Community-Driven Flood Risk Identification Using Participatory Mapping in Nakhon Nayok Province, Thailand

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Abstract: Flooding poses significant risks to communities worldwide, necessitating innovative strategies for risk management and resilience. This study explores participatory flood risk mapping (PFRM) in Nakhon Nayok Province, Thailand, a region characterized by recurrent flood hazards. By integrating local knowledge with Geographic Information Systems (GIS), this research investigates community-driven approaches to flood risk identification and contrasting these findings with GIS-based map and traditional top-down official government map. Results highlight discrepancies between perceived and modeled risks, emphasizing the value of participatory methods in bridging gaps between scientific and local perspectives. The study underscores the importance of community involvement in developing adaptive, inclusive, and effective flood risk management strategies, ultimately fostering resilience and ownership within affected populations.

Keywords: Participatory flood risk mapping, community engagement, flood resilience, local knowledge integration, disaster risk management.

1 Introduction

Flooding is a pervasive global hazard, inflicting devastating social, economic, and environmental damage on communities worldwide. While traditional flood risk management often relies on top-down approaches, these methods frequently fall short by neglecting the invaluable insights of the communities most impacted. A growing body of research emphasizes the crucial role of integrating local knowledge and community participation in flood risk assessment and mitigation (WATKINS & COLLINS 2025, AMARAKOON et al. 2024). This participatory approach recognizes that residents possess intimate, firsthand understanding of local flood patterns, vulnerabilities, and coping mechanisms – knowledge essential for developing effective and sustainable flood risk reduction strategies. Participatory mapping has emerged as a powerful tool in this regard, empowering communities to actively engage in identifying, visualizing, and communicating risks for public (PARK et al. 2024, ARIFWIDODO & CHANDRASIRI 2024).

Thailand, a nation highly vulnerable to flooding, underscores the critical need for community-inclusive flood risk management (ARIFWIDODO et al. 2021, ARIFWIDODO & CHANDRASIRI 2023). Nakhon Nayok Province in central Thailand exemplifies this vulnerability. Its topography and the intense monsoon rains render it susceptible to both flash floods, which strike rapidly and disrupt daily life, and prolonged inundation, which submerges farmlands and displaces residents for weeks, causing significant socio-economic hardship. Historically, the province experiences peak flooding between August and October, a pattern linked to rainfall variability (HYDRO-INFORMATICS INSTITUTE (PUBLIC ORGANIZATION) 2024)). Despite the clear and present danger, the provincial government relies on outdated flood risk

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map, last updated in 2019, that were developed using a top-down approach, excluding crucial input from residents in flood-prone areas (THE OFFICE DISASTER PREVENTION AND MITIGATION NAKHON NAYOK PROVINCE 2019). This disconnects results in inaccurate flood prediction and inadequate risk management, highlighting the urgent need for a more inclusive and dynamic approach.

This study explored a community-driven approach to flood risk identification in Nakhon Nayok Province, using a method called Participatory Flood Risk Mapping (PFRM). By actively involving residents in the mapping process, we aim to capture local knowledge of flood hazards, vulnerable areas, and crucial community assets. Specifically, this study aimed to answer the following questions: (1) How do community perceptions of flood risk, gathered through participatory mapping, differ from those generated by traditional Geographic Information System (GIS) modeling? (2) To what extent do these community perceptions align or diverge from the official government flood map created in 2019? This study contributes to disaster risk management both academically and practically by emphasizing participatory mapping's value in integrating local knowledge, bridging the gap between scientific models and real-world contexts, and offering replicable frameworks for flood-prone areas. Practically, it strengthens Nakhon Nayok Province's flood risk management through inclusive community engagement, enabling policymakers to develop adaptive, equitable, and resilient flood management plans.

