



A Systematic Literature Review on the Concept of Evacuation Route Planning and Assembly Points for Public and Residential Areas

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Abstract

Evacuation routes are a vital element in regional planning, particularly in densely populated urban areas prone to earthquakes and fires. High-density areas often face constraints such as limited space, poor road connectivity, potential congestion, and minimal disaster risk mapping. This complexity increases when comparing heterogeneous public areas with residential areas with a more homogeneous social character. This study aims to trace the development of evacuation route and assembly point planning concepts and identify their correlations through bibliometric mapping. The method used is a Systematic Literature Review (SLR) of international and national journals published in the last 10 years. The study results identified four main concepts: participatory, risk perception, agent, and activity. Of these, the participatory and risk perception concepts are considered the most relevant. The risk perception concept is effectively applied in public areas to increase awareness and preparedness, while the participatory concept is appropriate in residential areas because it directly involves the community in planning. The integration of the two is expected to produce an evacuation strategy that is adaptive, applicable, and oriented towards public safety.

Introduction

Evacuation routes are a vital element in regional planning, particularly in areas with high population density. Densely populated areas often face significant challenges in evacuation route planning due to limited space, high population concentration, and complex road networks. Evacuation routes serve as access to avoid hazards and direct people to safety during disasters such as earthquakes or fires. To function optimally, evacuation routes must meet several criteria, including being easily accessible, clearly visible, sufficiently wide, free of obstructions, and equipped with directional signs (Rumbayan et al., 2023; Ahmed, 2024; Al Bochi et al., 2023; Lyu & Wang, 2025).

The choice of evacuation route planning approach depends heavily on the characteristics of the disaster, the users, and the location. For example, in high-density urban areas, pedestrian-based evacuation is considered more effective (D'Orazio et al., 2014). However, in informal and unplanned settlements, the situation becomes more complex. The chaotic nature of the built environment and limited mitigation infrastructure often trigger unpredictable refugee behavior, necessitating alternative approaches to evacuation route planning (Irsyad & Hitoshi, 2022; Janković, 2024; Al-Homoud & Samarah, 2025; Khalili et al., 2024).

In addition to evacuation routes, assembly points play a crucial role as safe spaces that accommodate disaster-affected communities. Assembly points are not only temporary shelters but also distribution centers for emergency services such as medical aid, food, and specialized

support for vulnerable groups (Esposito Amideo et al., 2019). The success of evacuation route and assembly point planning can be seen in the low number of fatalities and injuries. Supporting factors such as smooth circulation and good spatial organization will result in a spatial configuration that supports an effective evacuation process (Nurhalimah & Astuti, 2020; Cao et al., 2025; Tsai & Chang, 2023). Therefore, a thorough understanding of the spatial configuration of an area is key to formulating sustainable evacuation planning solutions.

The area studied has a high population density and is prone to earthquakes and fires. Key issues include limited open space, poor road connectivity, potential congestion during evacuation, and minimal disaster risk mapping. These conditions demand efficient, accessible, and inclusive evacuation routes for all levels of society, including those with limited mobility. In reality, available evacuation routes are often inadequate in terms of dimensions, completeness of signs, and information, which can slow down the evacuation process.

This research highlights two types of areas with distinct characteristics. First, public areas, which are generally densely populated with socio-economic activity, have diverse users with evacuation needs, and fluctuating visitor density levels (D'Orazio et al., 2014). Second, residential areas, which function as residential areas with high population densities, narrow road networks, and complex daily mobility (Forrister et al., 2023; Liu et al., 2022; Yuan et al., 2023). Both areas face disaster risks, necessitating an adaptive and contextual approach to evacuation planning.

Based on these phenomena, this research was born to address the need for conceptual solutions for planning evacuation routes and assembly points in densely populated areas. A systematic literature review is needed to identify the state of the art regarding evacuation planning criteria, challenges, and solutions based on relevant research from the past 10 years. Through this approach, it is hoped that an overview of conceptual developments, bibliometric mapping, and correlation of visual ideas will be obtained, which can enrich understanding and strengthen the direction of future planning.

The research problem formulation focuses on two main questions:

Through a Systematic Literature Review (SLR), how has the concept of planning evacuation routes and assembly points developed?

