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GIS-based overlay analysis of flood hazard and settlement exposure in Bandar Lampung City

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ABSTRACT

Flooding is one of the most frequent hydrometeorological disasters in Indonesia, with increasing intensity due to climate change, rapid urbanization, and inadequate drainage systems. Bandar Lampung City has experienced a significant rise in flood events, affecting thousands of households and expanding into densely populated residential areas. This study aims to analyze the spatial distribution of flood hazards and their relationship with settlement areas using a Geographic Information System (GIS)-based overlay method. Flood hazard data were obtained from InaRISK (2025), while settlement data were derived from Ina-Geoportal (2022). The overlay analysis was combined with a scoring method to classify hazard levels into low, medium, and high categories. The results indicate that flood-prone areas cover 3,225.69 ha, dominated by the medium hazard class. Settlement areas affected by flood hazards reach 1,539.14 ha, with the majority falling into the medium hazard category. Subdistricts such as Sukarame, Tanjung Senang, and Kedamaian show the highest exposure of settlements to flood hazards. These findings highlight that urban development patterns and land-use changes significantly influence flood vulnerability. Therefore, integrating flood risk considerations into spatial planning and improving drainage systems are essential to reduce potential impacts and support sustainable urban development.

Keywords: flood; hazard; settlement area; climate change.

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1. INTRODUCTION

Floods are one of the most frequent hydrometeorological disasters in Indonesia (Heo et al., 2024). This phenomenon is closely related to the impacts of global climate change, which has increased the intensity and frequency of extreme rainfall events (Müller et al., 2024; Lameche et al., 2026). In addition to climatic influences, technical factors such as inadequate drainage capacity and poor urban water management systems also contribute significantly to the occurrence of urban flooding (Maghsood et al., 2019; D'Ambrosio et al., 2023). These conditions indicate that flooding is not solely driven by natural processes, but also by infrastructure limitations and unsustainable urban development patterns. Previous studies in Bandar Lampung have primarily focused on identifying flood-causing factors, flood prediction models, and flood susceptibility mapping using statistical, machine learning, or GIS approaches (Ramadhani et al., 2023). Other studies have emphasized rainfall as the dominant factor influencing flood occurrence and explored flood forecasting through ARIMA, Random Forest, and XGBoost methods (Suaif and Rahayu, 2025). However, these studies have not specifically examined the spatial relationship between flood hazard zones and settlement distribution at the Subdistrict level using integrated national geospatial datasets. Therefore, this study addresses this gap by combining InaRISK 2025 flood hazard data with Ina-Geoportal 2022 settlement data through a GIS-based overlay analysis to identify settlement exposure to flood hazards in Bandar Lampung City.

Bandar Lampung City is one of the urban areas in Indonesia that has experienced an increase in flooding in recent years. Flood data shows an increasing trend in flood frequency and intensity, particularly during the rainy season with high rainfall and long duration. According to BNPB (2025) data, 21 floods were recorded in Bandar Lampung City, inundating more than 3,600 homes. This phenomenon indicates that flooding has become a serious threat with widespread impacts, including economic losses, infrastructure damage, and public safety. Furthermore, flooding is no longer limited to low-lying areas but has expanded into densely populated residential areas as a result of changes in land use and suboptimal drainage systems (Priyadi et al., 2020).

Geographically, Bandar Lampung City has complex characteristics, characterized by hilly topography interacting with lowlands and the presence of several rivers flowing into Lampung Bay. These conditions make the area highly vulnerable to inundation and uncontrolled surface runoff, especially during heavy rainfall. Furthermore, rapid urban development has driven land conversion from open areas to built-up areas, reducing soil infiltration capacity (Zhong et al., 2025). High population growth also increases the demand for residential land, which in many cases is developed without considering disaster vulnerability (Laidlaw and Percival, 2024; Irham et al., 2025). Furthermore, urban drainage systems that are not optimally integrated with the main river network exacerbate flooding because rainwater cannot be effectively channeled to receiving water bodies.

