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Smart Solutions for Developing Safe and Comfortable Housing Against Flood Threats in Palangka Raya City

Efektivitas Pengelolaan Hibah Biro Kesra Setda Provinsi Kalimantan Tengah

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Abstract

Palangka Raya City faces increasing vulnerability to floods due to its lowland geography, extensive peatlands, and inadequate urban drainage systems. As climate change intensifies rainfall patterns and urban expansion alters natural water flows, the city's infrastructure and communities face heightened risks. This paper explores smart, integrated strategies to develop flood-resilient and comfortable housing in Palangka Raya. The approach combines adaptive spatial planning, disaster-aware building design, green infrastructure, and participatory risk reduction programs. Key solutions include geospatial flood zoning, elevated housing designs, and the use of flood-resistant construction materials. In addition, early warning systems and community education initiatives are essential to enhance preparedness. The research also highlights the role of local government policies and inter-agency coordination, referencing national regulations such as Law No. 24/2007 on Disaster Management and regional plans like the Palangka Raya Spatial Plan (RTRW). Drawing from case studies, stakeholder interviews, and flood risk data, this paper provides practical recommendations for integrating flood resilience into urban development. By aligning local policies with international frameworks like the Sendai Framework and promoting community-based actions, Palangka Raya can transition toward a safer, more sustainable urban environment. The findings emphasize that technology, policy coherence, and grassroots involvement are key to achieving long-term housing security in flood-prone areas.

INTRODUCTION

Floods are one of the most common natural disasters affecting urban areas in Indonesia, especially in lowland cities like Palangka Raya. The city lies within a basin dominated by rivers and peatland ecosystems, making it highly prone to inundation during heavy rains. When peatlands are degraded by land conversion, burning, or drainage, their natural capacity to absorb water declines significantly. As a result, water runs off more quickly, increasing flood intensity. Climate change has further aggravated the situation by intensifying rainfall variability and extreme weather events. Consequently, urban communities in Palangka Raya face repeated disruptions, from infrastructure damage to increased health and sanitation risks, particularly in vulnerable neighborhoods (BNPB, 2018; Sudiatmoko, 2017).

Human-induced factors have worsened Palangka Raya's flood vulnerability. The expansion of residential and commercial areas into wetlands and flood-prone zones has reduced natural absorption areas. Drainage systems are often inadequate in capacity and poorly maintained, frequently clogged by garbage and sediment. Development practices frequently overlook spatial flood zoning, resulting in new housing being built in areas with high water retention risks. Without smart planning and sustainable infrastructure, the city remains at high risk of seasonal flooding. A shift toward climate-adaptive development, integrating local hydrological data into decision-making, is urgently needed (Hermawan & Suryani, 2020; Marfai, 2012).

The ecological foundation of Palangka Raya rests on vast peatlands, which are highly sensitive to environmental changes. These peatlands, when intact, serve as natural sponges that moderate water flow and reduce runoff. However, once disturbed, especially through illegal logging, fires, or infrastructure development, they become compacted and hydrologically dysfunctional. Degraded peatlands contribute directly to increased flood volumes and faster inundation cycles. Their loss not only affects hydrology but also adds to carbon emissions and ecosystem degradation. The restoration of these landscapes is crucial, yet often overlooked in mainstream urban planning. Without active peatland conservation strategies, flood control will remain reactive rather than preventive (Sudiatmoko, 2017; Rustiadi et al., 2011).

Climate variability further amplifies flood hazards in Palangka Raya. The region has witnessed more frequent intense rainfall events, many of which exceed the design capacity of existing drainage systems. Urban floods are no longer a rare occurrence; they have become seasonal expectations. According to climate projections, the frequency of high-intensity rainfall will increase across Kalimantan, including inland cities such as Palangka Raya. This trend is consistent with global patterns where urban areas lacking adaptive infrastructure face increasing risks. As rainfall outpaces drainage and storage capacity, water stagnates in residential areas, damaging homes and disrupting access to education, healthcare, and mobility (UN-Habitat, 2021; World Bank, 2020).

While Palangka Raya has a spatial plan (RTRW) that outlines zoning regulations and land-use designations, its implementation often lacks the granularity and enforcement required for flood-sensitive urban design. Many floodplain areas continue to be developed without integrated flood risk assessments. The city's planning instruments are not yet fully synchronized with hydrological modeling or updated GIS data that reflect current flood patterns. This disconnect has allowed for the emergence of new settlements in high-risk areas. Strengthening planning enforcement and integrating digital tools into spatial governance are vital to reversing this trajectory. Collaborative planning with data-driven insights will ensure safer land allocation (Pemerintah Kota Palangka Raya, 2014; Bappenas, 2021).

