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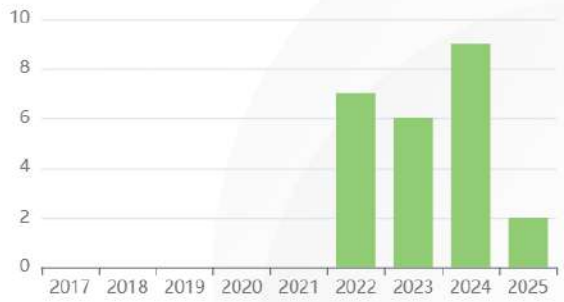

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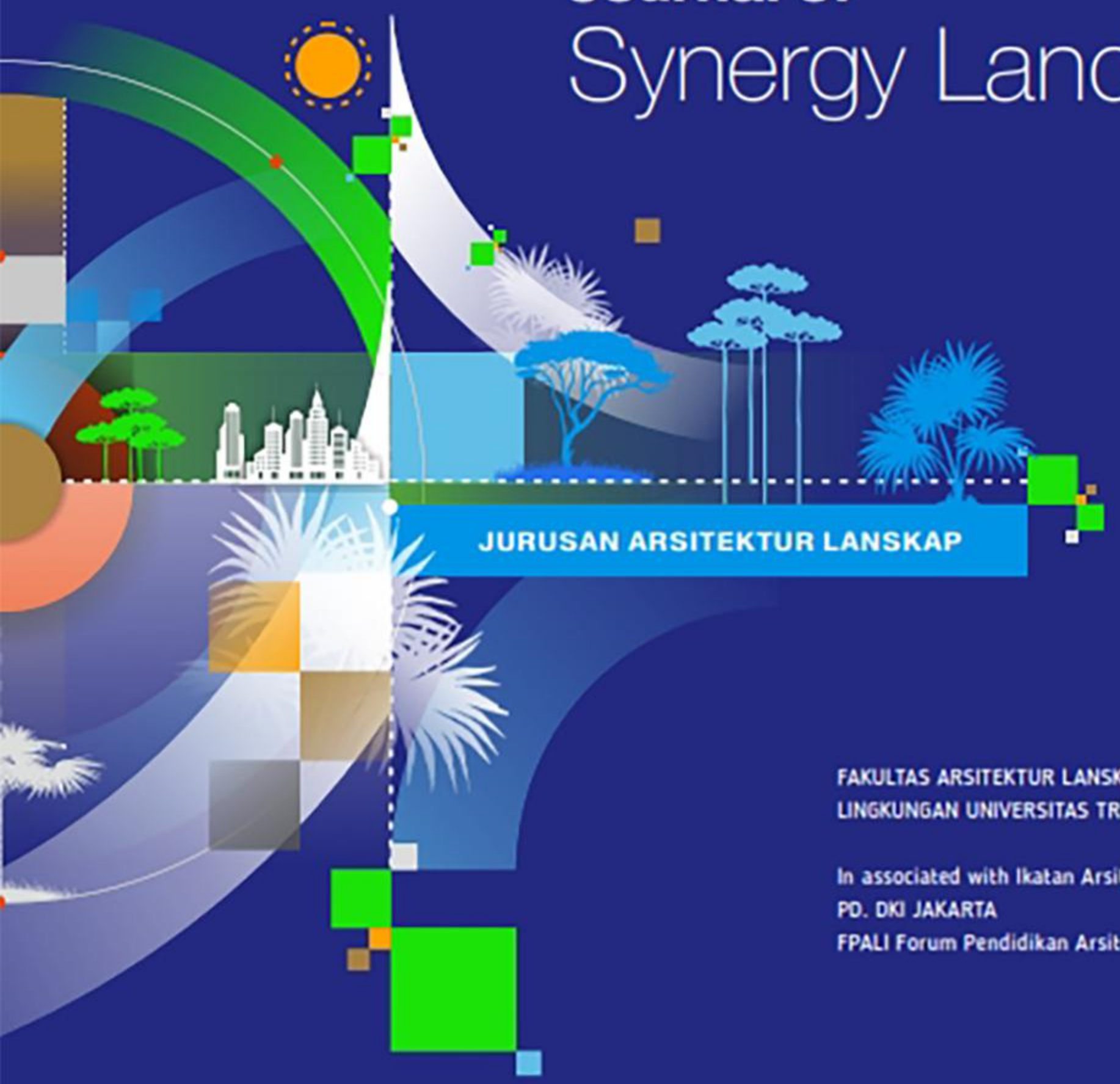

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LAND USE CHANGES IN BANGKA SUB-DISTRICT, SOUTH JAKARTA, AS A FLOOD-PRONE AREA

Ghefira Zahra Putri Salsabilla[1], Rahel Situmorang[1], Dibyanti Danniswari*[2]
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ABSTRACT

