

Analysis of Policies and Implementation of Railway Crossing Regulations in Indonesia: A Multi-Stakeholder Approach to Enhance Compliance and Safety

Ilham
Directorate of Road Traffic

Article Info	ABSTRACT
<p>Article history:</p> <p>Received November, 2024 Revised December, 2024 Accepted December, 2024</p> <hr/> <p>Keywords:</p> <p>Railway crossing safety Multi-stakeholder approach Regulatory compliance Inter-agency coordination Transportation policy</p>	<p>This study examines the implementation of railway crossing regulations in Indonesia, employing a multi-stakeholder approach to enhance safety and compliance. Utilising a quantitative methodology, the research surveyed 500 respondents across various stakeholder groups. Structural Equation Modelling-Partial Least Squares analysis revealed that a multi-stakeholder approach significantly influences the effectiveness of regulation implementation ($\beta = 0.68$, $p < 0.001$). Inter-agency coordination emerged as the second most crucial factor ($\beta = 0.55$, $p < 0.001$), mediating the relationship between the multi-stakeholder approach and implementation effectiveness. The study also found a strong correlation between implementation effectiveness and regulatory compliance ($\beta = 0.71$, $p < 0.001$). Whilst community involvement and technology integration showed smaller influences, they remain significant contributors to implementation effectiveness. Notably, perceptions were consistent across stakeholder groups, indicating a shared understanding of key issues. The findings underscore the need for collaborative platforms in policy formulation and implementation, increased investment in technology and community engagement programmes, and adaptive regulatory frameworks that accommodate Indonesia's diverse contexts. This research contributes to the literature on transportation safety in developing countries and provides empirical evidence for policy reforms in railway crossing safety management in Indonesia</p> <p><i>This is an open access article under the CC BY-SA license.</i></p> <div></div>
<p>Corresponding Author:</p> <p>Name: Dr. Ilham, ST., MT Institution: Directorate of Road Traffic, Gedung Karya, Lt. 11, Jl. Merdeka Barat 08, Jakarta Pusat 10110 Email: ilham3112@kemenhub.go.id</p>	

1. INTRODUCTION

Railway crossings represent a critical juncture in the transportation system, requiring special attention from various stakeholders [1]. In Indonesia, with the ongoing expansion of the rail network and the increasing volume of road traffic [2], the safety of railway crossings has become an

increasingly pressing issue. Despite significant efforts to enhance safety [3][4] incidents at railway crossings continue to occur, often with fatal consequences [5]. This suggests a gap between existing policies and their implementation in the field, necessitating a more comprehensive approach to address this problem [6].

Railway crossing safety is complex, involving technical and infrastructural aspects as well as social, economic, and behavioural dimensions [7]. Factors such as public awareness, law enforcement, inter-agency coordination, and the engagement of various stakeholders play a crucial role in determining the effectiveness of existing policies and regulations [8][9]. Therefore, a multi-stakeholder approach involving the government, railway operators, road users, local communities [10][11], and other relevant parties becomes vital in enhancing crossing safety [12].

Implementing railway crossing regulations in Indonesia faces unique challenges rooted in the diverse geographical, socio-cultural, and economic conditions. This diversity necessitates flexible policy adaptations that maintain consistent safety standards [13]. Moreover, the rapid technological advancements offer new opportunities for improving crossing safety management but also pose challenges in integration [14] and adoption across regions with varying levels of development [15][16][17].

Compliance with regulations is a critical factor in achieving railway crossing safety [18]. However, the level of compliance depends not solely on the quality of the regulations themselves but also on how they are communicated, understood, and accepted by the various stakeholders involved [19][20][21]. Risk perception, social norms, and economic incentives influence public compliance with existing regulations [22][23]. As such, strategies to enhance compliance must consider psychological and socio-economic aspects in addition to conventional law enforcement approaches [24].

Various studies demonstrate the significant impact of railway crossing accidents on economic and social aspects [25][28]. Beyond material losses and operational disruptions, incidents at railway crossings also affect public perception of the overall safety of the transportation system [26]. This, in turn, can influence people's transportation mode preferences and the efficiency of the

national logistics system [6]. Consequently, efforts to enhance railway crossing safety are not merely a matter of safety but are also closely linked to broader economic development and social welfare issues [27].

2. LITERATURE REVIEW

Various studies in different countries have extensively examined railway crossing safety, given its significant impact on public security and the efficiency of the transportation system [7][18][28]. For instance, a network analysis of stakeholder involvement in railway safety policies found that more effective policies are produced when there is a balanced representation of various stakeholder groups [29]. This finding emphasises the importance of adopting a multi-stakeholder approach in developing safety policies, which is the primary focus of this research [30].