2 Material and Method

2.1 Participatory Flood Risk Mapping

Participatory flood risk mapping (PFRM) actively involves communities in creating flood risk maps based on their experiences (KLONER et al. 2021). PFRM empowers communities to understand, manage, and mitigate flood risks, informing decision-making on evacuation routes, shelters, and vulnerable populations. Focus group discussions facilitate stakeholder consensus in PFRM by providing a platform for sharing perspectives and negotiating solutions (SAMADAR et al. 2022). Qualitative mapping, including participatory mapping and diagramming, effectively captures local knowledge and empowers community participation in flood risk management (FACINI et al. 2023). This participatory approach fosters increased local knowledge and preparedness, enhances disaster resilience, and strengthens communication and trust between stakeholders.

2.2 Study Area

The Nakhon Nayok province was chosen for this flood risk study due to its diverse landscape, socioeconomic importance, and the recurring flash floods and inundation experienced by the Hin Tang, Sarika, and Khao Phra sub-districts. These sub-districts are home to critical water bodies and infrastructure, including the Nakhon Nayok River, Nang Rong and Sarika Waterfalls, and the Khun Dan Prakarnchon Dam, which are integral to the region's economy and ecology but also contribute to its vulnerability to flooding (HYDRO-INFORMATICS INSTITUTE 2023). Moreover, the sub-districts' role as a hub for ecotourism and agriculture makes them significant contributors to the local and national economy. However, rapid growth in tourism and land-use changes have increased the vulnerability of the natural and built environments to flooding, particularly impacting agricultural activities like rice farming, which are directly affected by water availability and flood cycles. Table 1 summarizes the specific characteristics of three sub-districts selected for the study.

Table 1: The specific characteristics of three sub-districts selected for the study

Characteristics	Sarika Sub-district	Hintang Sub-district	Khao Phra Sub-district
Population (population density)	10,96 (96.2 person/km^2)	5,752 (69.7 person/km^2)	9,296 (118.5 person/km^2)
Land use	Predominantly residential and tourism	Agricultural, residential areas and reservoir	Mixed-use: urban, reservoir, and forest
Major economic activities	Tourism, farming; with increasing shifts towards residential and tourism-related developments	Tourism, services; significant growth in residential and hospitality infrastructure and tourism-related developments	Farming (rice, fruits), small-scale trade; experiencing gradual conversion of agricultural areas into residential zones
Types of Floods Experienced in the Last 5 Years	Flash floods and annual inundation consistently affect all three subdistricts, primarily driven by heavy monsoon rains and rapid runoff from surrounding mountainous areas. These similarities highlight shared vulnerabilities in flood management and the critical need for coordinated strategies.		
Severity of Floods in the Last 5 Years	Moderately severe, causing widespread property damage and disruptions especially to tourist attraction sites	Moderately severe mostly localized to residential and other specific areas	Moderately severe mostly localized to residential areas with significant agricultural impacts

Source: THE OFFICE DISASTER PREVENTION AND MITIGATION NAKHON NAYOK PROVINCE 2019, LAND DEVELOPMENT NAKHON NAYOK 2019, NAKHON NAYOK PROVINCIAL AGRICULTURE AND COOPERATIVES 2022, THE BUREAU OF REGISTRATION ADMINISTRATION 2023

2.3 Study Design

Phase one developed a GIS-based flood risk map using secondary topographic, hydrological, meteorological, land-use, and socio-economic data, combined with existing hazard maps and river/precipitation data. GIS techniques created hazard, exposure, and vulnerability layers, producing a geospatial risk map. Phase two used this baseline map for participatory flood risk mapping with community stakeholders. Phase three compared PFRM and GIS-based map with the 2019 official government flood risk map (THE OFFICE DISASTER PREVENTION AND MITIGATION NAKHON NAYOK PROVINCE 2019) using QGIS overlay analysis. Community workshop insights contextualized differences, validated through follow-up workshops. The study was approved by Kasetsart University's Institutional Review Board (COE65/129), adhering to Helsinki Declaration guidelines.