Jakarta, a city experiencing rapid urbanization, is known to experience frequent flooding. Land use changes have long been recognized as contributors to flood hazards. However, there is limited research on the inverse relationship, how flood hazards influence land use dynamics. This study aims to fill that gap by examining the impact of flood hazards on land use changes in Bangka sub-district, South Jakarta, an area regularly impacted by flooding. Data on flood frequency, flood heights, and land use patterns from 2015 to 2023 were collected and analyzed using a quantitative descriptive and map overlay approach. The findings revealed that most neighborhoods in Bangka sub-district fall under the high flood hazard category, with residential areas dominating the land use. Land use changes were observed in the residential, vacant land, and commercial categories. The analysis suggests that parts of the residential area were converted into vacant land and commercial areas. There appears to be a tendency where areas with a high level of flood hazard level experience more land use changes compared to areas with medium or low flood hazard levels. However, it is important to note that the overall land use changes across the study area remains limited, with the majority of the land use largely unchanged, despite the area's repeated exposure to flood hazards. This study highlights the need for further exploration of the relationship between flood hazards and land use to support better urban planning in flood-prone areas.

Keywords: flood frequency, flood hazard level, flood height, land use change

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INTRODUCTION

Flooding is a frequent disaster in Jakarta, impacting both the city and its residents. Jakarta is crossed by six watersheds: Ciliwung, Sunter, Angke, Cakung, Pesanggrahan, and Krukut, resulting in many rivers flowing through the city (Daniswara et al., 2023; Fatimah, 2013). This, combined with the city's landscape and urban development, makes Jakarta prone to frequent flooding. As a result, some areas in the city are well-known for their flood risks, including Bangka sub-district in South Jakarta. Flooding is a recurring issue in South Jakarta, particularly in Bangka sub-district, due to the overflow of nearby rivers such as the Krukut and Mampang rivers (Rakuasa et al., 2023). In past flood events, water levels in Bangka have reached as high as 1.7 meters (Wardani & Ferdinan, 2021). The main contributing factor to flood in Jakarta is suspected to be heavy rainfall (Sari & Ruslin Anwar, 2021). Land use and land cover changes have been widely known to affect flooding hazards in urban areas (Giofandi et al., 2024). The reduction of natural land cover such as forests or wetlands, which help absorb and slow down water flow, often leads to an increase in impermeable surfaces, such as roads and buildings. This urbanization intensifies runoff and diminishes the land's natural ability to manage water, which worsens flooding events. Over time, such land use changes can alter the hydrological characteristics of a region, increasing both the frequency and intensity of floods (Alshammari et al., 2023; Banjara et al., 2024). In Jakarta, extensive urban development has also played a role in modifying the drainage system, which has struggled to cope with increased water volumes during heavy rainfall.

Many studies have focused on the relationship between land use or land cover changes and flood hazards, exploring how urbanization, deforestation, and infrastructure development results in flood risks (Avashia & Garg, 2020; Boudou et al., 2016; Zope et al., 2017). However, to the best of authors' knowledge, much fewer studies have explored the reverse, such as how flood hazards influence land use changes over time. Repetitive flooding might prompt land use alterations as residents and governments react to the recurring disasters by modifying land allocation, such as transforming residential areas into uses that are less vulnerable to flood damage, such as commercial developments or infrastructural adaptations, or even abandoning flood-prone areas altogether (Sun et al., 2022).

Despite the relevance of this issue, there is a notable research gap regarding how floods directly shape land use in affected regions. This gap is particularly evident when considering long-term urban planning and flood management strategies. A limited number of studies explicitly address the correlation between frequent flooding events and subsequent land use

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This study aims to address this gap by examining the impact of flood hazards on land use changes in the Bangka sub-district, South Jakarta, an area that regularly experiences flooding. By focusing on Bangka sub-district, the study seeks to contribute to the understanding of how recurring flood events influence land use decision-making in a rapidly urbanizing region. This research will provide valuable insights into the dynamics between natural disasters and urban development, filling a critical void in current flood and land use research. By filling this knowledge gap, the study will offer implications for future urban planning and disaster management, particularly in regions facing recurring flood hazards.

RESEARCH METHODS

Time and Location

This study was conducted for 4 (four) months, from April to July 2024. The study area was Bangka Sub-District, Mampang Prapatan District, South Jakarta City. In Indonesia, a sub-district is the fourth-level subdivision and the smallest administrative division of Indonesia below a district, regency/city, and province. Bangka Sub-District covers an area of 297.3 hectares. It consists of 5 RWs (neighborhoods) with a total population of 26,406 people in 2020 (BPS DKI Jakarta, 2021). The boundary of the study area is shown in Fig. 1.