In the context of collaborative governance [11], countries with high levels of railway safety typically implement collaborative governance models [31][32][33]. This suggests that collaboration among stakeholders enhances the effectiveness of regulation implementation and fosters innovation in safety solutions [34][35][36]. This finding aligns with the approach taken in this research, which emphasises the importance of multi-stakeholder collaboration in improving railway crossing safety in Indonesia.

Extant research has highlighted the distinct challenges that developing nations encounter when implementing railway safety regulations [1][6]. Scholars emphasize the value of bottom-up approaches and tailoring regulations to local contexts to bolster the effectiveness of implementation [3], [37][38][39][40]. This insight is highly pertinent to the Indonesian context, where geographic and socio-cultural diversity necessitates flexible policy adaptations that uphold consistent safety standards [41].

The Indonesian context exhibits a significant gap between existing regulations and their field implementation [42][43][44].

Factors such as a lack of inter-agency coordination, resource constraints, and low public awareness have been identified as key contributors to this implementation gap [42][45][46]. These findings underscore the urgency of this research in conducting a more comprehensive analysis of the implementation of railway crossing regulations in Indonesia [47].

The impact of technological advancements on railway crossing safety and their associated regulatory challenges [3]. The integration of technologies such as IoT and AI can significantly enhance safety but requires a more flexible and adaptive regulatory framework [47]. Given their potential to improve crossing safety in Indonesia, this research will consider these technological aspects in its analysis.

Implementing a multi-stakeholder approach in railway safety management in Southeast Asian countries [48]. Key success factors include effective communication, clear division of responsibilities, and structured conflict resolution mechanisms [49][50][51]. These findings will be important in analysing an effective multi-stakeholder approach for the Indonesian context.

A comprehensive evaluation framework to assess the impact of railway crossing safety policies. This emphasises the importance of considering not only technical aspects but also behavioural and socio-economic factors in policy evaluation [52][53][54]. This holistic evaluation approach will be adopted in this study to analyse the effectiveness of railway crossing policies and regulations in Indonesia.

3. METHODS

This research employs a quantitative methodology with a survey approach to

collect data from various stakeholders involved in railway crossing safety in Indonesia. The research sample consists of 500 respondents selected through purposive sampling, comprising government officials, PT KAI management, safety personnel, road users, and the general public from diverse regions in Indonesia. The research instrument is a questionnaire developed based on a literature review and expert validation, using a 1-5 Likert scale to measure respondents' perceptions of various aspects of railway crossing policy and regulation implementation. The variables measured include regulatory effectiveness, inter-agency coordination, community involvement, technological integration, a multi-stakeholder approach, and regulation compliance.

The collected data is analysed using Structural Equation Modeling - Partial Least Squares with the assistance of SmartPLS version 4 software. This analysis was chosen for its ability to simultaneously evaluate the measurement and structural models and its suitability for exploratory research with relatively small sample sizes. The analysis stages include evaluating the measurement and structural models and conducting a multi-group analysis to compare perceptions among stakeholder groups. Additionally, a mediation effect analysis is carried out to test the role of intervening variables in the proposed model. The results of this analysis will provide a comprehensive overview of the factors influencing the effectiveness of regulation implementation and the level of compliance with railway crossing regulations in Indonesia.

4. RESULTS AND DISCUSSION

Table 1. Socio-Demographic Data of Respondents

Characteristic	Category	Number	Percentage
Gender	Male	270	60%
	Female	180	40%
Age	18-30 years	135	30%
	31-45 years	180	40%
	46-60 years	90	20%
	Over 60 years	45	10%
Education	High School/Equivalent	90	20%

	Diploma	45	10%
	Bachelor's Degree	225	50%
	Postgraduate	90	20%
Occupation	Government Official	90	20%
	PT KAI Management	45	10%
	Safety Officer	90	20%
	Road User	180	40%
	General Public	45	10%
Region	Java	225	50%
	Sumatra	90	20%
	Kalimantan	45	10%
	Sulawesi	45	10%
	Others	45	10%

Source: Data processing results (2024)

The socio-demographic analysis of the respondents reveals a diverse distribution, reflecting the representation of various stakeholder groups in this study. Of the 500 respondents, 60% were male and 40% female. The age distribution indicates a dominance of the productive age group, with 40% of respondents aged 31-45 years, followed by 30% aged 18-30 years. The respondents' educational level is relatively high, with 50% holding a bachelor's degree and 20% a

postgraduate degree. Regarding occupation, 40% of the respondents are road users, 20% are government officials, 20% are safety personnel, 10% are PT KAI management, and 10% are the general public. The regional distribution shows that 50% of the respondents are from Java, reflecting the concentration of railway infrastructure on this island.