2.4 GIS Model of Flood Risk Map

The first phase of the study involved the development of a GIS-based flood risk map, integrating a wide range of secondary data. Data used for the GIS-based flood risk model include: land use data (U.S. Department of the Interior, 2022), Elevation – SRTM DEM 30 meter (U.S. Department of the Interior, 2019), Rainfall (Meteorological Station, Meteorological Department and Hydrological Center, 2020-2021), Slope (U.S. Department of the Interior, 2019), Soil texture (Land Development Department), Recurring flood areas, (Geo-Informatics and Space Technology Development Agency, 2015-2021), Geological structure (Department of Mineral Resources, 2021), Waterways and rivers (Land Development Department).

The study identified and scored eight flood risk factors on a scale of 1 (lowest risk) to 5 (highest risk). Weighted importance scores were derived from previous study (WANG et al. 2023). These indicators were then combined using the Simple Additive Weighting (SAW) method in a GIS model, with each indicator assigned a weight based on its importance in contributing to flood risk.

$$A_i = \sum W_i X_{ij}$$

where A_i is the aggregated flood risk score for spatial unit W_i is the weight assigned to indicator j, X_{ij} is the normalized value of indicator j for unit i. The calculated flood risk scores were then classified into five categories (Very Low, Low, Moderate, High, Very High) and visually represented on a GIS-generated map to provide a clear and actionable representation of spatial flood risk, following previous study in Nakhon Nayok (SEEJATA et al. 2018).

2.5 Data Collection for PFRM

The second phase of the study was the conduction of the PRFM. Data collection for PFRM was carried out through participatory workshops where participants identified perceived flood-prone areas using techniques such as sketch mapping on printed or digital base map. the number of stakeholders involved in the PFRM process varied across different sub-districts. In Sarika Sub-district, a total of 22 stakeholders participated, consisting of 8 local government representatives, 5 NGO and technical experts, and 9 community leaders and residents. In Hiutang Sub-district, the highest number of stakeholders was involved, totaling 35 participants, with 14 from local government, 11 from NGOs and technical experts, and 10 community leaders and residents. Meanwhile, Khao Phra Sub-district had 30 stakeholders, with 13 from local government, 6 from NGOs and technical experts, and 11 from community leaders and residents. During these workshops, qualitative data on past flood experiences, causes, and vulnerabilities were recorded. Open-ended questions elicited local knowledge regarding flood causes and characteristics. Annotated maps were consolidated and discrepancies resolved through consensus-building. Priorities were established through voting or discussion. Qualitative data, including historical accounts, perceived causes, and vulnerability patterns, were documented throughout the process.

2.6 Data Analysis

Data analysis integrated PFRM with GIS-based map and official government flood risk map. QGIS software (QGIS version 3.34) facilitated overlay analysis, identifying convergence and discrepancy zones between maps. Zonal analysis measured overlaps and mismatches. Qualitative analysis examined discrepancies by reviewing PFRM narratives and spatial annotations, evaluating GIS model inputs and assumptions, and assessing government map currency and detail. Validation and triangulation ensured reliability. We conducted field visits with stakeholders to all the hotspots areas identified in PFRM in all three sub-districts to validate the data and addressed discrepancies. Data triangulation cross-referenced findings with historical records, meteorological data, and infrastructure reports.

3 Result

3.1 GIS-based Flood Risk Map

The GIS-based map revealed a distinct spatial distribution of flood risk as summarized in figure 1. High-risk zones, shown in red, were concentrated in urban areas, where impervious surfaces increase runoff and reduce natural infiltration. In contrast, low-risk zones, marked in green, were primarily located in rural areas, which act as natural buffers by enhancing infiltration and reducing runoff. The map identified specific hotspots with overlapping risk factors, resulting in significantly elevated flood risk. Urban areas near water bodies or with inadequate drainage systems were notably high-risk due to their susceptibility to waterlogging and flooding. These findings highlight the spatial variability of flood risk, shaped by the interplay of topography, land use, and proximity to water sources. Figure 1 illustrates the identified flood risk areas.