Inadequate urban drainage is a chronic problem in Palangka Raya. Many of the city's drainage channels are narrow, shallow, and disconnected, unable to manage runoff during peak rainfall. Compounded by poor waste management, these channels often become clogged, further reducing water flow. Studies by the Ministry of Public Works (PUPR) highlight that sedimentation, illegal structures over drains, and a lack of maintenance have created systemic blockages in multiple zones. The problem is worsened in densely populated neighborhoods where household waste is frequently dumped into canals. Without consistent dredging, structural upgrades, and public awareness, the drainage system cannot support flood mitigation efforts (Ditjen Cipta Karya PUPR, 2019; Hermawan & Suryani, 2020).

National regulations such as Law No. 24/2007 on Disaster Management and Law No. 1/2011 on Housing mandate disaster-resilient planning. However, these legal frameworks are often underutilized at the municipal level. The translation of policy into practice faces gaps in coordination, funding, and enforcement. Local governments may lack technical capacity or political will to integrate flood risk mapping into housing development approvals. Meanwhile, property developers often prioritize short-term gains over long-term sustainability, exploiting regulatory loopholes. This results in poorly sited and flood-prone housing clusters that increase the city's vulnerability with each new development phase (UU No. 24/2007; UU No. 1/2011).

A shift toward resilient housing design is essential in minimizing household-level flood impacts. Elevated housing, stilt architecture, and the use of waterproof materials are proven strategies in flood-prone environments. Traditional Dayak

longhouses offer a cultural reference for such adaptive designs. Yet, modern construction in Palangka Raya rarely incorporates these principles due to cost constraints or lack of design guidelines. Local governments must adopt building codes that reflect the realities of flood exposure, including minimum elevation requirements and safe placement of electrical and sanitation systems. Incentivizing such construction through subsidies or tax relief could accelerate adoption (Hermawan & Suryani, 2020; Ditjen PUPR, 2019).

Nature-based solutions such as green infrastructure provide a complementary layer of flood defense. Urban features like rain gardens, bioswales, and permeable pavements slow down water movement and enhance infiltration. These solutions are cost-effective, environmentally friendly, and community-oriented. When integrated into neighborhood layouts, they reduce runoff while beautifying public spaces. However, implementation in Palangka Raya remains minimal due to limited awareness and institutional support. Urban planning must treat green infrastructure not as aesthetic add-ons, but as critical flood control assets. Incorporating these into new developments and retrofitting existing areas can significantly reduce peak flooding (World Bank, 2020; UN-Habitat, 2021).

Community participation is a vital component of flood resilience. In many flood-prone cities, grassroots organizations lead disaster preparedness initiatives, from early warning systems to evacuation planning. In Palangka Raya, such participation is still emerging. The Forum for Disaster Risk Reduction (FPRB) has highlighted the need to involve vulnerable groups—such as women, children, and the elderly—in planning and simulations. Public education campaigns, participatory mapping, and school-based disaster curricula can build a culture of preparedness. Engaging communities in flood monitoring and maintenance of local infrastructure not only builds ownership but also ensures rapid response and recovery when disasters strike (FPRB, 2025; UNDRR, 2015).

Schools and educational institutions have a critical role in shaping flood awareness from an early age. In Palangka Raya, however, school infrastructure and curriculum have not been fully adapted to address disaster preparedness. According to recent discussions between the City Council and school library heads, many public junior high schools still lack trained library personnel or up-to-date resources that can support disaster literacy. This gap diminishes students' exposure to essential risk knowledge. Integrating flood risk education into school programs and equipping libraries with relevant materials and simulations can prepare students to respond effectively. Long-term resilience depends not only on engineering solutions but also on informed and capable future generations (RDP Komisi III DPRD Kota Palangka Raya, 2025).

A robust early warning system is another fundamental element in urban flood resilience. Palangka Raya's current warning capabilities are fragmented and often delayed, particularly in reaching communities in low-lying or river-adjacent neighborhoods. Implementing a community-based early warning system—supported by sensors, weather forecasts, and mobile alerts—can drastically improve readiness. Successful models from other Indonesian cities show the potential of localized systems that combine technology with human networks, such as neighborhood watch groups or flood wardens. These systems work best when citizens are not just passive recipients of warnings but active participants in risk communication (UNDRR, 2015; World Bank, 2020).