Through bibliometric mapping, how does the visualization correlate between the concepts of evacuation route planning and assembly points?

The purpose of this research is to explore developments in global issues related to evacuation route and assembly point planning and to identify research patterns over the past 10 years. The results of this systematic literature review are expected to provide a conceptual foundation for formulating more effective, contextual, and public safety-oriented planning strategies.

Methods

This study uses the Systematic Literature Review (SLR) method or systematic literature review of the literature taken from similar journals. In this case, it will review 15 journal papers that have been published in the last 10 years, with a limit from 2014 to 2024. The search method for this paper uses the PoP application using the keywords evacuation routes and assembly points, with the index used is Scopus and Google Scholar. In addition, an independent literature search was also conducted through Science Direct, Research Gate and other sources. The study was also conducted using a mapping visualization method in bibliometrics to find correlations between these keywords. So the purpose of this Systematic Literature Review (SLR) is to explore information and planning solutions in it to obtain knowledge GAP. In this method, there are 4 (four) stages that are passed by searching journals over the last 10 years. First, a

total of 100 journal papers were obtained consisting of 50 local journals and 50 international journals based on title relevance. Second, journals were screened based on the suitability of the title to the theme. Third, journals were screened based on abstracts and theme equivalence. Fourth, selected journal data was obtained as final data for this Systematic Literature Review (SLR).

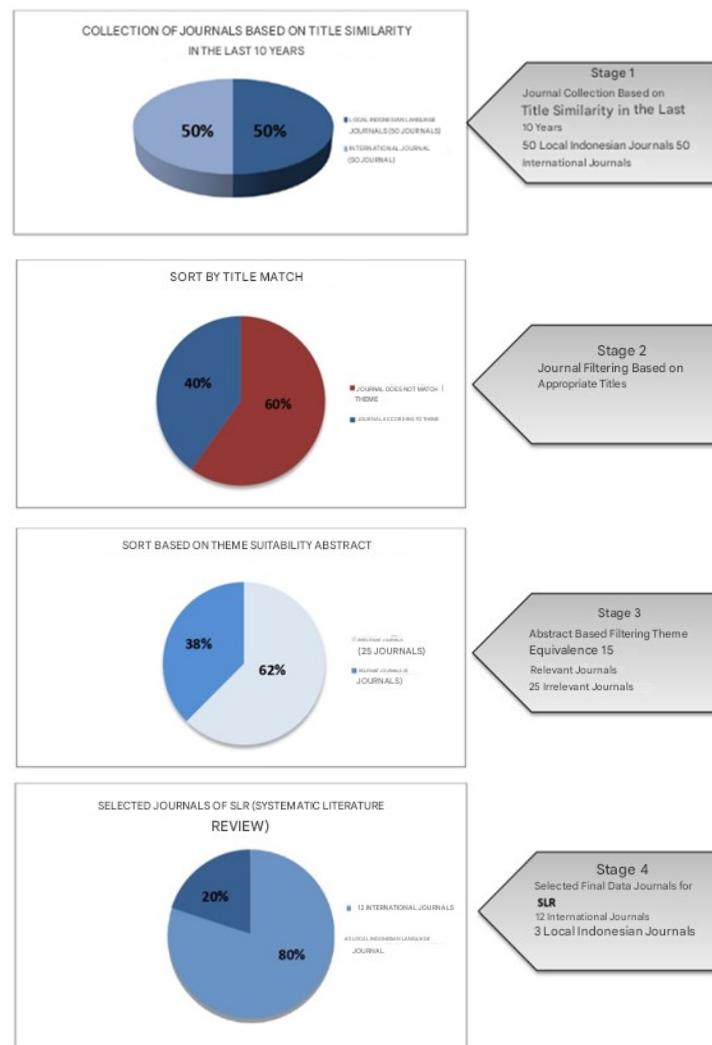


Figure 1. SLR Journal Screening

Source: Author, 2025

Results and Discussion

This research begins with a Systematic Literature Review (SLR) analysis obtained from Scopus and Google Scholar data sources. An independent literature search was also conducted through Science Direct, Research Gate, and other sources, resulting in 15 articles on evacuation routes and assembly points. The flow of this chapter begins with keyword restrictions as a basis for journal filtering. After narrowing down, several references were found, which in their groupings discuss evacuation routes and assembly points using the concepts of participatory, activity, agent, and risk perception. Knowledge GAP from the systematic literature review (SLR) table data will of course be grouped according to the theme of the issue or problem over the past 10 years. This bibliometric analysis was conducted to understand research trends in evacuation route and assembly point planning. Visualization was performed using VosViewer

