INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 15, Issue 2, (2025) E-ISSN: 2222-6990

Assessing the Distribution and Accessibility of Emergency Services in the Langat Basin, Malaysia: A GIS-Based Evaluation of Infrastructure and Risk Factors

Nurakmar Hakim Jasni[1] & Nuriah Abd Majid[1]
Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia[1]
Corresponding Author Email: nuriah@ukm.edu.my

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v15-i2/24467 DOI:10.6007/IJARBSS/v15-i2/24467

Published Date: 24 February 2025

Abstract
Emergency services play a vital role in mitigating the impacts of disasters and safeguarding communities, particularly in regions prone to natural hazards such as landslides and floods. This study investigates the distribution and accessibility of emergency services in the Langat Basin, a geographically diverse region in Peninsular Malaysia characterized by urban-rural disparities. Utilizing Geographic Information Systems (GIS), the research evaluates the road networks, hydrological risks, spatial distribution of healthcare facilities, and educational institutions as evacuation centers to identify underserved areas and high-risk zones. The findings reveal significant accessibility disparities, with urban centers benefitting from well-connected road networks and a dense distribution of emergency facilities, while rural areas face challenges due to sparse infrastructure and proximity to landslide-prone zones. Buffer zone analysis highlights large portions of rural populations residing beyond the service range of critical facilities, emphasizing the urgent need for targeted interventions. Landslide risk assessments further underscore the compounded vulnerabilities of these communities. This study demonstrates the utility of GIS in visualizing service gaps and guiding data-driven decision-making for emergency service optimization. By integrating road and facility connectivity analyses with geological and hydrological risk assessments, actionable recommendations are provided to improve emergency preparedness and response capacity in the Langat Basin.
Keywords: Emergency Services, Landslide Risk, Disaster Preparedness, Crucial Facilities, Spatial Analysis, Geographic Information Systems (GIS)

Introduction

Emergency services play a critical role in safeguarding communities during crises, providing essential healthcare, disaster response, and evacuation support (Paturas et al., 2010;

Rockenschaub & Harbou, 2013). However, service accessibility can vary significantly across regions, with some areas benefiting from adequate resources while others face critical gaps. Globally, the efficient planning and distribution of these services have been important to disaster preparedness and management strategies, particularly in regions prone to natural hazards such as landslides, earthquakes, and floods (Dariagan et al., 2021; Prenger-Berninghoff et al., 2014). These disasters further compound the need for accessible and well-coordinated emergency services to mitigate risks and ensure rapid response. Despite progress in many regions, disparities in accessibility and coverage often leave rural and underserved communities vulnerable to heightened risks (Davis et al., 2010; Sanuki et al., 2013). For instance, studies from regions in South Asia and Sub-Saharan Africa underscore the severe delays in emergency response times due to inadequate infrastructure, limited road networks, and sparse facility distribution (Geleto et al., 2018; Tey & Lai, 2013). These delays not only exacerbate the immediate impact of emergencies but also impede recovery, creating long-lasting socioeconomic consequences for affected populations. In developed nations, advanced tools like Geographic Information Systems (GIS) have significantly enhanced emergency service planning by enabling precise mapping of service coverage and identifying underserved areas (Newsom & Mitrani, 1993; Tomaszewski et al., 2015). For example, in Europe, GIS-based analyses have been widely adopted to optimize ambulance locations, leading to measurable reductions in response times and improved equity in service distribution. Similarly, in North America, GIS applications have been instrumental in disaster response planning, particularly in areas prone to natural hazards such as hurricanes, wildfires, and earthquakes (Derekenaris et al., 2001; Johnson, 1995). These cases demonstrate how data-driven and technology-enabled solutions can effectively address the challenges of uneven emergency service accessibility, serving as benchmarks for other regions seeking to improve their systems. This brings to the emergency services that is vital for safeguarding communities during disasters, particularly in regions prone to natural hazards like landslides and floods. Their timely accessibility significantly reduces casualties, mitigates damages, and supports rapid recovery. However, disparities in the distribution and accessibility of these services can leave certain populations disproportionately vulnerable. In rural and geographically challenging regions, insufficient road networks, sparse emergency facilities, and limited resources amplify risks, prolong response times, and impede recovery efforts. Addressing these disparities is not only crucial for disaster management but also for ensuring equitable access to life-saving services, particularly in high-risk areas like the Langat Basin.

Transitioning to Southeast Asia, the challenges become more nuanced due to the region's rapid urbanization, economic diversity, and geographical complexities. Countries in ASEAN like Indonesia and the Philippines face dual challenges of urban congestion, where demand often outpaces capacity, and rural inaccessibility, where communities are left without immediate access to essential healthcare or disaster response facilities (Resosudarmo et al., 2016). Malaysia, while advancing in infrastructure development, continues to encounter similar disparities. Geographically challenging regions such as the Langat Basin present a clear example of how these issues manifest locally, creating a mix of well-served urban areas and underserved rural communities. This mixed context highlights the importance of localized assessments and tailored solutions. Landslides present considerable challenges, particularly in regions like Malaysia, where diverse land uses, steep terrains, and high rainfall contribute to their frequent occurrence. Advanced techniques, such as artificial neural networks (ANN), have been employed to improve predictive modeling for landslides, with a particular focus on the Langat River Basin, a key area for understanding susceptibility patterns (Selamat et al., 2022, 2023). Furthermore, the spatial connection between landslide events and human activities emphasizes the importance of sustainable land-use planning (Selamat et al., 2023). Research on local variations of landslide factors in regions such as Pulau Pinang and Kuala Lumpur has revealed the significant influence of physical and demographic factors on landslide risks (Zulkafli et al., 2023a, 2023b). These studies highlight the importance of integrating geospatial analysis and interdisciplinary approaches to develop effective mitigation strategies.

