

Landuse And Land Cover Change Of Alluvial Plain Using Geographic Information System And Integration High Resolution Imagery And Google Street View In Sempaja, Samarinda City

Mulyadi*¹, T Martosenjoyo², I J Asmal², and E Syarif²

¹Doctoral Program of Architecture Department, Engineering Faculty, Hasanuddin University, Gowa, Indonesia

²Architecture Department, Engineering Faculty, Hasanuddin University, Gowa, Indonesia

*Corresponding author: mulyadi.alimuddin@gmail.com

ABSTRACT

Rapid urbanization in urban alluvial plains presents significant challenges, including changes in land use and land cover in the Sempaja alluvial plain of Samarinda City from 2002 to 2023 have increased flood risk in the area. This study aims to analyze land use and land cover changes and their impact on flood risk using Geographic Information Systems (GIS) and the integration of high-resolution imagery with Google Street View. Data were obtained from high-resolution satellite imagery (2002, 2013) by google earth pro and the 2023 photo map by the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency of the Republic of Indonesia (ATR/BPN) which were then processed and analyzed using ArcGIS 10.8 software. GIS analysis revealed an increase in built-up areas from 30.6 hectares (14%) in 2002 to 73 hectares (34%) in 2023. The findings also show a decrease in the area of natural wetlands and rice fields converted into residential and commercial zones, leading to increased surface runoff and flood risk. The construction of stilt houses around the Karang Mumus River represents an effective adaptive strategy to local hydrological conditions. This study highlights the need for sustainable urban planning and improved flood management, including wetland preservation, green infrastructure creation, and adequate drainage systems. The implications of this research emphasize the importance of integrating various building types in urban planning to enhance flood resilience.

Keywords: Land Use Change, Flood Risk, Geographic Information Systems, High-Resolution Imagery, Google Street View, Sempaja Alluvial Plain.

1. INTRODUCTION

The study of land use and land cover (LULC) changes in urban areas is crucial for understanding the dynamics of urbanization and its environmental impacts (Meshesha et al., 2016). Urbanization, especially in alluvial plains, often leads to significant alterations in the natural landscape, with profound consequences for local ecosystems and communities. The Sempaja alluvial plain in Samarinda City, Indonesia, serves as an exemplary case due to its rapid urban development and associated environmental challenges. Geographic Information Systems (GIS) have emerged as powerful tools in monitoring and analyzing these changes, providing spatial and temporal insights into the evolving urban fabric. This research leverages the integration of high-resolution satellite imagery with Google Street View to offer a more granular and comprehensive analysis of LULC changes (Khan et al., 2016). By employing these advanced techniques, the study aims to address the limitations of traditional methods and enhance our understanding of urbanization's impact on alluvial plains, particularly in terms of flood risk and sustainable urban planning.

Rapid urbanization in the Sempaja alluvial plain of Samarinda City has led to significant changes in land use and land cover, transforming natural wetlands and agricultural lands into residential and commercial areas. This conversion poses several environmental challenges, including increased flood risk, disrupted natural hydrological cycles, and loss of ecological habitats. Traditional methods of monitoring these changes often fall short in capturing the full scope and detail of urban transformation (Saha et al., 2022). Consequently, there is a pressing need for more sophisticated analytical tools and approaches to effectively assess and manage these changes. This study addresses this gap by integrating high-resolution satellite imagery with Google Street View within a GIS

framework to provide a detailed and accurate assessment of LULC changes. The research aims to offer new insights into the patterns and drivers of urbanization in the Sempaja alluvial plain, highlighting the critical need for informed urban planning and sustainable development practices to mitigate adverse environmental impacts (Liu et al., 2018).

The primary objective of this study is to analyze the land use and land cover (LULC) changes in the Sempaja alluvial plain of Samarinda City using an integrated approach that combines Geographic Information Systems (GIS), high-resolution satellite imagery, and Google Street View. By systematically assessing these changes from 2002 to 2023, the study aims to identify the extent and nature of urbanization, particularly the transformation of natural wetlands and agricultural lands into built-up residential and commercial zones. Additionally, this research seeks to evaluate the environmental implications of these changes, with a specific focus on flood risk and hydrological disruptions. The study endeavors to provide a comprehensive understanding of the urbanization patterns in the area, offering valuable insights for urban planners and policymakers to develop sustainable development strategies that mitigate the adverse effects of rapid urban expansion.