3.2 Comparing PFRM and GIS-based Flood Risk Map

The PFRM process involved two sessions: (1) documenting residents' perceived flood risks and (2) comparing them with a GIS-based map and official flood risk map. This identified flash flood and inundation hotspots, supplemented by local narratives detailing socio-economic impacts. Participants marked hotspots on base maps, delineated with 1-km buffer zones. Flash flood hotspots were located in low-lying urban areas and near steep slopes, while inundation hotspots were mainly in agricultural and peri-urban areas. Community members emphasized how floods disrupt daily life, notably affecting housing, agriculture, and tourism. Residents recounted specific flood events and their impacts, including inundated homes, damaged crops, and economic hardship.

Comparing PFRM and GIS-based map revealed similarities and differences. PFRM participants perceived higher flood risks in some areas, influenced by flooding frequency and localized impacts. PFRM also highlighted flash floods as more severe, often overlapping with high-risk zones. These areas, with steep slopes and urban development, contribute to rapid water accumulation. GIS-based map categorized these with lower risk, focusing on hydrological factors. Urbanized areas were perceived as having higher severity and frequency of flood risks in the PFRM compared to GIS-based map due to poor drainage and amplified impacts on infrastructure and livelihoods.

3.3 Comparing PFRM and the Official Flood Risk Map

Figure 3 illustrates the overlay of PFRM with GIS-based map and the official flood risk map, revealing notable differences in approach and outcomes. While official map primarily used hydrological models to forecast broad flood areas, PFRM emphasizes localized hotspots, integrating community-reported risks and historical flood experiences. This participatory approach highlights several discrepancies. First, PFRM identifies specific flash flood and inundation hotspots that may not align with the generalized predictions of official map. For instance, community feedback often pinpoints urban and residential zones with poor drainage, which conventional models may overlook.

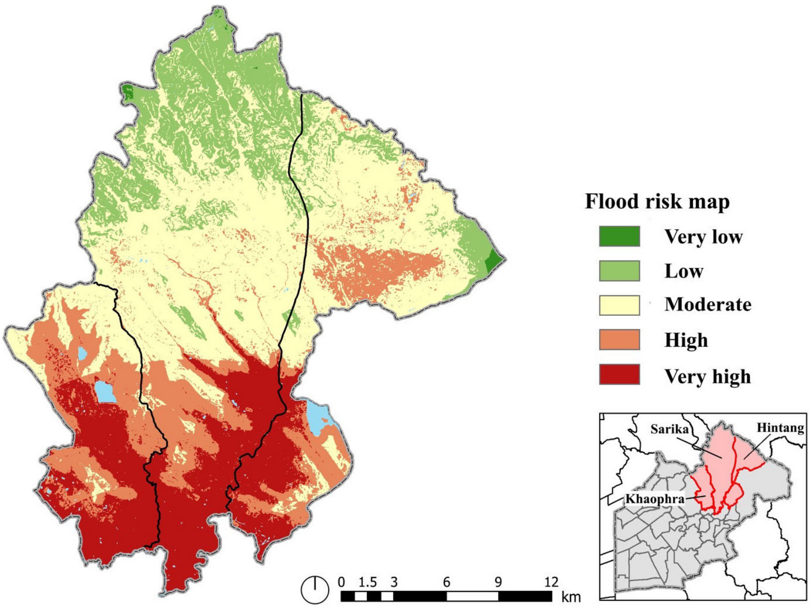

Fig. 1: GIS-based flood risk map

Second, community inputs frequently challenge official "low-risk" or "safe" zone designations. Areas deemed safe by models may still be flagged by residents due to recurrent minor flooding or inadequate infrastructure. While official maps prioritizde broader infrastructure risks, PFRM accounted for vulnerabilities of smaller-scale infrastructure, such as compromised culverts, erosion near pathways, or overflow from under-maintained drains, based on local observations.