The Langat Basin, with its diverse topography, mixed land use, and significant population distribution, exemplifies the varied challenges of emergency service accessibility. Urbanized sections of the basin benefit from relatively well-distributed facilities and infrastructure, but certain rural areas remain underserved, particularly during crises that require rapid and coordinated responses. Limited road networks, resource allocation challenges, and the absence of nearby emergency services in these rural areas amplify the vulnerability of their populations (Cutter et al., 2003; Feng et al., 2015; Fernandez et al., 2002; Pollock & Wartman, 2020). These localized challenges not only heighten the risk for communities but also create significant barriers to effective disaster management and recovery efforts. These disparities are also compounded by the region's susceptibility to landslides and floods, which further isolate vulnerable populations during emergencies.

This study seeks to address these specific challenges by leveraging GIS tools to assess the current distribution and accessibility of emergency services within the Langat Basin, while also incorporating an evaluation of landslide risk as a critical factor influencing emergency preparedness and response. By focusing on critical components such as healthcare facilities, educational institutions as potential evacuation centers, and disaster response teams, this research aims to identify underserved areas and propose actionable solutions for enhancing emergency preparedness and response capacity. The integration of GIS-based analyses, including buffer zone assessments, road network evaluations, and landslide risk mapping, is expected to provide a comprehensive understanding of service gaps and vulnerabilities, thereby informing data-driven recommendations for improved service delivery and disaster risk mitigation in the region. This study contributes to the broader discourse on equitable disaster risk reduction and sustainable development, aligning with global frameworks such as the United Nations Sustainable Development Goals (SDG 11). By integrating GIS-based analyses with socio-economic and environmental assessments, the research offers a replicable model for addressing emergency service disparities in regions with diverse geographical and demographic profiles. The actionable recommendations generated from this study not only enhance resilience within the Langat Basin but also serve as a blueprint for improving emergency service delivery in similar contexts worldwide. Ultimately, bridging the gaps in service accessibility ensures no community is left behind, fostering inclusive and sustainable disaster preparedness systems.

Study Area and Methodology

Study Area

The Langat Basin is situated in the central region of Peninsular Malaysia, spanning latitudes of approximately 2.500°N to 3.200°N and longitudes of 101.300°E to 102.000°E. Encompassing an area of about 2,350 km², the basin features a diverse geographical landscape characterized by hilly terrains in the upstream regions and flatlands in the downstream areas (Zainol et al., 2021). The upstream regions, with their steep slopes and complex geology, are particularly susceptible to slope instability and landslides, while the downstream areas house urbanized and agricultural zones with better-developed infrastructure. The Langat Basin experiences a tropical climate with consistently high temperatures averaging around 27°C throughout the year. The region also receives significant rainfall, with an annual average of approximately 2,100 mm, primarily concentrated in the months of March and November (Selamat et al., 2024). This combination of heavy rainfall and the basin's geological features contributes to frequent slope failures and increases the risk of landslides, particularly in upstream areas The Langat Basin's mixed urban-rural profile further underscores its importance as a study area. While urbanized sections are well-served by emergency facilities, the rural regions often face challenges related to accessibility, particularly during emergencies such as landslides or flooding. These disparities highlight the need for a comprehensive evaluation of emergency service distribution that considers both the physical vulnerabilities and the socioeconomic dynamics of the basin. Given these factors, the Langat Basin serves as an ideal focus for assessing emergency services, with this study integrating GIS-based analyses to explore accessibility issues and propose actionable solutions for improving service delivery. By incorporating landslide risk mapping alongside evaluations of healthcare and disaster response infrastructure, this research aims to address the basin's critical needs and provide a template for similar regions facing comparable challenges.

Data Collection and Analysis

This study adopts a mixed-methods approach to analyze the distribution and accessibility of emergency services within the Langat Basin, emphasizing the use of Geographic Information Systems (GIS) for spatial analysis. The methodology focuses entirely on secondary data and is structured into three main phases to address the issue comprehensively. The first phase involves data collection from various secondary sources. Spatial data is obtained to map the locations of healthcare facilities, and educational institutions that can serve as evacuation centers and disaster response teams. This data will be used to assess the accessibility of critical infrastructure during emergencies and understand how their locations contribute to social vulnerability in the event of a slope failure. Additional spatial layers, including road networks, transportation infrastructure, topographical maps, and geological features, are integrated to provide a comprehensive understanding of accessibility. Climate-related data, particularly rainfall patterns, is sourced from processed findings in past studies, while slope stability indices and historical landslide records are gathered from local authorities and national databases. Demographic information, such as population density and socioeconomic profiles, is retrieved from census reports and government publications to understand service demand and identify vulnerable populations.