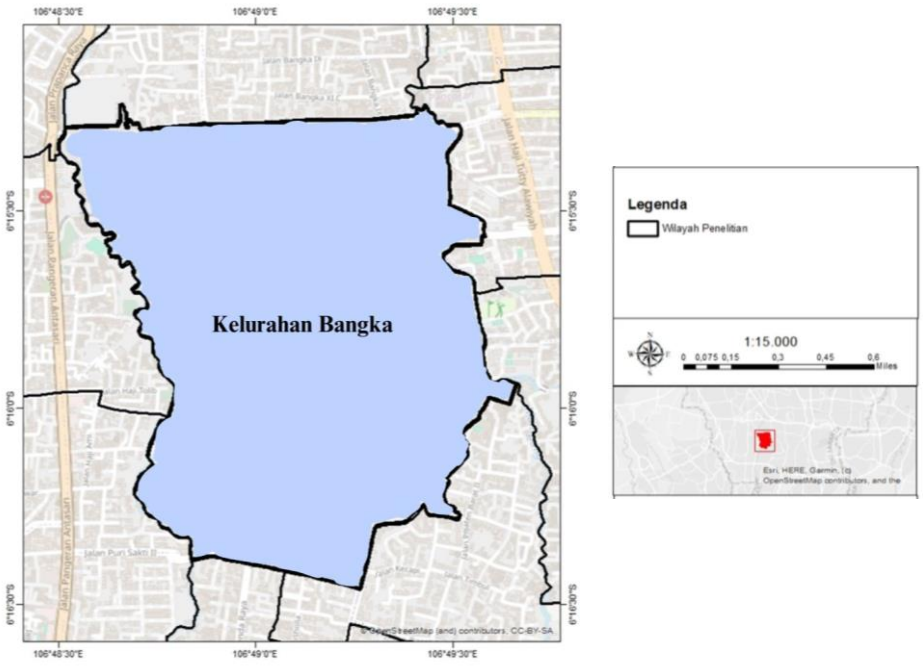

Figure 1. Map of the research location
Source : Jakarta Satu and Open Street Map, 2024

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Data Collection

The data collected in this study includes primary and secondary data. Primary data were ground truth data collected through survey and observations at the research location. Secondary data include information on the flood frequency, flood level, and land use patterns from 2015 to 2023. Secondary data were obtained through various sources such as books, scientific journals, theses, internet, and relevant agencies such as local government bureau, DKI Jakarta Regional Disaster Management Agency, Central Bureau of Statistics (BPS), and DKI Jakarta Regional Planning & Development Agency (BAPPEDA).

Data Analysis

This research used quantitative descriptive analysis methods. Descriptive analysis is used to provide a detailed description of the situation at the research location. Map overlay was also done to analyze the impact of flood hazard on land use patterns. Map overlay is a very important procedure for Geographic Information System research, which is a way of overlaying one map over another map and displaying the results of the overlay on a computer screen. The result displays a combined attribute information of the overlayed maps.

RESULTS AND DISCUSSION

Flood Hazard in 2015 – 2023

There are 5 RWs or neighborhood in the study area. According to the data obtained from BPBD DKI Jakarta, every year from 2015 to 2023, the study area consistently experienced flood hazards with varying severity. The flood hazard in the study area is summarized in Table 1. The flood severity between 2015 and 2023 showed noticeable fluctuations. In terms of area affected, the most severe flood occurred in 2016, when all five neighborhoods in the study area were impacted. However, in terms of flood height, the most extreme event happened in 2015, with water levels exceeding 150 cm. The least severe flood occurred in 2019, impacting only one neighborhood, with flood heights ranging from 10 to 70 cm. Despite these variations, the study area experienced flood hazards every year from 2015 to 2023, highlighting its persistent vulnerability to flooding.

The flood hazard level in each neighborhood is categorized into low, medium, and high, determined by the frequency and height of flooding. Areas with a low flood hazard level experienced flooding 1 to 3 times during the studied period, with flood heights ranging from 10 to 70 cm. Medium flood hazard areas were flooded 4 to 6 times, with flood heights between 70

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and 150 cm. High flood hazard areas experienced flooding 7 to 9 times, with water levels exceeding 150 cm. These classifications are relative to the conditions in the study area. Based on this classification, most neighborhoods, specifically RW 002, 003, and 004, fall under the high flood hazard category. The flood hazard levels across the study area are illustrated in Figure 2.

Table 1. Flood Hazard in the Study Area

Year	Impacted RWs (neighborhoods)		Flooded Area	Flood Height
	Total	RW	(hectares)	(cm)
2015	3	002, 003, 004	198.99	>150
2016	5	001, 002, 003, 004, 005	317.86	10-150
2017	4	001, 002, 003, 004	251.85	10-150
2018	4	001, 002, 003, 004	251.85	71-150
2019	1	003	70.24	10-70
2020	4	001, 002, 003, 004	251.85	71-150
2021	4	001, 002, 003, 004	251.85	31-150
2022	4	001, 002, 003, 004	251.85	31-150
2023	1	001	53.13	31-70

Source: Regional Disaster Management Agency (BPBD) of DKI Jakarta Province (2024)