4 Discussion

This study integrated explored the role of Participatory Flood Risk Mapping (PFRM) to assess spatial variability and discrepancies between community perceptions, and comparing it with GIS-based map and official flood map. The findings revealed that high-risk urban zones are primarily influenced by impervious surfaces, reduced infiltration, and inadequate drainage systems, aligning with previous research on urbanization's impact on flood risk (KAICAN et al. 2024, ARIFWIDODO 2014).

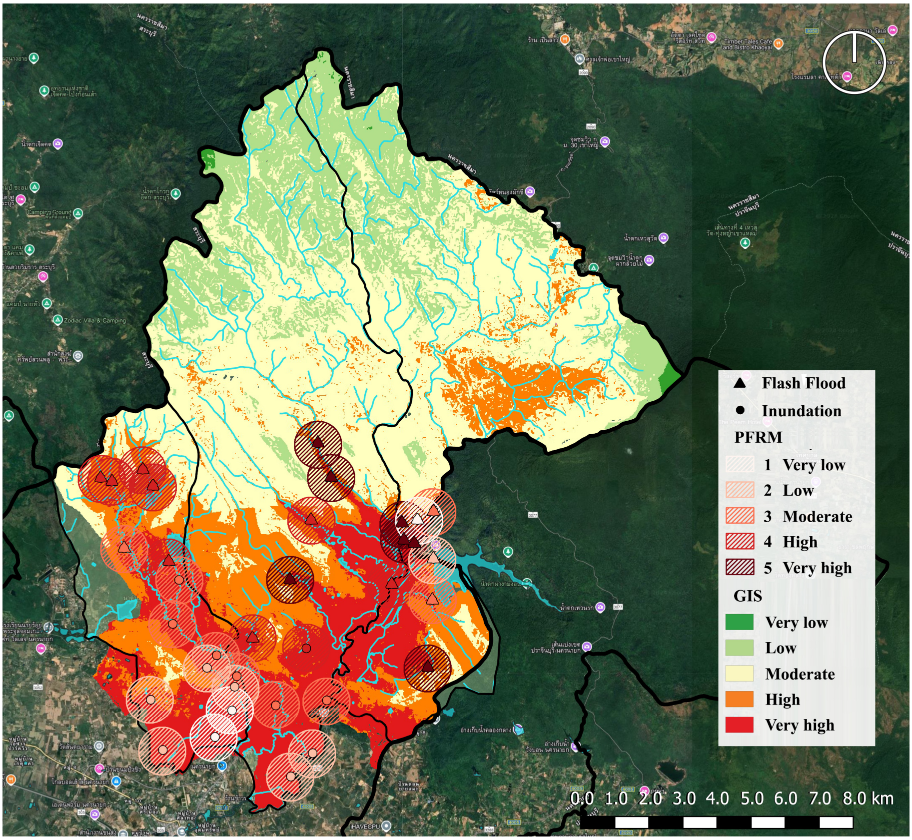

Fig. 2: Overlay from PFRM and the GIS-based flood risk map

While GIS-based maps effectively identified physical and environmental risk factors, they often overlook localized vulnerabilities and socio-economic impacts. PFRM highlights these risks, such as recent land-use changes, informal settlements, and infrastructural deficiencies (ABDUL-SALAM et al. 2024, ARIFWIDODO et al. 2022). A key discrepancy occurred in perceived flood severity: communities often identify areas with recurrent flooding and infrastructure deficiencies as high-risk, even when GIS-based map rated them lower, suggesting GIS models may not reflect localized dynamic changes in land use and drainage. PFRM also emphasized the socio-economic consequences of flooding, often omitted from GIS-based models. Comprehensive flood risk assessment requires integrating both scientific modelling and community-driven data.