The second phase utilizes GIS-based spatial analysis to evaluate service accessibility and identify underserved areas. Emergency facility distribution is mapped to visualize their spatial placement and highlight disparities between urban and rural regions. Buffer zone analysis is conducted to assess service coverage within predefined distances which is 5 km, revealing regions with limited access to emergency services. Road network analysis is employed to study connectivity and travel times to emergency facilities, pinpointing bottlenecks and poorly connected areas. Landslide risk mapping is carried out by overlaying landslide-prone zones with emergency facility locations, combining slope and rainfall data from previous studies to refine the identification of high-risk areas. Slope steepness will be derived from Digital Elevation Model (DEM) data to identify the areas that are prone to instability due to steep gradients. The analysis will involve calculating the slope angle for each cell in the DEM using ArcGIS Toolboxes, then categorizing regions based on predefined multiple slope classes that represent different levels of risk. Areas with slope angles exceeding a critical threshold typically above 20 degrees will be classified as high-risk zones because the higher slope angles can further added to the slope and soil instability. The slope layer will thus provide a foundational understanding of how topographic variations contribute to landslide susceptibility across the Langat Basin.

In the third phase, the data from spatial analyses is integrated and analyzed together with demographic and geological information such as slope angle data, population data, and river network data to provide actionable insights. These GIS layers will be integrated using overlay analysis to provide a better comprehensive assessment of areas where physical attributes and proximity factors contribute significantly to an increased risk of slope failures. The output will be a multi-layered susceptibility model that identifies high-risk areas across the Langat Basin, which will serve as the foundation for more targeted risk mitigation and planning efforts. This integration identifies critical service gaps and high-risk zones, informing strategies for optimizing the placement of emergency facilities and improving road infrastructure. The study proposes a simple framework for emergency response that integrates healthcare facilities, evacuation centers, and disaster response teams to enhance preparedness and accessibility. The tools and software utilized in this study include ArcGIS and QGIS for spatial analysis and mapping, to process and analyze demographic data as needed. By employing this methodology, the research aims to deliver practical recommendations and insight that can be use for improving emergency service delivery in the Langat Basin, particularly in underserved rural areas and landslide-prone zones.

Result

Road Network Analysis

The road network in the Langat Basin was analyzed to assess its connectivity and coverage, particularly about emergency service accessibility. The analysis revealed a dense network of roads in urban areas, providing high connectivity and shorter travel times to healthcare and educational facilities. Conversely, rural areas exhibited sparse road networks, with many communities relying on unpaved or single-lane roads. This limited connectivity not only increases travel times but also poses significant challenges during emergency responses, especially in landslide-prone zones. Moreover, The river network in the Langat Basin was also mapped together with the road network to assess its impact on emergency service accessibility and potential hazards. Many rural communities were located near rivers, increasing their risk of flooding and isolation during heavy rainfall events. Additionally, the proximity of key roadways to rivers posed a threat to transportation during emergencies, as riverbank erosion or flooding could render these roads impassable. This analysis emphasizes the importance of incorporating hydrological risks into emergency service planning.

The analysis of the Langat Basin also shows that high-risk zones are mostly located in the upstream region, where the gradient is steepest and river flow is most intense. However, a certain high-risk zone for a landslide to happen has also been identified in Bukit Jugra, Kuala

Langat despite being in the downstream region. This anomaly is attributed to the unique geological conditions of the hill and human activities in that area. Additionally, areas around the river are particularly prone to landslides due to proximity and soil erosion, which weakens slope stability. Unlike healthcare and educational facilities, no buffer zones were applied for road analysis. Instead, the road network was analyzed based on connectivity between communities and access to critical facilities. Areas with limited road connectivity were found to be significantly more vulnerable, particularly in regions classified as high-risk for landslides, where connectivity to healthcare and educational services is crucial. Moreover, it is also important to consider potential disparities because while the majority of the population may benefit from this accessibility, there might be underserved areas, particularly in Langat Basin regions with less developed road networks or higher geographic constraints, such as hilly terrains or more remote sections of the basin. These areas may face challenges in accessing the same level of road networks which could contribute to localized social vulnerabilities. Additional analysis of the social networks could identify such gaps enabling policymakers to implement targeted infrastructure improvements and resource allocations.