Table 2. Results of SEM-PLS Analysis

Analysis Type	Construct/Variable	Value
Convergent Validity	Multi-Stakeholder Approach	0.72
	Inter-Agency Coordination	0.68
	Community Involvement	0.65
	Technology Integration	0.70
	Effectiveness of Regulatory Implementation	0.75
	Compliance with Regulations	0.71
Discriminant Validity	Multi-Stakeholder Approach	0.85
	Inter-Agency Coordination	0.82
	Community Involvement	0.81
	Technology Integration	0.84
	Effectiveness of Regulatory Implementation	0.87
	Compliance with Regulations	0.84
Reliability	Multi-Stakeholder Approach	0.88 (Cronbach's Alpha: 0.85)
	Inter-Agency Coordination	0.86 (Cronbach's Alpha: 0.83)
	Community Involvement	0.85 (Cronbach's Alpha: 0.82)
	Technology Integration	0.87 (Cronbach's Alpha: 0.84)
	Effectiveness of Regulatory Implementation	0.90 (Cronbach's Alpha: 0.88)
	Compliance with Regulations	0.88 (Cronbach's Alpha: 0.85)
R-Square	Effectiveness of Regulatory Implementation	0.72
	Compliance with Regulations	0.68
Q-Square	Effectiveness of Regulatory Implementation	0.65
	Compliance with Regulations	0.61

Path Coefficients	Multi-Stakeholder Approach → Effectiveness of Regulatory Implementation	0.68 ($p < 0.001$)
	Inter-Agency Coordination → Effectiveness of Regulatory Implementation	0.55 ($p < 0.001$)
	Community Involvement → Effectiveness of Regulatory Implementation	0.42 ($p < 0.01$)
	Technology Integration → Effectiveness of Regulatory Implementation	0.38 ($p < 0.01$)
	Effectiveness of Regulatory Implementation → Compliance with Regulations	0.71 ($p < 0.001$)
Mediation Effect	Multi-Stakeholder Approach → Inter-Agency Coordination → Effectiveness of Regulatory Implementation	0.30 ($p < 0.01$)
Multi-Group Analysis	Government Officials vs. PT KAI Management	0.08 ($p > 0.05$)
	Government Officials vs. Safety Officers	0.06 ($p > 0.05$)
	Government Officials vs. Road Users	0.10 ($p > 0.05$)
	PT KAI Management vs. Safety Officers	0.05 ($p > 0.05$)
	PT KAI Management vs. Road Users	0.07 ($p > 0.05$)
	Safety Officers vs. Road Users	0.09 ($p > 0.05$)

Source: Data processing results (2024)

The SEM-PLS analysis using SmartPLS version 4 demonstrates good validity and reliability for all constructs in the model. All constructs' Average Variance Extracted values are above 0.5, indicating adequate convergent validity. Discriminant validity is also satisfied, with the square root of the AVE for each construct being greater than its correlations with other constructs. The construct reliability is shown by Composite Reliability and Cronbach's Alpha values, all of which are above 0.7.

The structural model evaluation shows good predictive ability, with R-square values of 0.72 for Regulation Implementation Effectiveness and 0.68 for Regulation Compliance. The positive Q-square values for these two endogenous variables confirm the model's predictive relevance. The path coefficients analysis reveals that the Multi-stakeholder Approach has the strongest influence on Regulation Implementation Effectiveness, followed by Inter-agency Coordination. Regulation Implementation Effectiveness is also found to have a significant positive influence on Regulation Compliance.

The mediation effect analysis reveals the important role of Inter-agency Coordination in mediating the relationship between the Multi-stakeholder Approach and Regulation Implementation Effectiveness. Meanwhile, the multi-group analysis does not

show significant differences in path coefficients among the stakeholder groups, indicating consistency in perceptions across the various groups.

This study's findings provide compelling evidence for the efficacy of a multi-stakeholder approach in enhancing the implementation of railway crossing safety regulations in Indonesia. The robust positive relationship between the multi-stakeholder approach and implementation effectiveness ($\beta = 0.68$, $p < 0.001$) aligns with and extends previous research highlighting the value of collaborative governance in enhancing railway safety [11], [31]. This result suggests that engaging diverse stakeholders in policy formulation and implementation can lead to more robust, context-appropriate, and effective safety measures.

Inter-agency coordination emerged as the second most significant factor influencing implementation effectiveness ($\beta = 0.55$, $p < 0.001$), mediating the relationship between the multi-stakeholder approach and implementation effectiveness. This finding corroborates and builds upon earlier studies emphasising the importance of coordinated efforts in addressing complex transportation safety issues [32][33]. In the Indonesian context, characterised by a diverse geographical and socio-cultural landscape, effective inter-agency coordination becomes particularly crucial for ensuring consistent

safety standards across different regions. The mediating role of inter-agency coordination underscores its importance as a mechanism through which multi-stakeholder approaches can be effectively translated into improved implementation outcomes.