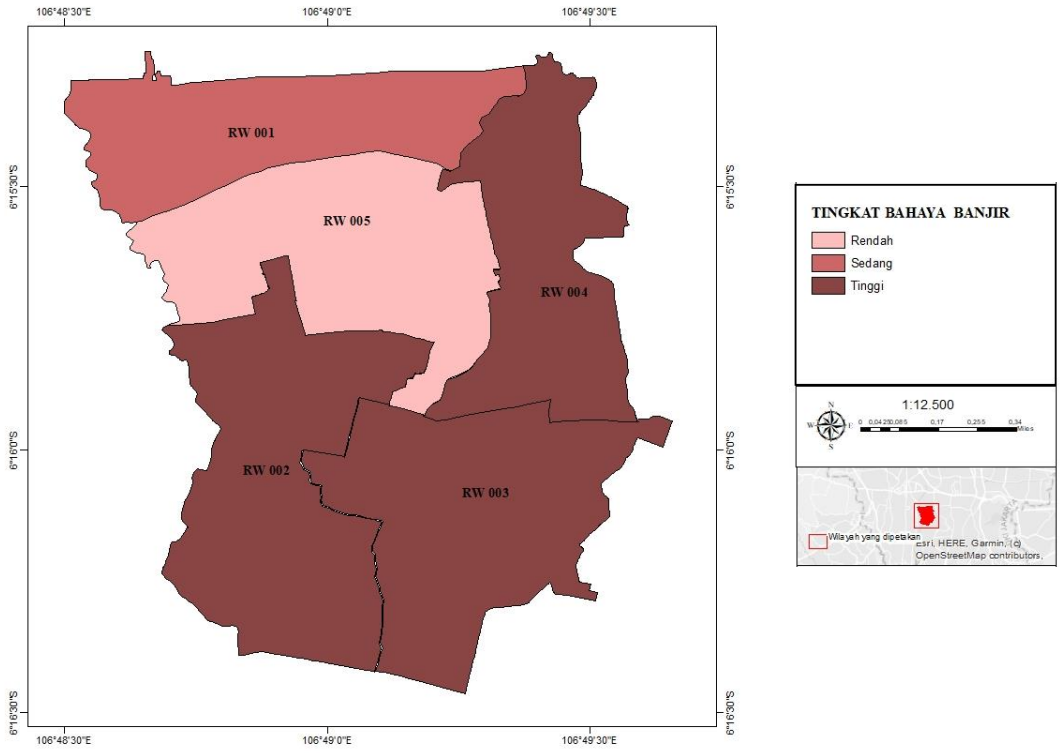

Figure 2. Flood Hazard Levels in the Study Area

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Land Use Patterns in 2015 and 2023

The land use patterns in the study area in 2015 and 2023 are summarized in Table 2. In 2015, the majority of the land use in the study area was dominated by residential areas, followed by commercial land, vacant plots, sociocultural spaces, and water bodies, with religious land use being the smallest. A similar pattern can be observed in 2023, as there was little change in land use between 2015 and 2023. The distribution of land use remained largely the same, with residential areas continuing to occupy the largest portion of the study area.

Table 2. Land Use in the Study Area

No.	Land Use	2015		2023		Change
		Area (ha)	(%)	Area (ha)	(%)	
1	Residential	205.47	69.01	202.65	68.07	Decrease
2	Religious	1.16	0.39	1.16	0.39	Still
3	Vacant land	23.67	8.00	25.83	9.00	Increase
4	Sociocultural	11.75	3.95	11.75	3.95	Still
5	Water body	1.71	0.57	1.71	0.57	Still
6	Commercial	53.98	18.13	54.63	18.35	Increase
	Total	**297.73**	**100.00**	**297.73**	**100.00**	

Source: Regional Planning & Development Agency (BAPPEDA) of DKI Jakarta Province (2024)

Changes in land use were noticeable in the residential, vacant land, and commercial categories. Residential areas decreased in 2023, while vacant land and commercial areas both increased slightly. Other types of land use remained unchanged throughout the studied period. The results suggest portions of the residential areas were likely converted into vacant land and commercial spaces, indicating land use changes in the study area. In Figure 3, land use changes are marked in blue, while unchanged areas are marked in yellow. It is evident from the figure that the unchanged areas dominate the landscape. This visual distinction emphasizes that, despite some changes, most of the study area has remained stable over the observed period.

Despite frequent flood hazards, the land use changes in the study area are less than expected. One possible explanation for this is that the study area, being already developed, may have limited opportunities for large-scale land use changes. In well-developed urban environments, there is less land available, which naturally slows down changes in land use (Mehra & Swain, 2024). There is also a possibility that certain land use changes might be

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occurring in ways not immediately visible in official land use classifications. For example, areas that are still categorized as "residential" might actually be utilized for commercial purposes, such as cafes or small businesses. Further investigations are required to confirm this possibility.