software. The dataset used includes 15 articles published between 2014 and 2024 that focus on the concepts of participatory, activity, agent, and risk perception. This analysis includes keywords, authors, and journals involved in the topic. The following table shows the results of the SLR journal filtering.

Table 1. Results of SLR journal screening

Author	Concept	Title	Problem
Abraham et al. (2015)	Participatory Concept	Determination of Evacuation Routes and Participatory Assembly Points in Efforts to Reduce the Risk of Mount Merapi Disaster	The condition of evacuation routes that do not support safety increases community vulnerability to disasters, and the lack of community participation in determining evacuation routes creates excessive dependence on the government.
Van Der Gun et al. (2016)	Activity-Based Concept	A General Activity-Based Methodology for Simulating Multimodal Transportation Networks During Emergencies	Identified several problems in evacuation route and assembly point planning, such as capturing interactions between transport modes and traffic flows. These factors may cause failure mechanisms that could be overlooked by less comprehensive models.
Nilufar & Choiti (2019)	Agent-Based Concept	Morphological Properties of the Spatial Layout of Factories – A Key Determinant in Setting the Emergency Escape Routes for Evacuation	The RMG sector significantly contributes to Bangladesh’s socio-economic development, but it is highly vulnerable to fire hazards, identified as a major risk leading to numerous worker fatalities.
Grumbly et al. (2019)	Risk Perception Concept	Examining the Impact of Risk Perception on the Accuracy of Anisotropic, Least-Cost Path Distance Approaches for Estimating the Evacuation Potential for Near-Field Tsunamis	With projected coastal population growth, exposure is likely to increase. For near-field tsunamis, the evacuation window may only last 15–20 minutes, and evacuation becomes challenging due to demographics, limited road networks, topographic constraints, and misaligned public risk perceptions.
Wibowo et al. (2020)	Participatory Concept	Increasing Community Participation in Participatory Mapping Studies for Tsunami Evacuation Routes in Pagar Jaya Tourism Village	Pagar Jaya tourism village has several attractive geotourism sites, all located in coastal areas vulnerable to tsunami hazards.

Liu & Lim (2016)	Agent-Based Concept	Integration of Spatial Analysis and an Agent-Based Model Into Evacuation Management for Shelter Assignment and Routing	Challenges include limited shelter accessibility, flood risks threatening evacuation routes, variations in public response to evacuation warnings, inadequate infrastructure, and limited shelter resources.
Takabatake et al. (2017)	Agent-Based Concept	Simulated Tsunami Evacuation Behavior of Local Residents and Visitors in Kamakura, Japan	Evacuation is seen as the most effective method to save lives from tsunamis, especially after the 2011 Tohoku Earthquake and Tsunami. Coastal threats affect not only local residents who know the area well, but also tourists, making it essential to consider both groups in evacuation planning.
Ao et al. (2020)	Risk Perception Concept	Influence of Built Environment and Risk Perception on Seismic Evacuation Behavior: Evidence from Rural Areas Affected by Wenchuan Earthquake	Identified several issues in evacuation route and assembly point planning, including capturing interactions between transport modes and traffic flows, which may cause failure mechanisms overlooked in less comprehensive models.
Sabani et al. (2021)	Participatory Concept	Participatory Mapping of Tsunami Evacuation Routes (Case Study of Karangbenda Village, Cilacap Regency)	Indonesia is one of the countries with high tsunami risk; communities play a crucial role in disaster management, one of which is participatory mapping of tsunami evacuation routes.
D’Orazio et al. (2014)	Agent-Based Concept	Agent-Based Model for Earthquake Pedestrians’ Evacuation in Urban Outdoor Scenarios: Behavioural Patterns Definition and Evacuation Paths Choice	Seismic risk assessments at the urban scale often fail to adequately consider human behavior. Moreover, simulations of pedestrian evacuation and movement during earthquakes are rarely studied.
Forrister et al. (2023)	Risk Perception Concept	Analyzing Risk Perception, Evacuation Decision and Delay Time: A Case Study of the 2021 Marshall Fire in Colorado	These areas often have different socio-demographic and built environment characteristics compared to WUI (wildland-urban interface) areas, making it uncertain whether prior knowledge can be transferred.
Madina, R. F. et al. (2024)	Participatory Concept	Planning of Assembly Points and Evacuation Routes in Rusunawa	Rusunawa Rorotan does not yet have evacuation routes and assembly points communicated