Despite numerous studies on urbanization and its environmental impacts, there remains a significant gap in the literature regarding the specific dynamics of land use and land cover changes in alluvial plains, particularly in tropical regions such as Samarinda City. Previous research has often overlooked the nuanced interplay between rapid urban expansion and the hydrological systems in these areas. While some studies have utilized GIS and satellite imagery to monitor urban growth, few have integrated high-resolution imagery with ground-level perspectives from Google Street View to provide a more detailed and accurate analysis. This gap highlights the need for a more comprehensive approach that combines multiple data sources to better understand the spatiotemporal patterns of urbanization and their implications. This study addresses this critical gap by employing an innovative methodology that merges GIS, high-resolution satellite imagery, and Google Street View to examine the land use and land cover changes in the Sempaja alluvial plain. Through this approach, the research aims to contribute to the existing body of knowledge by offering a more holistic understanding of urbanization processes and their environmental impacts in tropical alluvial plains.

This study presents a novel approach to analyzing land use and land cover changes by integrating high-resolution satellite imagery with ground-level data from Google Street View, a methodology not previously applied in the context of tropical alluvial plains like Sempaja in Samarinda City. The research's innovative use of these complementary data sources allows for a more detailed and nuanced understanding of urbanization's impact on the landscape. Unlike traditional methods that primarily rely on remote sensing data, the incorporation of Google Street View provides additional ground-truthing capabilities, enhancing the accuracy and reliability of the findings. This study's significance lies in its ability to offer new insights into how urban development alters natural hydrological systems, contributing valuable knowledge to the field of urban geography and environmental science. By addressing the specific challenges faced by rapidly urbanizing regions in tropical environments, this research not only fills a critical gap in the existing literature but also provides practical implications for urban planning and sustainable development practices. The findings will inform policymakers and urban planners about the importance of integrating advanced geospatial technologies in managing urban growth and mitigating environmental risks, thereby supporting more resilient and sustainable urban development in similar contexts globally.

2. METHODS

2.1 Study Area

The study area is a 212.7 hectare in Sempaja Selatan Village, North Samarinda Subdistrict, Samarinda City, East Kalimantan Province, Indonesia. The existence of the alluvial plains in Sempaja Selatan Village was identified from the land system map issued by the Regional Physical Planning Programme for Transmigration (RePPPProT), a collaboration between the Indonesian Department of Transmigration and the British government in 1987-1990. The alluvial plain in Sempaja, according to the RePPPProT land system, are categorized as alluvial plains (F4) and are part of the Kahayan landform (KHY), characterized as river plains; the landform has a slope gradient of <2%, and a relief of 2-10; the dominant rock type is newly deposited river peat. The river flood category is high (up to 25 cm, for more than 5 consecutive days, one or more times per season).