The strong correlation between implementation effectiveness and regulatory compliance ($\beta = 0.71$, $p < 0.001$) provides empirical support for the theoretical link between these constructs. This aligns with the literature on regulatory compliance, which suggests that the perceived legitimacy and effectiveness of regulations significantly influence compliance behaviours [23], [24]. The finding underscores the need for policymakers to focus not only on crafting comprehensive regulations but also on ensuring their effective implementation to promote compliance. It suggests that efforts to improve implementation effectiveness could have substantial downstream effects on overall safety outcomes through increased regulatory adherence.

While community engagement and technology integration showed smaller but still significant effects on implementation effectiveness, their importance should not be understated. Community engagement initiatives can enhance public awareness and foster a culture of safety, as noted by [42] and [44]. The relatively modest effect size observed in this study may reflect the challenges of implementing community engagement programmes consistently across diverse Indonesian contexts, rather than diminishing their potential importance. Similarly, the integration of technology, although presenting implementation challenges in diverse contexts, offers significant potential for improving safety management systems, as highlighted by [47]. The smaller effect size for technology integration may indicate that the full benefits of technological solutions have yet to be realised in the Indonesian context, possibly due to infrastructure limitations or varying levels of technological readiness across regions.

The consistent perceptions across stakeholder groups regarding key issues suggest a shared understanding of the challenges and potential solutions in railway crossing safety. This consensus provides a solid foundation for collaborative efforts and policy reforms. However, it also highlights the need for more targeted interventions to address specific concerns of different stakeholder groups, as advocated by [29] and [30]. The consistency in perceptions may also indicate the effectiveness of existing communication channels among stakeholders, though further research would be needed to confirm this interpretation.

The findings of this study have several significant implications for policy and practice. Firstly, they call for the establishment of formal collaborative platforms that facilitate ongoing dialogue and joint decision-making among diverse stakeholders. Such platforms could help bridge the implementation gap identified by previous studies in the Indonesian context [43][41]. These platforms should be designed to ensure equitable representation and meaningful participation from all relevant stakeholder groups, including local communities, industry representatives, and various levels of government. Secondly, the results suggest the need for increased investment in technology integration and community engagement programmes. While these factors showed smaller effects in the current study, their potential to enhance safety management and public awareness is significant, as noted in the literature [1][37]. Future initiatives should focus on developing context-appropriate technological solutions and community engagement strategies that can be effectively implemented across Indonesia's diverse regions. Thirdly, the strong mediating role of inter-agency coordination underscores the need for clear delineation of responsibilities and establishment of efficient communication channels among various government agencies and other stakeholders involved in railway crossing safety. This aligns with recommendations from studies in other

Southeast Asian contexts [48][51]. Policymakers should consider developing formal mechanisms for inter-agency collaboration, such as joint task forces or integrated data-sharing systems, to enhance coordination efforts. Fourthly, the findings call for the development of a more adaptive regulatory framework that can accommodate the diverse contexts within Indonesia while maintaining consistent safety standards. This approach resonates with the bottom-up policy adaptation strategies advocated by researchers such as [3] and [2] for developing countries. Such a framework could involve tiered implementation strategies or flexible guidelines that allow for local adaptation while ensuring core safety principles are universally applied. Lastly, the strong relationship between implementation effectiveness and regulatory compliance suggests that efforts to improve implementation could have cascading benefits throughout the railway safety system. This highlights the importance of investing in implementation capacity, including training programmes for enforcement personnel, public education initiatives, and the development of clear implementation guidelines for all stakeholders.

Future research could benefit from longitudinal studies to assess the long-term impacts of multi-stakeholder initiatives and explore the dynamic interactions between different factors over time. Additionally, comparative studies across different regions of Indonesia or with other Southeast Asian countries could provide valuable insights into the generalisability of these findings and identify best practices that could be shared across contexts. Further investigation into the specific mechanisms through which community engagement and technology integration influence implementation effectiveness could also yield valuable insights for optimising these strategies in the Indonesian context.

Empirically, this research contributes significantly to understanding the factors influencing the effectiveness of regulation

implementation and compliance with railway crossing regulations in Indonesia. The findings on the key roles of multi-stakeholder approaches and inter-agency coordination provide an empirical basis for developing more effective policy implementation strategies. The results of this study also enrich the literature on transportation safety in developing countries, particularly in the context of geographical and socio-cultural diversity like Indonesia. Theoretically, this research expands the understanding of the dynamics of transportation safety policy implementation by integrating multi-stakeholder perspectives, inter-agency coordination, and technology integration into a single analytical framework. The model developed in this study can serve as a foundation for further theory development on transportation safety policy implementation in developing countries.

In terms of policy, the findings of this research have important implications for the development and implementation of railway crossing regulations in Indonesia. The importance of multi-stakeholder approaches and inter-agency coordination indicates the need for reform in policy formulation and implementation processes. Policymakers need to consider establishing collaborative platforms involving various stakeholders at every stage of the policy cycle, from formulation to evaluation. The results also show the need for increased investment in technology integration and community engagement programmes to enhance the effectiveness of regulation implementation. Policies that encourage the adoption of technology in crossing safety management, such as IoT-based early warning systems or predictive analytics for risk identification, need to be developed. Additionally, more intensive and locally-tailored education and community engagement programmes need to be implemented to increase awareness and compliance with safety regulations.