		Rorotan Through Participatory Planning	either verbally or in written form.
Wang & Jia (2021)	Agent-Based Concept	Simulation-Based and Risk-Informed Assessment of the Effectiveness of Tsunami Evacuation Routes Using Agent-Based Modeling: A Case Study of Seaside, Oregon	Identified several issues in evacuation route and assembly point planning, such as capturing interactions between transport modes and traffic flows, potentially causing overlooked failure mechanisms in less comprehensive models.
Kinatader et al. (2015)	Risk Perception Concept	Risk Perception in Fire Evacuation Behavior Revisited: Definitions, Related Concepts, and Empirical Evidence	Literature on risk perception and evacuation often does not clearly define risk perception, lacks updated knowledge, and fails to address modulating factors influencing evacuation processes.
Lovreglio et al. (2016)	Risk Perception Concept	An Evacuation Decision Model Based on Perceived Risk, Social Influence and Behavioural Uncertainty	Pre-evacuation behavior has been studied in various evacuation scenarios, but in many existing models, such behavior is often oversimplified.

Source: Author, 2025

Vosviewer Bibliometric Analysis

The results of the keyword analysis indicate several main clusters within the concepts of participatory, activity, agent, and risk perception. The first cluster, which focuses on the concept of risk perception, contains keywords such as built environment perception, earthquake, and binary logistic regression. The second cluster, related to the concept of participation, identifies keywords such as risk perception and evacuation modeling. The third cluster, related to the concept of activity, identifies keywords such as dynamic network loading. The fourth cluster, related to the concept of agent, identifies keywords such as human behavior. The research trends emerging in Figures 2 and 3 indicate that the concepts of risk perception and participatory have grown rapidly since 2020, while the concepts of activity and agent have shown a decline in interest in recent years. In terms of their close relationship, the concepts of risk perception and participatory have a very close relationship. In contrast, the concepts of agent and activity have a relatively distant relationship, even when trying to connect them, the concepts of participatory and risk perception also have a fairly distant relationship. The closeness between the concepts of participation and risk perception can be a positive consideration between the two. The distance between the concepts of activity and agency can be a negative consideration between the closeness of the two concepts.