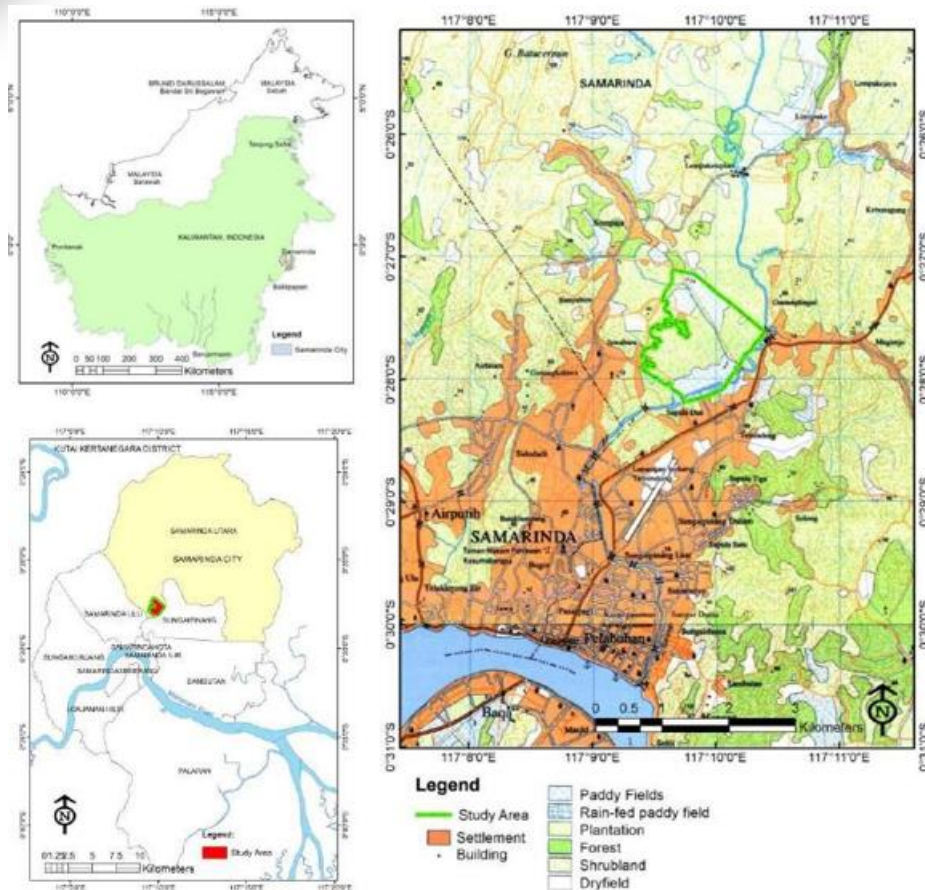


Figure 1. Study area

2.2. Data Colection

Satellite imagery was obtained from Google Earth pro have approximately with a spatial resolution of less than 1 meters for 2002 and less than 1 meter for the 2013 (Tilahun, 2015). The photo maps created in desember 2023 by the Ministry of Agrarian Affairs and Spatial Planning / National Land Agency the Republic of Indonesia (ATR/BPN) can be accessed through the link <https://petadasar.atrbpn.go.id>. This map has undergone a photogrammetry mapping process, ensuring that the measurements on the photo map are accurate. Consequently, the details on the photo map that can be identified in the field have correct positions on the map. The photo map was created using an Unmanned Aerial Vehicle (UAV) per grid, with each grid covering an area of 36 hectares. The photo map verification includes the following Service Level Agreement: GSD resolution < 0.12 m, horizontal accuracy < 0.40 m, vertical accuracy < 2 m, seamless visualization, and no blur. All photos are natural color images with three bands.

Table 1. Description of spatial data

Data	Year of acquisition	Resolution (M)	Source
Indonesian topography map	1991	1:50.000	Geospatial Information Agency (BIG) of Indonesia
Digital Elevation Model	2008	5 m	DEMNAS by Geospatial Information Agency (BIG) of Indonesia
Landuse map	2019	1:5.000	Public work and Spatial planning Departemen of Samarinda City Government
High resolution image	2002, 2013	< 1 m	Google Earth Pro
Digital Map Photo	Des,2023	0.04 m	the Ministry of Agrarian Affairs

South Sempaja Village
boundary

2020

1:5.000

and Spatial Planning / National
Land Agency of the Republic of
Indonesia (ATR/BPN)
Samarinda mayor regulation
number 85/2020

2.3. Image classification and Validation

Interpretation of satellite imagery and map photos in this research was conducted using visual interpretation to identify and assess objects. The objects have visual characteristics that allow us to distinguish them, such as size, shape, pattern, tone, association, and texture (Bell et al., 2018; Svatonova, 2016; Tiede, 2014). The maps and imagery satelits were obtained in digital format and subsequently digitized on-screen using ArcGIS 10.8 to be conducted spastial analysis. Land use is processed based on the Norms, Standards, Procedures and Criteria (NSPK) of the Ministry of Agrarian Affairs and Spatial Planning / National Land Agency of the Republic of Indonesia (ATR/BPN) classification on 2012.

Table 2. Imagery Data Sample and Google street view (GSV) Photo

1/27/2002 (Resolution < 1m)	Imagery Data 12/2013 (Resolution <1m)	12/2023 (Resolution < 0,04m)	GSV Photo
			
Wetland	Vegetable garden (reclamation)	Vegetable garden (reclamation)	Commercial Building, Vegetable garden
			
Planned Settlement, river/canal	Planned Settlement, river/canal	Planned Settlement, river/canal	Rapak Binuang residence
			
UnPlanned Settlement	UnPlanned Settlement	UnPlanned Settlement	Housing and neighborhood road
			