Based on these conditions, a spatial analysis approach is needed that can identify the level of flood hazard and its relationship to settlement distribution. One method that can be used is a Geographic Information System (GIS)-based overlay analysis, which allows for the overlay of flood hazard maps and settlement maps, allowing for more accurate identification of settlement exposure to flood risk. The novelty of this study lies in the integration of InaRISK 2025 flood hazard data and Ina-Geoportal 2022 settlement data to analyze settlement exposure spatially at the Subdistrict level in Bandar Lampung City. The results of this analysis are expected to provide a more detailed understanding of flood-prone settlement areas and serve as a basis for adaptive and sustainable spatial planning, as well as supporting disaster mitigation efforts in Bandar Lampung City.

2. METHODOLOGY

This research employed spatial analysis methods using Geographic Information Systems (GIS) to examine the spatial relationship between flood hazard areas and settlement distribution. Spatial analysis is an approach utilized in GIS data processing that focuses on the assessment and analysis of data based on spatial aspects, including location, distribution, and relationships between objects within a space.

Therefore, spatial analysis not only views data as numbers or attributes but also considers geographic location as a key component in understanding a phenomenon. All methods related to spatial data are applied through spatial analysis functions (Sadahiro, 2006). In this study, spatial processing and analysis were conducted using GIS software within a unified coordinate system to ensure consistency between datasets. The spatial datasets were first clipped to the administrative boundary of the study area and then reclassified into comparable categories before the overlay process was carried out.

In general, spatial analysis encompasses various methods aimed at identifying, measuring, and visualizing patterns of phenomena occurring within a geographic space, enabling a more comprehensive understanding of these phenomena. Through this process, researchers can identify distribution patterns, the degree of interrelationship between variables, and even trends in changes in a phenomenon within a specific region. Furthermore, spatial analysis also allows for the integration of various different data sources, both raster and vector, resulting in richer and more in-depth information. This process aims to generate new information that can be used as a basis for decision-making in the field being researched, particularly in the context of regional planning and disaster mitigation. In order to maintain methodological consistency, all spatial layers were standardized in terms of projection, spatial extent, and attribute classification prior to analysis.

One technique commonly used in spatial analysis is the overlay method, which is the process of combining several layers of different spatial data to examine the relationships between variables within a single coordinate system (Wang et al., 2015). This technique allows researchers to identify areas with overlapping characteristics, for example, between disaster-prone areas and built-up areas. In this study, flood hazard data were obtained from BNPB's InaRISK 2025 dataset, while settlement distribution data were derived from the Ina-Geoportal 2022 dataset. Although the datasets originate from different years, they remain comparable because both datasets represent official baseline spatial information that reflects relatively stable physical conditions and regional development patterns within the study area. Moreover, no significant changes in settlement expansion or flood hazard zoning were identified during the period, allowing both datasets to be integrated for spatial analysis purposes.

Through the overlay method, these two datasets were combined using an intersect overlay procedure to examine the relationship between flood hazard levels and settlement distribution, resulting in a more comprehensive analysis. The overlay results indicate settlement areas located within specific flood hazard classes, allowing for the identification of areas with high vulnerability. This information is crucial for disaster mitigation efforts, spatial planning, and the formulation of more risk-adaptive development policies. To improve data reliability, the overlay outputs were visually checked and compared with existing spatial conditions in the study area.

To interpret the overlay results, a scoring method was applied as a quantitative measure to assess or weight each criterion or variable analyzed. This method involved assigning specific values to each variable class, such as flood hazard level and settlement density. Flood hazard classes were categorized into low, medium, and high levels based on the classification provided in the InaRISK dataset, while settlement exposure was measured according to the extent of settlement areas intersecting each hazard zone. Each spatial element was assigned a score and subsequently classified into low, medium, and high categories to simplify interpretation and analysis. Furthermore, the scoring method allowed for weighting that reflects the level of influence of each variable on the final result, thereby producing a more objective, systematic, and transparent spatial analysis.