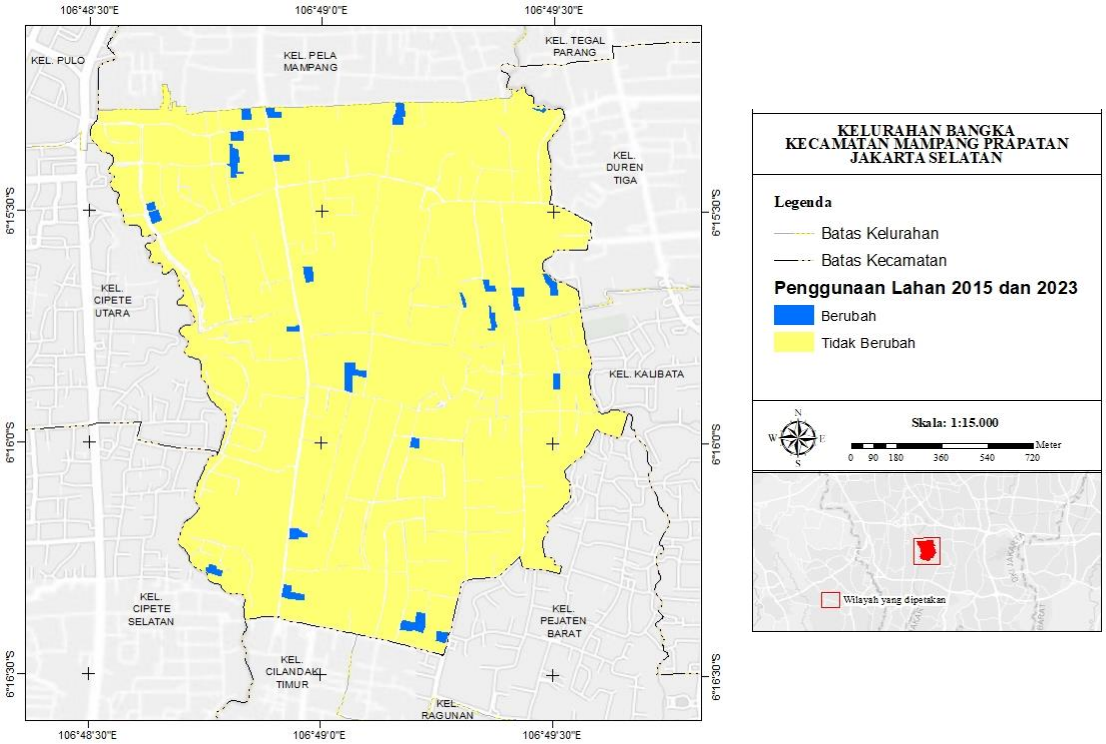

Figure 3. Land Use Change in the Study Area

Flood Hazard Level and Land Use Change

Figure 4 presents the overlayed map of flood hazard level and land use change in the study area. The data suggests that areas with high flood hazard levels underwent the most significant land use changes, which could imply that these areas are more prone to adjustments in land use practices. Areas with medium flood hazard levels also underwent change, however, the result shows that the changes are less than high flood hazard. Low flood hazard areas show the least amount of change, indicating that they stay stable. This is probably because flood hazards are lower there and thus don't require major adaptation. This pattern may reflect how flood risks influence land use decisions, with high flood hazard level areas being the most dynamic. Repeated flooding probably leads to the conversion of land into uses that are less affected by flooding. For example, conversion of previously residential areas into uses that are less vulnerable to flood damage, such as commercial or vacant areas. However, this notion requires further investigation.