Institutional coordination remains a challenge across agencies responsible for urban development, disaster response, and environmental conservation. Overlapping mandates and unclear lines of authority often lead to fragmented actions and resource inefficiencies. For instance, drainage maintenance may fall under the Department of Public Works, while solid

waste blocking those drains is managed separately. Establishing a unified flood task force or a shared data platform across agencies could bridge this gap. Cross-sector collaboration that includes local NGOs, universities, and private developers is essential to ensure continuity from planning to implementation (Bappenas, 2021; Pemerintah Kota Palangka Raya, 2014).

The integration of modern technology into urban flood management opens new possibilities for prediction, planning, and performance monitoring. Geographic Information Systems (GIS), remote sensing, and AI-based hydrological modeling enable planners to simulate flood scenarios with greater precision. These tools can inform zoning, infrastructure investment, and emergency logistics. Yet, adoption remains low due to limited technical capacity and underfunded IT systems. Municipal governments must invest in both digital infrastructure and human resources to close this gap. Collaborations with universities and technology providers could accelerate digital transformation tailored to Palangka Raya's unique needs (UN-Habitat, 2021; Rustiadi et al., 2011).

This paper is built upon the understanding that flooding in Palangka Raya is not a singular issue of water management, but a complex urban governance challenge. It spans across infrastructure design, environmental conservation, community empowerment, education, and policy enforcement. Therefore, the solutions proposed must be integrative, context-sensitive, and forward-looking. Addressing this problem requires collaboration between government agencies, civil society, academic institutions, and the residents themselves. Only through a shared commitment to resilience and smart innovation can Palangka Raya move toward a future where housing is not only livable but also secure from the persistent threat of floods.

METHOD

This study employs a qualitative descriptive research design supported by policy analysis and field-based observations. The primary objective is to explore and synthesize strategic solutions that promote flood-resilient and comfortable housing in Palangka Raya through integrative approaches involving planning, policy, infrastructure, and community participation. The research adopts a multi-source data collection strategy comprising:

1. Document Analysis: National and regional policy documents were reviewed, including Law No. 24/2007 on Disaster Management, Law No. 1/2011 on Housing and Settlement Areas, the Spatial Plan (RTRW) of Palangka Raya City, and local disaster risk reduction strategies issued by FPRB and BPBD. These documents were analyzed to understand existing frameworks and institutional gaps.
2. Literature Review: Academic journals, technical manuals, and international reports from BNPB, UN-Habitat, the World Bank, and other credible sources were systematically reviewed. The literature provided theoretical grounding and case comparisons on flood mitigation, green infrastructure, and smart urban planning.
3. Field Observation and Secondary Data: Data on flood-prone zones, drainage capacity, and land-use patterns were obtained from the Department of Public Works and BPBD of Palangka Raya. Visual evidence, including satellite imagery, topographic maps, and community reports, was triangulated to validate the spatial extent and frequency of flooding.
4. Stakeholder Input: Key insights were derived from previous hearing reports (RDP) conducted by the DPRD of Palangka Raya with school library heads and community groups, which revealed grassroots perspectives on disaster literacy, infrastructure gaps, and response capacities.

The collected data were analyzed thematically and triangulated to ensure validity. Emphasis was placed on identifying cross-cutting patterns, local innovations, and replicable models that inform the proposed smart solutions. This methodology enables a holistic understanding of urban flood resilience and helps generate policy-oriented recommendations tailored to Palangka Raya's socio-ecological context.

RESULTS AND DISCUSSION

This section presents the key findings derived from policy analysis, spatial data interpretation, field observations, and institutional documents related to flood resilience in Palangka Raya. The discussion is structured into five strategic dimensions: spatial planning, infrastructure, housing design, community preparedness, and institutional coordination.

1. Spatial Planning and Risk Mapping Integration

   Analysis of Palangka Raya's Spatial Plan (RTRW – Perda No. 1/2014) revealed that several historically flood-affected areas are still designated for residential and commercial expansion. This misalignment indicates a lack of integration between spatial planning and real-time hydrological realities.

   Table 1. Misalignment Between Zoning and Flood Risk Levels

Zoning Area	Flood Risk Status (BPBD)	Recommendation
Panarung Subdistrict	High Risk	Rezone as protected area
Bukit Tunggal Area	Medium Risk	Elevated housing required
Langkai Area	Low Risk	Maintain as per zoning designation

   Source: Analysis of RTRW documents & Flood Risk Maps by BPBD Palangka Raya (2024)

   A revision of the city's spatial plan must incorporate GIS-based microzonation using historical rainfall, elevation, and waterlogging data modeled through hydrological tools (e.g., HEC-RAS).

2. Drainage Infrastructure and Technical Gaps

   Field observation and 2023 reports from the Public Works Department show that most secondary drainage channels in central districts are clogged by sediment and household waste. In Kelurahan Pahandut and Jekan Raya, daily runoff frequently exceeds drainage capacity when rainfall exceeds 80 mm/hour.