3. RESULT AND DISCUSSION

3.1. Flood Hazard Distribution Bandar Lampung City

The analysis results show that the total area affected by flood hazards reaches 3,225.69 ha, with a dominance of the medium hazard class of 1,392.04 ha, followed by the high class of 930.68 ha and the low class of 902.97 ha (Table 1) as shown in Figure 1. This composition indicates that most areas have a significant level of flood vulnerability (medium-high class), thus requiring attention in mitigation planning. Spatially, the distribution of flood hazards shows variation between Subdistricts. Sukarame Subdistrict has the largest high flood hazard area (400.98 ha), followed by Tanjung Senang (225.63 ha) and Rajabasa (96.91 ha). Meanwhile, for the medium class, the areas with the largest areas are in Tanjung Senang (234.67 ha), Rajabasa (231.58 ha), and Sukarame (223.35 ha). In the low-hazard category, Sukarame also dominates with an area of 201.08 ha, followed by Tanjung Senang (135.55 ha) and Rajabasa (105.47 ha) (Table 2). On the other hand, several Subdistricts, such as Enggal, Langkapura, and Tanjung Karang Barat, show very low to zero flood hazard areas, indicating relatively safe conditions or possible data limitations.

Table 1. Flood Hazard Classification of Bandar Lampung City

Flood Hazard Classification	Area (Ha)
Low	902,97
Medium	1392,04
High	930,68
Grand Total	**3225,69**

Source: Analysis, 2026

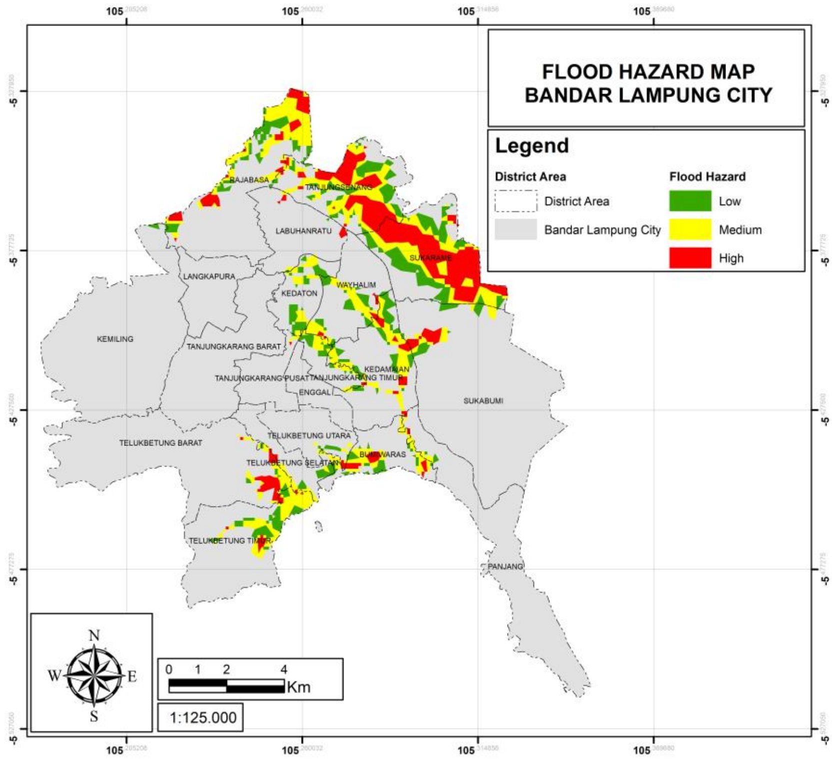

Figure 1. Flood Hazard Classification Map of Bandar Lampung City
Source: Analysis, 2026

Further discussion indicates that the high potential for flooding in Subdistricts such as Sukarame, Tanjung Senang, and Rajabasa can be attributed to their intensive land use characteristics, high levels of urbanization, and possible limitations in drainage systems. Furthermore, these areas tend to be located in low-lying areas or are close to rivers, increasing their vulnerability to inundation. The dominance of the moderate hazard category indicates that most areas are in a transitional state between safe and vulnerable, making interventions such as increasing drainage capacity, controlling land use, and implementing nature-based solutions essential. Meanwhile, areas with low hazard can be prioritized for development while still adhering to risk mitigation principles.

Furthermore, these areas tend to be located in low-lying areas or are close to rivers, increasing their vulnerability to inundation. The combination of topographic conditions and limited drainage capacity can worsen flood impacts, especially when rainfall intensity exceeds the ability of drainage systems to discharge water efficiently. In some urban areas, drainage problems may also be influenced by sedimentation, waste accumulation, poor maintenance, and the mismatch between drainage design and current urban growth. This shows that flooding is not only caused by natural factors but also by human activities and weak spatial planning control.