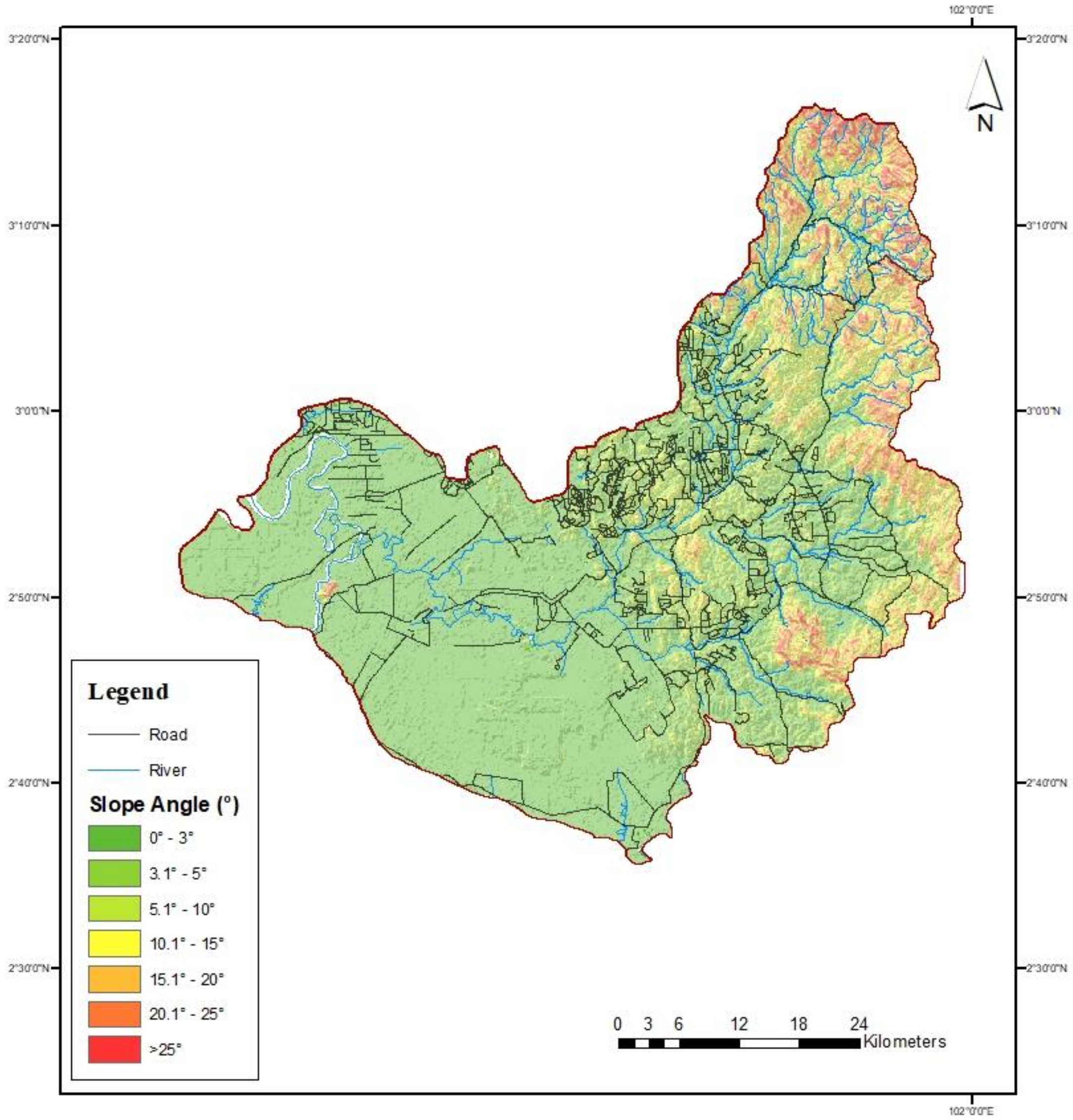

Figure 1: Road, River, and Slope Angle in Langat Basin

Healthcare and Educational Facility Distribution

The spatial distribution of healthcare facilities and educational institutions showed significant disparities between urban and rural areas. Urban centers in the Langat Basin were well-equipped with multiple healthcare facilities, including hospitals and clinics, as well as educational institutions that could function as evacuation centers. In contrast, rural areas were underserved, with some regions lacking access to either type of facility within a reasonable distance. This gap underscores the vulnerability of rural populations during emergencies and highlights the need for strategic facility placement. The analysis demonstrates that all of these education and healthcare facilities are strategically located near major and minor roads ensuring convenient accessibility for the local population of Langat Basin. This proximity significantly reduces travel time for the populations which is particularly important in emergencies that require immediate access to healthcare or when the people need reliable routes to schools and educational institutions for evacuation purposes. The distribution of facilities along the road network highlights the role of infrastructure in enhancing social resilience. Areas near dense road networks are well maintained suggesting that most of the populations in the Langat Basin can easily reach essential services without significant physical or logistical barriers caused by the road unavailability. Furthermore, the accessibility of the road indicates efficient planning and placement of facilities to cater to the population's needs.