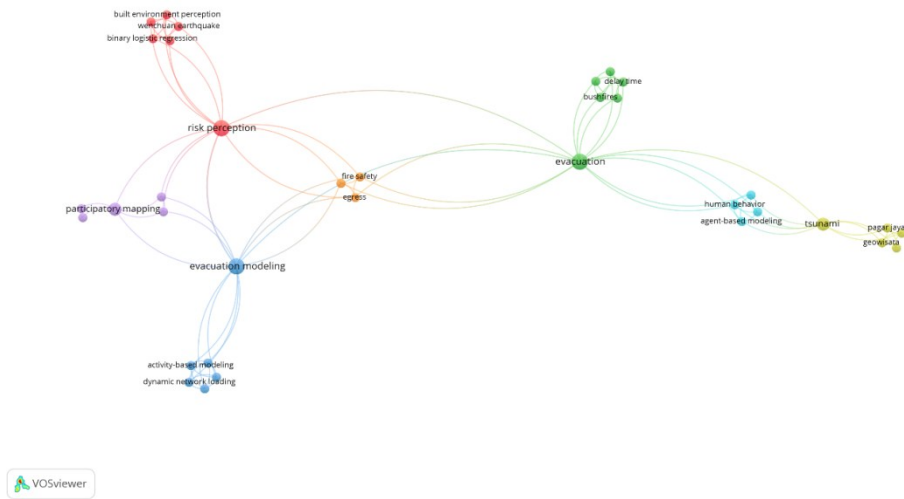


Figure 2. Network Visualization

Source: Author, 2025

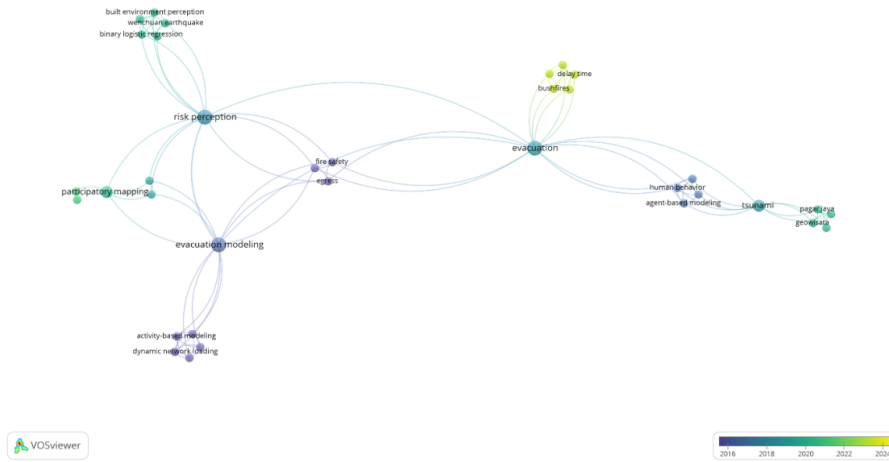


Figure 3. Overlay Visualization

Source: Author, 2025

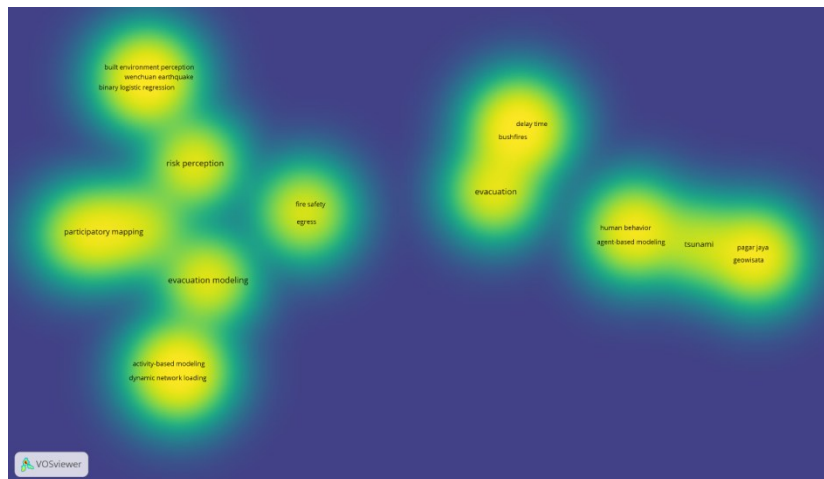


Figure 4. Density Visualization

Source: Author, 2025

Analysis using VOSviewer provides a clear overview of research trends in evacuation route planning and assembly points. Visualization of keyword networks and author collaborations reveals significant developments and collaboration patterns, which can help determine further research directions.

Concept Selection

In the context of this research, the selection of concepts is crucial to ensure the success of evacuation route and assembly point planning. The literature review identified several prominent concepts: risk perception, participation, agency, and activity. However, when related to the context of the research area, namely public areas and densely populated residential areas, the concepts of risk perception and participation are deemed more relevant than the concepts of agency and activity.

The concept of risk perception (Forrister et al., 2023; Ao et al., 2020) is closely related to public areas, which are often populated by diverse community groups with varying levels of disaster awareness. In public areas, the success of an evacuation depends heavily on the level of individual threat perception. Improving pre-disaster risk perception through education can encourage visitors or users of public areas to be more responsive in evacuating when a disaster occurs. In other words, this concept strengthens collective preparedness in the heterogeneous and dynamic nature of public spaces.