The dominance of the moderate hazard category indicates that most areas are in a transitional state between safe and vulnerable, making interventions such as increasing drainage capacity, controlling land use, and implementing nature-based solutions essential. Moderate hazard areas should not be interpreted as areas with minimal risk, because they may become high-risk zones if urban expansion continues without proper mitigation measures. Therefore, preventive action is needed before hazard levels increase. Improving drainage networks, restoring river buffers, increasing retention ponds, and expanding urban green spaces can help reduce runoff and improve water absorption. Nature-based solutions, such as rain gardens, infiltration wells, permeable pavements, and urban wetlands, can also support more sustainable flood management.

Meanwhile, areas with low hazard can be prioritized for development while still adhering to risk mitigation principles. Development in these areas should still consider environmental carrying capacity, drainage planning, and land-use regulations to prevent the creation of new flood-prone zones in the future. Thus, these results emphasize the need for an integrated flood risk-based planning approach across Subdistricts to reduce potential future losses. This approach should combine spatial planning, infrastructure improvement, environmental conservation, and community participation. Local governments need to use hazard maps as a basis for determining development priorities, controlling land conversion, and preparing disaster mitigation strategies. By integrating flood risk considerations into urban planning, Bandar Lampung can reduce vulnerability, protect communities, and support more resilient urban growth.

Table 2. Flood Hazard Classification of Bandar Lampung City Based on District

Subdistrict	Flood Hazard Classification (Ha)		
	Low	Medium	High
Bumi Waras	37,80	82,04	32,80
Enggal	0,02	0,00	0,00
Kedamaian	92,44	129,84	34,29
Kedaton	60,00	53,30	0,00
Kemiling	5,28	0,00	0,00
Labuhan Ratu	1,54	5,86	10,25
Langkapura	0,00	0,00	0,00
Panjang	5,29	18,01	1,72
Rajabasa	105,47	231,58	96,91
Sukabumi	40,71	43,02	37,43
Sukarame	201,08	223,35	400,98
Tanjung Karang Barat	0,00	0,00	0,00
Tanjung Karang Pusat	1,15	4,71	0,64
Tanjung Karang Timur	34,90	41,62	1,47
Tanjung Senang	135,55	234,67	225,63
Teluk Betung Barat	10,02	50,73	50,82
Teluk Betung Selatan	24,51	34,57	3,76
Teluk Betung Timur	76,90	138,52	15,70
Teluk Betung Utara	9,68	10,29	3,79
Wayhalim	54,70	82,61	8,78
Grand Total	**897,04**	**1384,72**	**924,97**

Source: Analysis, 2026

3.2. Settlement Area Distribution Bandar Lampung City

The analysis shows that the total settlement area in the study area reaches 7,200.42 ha, with uneven distribution across Subdistricts (Table 3) shown in Figure 2. The Subdistrict with the largest settlement area is Rajabasa (597.84 ha), followed by Sukarame (550.96 ha), and Kemiling (523.62 ha), reflecting the high intensity of built-up development in these areas. Furthermore, Sukabumi (494.53 ha), Wayhalim (466.17 ha), and Kedamaian (461.41 ha) also have significant settlement areas, indicating a pattern of settlement concentration spread across several growth centers. Conversely, Subdistricts with relatively small settlement areas include West Teluk Betung (169.42 ha), East Teluk Betung (172.69 ha), and East Tanjung Karang (177.88 ha), indicating a more limited level of land use for settlements.

Table 3. Settlement Distribution of Bandar Lampung City

Subdistrict	Settlement Area (Ha)
Bumi Waras	275,01
Enggal	258,75
Kedamaian	461,41
Kedaton	316,3
Kemiling	523,62
Labuhan Ratu	433,97
Langkapura	314,31
Panjang	384,57
Rajabasa	597,84
Sukabumi	494,53
Sukarame	550,96
Tanjung Karang Barat	400,89
Tanjung Karang Pusat	264,82
Tanjung Karang Timur	177,88
Tanjung Senang	405,05
Teluk Betung Barat	169,42
Teluk Betung Selatan	191,39
Teluk Betung Timur	172,69
Teluk Betung Utara	340,84
Wayhalim	466,17
Grand Total	7200,42