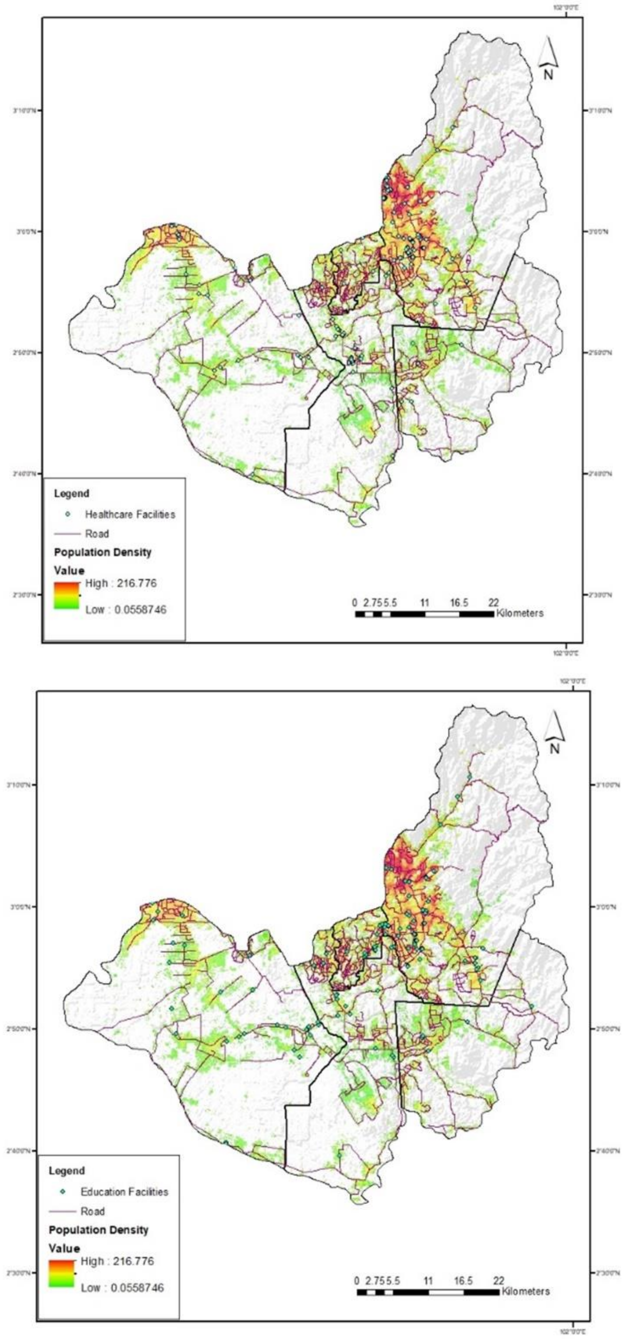

Figure 2: The Location of Crucial Facilities in Langat Basin

Buffer Zone Analysis

Buffer zone analysis for the emergency facilities was conducted to evaluate the service coverage of healthcare and educational facilities. Considering the type of healthcare and educational facilities, it is crucial to assess the access of the affected population in Langat Basin whether in the high-risk zone, medium-risk zone, low-risk zone to the roads, healthcare, and education facilities. During a disaster, multiple types of emergencies can occur simultaneously, making it essential to prioritize healthcare facilities that can provide early emergency treatment including doctors and nurses who can address immediate medical needs or the place with medical and emergency supplies. Therefore, the entire range of healthcare facilities is important, as long as they are located within accessible distances to affected populations. Additionally, the capacity of these facilities to handle a large number of patients during a major disaster is a critical factor that needs to be considered in the assessment. On the other hand, educational facilities, particularly schools such as Sekolah Kebangsaan (primary schools), Sekolah Menengah Kebangsaan (secondary schools), and universities, are often built with reinforced structures that can accommodate many people and also with a supply for emergency kit to be used for minor injuries and emergency treatment. These facilities could serve as temporary shelters during emergencies. However, kindergartens, due to their smaller size and limited infrastructure, can only play a minor role in providing support during disasters. The buffer analysis around educational facilities used a distance of 1km to visualize areas that are well covered versus those that are more vulnerable due to lack of access. For healthcare facilities, a 3km buffer was applied to visualize the vulnerable areas that lack coverage. By covering the 3KM areas of buffer zones, we can see the areas beyond these buffers the community is identified as having poor accessibility, which could lead to increased vulnerability in emergency situations. For education facilities, the buffer zone of 1KM was applied due to the immediate access for a evacuation center was needed either while walking, driving and considering the mobility access of the people in Langat Basin. The buffer distances were chosen based on the location of the facilities in Langat Basin and to better visualize lack of adequate infrastructure in the area. The road access available throughout the Langat Basin provides relatively easier access to these facilities, facilitating connectivity between the population and healthcare or educational infrastructure. However, a critical finding from the analysis is the lack of sufficient facilities in the northeastern part of the Langat Basin (a high-risk zone), which includes rural areas of Hulu Langat and also in the downstream part of Langat Basin. These regions face significant challenges in terms of facility access and require targeted interventions to improve accessibility and resilience of the communities. Similarly, proximity analysis for educational facilities highlighted areas where students might face significant challenges in accessing schools, particularly in the event of infrastructure disruptions caused by slope failures.

