Development of Disaster Mitigation Infrastructure for Urban Spatial Planning in Kota Kuala Simpang, Aceh Tamiang

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Abstract

Recurring floods in Kota Kuala Simpang District, Aceh Tamiang Regency, create a need not only to restore urban infrastructure but also to improve its resilience. This study aims to examine post-flood infrastructure conditions, identify internal and external factors affecting infrastructure development, and formulate disaster-mitigation-based strategies to support spatial planning. The research is designed using a descriptive qualitative approach, with data collection planned through observation, interviews, and documentation. Secondary data will be obtained from government documents, disaster reports, statistical data, maps, and relevant literature. Informants will be selected purposively from local government, the Regional Disaster Management Agency, technical agencies, subdistrict and village officials, and the community. Data analysis comprises data condensation, data display, and conclusion drawing and verification. Qualitative SWOT analysis will be used to identify strengths, weaknesses, opportunities, and threats and to formulate SO, WO, ST, and WT strategic alternatives. Initial issues to be examined include roads, drainage, bridges, public facilities, budget constraints, institutional coordination, policy support, and information technology. Since the source document is a thesis proposal, the factors and strategies presented remain an initial framework that must be verified using field data. The study is expected to provide input for developing more flood-resilient urban infrastructure integrated with spatial planning.

Keywords: Urban Infrastructure; Post-Flood; Disaster Mitigation; Spatial Planning; SWOT Analysis.

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Introduction

Infrastructure development is one of the key elements in supporting economic growth, improving community welfare, and achieving sustainable spatial planning. Infrastructure not only supports social and economic activities but also plays a role in strengthening regional resilience to disaster threats. The availability of quality infrastructure can facilitate the mobility of people and goods, improve public services, and support government and economic activities [1], [2].

Aceh Tamiang Regency has geographical characteristics that include low-lying areas traversed by several major rivers, including the Tamiang River. These conditions make some areas vulnerable to flooding, particularly during the rainy season when rainfall intensity is high. Kota Kuala Simpang District is one of the centers of government, trade, and services in Aceh Tamiang Regency. Recurring floods have the potential to disrupt road networks, drainage systems, bridges, public service facilities, and the social and economic activities of the community.

Post-disaster spatial arrangement cannot be achieved merely by rebuilding damaged facilities and infrastructure. Recovery efforts need to be accompanied by an evaluation of spatial utilization, improvements in infrastructure capacity, stronger maintenance systems, and the application of disaster risk reduction principles. This is consistent with the spatial planning framework, which comprises spatial planning, spatial utilization, and control of spatial utilization [3]. Disaster management also places risk reduction as an important part of community protection [4].

Issues that need to be examined in post-flood infrastructure development include limited budget resources, drainage conditions and capacity, the expansion of built-up areas, and inter-agency coordination. At the same time, potential opportunities include support from central and regional governments, the use of information technology and Geographic Information Systems (GIS), and increasing public awareness of disaster mitigation. These factors need to be confirmed through observation, interviews, documentation, and secondary data.

Research by Tarigan et al. on urban area design through an Internet of Things (IoT)-based smart drainage system highlights the importance of using sensors, data communication, and spatial information integration to support drainage monitoring and flood management [11]. This study is relevant as a basis for considering technological approaches, although their implementation in Kota Kuala Simpang must still be adjusted to local conditions, institutional readiness, budget availability, and field research findings.

In view of these issues, this study addresses three main questions: what are the post-flood urban infrastructure conditions in Kota Kuala Simpang District; what factors constitute the strengths, weaknesses, opportunities, and threats in its development; and what strategies can be implemented to support post-flood spatial arrangement? The objectives are to analyze infrastructure conditions, identify internal and external factors, and formulate infrastructure development strategies through SWOT analysis.

The novelty of this study lies in positioning post-flood infrastructure development as part of a spatial arrangement strategy that integrates physical aspects, disaster mitigation, institutions, and spatial utilization. Infrastructure is not viewed merely as facilities that need to be restored, but as an urban service system whose resilience and functional sustainability need to be improved.

Literature Review

Infrastructure is a system of facilities and networks that supports community activities, economic activities, government services, and interaction between regions. In an urban context, infrastructure includes transportation networks, water resources, basic services, energy, telecommunications, and public facilities. Kodoatie explains that infrastructure management needs to consider the interrelationships among technical, social, economic, environmental, and institutional aspects [1]. Therefore, urban infrastructure needs to be understood as an interconnected system.

Infrastructure development includes the planning, construction, rehabilitation, quality improvement, maintenance, and management of facilities. In post-disaster areas, development is not only intended to restore damaged facilities but also to improve their capacity and quality so that they are better able to withstand similar threats in the future. In this study, the objects of analysis focus on road networks, drainage, bridges, public facilities, and other supporting urban infrastructure. The assessment considers physical condition, function, capacity, accessibility, level of damage, maintenance, and ability to reduce disaster risks.