Source: Analysis, 2026

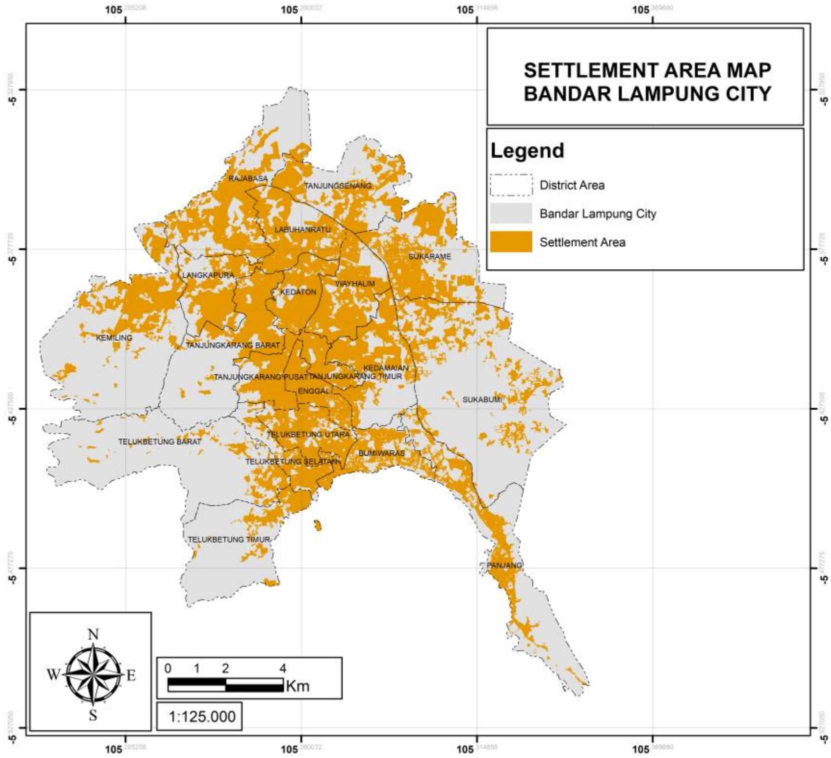

Figure 2. Settlement Distribution Map of Bandar Lampung City

Source: Analysis, 2026

Further discussion shows that variations in settlement area are influenced by several factors, such as land availability, accessibility, and infrastructure development and economic activity centers. Subdistricts with large settlement areas generally develop as primary residential areas supported by adequate road networks and urban facilities, thus attracting population growth and housing development. Meanwhile, subdistricts with smaller settlement areas tend to have limitations in terms of accessibility, the physical condition of the area, or land use that is dominated by non-residential functions. This distribution pattern illustrates the tendency for simultaneous concentration and dispersal of settlements, which is an important basis for understanding the dynamics of urban development and in formulating more targeted and sustainable spatial management policies.

Subdistricts with smaller settlement areas tend to have certain limitations, including lower accessibility, unfavorable physical conditions, or land use patterns dominated by non-residential functions. Some areas may be characterized by steep slopes, limited road access, conservation zones, agricultural land, industrial areas, or public facility zones, which restrict the expansion of residential land. In addition, land ownership patterns and spatial planning regulations may also influence the extent to which settlement areas can grow. Therefore, differences in settlement size between subdistricts cannot be understood only as a matter of population demand, but also as the result of interactions between physical, social, economic, and policy-related factors.

This distribution pattern illustrates the tendency for both concentration and dispersal of settlements within the urban area. Concentration occurs when residential development is clustered in areas with strong accessibility and complete infrastructure, while dispersal occurs when settlements spread toward peripheral areas due to land scarcity, rising land prices, or pressure from urban expansion. Such patterns are common in growing cities, where central areas become increasingly dense and new residential growth gradually shifts to surrounding subdistricts. However, if this process is not properly managed, it may create problems such as urban sprawl, traffic congestion, uneven infrastructure provision, and pressure on environmentally sensitive areas.