Meanwhile, the participatory concept (Abraham et al., 2015; Madina R. et al., 2024; Sabani et al., 2020) is more appropriate for residential areas. The main characteristic of residential areas is the relatively stronger social ties, and direct community involvement in planning can increase their awareness and preparedness. Resident participation in determining routes and assembly points makes the evacuation process more effective and tailored to local needs. This is crucial given that road networks in densely populated areas tend to be narrow and complex, requiring evacuation solutions to be based on residents' everyday understanding and experiences.

Conversely, the agent (Wang & Jia, 2021; Muttaqien et al., 2024) and activity (Van Der Gun et al., 2016) concepts, while offering in-depth analytical approaches, tend to be less practical for public areas or densely populated residential areas. The complexity of modeling, the need for detailed data, and the extensive resources required make these two concepts difficult to apply in research contexts that require rapid, adaptive, and applicable solutions for the community.

Therefore, the selection of risk perception and participatory approaches is more appropriate to address research needs in public areas and densely populated residential areas. Risk perception can increase preparedness in heterogeneous public spaces, while a participatory approach can empower residential communities to create evacuation routes that are appropriate to real-world conditions. The integration of the two is expected to produce evacuation route and assembly point planning that is not only theoretical but also contextual, applicable, and oriented towards public safety.

The study examined the characteristics of residential areas in Ngargomulyo Village, Dukun District, Magelang Regency. First, good and moderate road conditions, still providing adequate facilities, are found in hamlets near the main route, such as Sabrang, Batur Duwur, Germer, Kembang RT 2, Barman, and Batur Ngisor RT 1. Areas far from the city center are rated as poor and lacking adequate facilities, such as Ngandong, Karanganyar, Bojong, Tangkil, and Batur Ngisor RT 2 hamlets. Second, most respondents still believe that the existing roads are still very good and provide adequate facilities, as the only existing roads are existing roads, and it is difficult to build new roads in Ngargomulyo Village. Respondents who believe that the roads do not support/facilitate evacuations are due to poor road conditions that make it difficult

for motorized vehicles to navigate them. Differences in perceptions of road quality and serviceability indicate differences in the use of space and the function of space within evacuation routes. Third, regarding traffic, 34 respondents stated that road traffic was severely congested.

