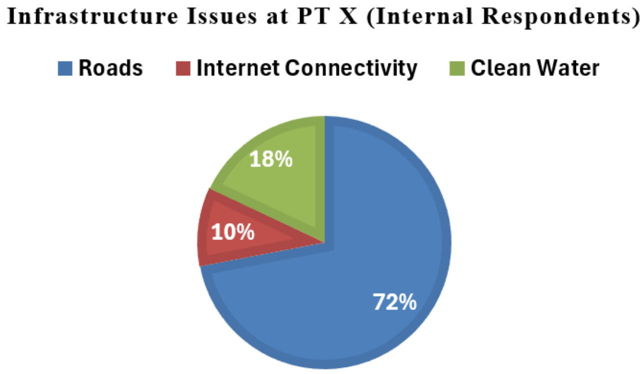

Figure 2. Distribution of infrastructure constraints (source: Field Survey, n=11 respondents; measured using percentage-based response analysis).

3.2. Gap analysis.

The gap analysis reveals substantial discrepancies between the existing infrastructure and the required operational standards. Table 2 sums it up: current setups fall short of demand across roads, power, water, and digital lines. Benchmarks match standard industrial estate plans and manufacturing logistics needs [12, 13]. Roads show the biggest gap at 41.7% on width, making them the clear priority for planning and strategy next.

Table 2. Infrastructure gap analysis.

Infrastructure	Existing	Ideal Standard	Gap (%)
Road Width	7 m	12 m	41.70%
Electricity	8 MW	12 MW	33.30%
Water Supply	800 m³	1200 m³	33.30%
Internet Speed	Low	High-speed ERP-ready	High

3.3. SWOT analysis (QUANTIFIED).

To gauge PT X's strategic stance, we ran quantified SWOT through IFE and EFE matrices. Table 3 breaks down internal factors (strengths, weaknesses); Table 4 handles external ones (opportunities, threats). Weights and ratings give crisper insight than plain descriptive SWOT. IFE (Table 3) hits 2.70 overall—a decent internal setup, with location and staff strengths tempered by infrastructure gaps and steep energy costs. EFE (Table 4) hits 2.85, signaling good external footing via government aid and PPPs, even with competition and red tape in play. The results position the company in a growth strategy quadrant, suggesting that aggressive infrastructure investment is required. This aligns with strategic infrastructure planning literature emphasizing alignment between internal capacity and external opportunity [23].

Table 3. IFE matrix (internal factors).

Factor	Weight	Rating	Score
Strategic location	0.25	4	1
Skilled workforce	0.2	3	0.6
Limited road capacity	0.3	2	0.6
High energy cost	0.25	2	0.5
Total	1		**2.7**

Table 4. EFE matrix (external factors).

Factor	Weight	Rating	Score
Government support	0.3	4	1.2
PPP opportunities	0.25	3	0.75
Competition	0.25	2	0.5
Regulatory risk	0.2	2	0.4
Total	1		**2.85**

3.4. Strategy formulation.

From quantified SWOT results, we built a strategy matrix linking internal and external factors to concrete actions. Table 5 maps SWOT elements to proposals—leveraging strengths for opportunities while tackling weaknesses and threats head-on. The SWOT-strategy matrix (Table 5) flags PPP-driven expansion and infrastructure upgrades as top priorities. In particular, addressing road capacity and utility constraints becomes critical to improving logistics performance and operational efficiency. These strategies are consistent with global trends in industrial infrastructure development, particularly the integration of digital and physical systems [19].

Table 5. SWOT–strategy matrix.

SWOT Factor	Strategy
Strength–Opportunity	Expand infrastructure via PPP
Weakness–Opportunity	Upgrade roads & utilities
Strength–Threat	Improve logistics efficiency
Weakness–Threat	Invest in resilient infrastructure

3.5. Conceptual framework.

To clarify the theory and analysis, we propose a conceptual framework linking infrastructure conditions, tools like gap and SWOT, and endgame strategies. The relationship between infrastructure condition, gap analysis, SWOT factors, and development strategy is illustrated in Figure 3. The framework demonstrates that infrastructure limitations serve as the initial input, which is then evaluated through gap analysis and SWOT analysis to generate strategic responses. These strategies ultimately influence operational performance and competitiveness, consistent with the Resource-Based View (RBV) and infrastructure performance theory.