Understanding the spatial distribution of settlement areas is important as a basis for sustainable urban planning. Areas with high settlement concentration require better infrastructure management, improved drainage systems, adequate public services, and green open spaces to maintain livability. Meanwhile, areas with lower settlement intensity need careful planning to ensure that future development does not exceed environmental carrying capacity. Spatial management policies should direct residential growth toward suitable areas while protecting zones that have ecological, agricultural, or disaster-risk significance. Thus, the analysis of settlement distribution can support more targeted land-use planning, balanced urban development, and the creation of a more organized, inclusive, and sustainable urban environment.

3.3. Flood Hazard Distribution on Settlement Area

The analysis results indicate that the total residential area affected by flood hazards in Bandar Lampung reached 1,539.14 ha (Table 4), consisting of 597.83 ha in the low hazard class, 687.16 ha in the medium hazard class, and 254.15 ha in the high hazard class. The dominance of the medium hazard class suggests that a large proportion of urban settlements are exposed to recurring flood risks with moderate intensity, reflecting the growing interaction between urban expansion and environmentally sensitive areas. Spatially, Sukarame Subdistrict recorded the largest affected settlement area of 349.65 ha, followed by Tanjung Senang (216.29 ha) and Kedamaian (169.28 ha). Other subdistricts such as Teluk Betung Timur (125.64 ha), Wayhalim (105.67 ha), and Kedaton (101.26 ha) also showed relatively extensive exposure, whereas Enggal (0.02 ha), Kemiling (2.15 ha), and Panjang (5.98 ha) experienced comparatively limited impacts, as presented in Figure 3**:**

Table 4. Flood Hazard Distribution On Settlement Area

Subdistrict	Flood Hazard Classification (Ha)			Flood Hazard Distribution in Settlement Area (Ha)
	Low	Medium	High	
Bumi Waras	25,37	51,09	23,21	99,67
Enggal	0,02	0,00	0,00	0,02
Kedamaian	78,76	78,35	12,17	169,28
Kedaton	55,26	46,00	0,00	101,26
Kemiling	2,15	0,00	0,00	2,15
Labuhan Ratu	0,80	5,01	7,77	13,58
Panjang	3,27	2,41	0,30	5,98
Rajabasa	35,96	27,96	20,13	84,05
Sukabumi	22,68	16,77	18,96	58,40
Sukarame	150,97	119,94	78,75	349,65
Tanjung Karang Pusat	1,15	4,71	0,64	6,50
Tanjung Karang Timur	31,05	34,10	0,36	65,51
Tanjung Senang	63,74	105,71	46,84	216,29
Teluk Betung Barat	8,28	29,34	29,39	67,01
Teluk Betung Selatan	22,27	23,28	1,38	46,93
Teluk Betung Timur	40,19	78,65	6,80	125,64
Teluk Betung Utara	9,38	8,44	3,71	21,54
Wayhalim	46,53	55,41	3,73	105,67
Grand Total	**597,83**	**687,16**	**254,15**	**1539,14**

Source: Analysis, 2026

The high exposure observed in Sukarame, Tanjung Senang, and Kedamaian is strongly associated with rapid land-use conversion and urban growth in the eastern and central parts of Bandar Lampung. These areas have experienced significant expansion of residential development over the last decade, resulting in the reduction of open spaces and natural infiltration areas that previously functioned as surface runoff buffers. In Sukarame, the dominance of flood-prone settlements across all hazard classes indicates that urban expansion has increasingly occupied low-lying and poorly drained areas. Similar conditions are found in Tanjung Senang and Kedamaian, where dense settlement patterns combined with limited drainage capacity contribute to higher flood exposure, particularly during periods of intense rainfall. In addition, the proximity of several residential clusters to river channels and secondary drainage networks increases the likelihood of inundation when runoff exceeds channel capacity.

In Sukarame, the dominance of flood-prone settlements across all hazard classes indicates that urban expansion has increasingly occupied low-lying and poorly drained areas. The growth of housing areas, commercial activities, and road networks has intensified land cover changes, making this subdistrict more vulnerable to flooding. Settlement development in areas with limited elevation and weak drainage performance can increase the duration and depth of inundation during heavy rainfall. This shows that exposure is not only determined by the presence of flood hazards but also by the concentration of people, buildings, and assets in vulnerable locations.