Selected Concepts

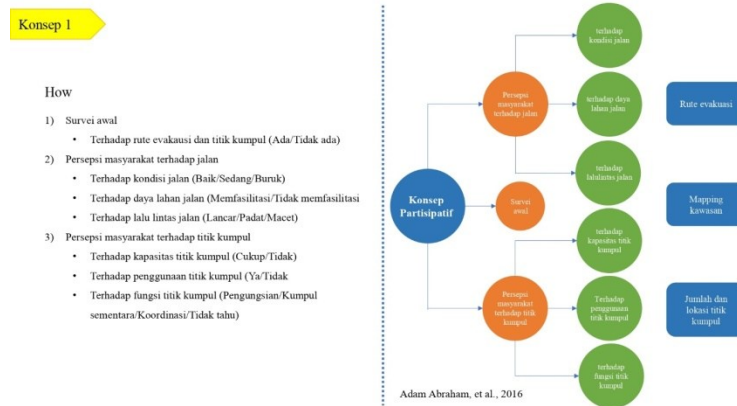


Figure 5. Participatory Concept

Source: Edited by the Author, 2025

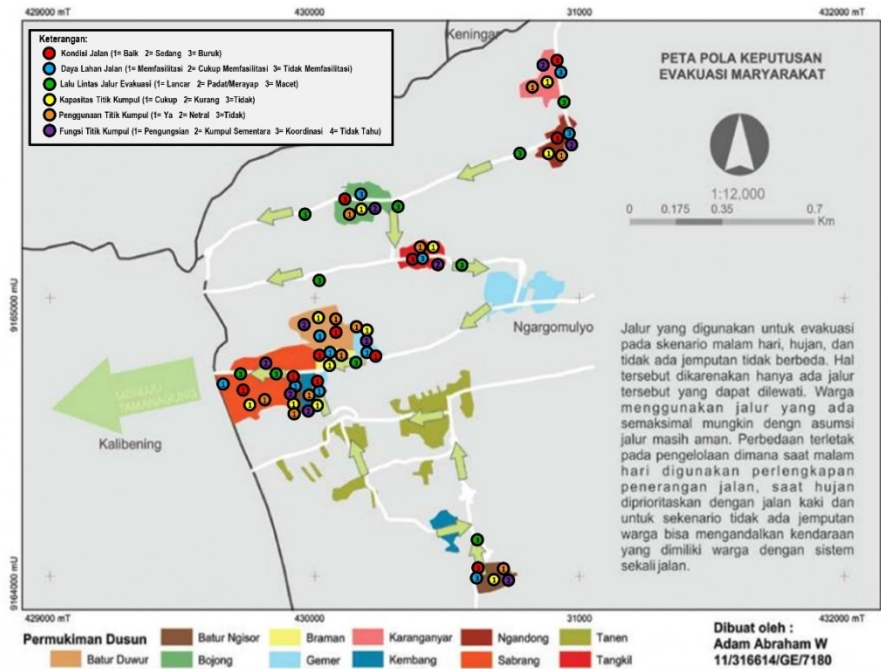


Figure 6. Case Study of Participatory Concepts

Source: Author, 2025

In addition to road conditions, evacuation time was a major factor. Poor road quality and serviceability contributed to a poorly integrated road system, as conditions were less conducive to the modes of transportation used for evacuation. Road conditions influenced the smoothness of evacuations, but time was the primary determinant. Fourth, regarding assembly point capacity, the public generally considered the existing assembly points to be adequate to accommodate the community in the hamlet prior to evacuation. Twenty-seven percent stated that the assembly points were inadequate to accommodate the village population. The lack of sufficient buildings for the assembly points could lead to two problems: first, an inefficient

evacuation system, and second, a risk to the community's weakened immune systems during rainy seasons.

Fifth, regarding the use of assembly points, respondents believed that using assembly points allowed them to gather with their families and reduced the risk of being separated. Respondents who did not use the assembly point were those who mostly did not evacuate and chose to stay to protect the surrounding environment, because they believed the eruption disaster would not be dangerous and could monitor the development of Mount Merapi's condition and village security. Sixth, regarding the function of the assembly point, 71% of respondents thought it was a temporary gathering place, so the majority of the community already understood the function of the assembly point. 21% of respondents who thought it was a coordination place were assumed to have been able to utilize the assembly point more efficiently and were an active component in the community during evacuation (Abraham et al., 2015; Liu et al., 2023; Odabaş et al., 2025).