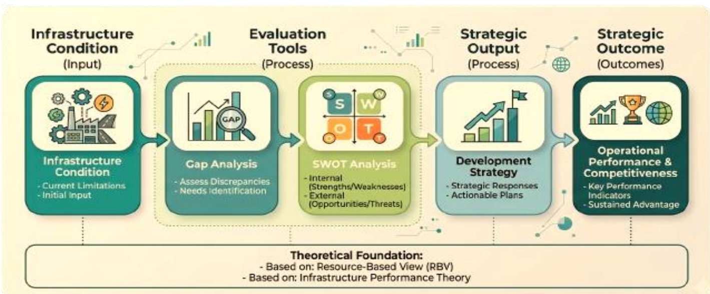

Figure 3. Conceptual Framework

3.6. Sustainability and risk analysis.

Infrastructure planning must blend risk management and sustainability with core strategy to secure enduring resilience. Table 6 sums up key risks by probability and impact. Power outages and road jams rate as critical, demanding immediate fixes. Water shortages and cyber threats fall into high-to-moderate, underscoring the push for tough physical and digital safeguards. This reinforces how infrastructure planning needs to weave in sustainability and resilience, as smart infrastructure research stresses [21].

Table 6. Infrastructure risk matrix.

Risk	Probability	Impact	Level
Power failure	High	High	Critical
Road congestion	High	High	Critical
Water shortage	Medium	High	High
Cyber risk	Medium	Medium	Moderate

4. Conclusions

Our work advances infrastructure strategy literature through a firm-level breakdown in an industrial zone setting, blending physical and digital elements via a tight analytical frame. Unlike earlier studies locked onto regional or national plans, ours reveals precisely how infrastructure constraints slam daily operations and steer firm-level decisions. The findings highlight that transportation infrastructure, energy supply, and digital connectivity are critical determinants of logistics efficiency and competitiveness. The quantified SWOT and gap analysis confirm the need for aggressive infrastructure investment supported by external collaboration mechanisms such as PPP. From a management standpoint, this study offers concrete steps: phased infrastructure upgrades, tight digital integration, and sustainability-focused development. From a policy perspective, the results emphasize the importance of improving industrial estate governance, infrastructure financing mechanisms, and regulatory support. Future studies should broaden to multiple industrial zones for better generalizability and direct comparisons.

Author Contribution

Erlindo Situmorang conceptualized the study, designed the research methodology, conducted data collection, performed data analysis, and drafted the original manuscript. Mulia Pamadi contributed to the supervision of the research, provided critical input on the research framework and methodology, and reviewed the manuscript for intellectual content. Indrastuti contributed to data interpretation, validation of the analysis, and manuscript revision. All authors have read and approved the final version of the manuscript.

Competing Interest

The authors declare that they have no competing interests, financial or non-financial, that could be perceived as influencing the work reported in this manuscript. The research was conducted independently, and no external organization influenced the study design, data analysis, interpretation of results, or the preparation of the manuscript.

References

[1] Sun, Y.; Ma, A.; Su, H.; Su, S.; Chen, F.; Wang, W.; Weng, M. (2020). Does the establishment of development zones really improve industrial land use efficiency? Implications for China's high-quality development policy. *Land Use Policy*, *90*, 104265. https://doi.org/10.1016/j.landusepol.2019.104265.

[2] Schindler, S.; Kanai, J.M. (2021). Getting the territory right: Infrastructure-led development and the re-emergence of spatial planning strategies. *Regional Studies*, *55*, 40–51. https://doi.org/10.1080/00343404.2019.1661984.

[3] Enns, C.; Bersaglio, B. (2020). On the coloniality of "new" mega-infrastructure projects in East Africa. *Antipode*, *52*, 101–123. https://doi.org/10.1111/anti.12582.

[4] Nag, A. (2022). Industrial infrastructure development of cottage industries for inclusive economic growth in a sustainable manner: Case study of the urban growth centre in Bishnupur, West Bengal, India. *International Journal of Indian Culture and Business Management*, *26*, 204–233. https://doi.org/10.1504/IJICBM.2022.123591.

[5] Wang, N.; Zhu, Y.; Yang, T. (2020). The impact of transportation infrastructure and industrial agglomeration on energy efficiency: Evidence from China's industrial sectors. *Journal of Cleaner Production*, *244*, 118708. https://doi.org/10.1016/j.jclepro.2019.118708.