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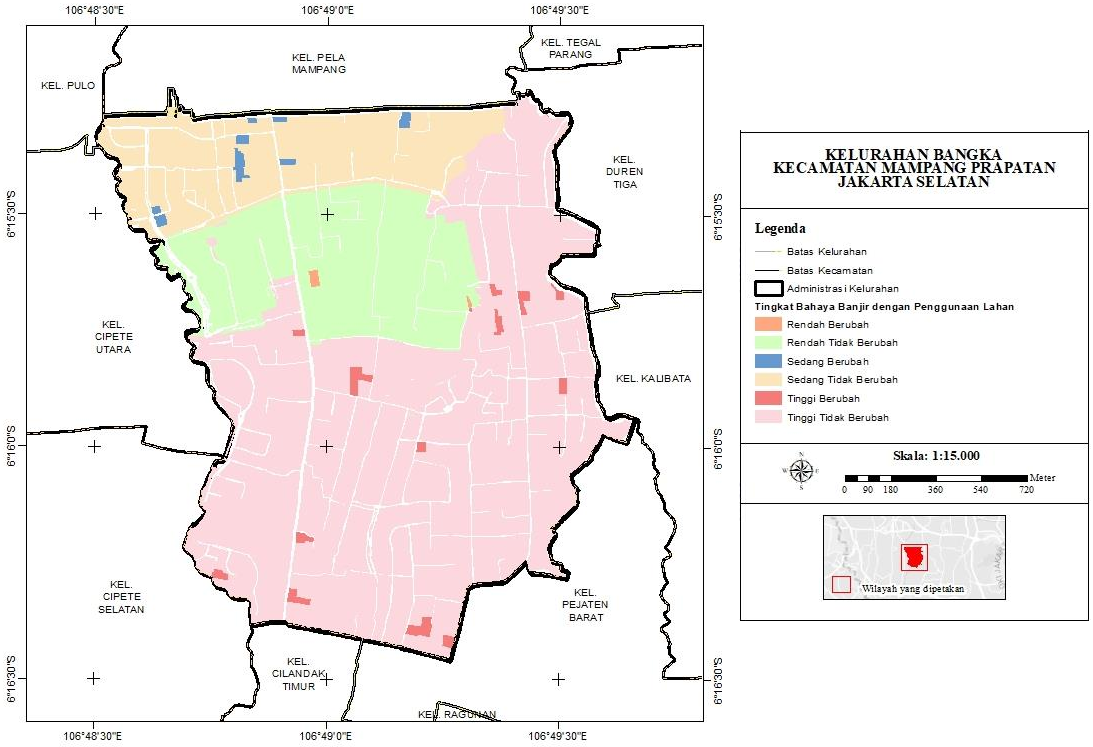

Figure 4. Overlayed Map of Flood Hazard Level and Land Use Changes in the Study Area

The limited land use changes found in this study highlight how flood risks are not the sole determinant of land use decisions. Economic factors, urban development potential, and even resilience strategies might also play a key role in shaping how land use evolves in flood-prone areas (Takin et al., 2023), particularly in mature urban areas where the capacity for further development is limited. Urban planning strategies in the study area must be enhanced to strengthen resilience and minimize the impact of flood hazards, reducing potential losses for the local residents.

CONCLUSION

There appears to be a tendency where areas with a high level of flood hazard level experience more land use changes compared to areas with medium or low flood hazard levels. However, it is important to note that the overall land use change in the study area remains minimal. The majority of areas remain largely unchanged, regardless of their vulnerability to flooding. This study highlights the need for further exploration of the relationship between flood hazards and land use to support better urban planning in flood-prone areas.

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Land Use Changes in Bangka Subdistrict

by Silia Yuslim FALTL

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Time and Location

This study was conducted for 4 (four) months, from April to July 2024. The study area was Bangka Sub-District, Mampang Prapatan District, South Jakarta City. In Indonesia, a sub-district is the fourth-level subdivision and the smallest administrative division of Indonesia below a district, regency/city, and province. Bangka Sub-District covers an area of 297.3 hectares. It consists of 5 RWs (neighborhoods) with a total population of 26,406 people in 2020 (BPS DKI Jakarta, 2021). The boundary of the study area is shown in Fig. 1.

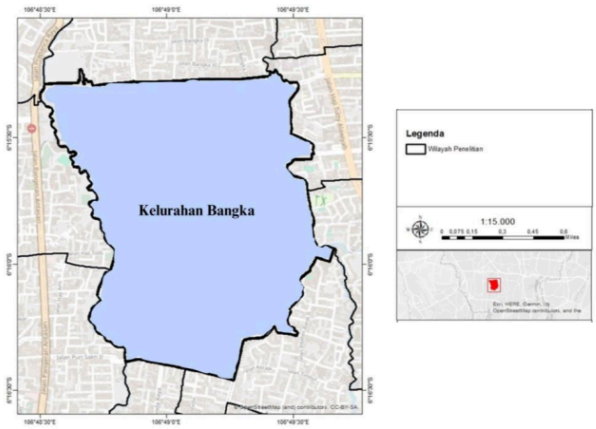

Figure 1. Map of the research location
Source : Jakarta Satu and Open Street Map, 2024

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Data Collection

The data collected in this study includes primary and secondary data. Primary data were ground truth data collected through survey and observations at the research location. Secondary data include information on the flood frequency, flood level, and land use patterns from 2015 to 2023. Secondary data were obtained through various sources such as books, scientific journals, theses, internet, and relevant agencies such as local government bureau, DKI Jakarta Regional Disaster Management Agency, Central Bureau of Statistics (BPS), and DKI Jakarta Regional Planning & Development Agency (BAPPEDA).

Data Analysis

This research used quantitative descriptive analysis methods. Descriptive analysis is used to provide a detailed description of the situation at the research location. Map overlay was also done to analyze the impact of flood hazard on land use patterns. Map overlay is a very important procedure for Geographic Information System research, which is a way of overlaying one map over another map and displaying the results of the overlay on a computer screen. The result displays a combined attribute information of the overlayed maps.