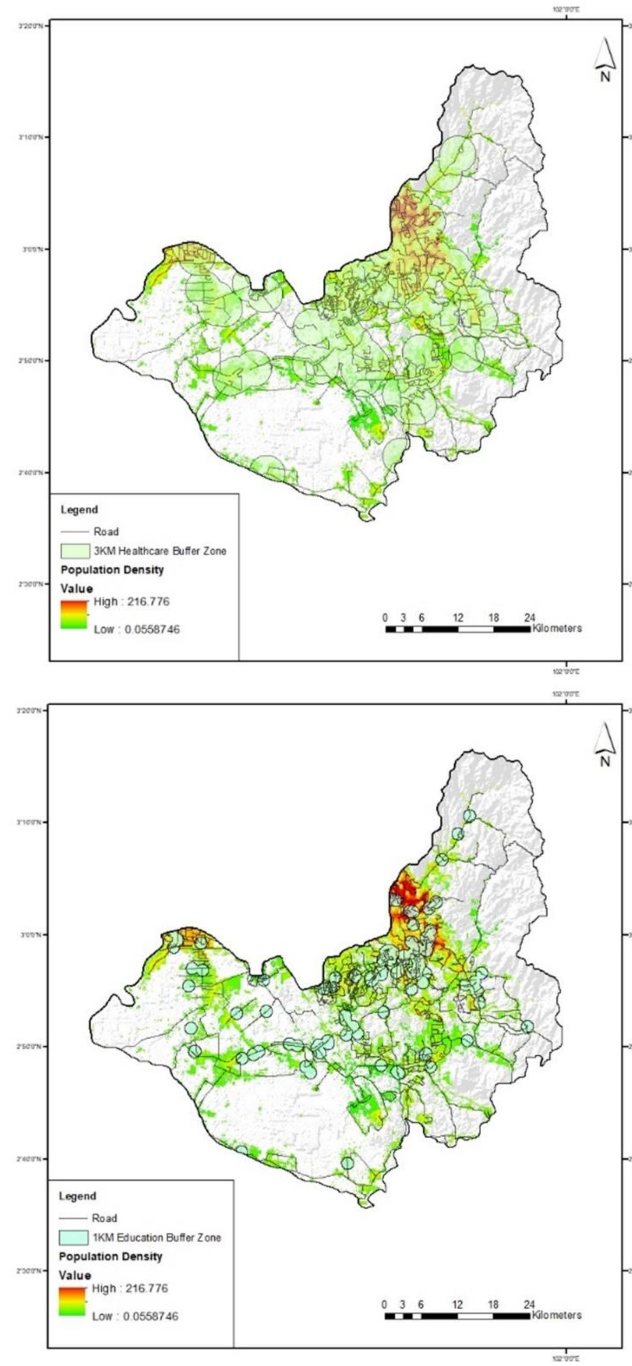

Figure 3: Buffer Zone of Facilities in Langat Basin

Discussion

The findings highlight a pronounced disparity in emergency service accessibility between urban and rural areas of the Langat Basin. Urban centers benefit from well-connected road networks and a dense distribution of facilities, ensuring relatively quick access to critical services during emergencies. In contrast, rural areas face significant challenges, such as sparse infrastructure and limited facility coverage, which increase response times and exacerbate vulnerabilities during disasters (Jerolleman, 2020; Kapucu et al., 2013). This disparity is further evident in the buffer zone analysis, where large portions of rural populations reside beyond the service range of critical facilities, highlighting a pressing need for targeted interventions. The integration of river network analysis adds another layer of complexity, as hydrological risks such as flooding and riverbank erosion compound the challenges faced by rural communities (Ali et al., 2016; Fan et al., 2020; Nazrien Ng et al., 2022; Ning et al., 2022). These risks not only isolate vulnerable populations but also disrupt transportation networks essential for emergency response. Combined with the risk of landslides in upstream areas, the Langat Basin presents a unique interplay of natural hazards that require comprehensive planning and mitigation efforts.

Furthermore, the findings underscore the importance of adopting a multi-dimensional approach to emergency service planning. Addressing infrastructure gaps in underserved areas is critical, but equally important is the need for proactive disaster risk management strategies. For instance, placing healthcare and evacuation facilities in strategic locations can significantly improve accessibility while also enhancing community resilience. Integrating hydrological and geological risk assessments into planning processes ensures that emergency services are not only accessible but also resilient to natural hazards (Bandecchi et al., 2019; Pazzi et al., 2016). GIS-based analyses, as demonstrated in this study, serve as powerful tools for visualizing service gaps and guiding data-driven interventions (de Silva & Eglese, 2000; Derekenaris et al., 2001; Johnson, 1995). The insights gained from spatial analyses can inform the allocation of resources and the design of infrastructure projects tailored to the specific needs of both urban and rural areas. Additionally, policymakers can leverage these findings to prioritize investments in regions with the greatest service gaps and risk exposure.

Long-term resilience requires a collaborative effort involving local authorities, emergency service providers, and community stakeholders. By incorporating local knowledge and ensuring community participation in planning processes, the effectiveness and sustainability of proposed interventions can be significantly enhanced (Dariagan et al., 2021; Kaur et al., 2018; Ruiz-Cortes & Alcantara-Ayala, 2020; Shaw, 2016). The Langat Basin's diverse geographical and demographic context offers an opportunity to pilot innovative solutions that balance equity and efficiency in emergency service delivery. These approaches can serve as models for other regions facing similar challenges, reinforcing the broader relevance of this research.

Conclusion

This study highlights significant disparities in emergency service accessibility within the Langat Basin, emphasizing the challenges faced by rural areas compared to the well-equipped urban centers. Sparse road networks, limited facility coverage, and proximity to natural hazards such as landslides and flooding exacerbate the vulnerabilities of rural communities. These findings underscore the urgent need for targeted interventions to address infrastructure and service gaps. Through GIS-based spatial analysis, this research identifies underserved regions and high-risk zones, offering actionable insights for policymakers and planners. The integration of buffer zone analyses, road network assessments, and hydrological risk mapping provides a comprehensive framework for improving emergency service delivery. By prioritizing the strategic placement of healthcare and evacuation facilities, enhancing road connectivity, and incorporating geological and hydrological risk assessments, emergency response systems in the Langat Basin can be significantly strengthened.

Furthermore, this study demonstrates the utility of GIS as a tool for visualizing complex spatial dynamics and informing data-driven decision-making. These methods not only enhance local emergency planning efforts but also serve as a template for addressing similar challenges in other regions with mixed urban-rural profiles. The findings call for a collaborative approach involving local authorities, service providers, and community stakeholders to ensure equitable and sustainable improvements in emergency preparedness and resilience. In conclusion, addressing the unique challenges of the Langat Basin requires a multi-dimensional and inclusive strategy. By leveraging the insights provided in this study, policymakers can take decisive steps toward reducing vulnerabilities, enhancing accessibility, and building a more resilient emergency service framework that serves the needs of all communities, urban and rural alike.