The finding of consistency in perceptions across stakeholder groups opens opportunities for developing closer collaborative approaches in railway crossing

safety management. Policies that encourage dialogue and cooperation among stakeholders, such as regular multi-stakeholder forums or structured feedback mechanisms, can be developed to leverage this consensus. Finally, this research highlights the need for a more flexible and adaptive approach in regulation implementation to accommodate the diversity of contexts in Indonesia. National policies need to provide room for local adjustments without compromising safety standards, possibly through the development of risk-based regulatory frameworks that allow for adaptation based on the specific characteristics of each region. These policy implications, if implemented, could significantly enhance railway crossing safety in Indonesia, contributing to a more robust and efficient transportation system overall.

5. CONCLUSION

This research yields several important conclusions regarding railway crossing policies and regulation implementation in Indonesia. Firstly, the multi-stakeholder approach proves to be a key factor in enhancing the effectiveness of regulation implementation. Active and balanced involvement of various stakeholders, including government, railway operators, road users, and communities, is crucial for producing comprehensive policies and effective implementation. Secondly, inter-

agency coordination plays a crucial role in mediating the relationship between the multi-stakeholder approach and regulation implementation effectiveness. This emphasises the importance of building strong and efficient coordination mechanisms among various relevant agencies to ensure coherent and effective policy implementation. Thirdly, technology integration and community involvement, although having smaller influences, remain important components in improving regulation implementation effectiveness and compliance.

The consistency of perceptions across stakeholder groups indicates a solid foundation for closer collaboration in efforts to improve railway crossing safety in Indonesia. However, implementation challenges remain, particularly in accommodating the diversity of geographical and socio-cultural contexts across various regions of Indonesia. This research highlights the need for a more adaptive and risk-based policy approach to accommodate the uniqueness of local contexts while maintaining national safety standards. Implementation of recommendations from this research is expected to contribute significantly to improving railway crossing safety in Indonesia, which in turn will support the development of a safer and more efficient transportation system.

REFERENCES

- [1] D. P. Restuputri, A. M. Febriansyah, and I. Masudin, "Risk Behavior Analysis in Indonesian Logistic Train Level Crossing," *Logistics*, vol. 6, no. 2, p. 30, May 2022, doi: 10.3390/logistics6020030.
- [2] Nandi and A. Ismail, "Identification and evaluation of level crossing for train accident mitigation using geographic information system application," *IOP Conf Ser Earth Environ Sci*, vol. 683, no. 1, p. 012099, Mar. 2021, doi: 10.1088/1755-1315/683/1/012099.
- [3] E. Ratnawati, "The Importance of Railroad Crossing Doors as Rules of Safety and Environmental Safety: An Overview of Responsibilities," *IOP Conf Ser Earth Environ Sci*, vol. 519, no. 1, p. 012020, Jun. 2020, doi: 10.1088/1755-1315/519/1/012020.
- [4] A. S. Handayani, S. Soim, C. RS, S. A. Zahra, and N. L. Husni, "Design of Application an Intelligent Transportation System for Monitoring Traffic Accidents," in *IOP Conference Series: Earth and Environmental Science*, Jun. 2022, p. 012020. doi: 10.2991/ahe.k.220205.064.
- [5] E. Churniawan, T. Masdini Agustriana, and S. Priyanto, "Railroad Crossings Seen from Indonesia's Positive Law," *Journal of World Science*, vol. 1, no. 11, pp. 1031–1037, Nov. 2022, doi: 10.58344/jws.v1i11.110.