Spatial arrangement is the process of organizing space to achieve planned, effective, efficient, safe, comfortable, productive, and sustainable spatial utilization. Law Number 26 of 2007 explains that spatial planning includes spatial planning, spatial utilization, and control of spatial utilization [3]. Infrastructure requires space for construction and operation, while the existence of infrastructure networks also influences the direction of regional development. Accordingly, infrastructure development and spatial planning need to be implemented in an integrated manner.

Disaster risk-based spatial arrangement considers hazard characteristics, vulnerability, regional capacity, land-use patterns, the density of built-up areas, and environmental conditions when determining spatial utilization. Measures that may be considered include identifying disaster-prone areas, controlling spatial utilization, protecting water absorption areas, providing green open spaces and evacuation routes, increasing drainage capacity, and regulating the locations of public facilities.

Law Number 24 of 2007 defines a disaster as an event or series of events that threatens and disrupts community life and may result in loss of life, environmental damage, property losses, and socio-economic impacts [4]. Disaster mitigation is an effort to reduce risks through physical development as well as improvements in community and institutional capacity. Structural mitigation may include improving drainage systems, embankments, retention ponds, road and bridge resilience, green open spaces, and water absorption areas. Non-structural

mitigation may be carried out through spatial planning policies, development regulations, early warning systems, disaster education, institutional strengthening, and inter-agency coordination.

Tarigan et al. discuss the use of IoT technology in planning smart drainage systems to address flooding in urban areas [11]. The use of water-level sensors, data communication devices, and integration with GIS can support real-time monitoring of channel conditions and provide spatial information for decision-making. The relevance of this research lies in the importance of improving drainage capacity and management through information technology. In the context of Kota Kuala Simpang, this approach may be considered after technical requirements and implementation readiness have been identified.

SWOT analysis is used to identify internal and external factors that influence the achievement of objectives and to formulate alternative strategies [5]. Strengths and weaknesses are internal factors, while opportunities and threats are external factors. The SWOT matrix links these factors into four strategic alternatives: SO, which uses strengths to seize opportunities; WO, which uses opportunities to overcome weaknesses; ST, which uses strengths to address threats; and WT, which reduces weaknesses and avoids threats. In this study, SWOT is used qualitatively based on field evidence, without weighting or score calculations.

Research Method

This study uses a descriptive qualitative approach to describe urban infrastructure conditions and post-flood spatial arrangement in Kota Kuala Simpang District, Aceh Tamiang Regency. This approach is used to gain an understanding of existing infrastructure conditions, problems, needs, regional potential, and factors influencing infrastructure development. The research location was selected because Kota Kuala Simpang District is the center of government and economic activity in Aceh Tamiang Regency and is vulnerable to flooding, as described in the research proposal.

Primary data are planned to be obtained through observation, interviews, and documentation. Observation will focus on road networks, drainage, bridges, public facilities, environmental conditions, flood-affected areas, accessibility, and land use. Interviews will be conducted with parties who understand or are involved in infrastructure development, disaster management, and spatial arrangement. Documentation will include photographs, maps, government documents, damage reports, disaster reports, infrastructure data, and planning documents.

Secondary data are planned to be sourced from the Aceh Tamiang Regency Government, the Regional Disaster Management Agency (BPBD), the Public Works and Spatial Planning Office, Statistics Indonesia, Regional Spatial Plan documents, development planning documents, disaster reports, regional maps, scientific journals, books, and previous research. Informants will be selected purposively based on their knowledge, experience, or involvement. Informant groups will include local government, BPBD, the Public Works and Spatial Planning Office and related agencies, subdistrict/village officials, the community, and supporting informants.

Data analysis is carried out through three stages: data condensation, data display, and conclusion drawing and verification [6], [7]. Data from various sources are selected and grouped according to infrastructure conditions, problems, spatial arrangement needs, disaster mitigation, and factors influencing infrastructure development. Data validity is strengthened through source triangulation and method triangulation by comparing information from the government, technical agencies, the community, observations, interviews, documentation, and secondary data.

SWOT analysis is conducted by classifying findings into internal factors, namely strengths and weaknesses, and external factors, namely opportunities and threats. These factors are then linked to formulate SO, WO, ST, and WT strategies. In this study, SWOT analysis is a qualitative analytical tool for interpreting conditions based on observations, interviews, and documentation. Therefore, this study does not use weighting, ratings, IFAS and EFAS matrices, or score calculations.

Results and Discussion

The discussion in this paper is prepared based on the scope and analytical framework contained in the thesis proposal. Accordingly, the following description represents an initial identification of aspects that need to be examined and analyzed, rather than a claim that all conditions have been verified through field observations. The final findings need to be supplemented with observation notes, interview results, documentation, and relevant secondary data.

The assessment of infrastructure conditions focuses on road networks, drainage systems, bridges, public facilities, and supporting urban facilities. For road networks, the aspects to be examined include physical condition, level of damage, function, accessibility, and continuity of connections between areas. For bridges, the assessment needs to consider structural condition, function, safety, and their role in maintaining community access. This information is required to determine the need for rehabilitation, reconstruction, capacity improvement, or maintenance.