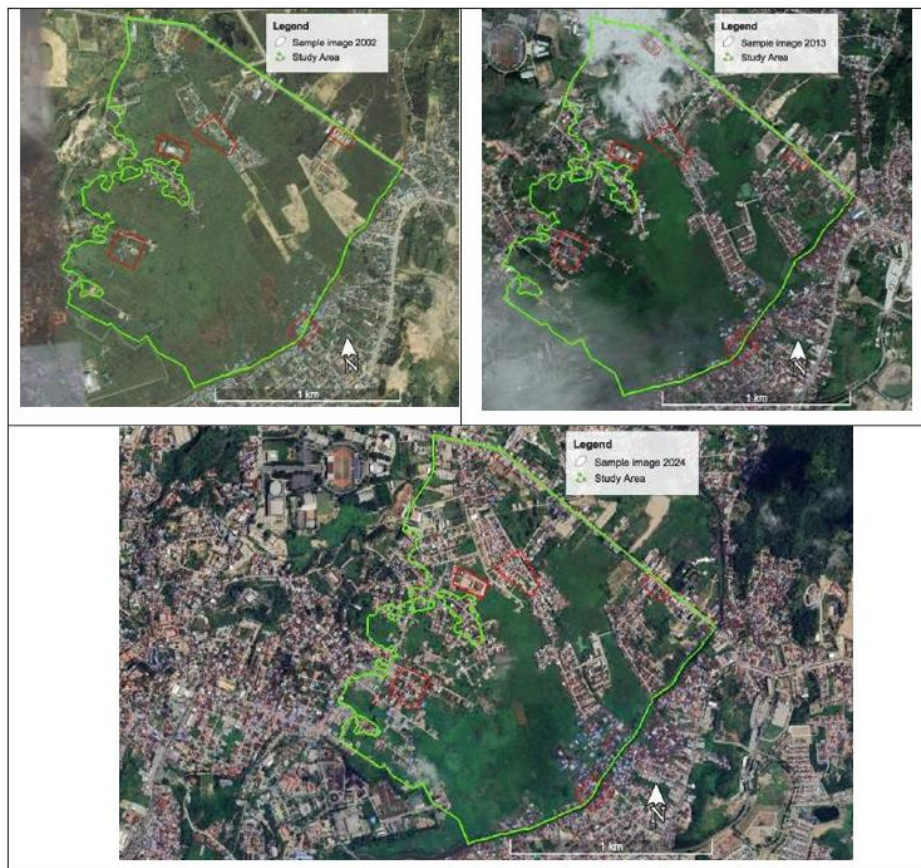
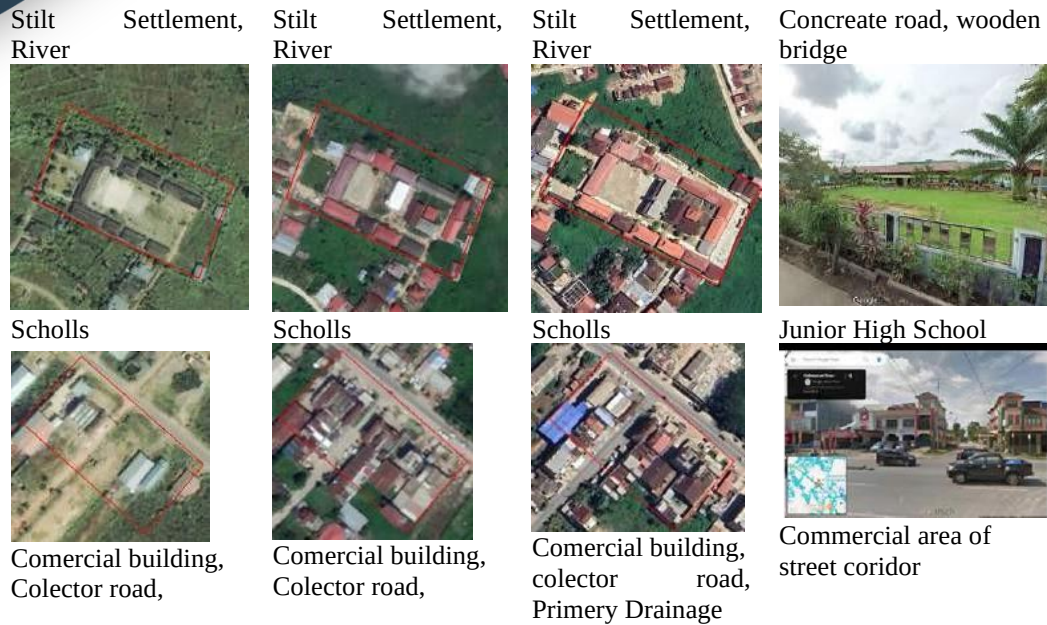