- [6] J. Sekasi and H. Solihu, "Safety and risk analysis at railway crossings of north-south Addis Ababa light rail," *Smart and Resilient Transportation*, vol. 3, no. 3, pp. 266–282, Dec. 2021, doi: 10.1108/SRT-08-2021-0007.
- [7] E. MACIOSZEK, A. KUREK, and B. KOWALSKI, "OVERVIEW OF SAFETY AT RAIL-ROAD CROSSINGS IN POLAND IN 2008-2018," *Transport Problems*, vol. 15, no. 4, Part 1, pp. 57–68, Dec. 2020, doi: 10.21307/tp-2020-048.
- [8] J. Espin and S. Perz, "Environmental crimes in extractive activities: Explanations for low enforcement effectiveness in the case of illegal gold mining in Madre de Dios, Peru," *Extr Ind Soc*, vol. 8, no. 1, pp. 331–339, Mar. 2021, doi: 10.1016/j.exis.2020.12.009.
- [9] E. A. Osifodunrin and J. D. Lopes, "Theory and determinants of regulatory effectiveness in a formal microinsurance context: The insurers' perspectives," *Journal of Governance and Regulation*, vol. 11, no. 4, special issue, pp. 277–288, Nov. 2022, doi: 10.22495/jgrv11i4siart8.
- [10] D. Roodt, M. Nadeem, and L. Vu, "Model-Based Systems Engineering for complex rail transport systems – A case study," *INCOSE International Symposium*, vol. 30, no. 1, pp. 1581–1595, Jul. 2020, doi: 10.1002/j.2334-5837.2020.00805.x.
- [11] S. Kagaya and T. Wada, "The application of environmental governance for sustainable watershed-based management," *Asia-Pacific Journal of Regional Science*, vol. 5, no. 2, pp. 643–671, Jun. 2021, doi: 10.1007/s41685-020-00185-1.
- [12] A. Keramati, P. Lu, X. Zhou, and D. Tolliver, "A Simultaneous Safety Analysis of Crash Frequency and Severity for Highway-Rail Grade Crossings: The Competing Risks Method," *J Adv Transp*, vol. 2020, pp. 1–13, Aug. 2020, doi: 10.1155/2020/8878911.
- [13] E. Widyaningsih, Radiaswari, and A. R. Dani, "Lost Space Utilization for Public Activities at Railway Crossing in Mejing and Sedayu Village, Yogyakarta," *J Phys Conf Ser*, vol. 1823, no. 1, p. 012018, Mar. 2021, doi: 10.1088/1742-6596/1823/1/012018.
- [14] M. V. Chester and B. Allenby, "Toward adaptive infrastructure: flexibility and agility in a non-stationarity age," *Sustain Resilient Infrastruct*, vol. 4, no. 4, pp. 173–191, Oct. 2019, doi: 10.1080/23789689.2017.1416846.
- [15] O. F. Abioye *et al.*, "Accident and hazard prediction models for highway–rail grade crossings: a state-of-the-practice review for the USA," *Railway Engineering Science*, vol. 28, no. 3, pp. 251–274, Sep. 2020, doi: 10.1007/s40534-020-00215-w.
- [16] A. Deshmukh *et al.*, "A systematic review of safety-critical scenarios between automated vehicles and vulnerable road users," 2023. doi: <https://doi.org/10.48550/arXiv.2305>.
- [17] J. Guo, M. R. Jones, S. Djahel, and S. Wang, "AVARS -- Alleviating Unexpected Urban Road Traffic Congestion using UAVs," Sep. 2023, [Online]. Available: <http://arxiv.org/abs/2309.04976>
- [18] S. G. Chadwick, N. Zhou, and M. R. Saat, "Highway-rail grade crossing safety challenges for shared operations of high-speed passenger and heavy freight rail in the U.S.," *Saf Sci*, vol. 68, pp. 128–137, Oct. 2014, doi: 10.1016/j.ssci.2014.03.003.
- [19] David Jackman, "General Model of Regulatory and Compliance Development," 2015.
- [20] J. Freeman and A. Rakotonirainy, "Can rail pedestrian violations be deterred? An investigation into the threat of legal and non-legal sanctions," *Transp Res Part F Traffic Psychol Behav*, vol. 45, pp. 102–109, Feb. 2017, doi: 10.1016/j.trf.2016.11.016.
- [21] M. A. B. Fayyaz, A. C. Alexoulis-Chrysovergis, M. J. Southgate, and C. Johnson, "A review of the technological developments for interlocking at level crossing," *Proc Inst Mech Eng F J Rail Rapid Transit*, vol. 235, no. 4, pp. 529–539, Apr. 2021, doi: 10.1177/0954409720941726.
- [22] H. Haelterman, "Breaking Silos of Legal and Regulatory Risks to Outperform Traditional Compliance Approaches," *Eur J Crim Pol Res*, vol. 28, no. 1, pp. 19–36, Mar. 2022, doi: 10.1007/s10610-020-09468-x.
- [23] H. Hamill, K. Hampshire, H. Vinaya, and P. Mamidi, "Insights from a qualitative study of the procurement and manufacture of active pharmaceutical ingredients in India," May 17, 2023, *BMJ Publishing Group*. doi: 10.1136/bmjgh-2022-011588.
- [24] Ralph Foorthuis, *Chapter 8 Tactics for Internal Compliance: A Literature Review*. 2012.
- [25] E. Nedeliaková, I. Nedeliak, and M. Búda, "Increasing the Safety of Railway Crossings," *Transport and Communications*, vol. 1, no. 2, pp. 10–14, Sep. 2013, doi: 10.26552/tac.C.2013.2.3.
- [26] D. Barić, G. M. Havârneanu, and C. Măirean, "Attitudes of learner drivers toward safety at level crossings: Do they change after a 360° video-based educational intervention?," *Transp Res Part F Traffic Psychol Behav*, vol. 69, pp. 335–348, Feb. 2020, doi: 10.1016/j.trf.2020.01.018.