Comparison with the official flood risk map reveals another contrast. While the official maps identified broad flood-prone areas, PFRM provided more granular insights into localized hotspots. The official map, last updated in 2019, may no longer reflect current realities, especially given urban expansion and climate variability. The community-driven approach revealed flash flood risks in newly developed areas, absent from older government maps, highlighting the need for more frequent updates and participatory methodologies in official assessments.

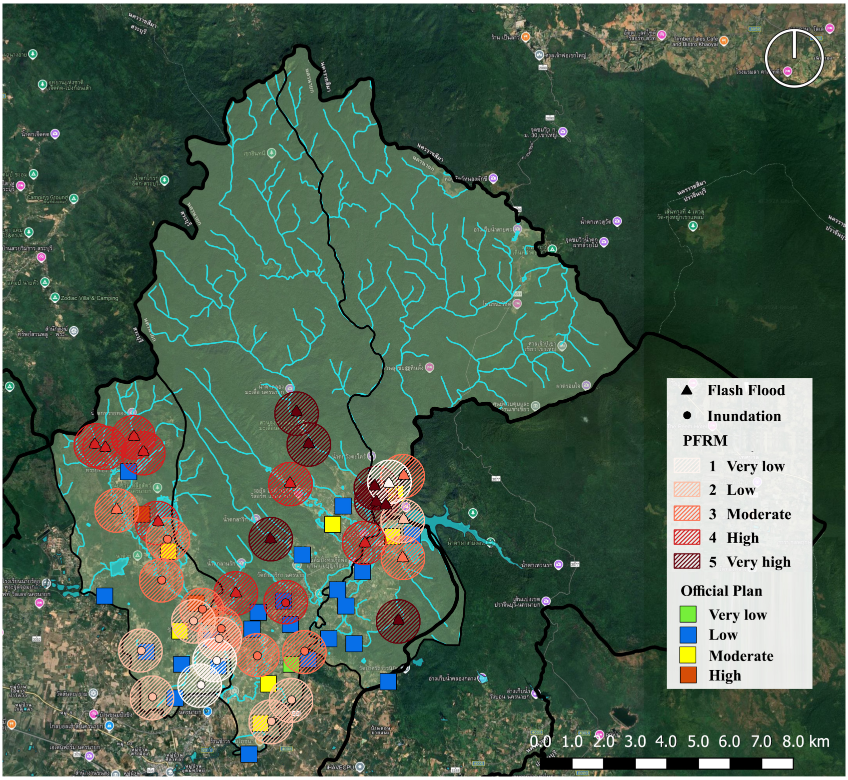

Fig. 3: Overlay of PFRM and official flood risk map

Despite its advantages, PFRM has limitations. Community perceptions can be subjective, and participatory map accuracy depends on participant memory. Similarly, GIS-based map relied on potentially outdated or insufficiently detailed secondary data. A hybrid approach, where participatory findings inform and validate GIS-based map, can enhance flood risk assessment accuracy and relevance. Engaging communities in the mapping process fosters local ownership of disaster risk management and enhances preparedness. Participatory insights provide policymakers with valuable qualitative data, aiding in targeted mitigation strategy design. Future research should refine the integration of GIS and PFRM, incorporating real-time data collection and fostering collaboration between communities and government agencies.

5 Conclusion

This study conducted PFRM to compare community perceptions with GIS-based map and official flood risk map. Participatory mapping revealed discrepancies, underscoring the value of community perspectives. Integrating these approaches highlighted the importance of local knowledge in identifying overlooked vulnerabilities. While acknowledging challenges like data quality, the study recommends enhancing data accuracy, community engagement, and multidisciplinary methods. Integrating scientific and community knowledge offers a sustainable pathway to flood risk management, strengthening models and building stakeholder trust for inclusive resilience strategies. These principles can enhance preparedness and mitigation in Nakhon Nayok and other flood-prone areas.

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