Acknowledgment

We are profoundly grateful for the support offered by the Fundamental Research Grant Scheme (FRGS/1/2024/SS07/UKM/02/1). This funding has provided crucial resources, enabling us to advance our research initiatives and deliver impactful results that align with our goals.

References

Ali, M. F., Ahmad, S. M., Khalid, K., & Rahman, N. F. A. (2016). Sediment Load Distribution Analysis of Langat River Basin, Selangor. In *ISFRAM 2015*. https://doi.org/10.1007/978-981-10-0500-8_9

Bandecchi, A. E., Pazzi, V., Morelli, S., Valori, L., & Casagli, N. (2019). Geo-hydrological and seismic risk awareness at school: Emergency preparedness and risk perception evaluation. *International Journal of Disaster Risk Reduction*, *40*. https://doi.org/10.1016/j.ijdrr.2019.101280

Cutter, S., Boruff, B., & Shirley, W. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*, *84*, 242–261. https://doi.org/10.1111/1540-6237.8402002

Dariagan, J. D., Atando, R. B., & Asis, J. L. B. (2021). Disaster preparedness of local governments in Panay Island, Philippines. *Natural Hazards*, *105*, 1923–1944. https://doi.org/10.1007/s11069-020-04383-0

Davis, J. R., Wilson, S., Brock-Martin, A., Glover, S., & Svendsen, E. R. (2010). The impact of disasters on populations with health and health care disparities. In *Disaster Medicine and Public Health Preparedness* (Vol. 4, pp. 30–38). Cambridge University Press. https://doi.org/10.1017/S1935789300002391

Silva, F. N., & Eglese, R. W. (2000). Integrating Simulation Modelling and GIS: Spatial Decision Support Systems for Evacuation Planning. *The Journal of the Operational Research Society*, *51*(4), 423. https://doi.org/10.2307/254169

Derekenaris, G., Garofalakis, J., Makris, C., Prentzas, J., Sioutas, S., & Tsakalidis, A. (2001). Integrating GIS, GPS and GSM technologies for the effective management of ambulances. *Computers, Environment and Urban Systems*, *25*, 267–278. https://doi.org/10.1016/S0198-9715(00)00025-9

Fan, X., Yang, F., Siva Subramanian, S., Xu, Q., Feng, Z., Mavrouli, O., Peng, M., Ouyang, C., Jansen, J. D., & Huang, R. (2020). Prediction of a multi-hazard chain by an integrated numerical simulation approach: the Baige landslide, Jinsha River, China. *Landslides*, *17*, 147–164. https://doi.org/10.1007/s10346-019-01313-5

Feng, L., Vodopivec, N., & Miller-Hooks, E. (2015). Supporting mobility-impaired populations in emergency evacuations. *Transportation Research Record*. https://doi.org/10.3141/2532-14

Fernandez, L. S., Byard, D., Lin, C. C., Benson, S., & Barbera, J. A. (2002). Frail elderly as disaster victims: Emergency management strategies. *Prehospital and Disaster Medicine*. https://doi.org/10.1017/S1049023X00000200

Geleto, A., Chojenta, C., Musa, A., & Loxton, D. (2018). Barriers to access and utilization of emergency obstetric care at health facilities in sub-Saharan Africa: a systematic review of literature. *Systematic Reviews*, *7*. https://doi.org/10.1186/s13643-018-0842-2

Jerolleman, A. (2020). *Challenges of Post-Disaster Recovery in Rural Areas* (pp. 285–310). https://doi.org/10.1007/978-3-030-27205-0_11

Johnson, G. O. (1995). *GIS Applications in Emergency Management* (pp. 133–142). https://doi.org/10.1007/978-94-011-0245-2_8

Kapucu, N., Hawkins, C. V., & Rivera, F. I. (2013). Disaster Preparedness and Resilience for Rural Communities. *Risk, Hazards and Crisis in Public Policy*, *4*, 215–233. https://doi.org/10.1002/rhc3.12043

Kaur, H., Gupta, S., Parkash, S., & Thapa, R. (2018). Application of geospatial technologies for multi-hazard mapping and characterization of associated risk at local scale. *Annals of GIS*, *24*(1), 33–46. https://doi.org/10.1080/19475683.2018.1424739

Nazrien Ng, J., Mohd Taib, A., Razali, I. H., Abd Rahman, N., Wan Mohtar, W. H. M., A. Karim, O., Mat Desa, S., Awang, S., & Mohd, M. S. F. (2022). The Effect of Extreme Rainfall Events on Riverbank Slope Behaviour. *Frontiers in Environmental Science*. https://doi.org/10.3389/fenvs.2022.859427

Newsom, D. E., & Mitrani, J. E. (1993). Geographic Information System Applications in Emergency Management. *Journal of Contingencies and Crisis Management*, *1*, 199–202. https://doi.org/10.1111/j.1468-5973.1993.tb00110.x