RESULTS AND DISCUSSION

Flood Hazard in 2015 – 2023

There are 5 RWs or neighborhood in the study area. According to the data obtained from BPBD DKI Jakarta, every year from 2015 to 2023, the study area consistently experienced flood hazards with varying severity. The flood hazard in the study area is summarized in Table 1. The flood severity between 2015 and 2023 showed noticeable fluctuations. In terms of area affected, the most severe flood occurred in 2016, when all five neighborhoods in the study area were impacted. However, in terms of flood height, the most extreme event happened in 2015, with water levels exceeding 150 cm. The least severe flood occurred in 2019, impacting only one neighborhood, with flood heights ranging from 10 to 70 cm. Despite these variations, the study area experienced flood hazards every year from 2015 to 2023, highlighting its persistent vulnerability to flooding.

The flood hazard level in each neighborhood is categorized into low, medium, and high, determined by the frequency and height of flooding. Areas with a low flood hazard level experienced flooding 1 to 3 times during the studied period, with flood heights ranging from 10 to 70 cm. Medium flood hazard areas were flooded 4 to 6 times, with flood heights between 70

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and 150 cm. High flood hazard areas experienced flooding 7 to 9 times, with water levels exceeding 150 cm. These classifications are relative to the conditions in the study area. Based on this classification, most neighborhoods, specifically RW 002, 003, and 004, fall under the high flood hazard category. The flood hazard levels across the study area are illustrated in Figure 2.

Table 1. Flood Hazard in the Study Area

Year	Impacted RWs (neighborhoods)		Flooded Area	Flood Height
	Total	RW	(hectares)	(cm)
2015	3	002, 003, 004	198.99	>150
2016	5	001, 002, 003, 004, 005	317.86	10-150
2017	4	001, 002, 003, 004	251.85	10-150
2018	4	001, 002, 003, 004	251.85	71-150
2019	1	003	70.24	10-70
2020	4	001, 002, 003, 004	251.85	71-150
2021	4	001, 002, 003, 004	251.85	31-150
2022	4	001, 002, 003, 004	251.85	31-150
2023	1	001	53.13	31-70

Source: Regional Disaster Management Agency (BPBD) of DKI Jakarta Province (2024)

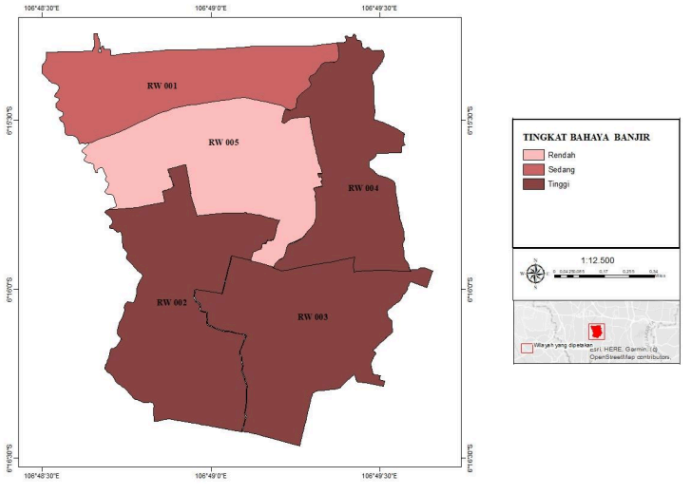

Figure 2. Flood Hazard Levels in the Study Area

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Land Use Patterns in 2015 and 2023

The land use patterns in the study area in 2015 and 2023 are summarized in Table 2. In 2015, the majority of the land use in the study area was dominated by residential areas, followed by commercial land, vacant plots, sociocultural spaces, and water bodies, with religious land use being the smallest. A similar pattern can be observed in 2023, as there was little change in land use between 2015 and 2023. The distribution of land use remained largely the same, with residential areas continuing to occupy the largest portion of the study area.

Table 2. Land Use in the Study Area

No.	Land Use	2015		2023		Change
		Area (ha)	(%)	Area (ha)	(%)	
1	Residential	205.47	69.01	202.65	68.07	Decrease
2	Religious	1.16	0.39	1.16	0.39	Still
3	Vacant land	23.67	8.00	25.83	9.00	Increase
4	Sociocultural	11.75	3.95	11.75	3.95	Still
5	Water body	1.71	0.57	1.71	0.57	Still
6	Commercial	53.98	18.13	54.63	18.35	Increase
	Total	**297.73**	**100.00**	**297.73**	**100.00**	

Source: Regional Planning & Development Agency (BAPPEDA) of DKI Jakarta Province (2024)

Changes in land use were noticeable in the residential, vacant land, and commercial categories. Residential areas decreased in 2023, while vacant land and commercial areas both increased slightly. Other types of land use remained unchanged throughout the studied period. The results suggest portions of the residential areas were likely converted into vacant land and commercial spaces, indicating land use changes in the study area. In Figure 3, land use changes are marked in blue, while unchanged areas are marked in yellow. It is evident from the figure that the unchanged areas dominate the landscape. This visual distinction emphasizes that, despite some changes, most of the study area has remained stable over the observed period.