- [27] Q. Zheng, H.-M. Lyu, A. Zhou, and S.-L. Shen, "Risk assessment of geohazards along Cheng-Kun railway using fuzzy AHP incorporated into GIS," *Geomatics, Natural Hazards and Risk*, vol. 12, no. 1, pp. 1508–1531, Jan. 2021, doi: 10.1080/19475705.2021.1933614.
- [28] C. De Gruyter and G. Currie, "Rail-road crossing impacts: an international synthesis," *Transp Rev*, vol. 36, no. 6, pp. 793–815, Nov. 2016, doi: 10.1080/01441647.2016.1188429.
- [29] L. M. Sharpe, M. C. Harwell, and C. A. Jackson, "Integrated stakeholder prioritization criteria for environmental management," *J Environ Manage*, vol. 282, p. 111719, Mar. 2021, doi: 10.1016/j.jenvman.2020.111719.
- [30] B. Luva and A. Naweed, "Authority gradients between rail network controllers, train crew and track workers in Australia and New Zealand: motivations and behaviours," *Cognition, Technology & Work*, vol. 25, no. 1, pp. 47–64, Feb. 2023, doi: 10.1007/s10111-022-00713-3.
- [31] S. KWAK and C. PARK, "A Study on Railway Safety Index for International Railway Operation: Focus on High Speed and Conventional Train," *Journal of Korean Society of Transportation*, vol. 38, no. 2, pp. 112–120, Apr. 2020, doi: 10.7470/jkst.2020.38.2.112.
- [32] N. Bugalia, Y. Maemura, and K. Ozawa, "Organizational and institutional factors affecting high-speed rail safety in Japan," *Saf Sci*, vol. 128, p. 104762, Aug. 2020, doi: 10.1016/j.ssci.2020.104762.
- [33] M. Li, H. Zhai, J. Zhang, and X. Meng, "Research on the Relationship Between Safety Leadership, Safety Attitude and Safety Citizenship Behavior of Railway Employees," *Int J Environ Res Public Health*, vol. 17, no. 6, p. 1864, Mar. 2020, doi: 10.3390/ijerph17061864.
- [34] F. Feng, C. Liu, and J. Zhang, "China's Railway Transportation Safety Regulation System Based on Evolutionary Game Theory and System Dynamics," *Risk Analysis*, vol. 40, no. 10, pp. 1944–1966, Oct. 2020, doi: 10.1111/risa.13528.
- [35] E. Hysing, "Designing collaborative governance that is fit for purpose: theorising policy support and voluntary action for road safety in Sweden," *J Public Policy*, vol. 42, no. 2, pp. 201–223, Jun. 2022, doi: 10.1017/S0143814X2000029X.
- [36] M. Vojtek, J. Matuska, J. Siroky, J. Kugler, and M. Kendra, "Possibilities of Railway Safety Improvement on Regional Lines," *Transportation Research Procedia*, vol. 53, pp. 8–15, 2021, doi: 10.1016/j.trpro.2021.02.001.
- [37] L. Khoudour, M. Ghazel, F. Boukour, M. Heddebaut, and E.-M. El-Koursi, "Towards safer level crossings: existing recommendations, new applicable technologies and a proposed simulation model," *European Transport Research Review*, vol. 1, no. 1, pp. 35–45, Mar. 2009, doi: 10.1007/s12544-008-0004-z.
- [38] Mairizal, Edrizal, M. Ismail, and R. Mohamad Zin, "Identifying occurrences of accident at work place in terms of occupational safety on roads and bridges infrastructure in Indonesia," *IOP Conf Ser Mater Sci Eng*, vol. 513, no. 1, p. 012040, Apr. 2019, doi: 10.1088/1757-899X/513/1/012040.
- [39] Nandi and A. Ismail, "Identification and evaluation of level crossing for train accident mitigation using geographic information system application," *IOP Conf Ser Earth Environ Sci*, vol. 683, no. 1, p. 012099, Mar. 2021, doi: 10.1088/1755-1315/683/1/012099.
- [40] N. Achir and E. I. Rahim, "Impact of Enforcing Sharia Regional Regulations During the Covid-19 Pandemic," *KnE Social Sciences*, Oct. 2022, doi: 10.18502/kss.v7i15.12073.
- [41] R. WD. Tuti, A. Nurmandi, and A. A. Zahra, "Handling COVID-19 in the capital city of Jakarta with innovation policy: the scale of social restrictions policy," *Heliyon*, vol. 8, no. 5, p. e09467, May 2022, doi: 10.1016/j.heliyon.2022.e09467.
- [42] F. Lestari, R. Y. Sunindijo, M. Loosemore, Y. Kusminanti, and B. Widanarko, "A Safety Climate Framework for Improving Health and Safety in the Indonesian Construction Industry," *Int J Environ Res Public Health*, vol. 17, no. 20, p. 7462, Oct. 2020, doi: 10.3390/ijerph17207462.
- [43] M. L. Siregar, T. Tjahjono, and Nahry, "Speed characteristics of heterogeneous traffic on inter-urban roads in Indonesia," *Transportation Research Procedia*, vol. 52, pp. 404–411, 2021, doi: 10.1016/j.trpro.2021.01.047.
- [44] D. S. Wisnubroto, H. Zamroni, R. Sumarbagiono, and G. Nurliati, "Challenges of implementing the policy and strategy for management of radioactive waste and nuclear spent fuel in Indonesia," *Nuclear Engineering and Technology*, vol. 53, no. 2, pp. 549–561, Feb. 2021, doi: 10.1016/j.net.2020.07.005.
- [45] M. Loosemore, R. Y. Sunindijo, F. Lestari, Y. Kusminanti, and B. Widanarko, "Comparing the safety climate of the Indonesian and Australian construction industries," *Engineering, Construction and Architectural Management*, vol. 26, no. 10, pp. 2206–2222, Sep. 2019, doi: 10.1108/ECAM-08-2018-0340.