For drainage systems, the aspects to be examined include channel condition, capacity, flow continuity, maintenance, and connection with the area's water management system. Meanwhile, public facilities need to be assessed based on physical condition, service function, accessibility, and their ability to continue providing services during floods. This assessment needs to be linked to environmental conditions, catchment areas, and the development of built-up areas so that the strategies formulated are not focused solely on physical repairs.

The initial identification of internal and external factors is based on the issues and potential mentioned in the research proposal. These factors must be confirmed through field data before being established as research findings. A summary of the initial identification is presented in Table 1.

Table 1. Initial Identification of Internal and External Factors

Factor	Initial Identification

Strengths	Kota Kuala Simpang's strategic role as a center of government and economic activities; the existence of infrastructure networks; potential institutional support and community participation.
Weaknesses	Possible budget constraints; drainage conditions and capacity; infrastructure conditions and maintenance; the need to strengthen coordination and infrastructure data.
Opportunities	Support from central and regional government programs; spatial planning and disaster risk reduction policies; use of information technology and GIS; opportunities for inter-agency cooperation.
Threats	Recurring flood events; high rainfall and river-flow pressure; expansion of built-up areas; land-use changes and environmental pressures.

The initial identification indicates that infrastructure development needs to consider the relationship between regional capacity, institutional support, the physical condition of infrastructure, and flood threats. The area's strategic position can serve as an asset for integrating development programs, while budget, maintenance, and data limitations need to be addressed through coordinated planning. Opportunities arising from policy support and technology can be used to strengthen information-based decision-making.

Based on this initial identification, alternative strategies that can be further tested are presented in Table 2.

Table 2. Alternative Strategies for Disaster Mitigation-Based Infrastructure Development

Strategy Type	Initial Strategic Direction
SO	Use the area's strategic position, infrastructure networks, and institutional support to promote integrated improvements to roads, drainage, bridges, and public facilities; integrate infrastructure programs with spatial planning and the use of GIS data.
WO	Use government program support, technical assistance, and inter-agency cooperation to address budget, data, maintenance, and drainage-capacity limitations; prepare an

	infrastructure inventory and maintenance plan.
ST	Optimize institutional capacity and community participation to strengthen preparedness, maintain access to essential facilities, and coordinate infrastructure management in facing recurring flood threats.
WT	Prioritize investment based on risk; control development in areas proven to be vulnerable using valid spatial data; improve maintenance and monitoring; and strengthen coordination to reduce infrastructure vulnerability.

The SO strategy is directed toward utilizing the area's strategic position and existing infrastructure networks to promote integrated service improvements. Infrastructure programs for roads, drainage, bridges, and public facilities need to be integrated with spatial planning documents to prevent sectoral development. The use of GIS can support asset inventory, mapping of affected areas, and identification of intervention needs.

The WO strategy emphasizes the use of government support, technical assistance, and inter-agency cooperation to address internal weaknesses. An inventory of infrastructure conditions and the preparation of a maintenance plan are initial steps to clarify budget requirements and intervention priorities. Improvements to drainage capacity also need to be based on technical inspections and channel connectivity, rather than merely repairing damaged points.

The ST strategy is directed toward strengthening institutional capacity and community participation in responding to recurring flood threats. Inter-agency coordination is required to maintain the function of critical infrastructure, ensure access to service facilities, and improve preparedness. The WT strategy emphasizes reducing vulnerability by setting risk-based investment priorities, controlling development in verified hazard-prone areas, conducting routine maintenance, and monitoring infrastructure conditions.

Infrastructure development needs to be linked to the spatial structure and spatial utilization patterns of Kota Kuala Simpang District. Drainage improvements need to consider catchment areas, flow paths, and the development of built-up areas. Road and bridge networks need to be viewed as an integrated system that maintains access to settlements, economic activity centers, and public service facilities. The location and improvement of public facilities need to consider accessibility and continuity of services during floods.

In addition to physical aspects, stronger institutional coordination, infrastructure maintenance, the use of information technology and GIS, and community participation are important elements of post-flood spatial arrangement. Infrastructure inventories can help the

government determine intervention needs and program priorities, while information from the community can explain service disruptions and infrastructure problems experienced directly.

Conclusion

Disaster mitigation-based urban infrastructure development is an important part of supporting post-flood spatial arrangement in Kota Kuala Simpang District, Aceh Tamiang Regency. The infrastructure examined includes road networks, drainage, bridges, public facilities, and other supporting urban facilities. The research is designed using a descriptive qualitative approach through observation, interviews, documentation, secondary data, purposive informant selection, triangulation, and qualitative SWOT analysis.

The initial identification indicates several issues that need further examination, namely infrastructure conditions and capacity, budget constraints, drainage capacity, the development of built-up areas, inter-agency coordination, policy support, and the use of GIS and information technology. The SO, WO, ST, and WT strategic alternatives are directed toward integrated infrastructure improvement, stronger maintenance and institutions, the use of program support, and vulnerability reduction based on risk information.

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