[6] Prus, P.; Sikora, M. (2021). The impact of transport infrastructure on the sustainable development of the region—Case study. *Agriculture*, *11*, 279. https://doi.org/10.3390/agriculture11040279.

[7] Jatayu, A.; Zahara, S.; Syafitri, R.A.W.D.; Dafadhilah, S.; Roosyanindhita, D.R.; Sidiq, M.I.; Priambodo, M.S. (2024). Measuring levels of infrastructure development and its impact on regional growth: Insights from Indonesia. *IOP Conference Series: Earth and Environmental Science*, *1353*, 012011. https://doi.org/10.1088/1755-1315/1353/1/012011.

[8] Bobryshev, A.D.; Tumin, V.M.; Savelyev, A.V.; Alenina, E.E.; Trifonov, V.A. (2022). Place of infrastructure in the innovation ecosystem of industry. *Advances in Economics, Business and Management Research*, *220*, 44–49. https://doi.org/10.2991/aebmr.k.220208.006.

[9] Kanwal, S.; Rasheed, M.I.; Pitafi, A.H.; Pitafi, A.; Ren, M. (2020). Road and transport infrastructure development and community support for tourism: The role of perceived benefits and community satisfaction. *Tourism Management*, *77*, 104014. https://doi.org/10.1016/j.tourman.2019.104014.

[10] Khadim, Z.; Batool, I.; Akbar, A.; Poulova, P.; Akbar, M. (2021). Mapping the moderating role of logistics performance of logistics infrastructure on economic growth in developing countries. *Economies*, *9*, 177. https://doi.org/10.3390/economies9040177.

[11] Suthanaya, P.A.; Suwarningsih, R. (2023). Infrastructure development strategy based on the accessibility to tourism location (case study of Bali Province-Indonesia). *IOP Conference Series: Earth and Environmental Science*, *1195*, 012050. https://doi.org/10.1088/1755-1315/1195/1/012050.

[12] Jayasooriya, V.M.; Ng, A.W.M.; Muthukumaran, S.; Perera, C.B.J. (2020). Optimization of green infrastructure practices in industrial areas for runoff management: A review on issues, challenges and opportunities. *Water*, *12*, 1024. https://doi.org/10.3390/w12041024.

[13] Grabowski, Z.J.; McPhearson, T.; Pickett, S.T.A. (2023). Transforming US urban green infrastructure planning to address equity. *Landscape and Urban Planning*, *229*, 104591. https://doi.org/10.1016/j.landurbplan.2022.104591.

[14] Meerow, S. (2020). The politics of multifunctional green infrastructure planning in New York City. *Cities*, *100*, 102621. https://doi.org/10.1016/j.cities.2020.102621.

[15] Akifieva, L.; Nechaeva, M.; Polyakov, M.; Sidorova, N.; Gruzdev, G. (2021). Factors of social infrastructure development in rural areas. *IOP Conference Series: Earth and Environmental Science*, *857*, 012005. https://doi.org/10.1088/1755-1315/857/1/012005.