Ning, L., Hu, K., Wang, Z., Luo, H., Qin, H., Zhang, X., & Liu, S. (2022). Multi-Hazard Chain Reaction Initiated by the 2020 Meilong Debris Flow in the Dadu River, Southwest China. *Frontiers in Earth Science*, *10*. https://doi.org/10.3389/feart.2022.827438

Paturas, J. L., Smith, D., Smith, S., & Albanese, J. (2010). Collective response to public health emergencies and large-scale disasters: putting hospitals at the core of community resilience. *Journal of Business Continuity & Emergency Planning*, *4*, 286–295. https://doi.org/10.69554/clfb2880

Pazzi, V., Morelli, S., Pratesi, F., Sodi, T., Valori, L., Gambacciani, L., & Casagli, N. (2016). Assessing the safety of schools affected by geo-hydrologic hazards: The geohazard safety classification (GSC). *International Journal of Disaster Risk Reduction*, *15*, 80–93. https://doi.org/10.1016/j.ijdrr.2015.11.006

Pollock, W., & Wartman, J. (2020). Human Vulnerability to Landslides. *GeoHealth*. https://doi.org/10.1029/2020GH000287

Prenger-Berninghoff, K., Cortes, V. J., Sprague, T., Aye, Z. C., Greiving, S., Głowacki, W., & Sterlacchini, S. (2014). The connection between long-term and short-term risk management strategies for flood and landslide hazards: examples from land-use planning and emergency management in four European case studies. *Natural Hazards and Earth System Sciences*, *14*, 3261–3278. https://doi.org/10.5194/nhess-14-3261-2014

Resosudarmo, B. P., Latiph, A., Sarntisart, S., & Sarntisart, I. (2016). 6. Development in Southeast Asia's Lagging Regions. In H. Hill & J. Menon (Eds.), *Essays in Honour of Prema-Chandra Athukorala* (pp. 132–162). ISEAS Publishing. https://doi.org/doi:10.1355/9789814762281-009

Rockenschaub, G., & Harbou, K. V. (2013). Disaster resilient hospitals: an essential for all-hazards emergency preparedness. *World Hospitals and Health Services : The Official Journal of the International Hospital Federation*, *49*, 28–30.

Ruiz-Cortes, N. S., & Alcantara-Ayala, I. (2020). Landslide exposure awareness: a community-based approach towards the engagement of children. *Landslides*, *17*(6), 1501–1514. https://doi.org/10.1007/s10346-020-01391-w

Sanuki, R., Satoh, E., Kumakawa, T., & Yoshikawa, T. (2013). Accessibility to medical care in case of major disasters. In *Journal of the National Institute of Public Health2013Vol* (Vol. 62, Issue 1).

Selamat, S. N., Majid, N. A., & Taha, M. R. (2024). Multicollinearity and spatial correlation analysis of landslide conditioning factors in Langat River Basin, Selangor. *Natural Hazards*. https://doi.org/10.1007/s11069-024-06903-8

Selamat, S. N., Abd Majid, N., & Mohd Taib, A. (2023a). A comparative assessment of sampling ratios using artificial neural network (ANN) for landslide predictive model in Langat River Basin, Selangor, Malaysia. Sustainability, 1–21.

Selamat, S. N., Abd Majid, N., Mohd Taib, A., Taha, M. R., & Osman, A. (2023b). The spatial relationship between landslide and land use activities in Langat River Basin: A case study. Physics and Chemistry of the Earth, 1–5.

Selamat, S. N., Abd Majid, N., Taha, M. R., & Osman, A. (2022). Landslide susceptibility model using artificial neural network (ANN) approach in Langat River Basin, Selangor, Malaysia. Land, 1–21.

Shaw, R. (2016). Community-Based Disaster Risk Reduction. In *Oxford Research Encyclopedia of Natural Hazard Science*. https://doi.org/10.1093/acrefore/9780199389407.013.47

Tey, N. P., & Lai, S. L. (2013). Correlates of and barriers to the utilization of health services for delivery in South Asia and Sub-Saharan Africa. *The Scientific World Journal*, *2013*. https://doi.org/10.1155/2013/423403

Tomaszewski, B., Judex, M., Szarzynski, J., Radestock, C., & Wirkus, L. (2015). Geographic Information Systems for Disaster Response: A Review. In *Journal of Homeland Security and Emergency Management* (Vol. 12, pp. 571–602). Walter de Gruyter GmbH. https://doi.org/10.1515/jhsem-2014-0082

Zainol, N. F. M., Zainuddin, A. H., Looi, L. J., Aris, A. Z., Isa, N. M., Sefie, A., & Yusof, K. M. K. K. (2021). Spatial analysis of groundwater hydrochemistry through integrated multivariate analysis: A case study in the urbanized langat basin, malaysia. *International Journal of Environmental Research and Public Health*, *18*. https://doi.org/10.3390/ijerph18115733

Zulkafli, S. A., Abd Majid, N., Syed Zakaria, S. Z., Razman, M. R., & Ahmed, M. F. (2023a). Influencing physical characteristics of landslides in Kuala Lumpur, Malaysia. Pertanika Journal of Science & Technology, 995–1010.

Zulkafli, S. A., Abd Majid, N., & Rainis, R. (2023b). Local variations of landslide factors in Pulau Pinang, Malaysia. Proceedings of the International Conference on Science & Technology Applications in Climate Change (STACLIM), 1–8.