Despite frequent flood hazards, the land use changes in the study area are less than expected. One possible explanation for this is that the study area, being already developed, may have limited opportunities for large-scale land use changes. In well-developed urban environments, there is less land available, which naturally slows down changes in land use (Mehra & Swain, 2024). There is also a possibility that certain land use changes might be

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occurring in ways not immediately visible in official land use classifications. For example, areas that are still categorized as "residential" might actually be utilized for commercial purposes, such as cafes or small businesses. Further investigations are required to confirm this possibility.

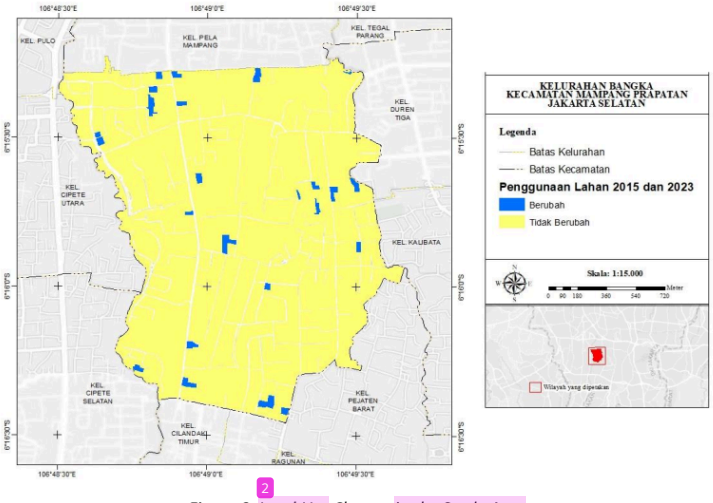

Figure 3. Land Use Change in the Study Area

Flood Hazard Level and Land Use Change

Figure 4 presents the overlayed map of flood hazard level and land use change in the study area. The data suggests that areas with high flood hazard levels underwent the most significant land use changes, which could imply that these areas are more prone to adjustments in land use practices. Areas with medium flood hazard levels also underwent change, however, the result shows that the changes are less than high flood hazard. Low flood hazard areas show the least amount of change, indicating that they stay stable. This is probably because flood hazards are lower there and thus don't require major adaptation. This pattern may reflect how flood risks influence land use decisions, with high flood hazard level areas being the most dynamic. Repeated flooding probably leads to the conversion of land into uses that are less affected by flooding. For example, conversion of previously residential areas into uses that are less vulnerable to flood damage, such as commercial or vacant areas. However, this notion requires further investigation.

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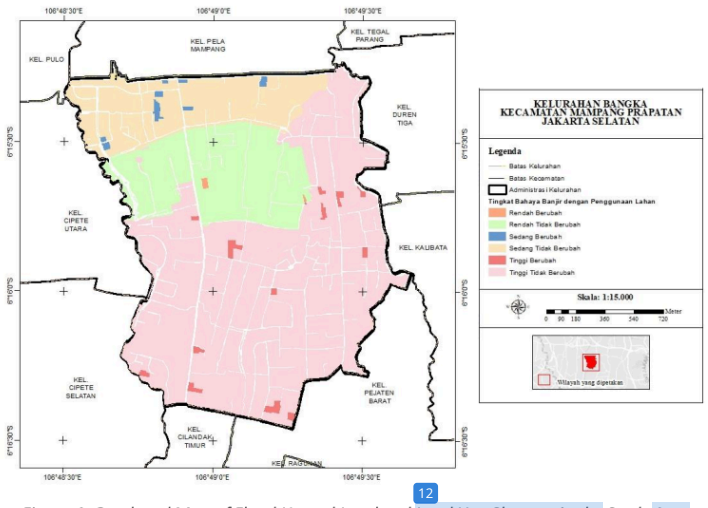

Figure 4. Overlayed Map of Flood Hazard Level and Land Use Changes in the Study Area

The limited land use changes found in this study highlight how flood risks are not the sole determinant of land use decisions. Economic factors, urban development potential, and even resilience strategies might also play a key role in shaping how land use evolves in flood-prone areas (Takin et al., 2023), particularly in mature urban areas where the capacity for further development is limited. Urban planning strategies in the study area must be enhanced to strengthen resilience and minimize the impact of flood hazards, reducing potential losses for the local residents.

CONCLUSION

There appears to be a tendency where areas with a high level of flood hazard level experience more land use changes compared to areas with medium or low flood hazard levels. However, it is important to note that the overall land use change in the study area remains minimal. The majority of areas remain largely unchanged, regardless of their vulnerability to flooding. This study highlights the need for further exploration of the relationship between flood hazards and land use to support better urban planning in flood-prone areas.

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Land Use Changes in Bangka Subdistrict

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