Figure 2. Sample image location

3. RESULTS AND DISCUSSION

3.1 Results

The land use and land cover change from natural wetlands to rice fields and then to residential and commercial areas to meet the needs of population growth and economic demands in the Sempaja alluvial plain of Samarinda City can be seen from high-resolution satellite imagery from 2002 and

2013 by Google Earth Pro, and the 2023 photo map by the Ministry of Agrarian Affairs and Spatial Planning / National Land Agency of the Republic of Indonesia (ATR/BPN) . GIS analysis indicates that there has been a conversion of natural wetlands and rice fields into built-up areas amounting to 30.6 hectares (14%) in 2002, increasing to 63.9 hectares (30%) in 2013, and 73 hectares (34%) in 2023. Additionally, some land had been filled but not yet built upon during the recording of the imagery, amounting to 19.1 hectares (8.9%) in 2002, 16.7 hectares (7.8%) in 2013, and 15.6 hectares (7.3%) in 2023, with land cover consisting of vegetable gardens and bushes (Table 2).

The temporal analysis of high-resolution imagery integrated with Google Street View revealed that the conversion of wetlands into built-up areas was done by landfilling, except for residential buildings around the Karang Mumus River that are not connected to the main road. These were constructed as stilt houses instead of landfilling. Based on this, a spatial clustering pattern was found in built-up areas, with commercial functions along the corridor of P.M. Noor Street, while residential functions are located behind it. The residential areas are distinguished by planning and management patterns into planned settlements, which are scattered behind commercial areas, and unplanned settlements, which have developed around Pramuka Street and the Karang Mumus River. Based on building types, structures can be classified as modern buildings and stilt houses (Figure 3).

Table 3. Landuse and landcover change in the Sempaja Alluvial Plains from 2002 to 2023

Landuse-Landcover	Area (hectar)		
	2002	2013	2023
A. Vegetation			
1. Wetland	51.0	39.2	35.4
2. Wetland ex paddy field	111.8	92.7	88.5
3. Vegetable garden (landfill area)	2.6	6.1	5.8
4. Bushland (landfill area)	16.5	10.6	9.8
Sub Total A	181.9	148.6	139.5
Prosentase	86%	70%	66%
B. Build up area			
1. Building			
1) Comercial building	1.3	6.9	7.1
2) Social building	3.4	3.6	3.7
3) Planned Settlement	8.8	21.0	21.9
4) UnPlanned Settlement	4.7	13.1	17.0
5) Stilt Settlement	1.8	4.2	5.1
2. Infrastructure			
1) Colector road	3.4	3.4	3.4
2) Local road	0.7	0.7	0.7
3) Neighborhood road	4.7	9.3	11.8
3. Water			
1) River (Sempaja river was relocated and canalized)	0.8	0.8	0.8
2) Primer Drainage (P.M.Noor street)	1.0	1.0	1.0
Sub Total B	30.6	63.9	73
Prosentase (%)	14%	30%	34%
Total	212.5	212.5	212.5