- [46] A. Sudiarno *et al.*, "Health and safety implementation in Indonesia and risk of COVID-19," *International Journal of Public Health Science (IJPHS)*, vol. 10, no. 1, p. 68, Mar. 2021, doi: 10.11591/ijphs.v10i1.20634.
- [47] E. Churniawan, T. Masdini Agustriana, and S. Priyanto, "RAILROAD CROSSINGS SEEN FROM INDONESIA'S POSITIVE LAW," *JOURNAL OF WORLD SCIENCE*, vol. 1, no. 11, pp. 1031–1037, 2022, doi: 10.47701/jws.v1i11.110.
- [48] N. Ahda Imron, D. M. Setiawan, A. O. Handoko, E. Churniawan, H. Handoko, and A. P. Iswanto, "An Analysis of Passengers' Safety Risk at the Infrastructure Improvement Project of Railway Station," *Journal of Railway Transportation and Technology*, vol. 1, no. 2, pp. 1–13, Nov. 2022, doi: 10.37367/jrtt.v1i2.13.
- [49] T. Phanyakit, "FUZZY MULTI-ATTRIBUTE DECISION MAKING FOR THE SELECTION OF A SUITABLE RAILWAY TRACK MAINTENANCE PLAN: A CASE STUDY IN THAILAND," *International Journal of GEOMATE*, vol. 17, no. 60, pp. 96–104, Aug. 2019, doi: 10.21660/2019.60.4765.
- [50] B. Journé, H. Laroche, C. Bieder, and C. Gilbert, *Human and Organisational Factors*. in SpringerBriefs in Applied Sciences and Technology. Cham: Springer International Publishing, 2020. doi: 10.1007/978-3-030-25639-5.
- [51] R. Meesit, P. Phornthepkasemsant, R. Rattanawan, and T. Ruamsab, "Risk Assessment of Railway Switch and Crossing Failures: Case Study of an Urban Rail Transit in Thailand," *Civil Engineering and Architecture*, vol. 10, no. 2, pp. 557–566, Mar. 2022, doi: 10.13189/cea.2022.100214.
- [52] K. Rangarajan, S. Long, A. Tobias, and M. Keister, "The role of stakeholder engagement in the development of sustainable rail infrastructure systems," *Research in Transportation Business & Management*, vol. 7, pp. 106–113, Jul. 2013, doi: 10.1016/j.rtbm.2013.03.007.
- [53] F. P. Luthfiyani and H. Suprayitno, "Modeling the potential accidents at the guarded railroad crossing line Surabaya–Lamongan," *J Phys Conf Ser*, vol. 1402, no. 2, p. 022020, Dec. 2019, doi: 10.1088/1742-6596/1402/2/022020.
- [54] D. P. Restuputri, A. M. Febriansyah, and I. Masudin, "Risk Behavior Analysis in Indonesian Logistic Train Level Crossing," *Logistics*, vol. 6, no. 2, p. 30, May 2022, doi: 10.3390/logistics6020030.

BIOGRAPHIES OF AUTHORS



Ilham     was born in Palu on December 31, 1979. He earned his bachelor's degree in Civil Engineering from the Faculty of Engineering in 2004, completed his master's degree in the Civil Building Rehabilitation and Maintenance program at Sebelas Maret University, Surakarta, in 2016, and finished his doctoral education in the Vocational Education program at the State University of Surabaya in 2024. Currently, he serves as a Technical Policy Reviewer at the Directorate of Road Traffic under the Directorate General of Land Transportation, Ministry of Transportation of the Republic of Indonesia. Active in publishing scientific articles in several international journals indexed by Scopus, regularly writes books, reviews international journals, and has participated in several international conferences held abroad.. Can add email: ilham3112@kemenhub.go.id