[16] Butt, J. (2020). A strategic roadmap for the manufacturing industry to implement Industry 4.0. *Designs*, *4*, 11. https://doi.org/10.3390/designs4020011.
[17] Albukhitan, S. (2020). Developing digital transformation strategy for manufacturing. *Procedia Computer Science*, *170*, 664–671. https://doi.org/10.1016/j.procs.2020.03.173.
[18] Brandt, T.; Wagner, S.; Neumann, D. (2021). Prescriptive analytics in public-sector decision-making: A framework and insights from charging infrastructure planning. *European Journal of Operational Research*, *291*, 379–393. https://doi.org/10.1016/j.ejor.2020.09.034.
[19] Broo, D.G.; Schooling, J. (2023). Digital twins in infrastructure: Definitions, current practices, challenges and strategies. *International Journal of Construction Management*, *23*, 1254–1263. https://doi.org/10.1080/15623599.2021.1966980.
[20] Li, X.; Li, J.; Yuan, C.; Guo, S.; Wang, Z. (2022). Digital infrastructure. In *Development Practice of Digital Business Environment in China*; Springer: Singapore. https://doi.org/10.1007/978-981-16-8527-9_3.
[21] Schmitt, M. (2023). Securing the digital world: Protecting smart infrastructures and digital industries with artificial intelligence (AI)-enabled malware and intrusion detection. *Journal of Industrial Information Integration*, *36*, 100520. https://doi.org/10.1016/j.jii.2023.100520.
[22] Pelden, S.; Banihashemi, S.; Mohandes, S.R.; Arashpour, M.; Kalantari, M. (2025). Enhancing infrastructure planning and design through BIM-GIS integration. *Structure and Infrastructure Engineering*, *1*, 1–20. https://doi.org/10.1080/15732479.2025.2461629.
[23] Bouraima, M.B.; Qiu, Y.; Yusupov, B.; Ndjegwes, C.M. (2020). A study on the development strategy of the railway transportation system in the West African Economic and Monetary Union (WAEMU) based on the SWOT/AHP technique. *Scientific African*, *8*, e00388. https://doi.org/10.1016/j.sciaf.2020.e00388.
[24] Kermanshachi, S.; Safapour, E. (2019). Gap analysis in cost estimation, risk analysis, and contingency computation of transportation infrastructure projects: A guide to resource and policy-based strategy establishment. *Practice Periodical on Structural Design and Construction*, *25*, 04019035. https://doi.org/10.1061/(ASCE)SC.1943-5576.0000460.
[25] Abdel-Kader, M.Y.; Ebid, A.M.; Onyelowe, K.C.; Mahdi, I.M.; Abdel-Rasheed, I. (2022). Artificial intelligence (AI) in infrastructure projects—Gap study. *Infrastructures*, *7*, 137. https://doi.org/10.3390/infrastructures7100137.
[26] Elghaish, F.; Matarneh, S.T.; Edwards, D.J.; Rahimian, F.P.; El-Gohary, H.; Ejohwomu, O. (2022). Applications of Industry 4.0 digital technologies towards a construction circular economy: Gap analysis and conceptual framework. *Construction Innovation: Information, Process, Management*, *22*, 647–670. https://doi.org/10.1108/CI-03-2022-0062.
[27] Bisu, A.A.; Ahmed, T.G.; Ahmad, U.S.; Maiwada, A.D. (2024). A SWOT analysis approach for the development of photovoltaic (PV) energy in Northern Nigeria. *Cleaner Energy Systems*, *9*, 100128. https://doi.org/10.1016/j.cles.2024.100128.
[28] Engel, E.; Fischer, R.D.; Galetovic, A. (2020). When and how to use public–private partnerships in infrastructure: Lessons from the international experience. *NBER Working Paper Series*, 26766. https://doi.org/10.3386/w26766.
[29] Bednyakov, A.S. (2022). Public–private partnership as a model of public infrastructure development. *MGIMO Review of International Relations*, *15*, 143–176. https://doi.org/10.24833/2071-8160-2022-1-82-143-173.
[30] Kuznetsova, S.N.; Kuznetsov, V.P.; Romanovskaya, E.V.; Lebedeva, T.E.; Kozlova, E.P. (2023). Application of the mechanism of public–private partnership by industrial parks in the context of the sustainable development paradigm. In *Technological Trends in the AI Economy (Smart Innovation, Systems and Technologies, Vol. 625)*; Springer: Singapore. https://doi.org/10.1007/978-981-19-7411-3_13.

[31] Akomea-Frimpong, I.; Jin, X.; Osei-Kyei, R.; Kukah, A.S. (2023). Public–private partnerships for sustainable infrastructure development in Ghana: A systematic review and recommendations. *Smart and Sustainable Built Environment*, *12*, 237–257. https://doi.org/10.1108/SASBE-07-2021-0111.

[32] Chileshe, N.; Njau, C.W.; Kibichii, B.K.; Macharia, L.N.; Kavishe, N. (2022). Critical success factors for public–private partnership (PPP) infrastructure and housing projects in Kenya. *International Journal of Construction Management*, *22*, 1606–1617. https://doi.org/10.1080/15623599.2020.1736835.

[33] Ruiz Díaz, G. (2020). What drives the failure of private participation in infrastructure projects? *International Journal of Managing Projects in Business*, *13*, 1167–1185. https://doi.org/10.1108/IJMPB-12-2019-0298.