   Illustrative Description
   A drainage canal 80 cm wide along Rajawali Street is visibly filled with 40 cm of mud and plastic waste. Residents report that flooding occurs every two weeks during the rainy season.

   Routine dredging, a comprehensive *Urban Drainage Master Plan*, and predictive maintenance using water level sensors are critical to address future extreme rainfall due to climate change.

3. Housing Design and Flood-Resilience Standards

   Most houses in flood-prone areas remain built with low foundations (<50 cm above street level), without waterproof materials or safely placed electrical systems. According to the *Technical Guidelines for Flood-Resilient Buildings* (PUPR, 2019), the standard includes:

   - Minimum elevation ≥ 1 meter above historical flood level
   - Use of water-resistant base materials (e.g., reinforced concrete with waterproof coating)

- High-positioned electrical installations (≥100 cm from floor)

Table 2. Current Housing Design vs. Recommended Standards

Design Aspect	Current Practice	Recommended Standard (PUPR, 2019)
Foundation Height	30–50 cm	≥ 100 cm above flood level
Base Material	Standard red bricks	Reinforced waterproof concrete
Socket Placement	40 cm from floor	≥ 100 cm from floor
Ventilation & Access	Low and narrow	Elevated access, flood-safe openings

Revitalizing modern stilt-house designs inspired by Dayak vernacular architecture offers a culturally aligned adaptation strategy.

4. Community Preparedness and Flood Literacy

Findings from the **July 2025 Public Hearing (RDP)** between the City Council (Komisi III DPRD) and the Working Forum of School Library Heads (MKKP) revealed that most junior high schools in Palangka Raya lack dedicated library staff and disaster education materials.

Table 3. School Readiness for Disaster Education (Sample of 10 SMPs)

School	Has Librarian	Disaster Literacy Materials	Evacuation Simulation
SMPN 1	Yes	None	Not regular
SMPN 2	No	None	None
SMPN 4	No	Available	Once a year
SMPN 6	Yes	Available	Regular

Source: Minutes from RDP Komisi III DPRD Palangka Raya, 2025

Community action remains mostly reactive (e.g., building small-scale embankments), with no centralized early warning system or neighborhood-based preparedness program. Strengthening school libraries and integrating flood education into curricula is vital for long-term capacity building.

5. Institutional Coordination and Collaborative Innovation

Flood mitigation in Palangka Raya suffers from fragmented coordination. Each agency (Public Works, BPBD, Environment, Education) operates in silos, with no shared data or command center. This results in redundant programs and delayed emergency responses. However, the city's *Forum for Disaster Risk Reduction (FPRB 2025–2028)* has created inter-agency forums that could evolve into formal coordination platforms. Institutionalizing these mechanisms and linking them to budgets, digital dashboards, and community reporting apps would enable proactive city-wide flood governance.

These findings confirm that flood resilience in Palangka Raya requires more than infrastructure improvements. It calls for adaptive urban governance, community engagement, resilient building policies, and inter-sectoral collaboration. Leveraging spatial data, local wisdom, and educational reform can create a safer, smarter, and flood-resilient housing system for future generations

CONCLUSION

Flooding in Palangka Raya is not merely a natural hazard—it is a multifaceted urban governance challenge deeply rooted in spatial planning, infrastructure inadequacies, weak policy implementation, and insufficient community preparedness. The findings of this study affirm that current urban development patterns in the city are incompatible with its hydrological realities, leading to frequent flood events, especially in low-lying and poorly drained areas. Efforts to build safe and comfortable housing in flood-prone areas must begin with the integration of flood risk assessments into spatial planning instruments such as RTRW and RDTR. These plans must be supported by accurate, real-time spatial data and enforced through zoning regulations that prioritize environmental safety. Infrastructure, particularly drainage systems, must be redesigned with increased capacity, predictive maintenance, and community-based monitoring systems.

Housing design also requires urgent reform. Mandatory elevation standards, water-resistant materials, and electrical safety features must be institutionalized through local building codes. Lessons from vernacular architecture—such as traditional stilt houses—can inform contextually relevant flood-resilient housing prototypes. Community participation and education are central to long-term resilience. Schools must serve as centers of disaster literacy, and public libraries should be equipped with resources that enhance risk awareness. Local governments, civil society, and academic institutions must collaborate to develop flood preparedness programs that engage citizens at all levels. Finally, institutional coordination must be strengthened through shared data platforms and unified command centers for flood response. By embracing smart, inclusive, and adaptive solutions, Palangka Raya can position itself as a model for flood-resilient urban development in Indonesia's peatland regions.

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