Similar conditions are found in Tanjung Senang and Kedamaian, where dense settlement patterns combined with limited drainage capacity contribute to higher flood exposure, particularly during periods of intense rainfall. In these areas, drainage channels may not be sufficient to accommodate increasing runoff from expanding impervious surfaces. Problems such as sedimentation, waste accumulation, and irregular building patterns can further reduce drainage efficiency. When drainage systems are blocked or undersized, rainwater accumulates rapidly and causes localized flooding in residential neighborhoods.

In addition, the proximity of several residential clusters to river channels and secondary drainage networks increases the likelihood of inundation when runoff exceeds channel capacity. Settlements located along riverbanks or near drainage corridors are especially exposed because they receive direct overflow when water levels rise. This condition highlights the importance of controlling residential development in flood-prone zones and maintaining buffer areas along rivers and drainage channels.

Therefore, flood exposure in Sukarame, Tanjung Senang, and Kedamaian reflects the interaction between physical vulnerability, rapid urbanization, and inadequate spatial control. To reduce future exposure, urban planning should prioritize stricter land-use regulation, drainage system upgrading, preservation of green open spaces, and community-based flood preparedness. Risk-sensitive settlement planning is also needed to ensure that future housing development does not continue to expand into areas with high flood potential.

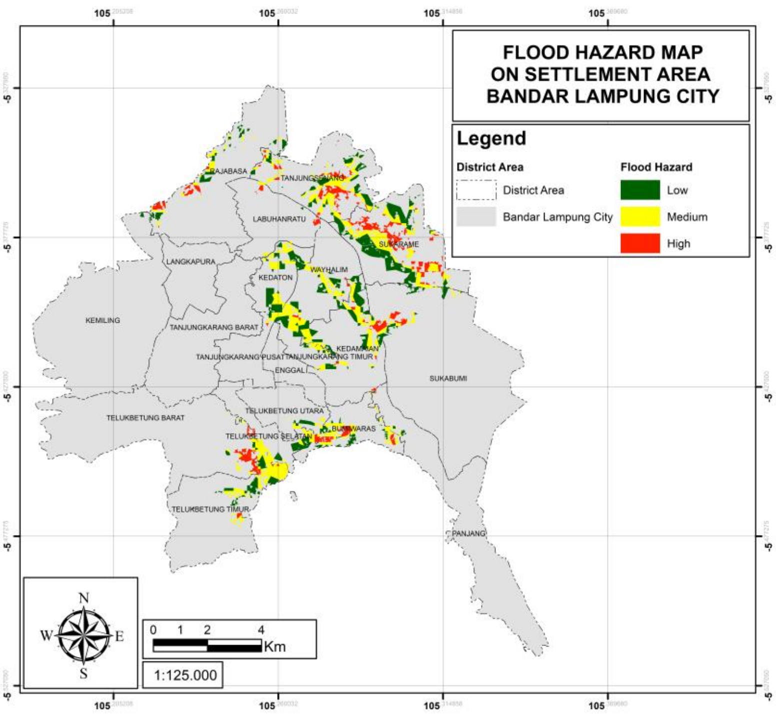

Figure 3. Flood Hazard Distribution On Settlement Area

Source: Analysis, 2026

Topographic conditions also influence the spatial variation of flood hazards among subdistricts. Areas such as Teluk Betung Barat and Rajabasa exhibit relatively high proportions of medium and high hazard classes due to their position near watershed flow accumulation zones and terrain with limited drainage efficiency. Conversely, subdistricts such as Enggal and Kemiling show smaller affected settlement areas because urban settlements are relatively more concentrated in elevated terrain or areas with better drainage infrastructure. These findings indicate that flood hazard distribution in Bandar Lampung is not solely determined by natural factors but is also closely linked to patterns of urban development and infrastructure provision.

Subdistricts such as Enggal and Kemiling show smaller affected settlement areas because urban settlements are relatively more concentrated in elevated terrain or areas with better drainage infrastructure. Higher elevation and more effective drainage networks can reduce the duration and extent of flooding by allowing water to move more efficiently away from residential zones. However, this does not mean that these areas are completely free from flood risk, as localized flooding may still occur if drainage channels are blocked, undersized, or poorly maintained.