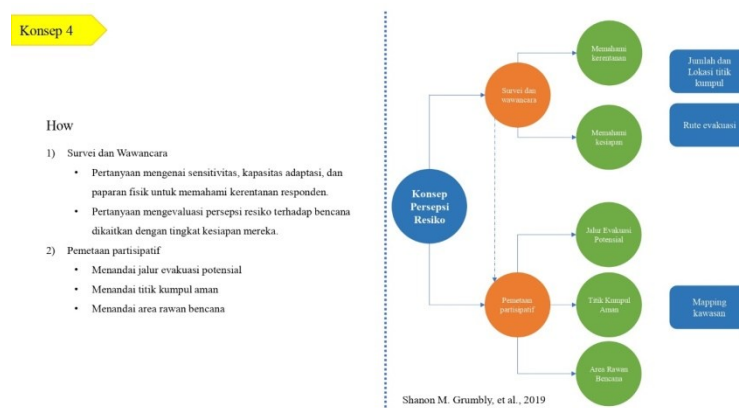


Figure 7. Risk Perception Concept

Source: Edited by the Author, 2025

The study was conducted on the character of residential areas in Aberdeen, Washington. First, understanding vulnerability, all respondents stated they had at least some awareness and understanding of the tsunami hazard near the location, acknowledged the danger and risk that a tsunami posed to Aberdeen, Washington, and agreed that deaths and injuries, damage to homes and businesses, and damage to critical infrastructure would result from a tsunami event. Second, understanding preparedness, respondents noted the need for a high level of preparedness and a general need for better information regarding tsunami hazards. Respondents reported general awareness of official evacuation routes, primarily through signs along roadways. Official routes were inadequate due to landslide hazards, ambulation problems within the population, and a lack of awareness or information, while knowledge of assembly areas within the community was limited. Third and fourth, there are 16 locations in Aberdeen Washington included in the potential evacuation route, because the area is included in the area that is not directly adjacent to the Chehalis River, namely 2701 Cherry Street, 2011 Bay Avenue, Harbor High School, Aberdeen City Sewer Department, Mcdermoth Elementary School, Safeway Parking Lot, Aberdeen High School, Chehalis River Coastline At South At F Street, 508 Third Avenue, Kurt Cobain Memorial Park, Walmart, 1300-2636 Olympic Highway, Entrance Of US Route 101 Bridge, Chehalis River Trail Near 711 Harding Road, Sears At Southshore Mall, Miller Junior High School. The five disaster-prone areas, problematic areas include locations 3 (End of Pasha Group Dock), 15 (598 North Custer Street), and 18 (Chehalis River Trail near US Route 105), with more than 90% of routes originating from these points failing the best tsunami arrival window of 45 minutes with a

tsunami wave arrival of 25 minutes and 100% of all routes originating from these points being infeasible. Location 14 (Chehalis River Coastline at Pacific Veneer), which is infeasible for all routes in all tsunami wave scenarios. Locations 3, 15, 18, and 14 border the Chehalis River, requiring pedestrians to travel very long distances to arrive at a safe location (Grumbly et al., 2019).

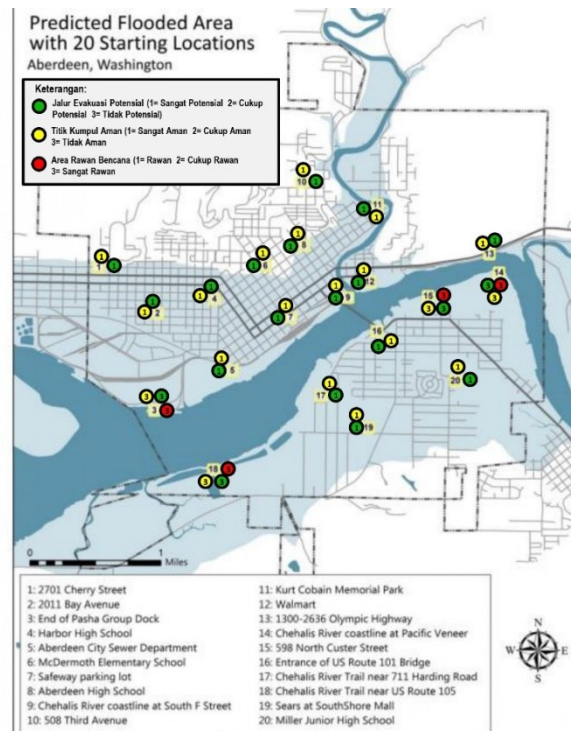


Figure 8. Case Study of the Risk Perception Concept

Source: Author, 2025

Conclusion

A systematic literature review (SLR) identified four concepts for planning evacuation routes and assembly points: the participatory concept, the activity concept, the agent concept, and the risk perception concept. Participatory and risk perception concepts have grown rapidly since 2020, while activity and agent concepts have shown declining interest in recent years. Selecting the best concept must ensure long-term success. First, the relationship between risk perception and participatory concepts is very close. In contrast, the agent and activity concepts are quite distant, even when attempting to link them. Second, the risk perception concept is important for improving preparedness in heterogeneous public areas, where successful evacuations depend heavily on the community's understanding of potential threats. Meanwhile, the participatory concept is more appropriate for residential areas, as direct community involvement in planning has been shown to improve the effectiveness of evacuation routes and assembly points based on real-world conditions. Third, while the agent and activity concepts offer more in-depth analysis, their high complexity, resource constraints, and detailed data requirements complicate practical implementation in the field. Therefore, the selection of the risk perception and participatory concepts provides a strong foundation for formulating evacuation route and assembly point planning strategies. Integrating the two is expected to produce an adaptive, applicable approach that significantly improves public safety, both in public areas and densely populated residential areas.

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