These findings indicate that flood hazard distribution in Bandar Lampung is not solely determined by natural factors but is also closely linked to patterns of urban development and infrastructure provision. The findings are consistent with previous studies highlighting that uncontrolled urbanization, land-cover change, and inadequate drainage systems are major drivers of urban flooding in Bandar Lampung. Furthermore, the results align with local spatial planning concerns identified in regional planning documents, which emphasize increasing flood vulnerability in rapidly developing suburban areas.

Thespatial distribution of flood-prone settlements identified in this study provides important information for prioritizing flood mitigation measures, particularly in high-growth residential zones such as Sukarame, Tanjung Senang, and Kedamaian. These areas require more intensive planning interventions, including drainage normalization, retention pond development, river buffer protection, and stricter control of settlement expansion in flood-prone zones. Flood mitigation should also be integrated into land-use planning so that future development is directed toward safer areas. In addition, community awareness and early warning systems are needed to reduce potential losses at the household level. By combining structural and non-structural mitigation strategies, Bandar Lampung can improve urban resilience and reduce the long-term impacts of flooding on settlements.

Additional development pressure in these subdistricts also needs to be viewed in relation to population growth and the increasing demand for housing. When residential expansion is not supported by adequate environmental planning, flood-prone land may gradually be converted into settlement areas. This condition can increase the number of exposed households and public facilities, especially in areas located near rivers, drainage channels, and low-lying zones. Therefore, flood risk reduction should not only focus on physical infrastructure but also on strengthening spatial governance. Local governments need to ensure that hazard maps are actively used in permit evaluation, settlement planning, and infrastructure investment decisions. Periodic monitoring of land-use change is also important to detect early signs of development in vulnerable areas. In this context, GIS-based flood exposure analysis can serve as a practical tool for identifying priority locations, supporting evidence-based planning, and guiding more resilient urban development in Bandar Lampung.

4. CONCLUSION

This study demonstrates that flood hazards in Bandar Lampung City are spatially distributed with a dominance of medium to high vulnerability levels, indicating a substantial risk across urban areas. The overlay analysis reveals that a significant portion of settlements is exposed to flood hazards, particularly in rapidly developing Subdistricts such as Sukarame, Tanjung Senang, and Kedamaian. The concentration of settlements in hazard-prone areas reflects the influence of land-use changes, population growth, and limited infrastructure capacity, especially drainage systems. Furthermore, the predominance of medium hazard classification suggests that many areas are in a transitional condition, where appropriate intervention can effectively reduce future risks.

These findings also indicate that flood risk in Bandar Lampung is not only a physical or environmental issue, but also a planning and governance challenge. The expansion of settlements into flood-prone zones shows the need for stronger control over land conversion and more consistent implementation of spatial planning regulations. Areas with high settlement exposure should become priority locations for mitigation programs, including drainage improvement, river normalization, retention pond development, and the preservation of green open spaces. At the same time, areas with lower hazard levels must still be managed carefully to prevent future risk accumulation caused by uncontrolled urban growth.

Therefore, it is essential to integrate flood risk assessment into spatial planning policies, prioritize infrastructure improvement, and implement sustainable land-use management. A risk-based planning approach, supported by spatial analysis, can serve as a strategic tool to minimize flood impacts, enhance urban resilience, and ensure safer settlement development in Bandar Lampung City. In addition, the use of GIS-based hazard and exposure mapping can help local governments identify vulnerable areas more accurately and allocate resources more effectively. Community participation, disaster preparedness education, and early warning systems should also be strengthened to reduce potential losses at the household and neighborhood levels. Thus, flood mitigation should be carried out through an integrated approach that combines infrastructure, policy enforcement, environmental protection, and public awareness.

Ethical Approval

Not Applicable

Informed Consent Statement

Not Applicable

Authors' Contributions

AMP played a role in the data collection process and the preparation of the article layout, including organizing the writing structure to ensure it was systematic and in accordance with scientific principles, as well as compiling the results and discussion sections by comprehensively integrating research findings. Meanwhile, ARI played a role in data processing, from analysis to interpretation of results, and also contributed to the preparation of the article layout to ensure consistency in data presentation and integration between the analysis section and the entire manuscript.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement

The data presented in this study are available on request from the corresponding author due to privacy reasons.

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