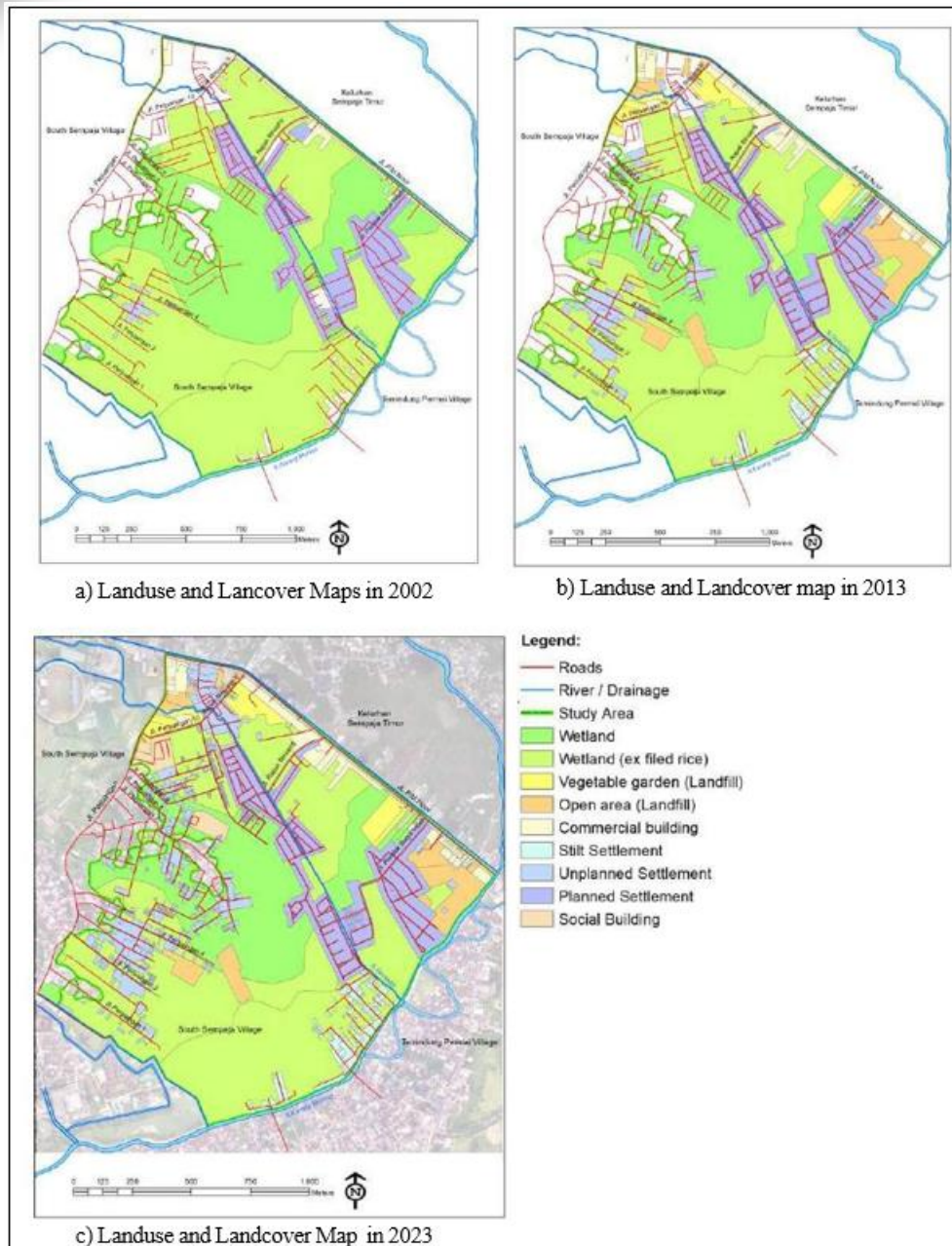


Figure 3. Landuse and Landcover map based on satellite imagery (a and b) and map photo (c)

The settlements in the Sempaja alluvial plain are categorized into two types based on planning and management aspects: planned settlements and unplanned settlements. Planned settlements are found around the main road, Jl. PM. Noor, with 175 buildings in 2002, increasing to 655 buildings in 2013, and 742 buildings in 2023. Unplanned settlement was 141 units in 2002, 536 units in 2013 and 836 units in 2023. Based on the building typology, Sempaja settlements are differentiated into modern buildings and stilt houses. The number of modern buildings due to land reclamation was 262 units in 2002, increasing to 1,008 units in 2013, and reaching 1.343 units in 2023, while the number of stilt houses was 54 units in 2002, increasing to 183 units in 2013, and 235 units in 2023 (Table 4).

Table 4. Development of the Number of Housing Units Based on the Typology of Sempaja Alluvial Plain Settlements from 2002 to 2023

Settlement Pattern		Number of Housing (unit)		
Planned and Management	Building type	2002	2013	2023
Planned Settlements	Modern Buildings with Land Reclamation	175	655	742
Unplanned Settlements	Modern Buildings with Land Reclamation	87	353	601
	Stilt Buildings	54	183	235
Total		316	1,192	1,578

3.2 Discussion

The conversion of natural wetlands and rice fields into residential and commercial areas in the Sempaja alluvial plain reflects the region's response to population growth and economic demands. High-resolution satellite imagery from 2002, 2013, and 2023 demonstrates a significant increase in built-up areas, from 30.6 hectares (14%) in 2002 to 73 hectares (34%) in 2023. This expansion highlights the pressing need for urban space to accommodate the growing population and economic activities. The GIS analysis reveals that this transformation primarily involved landfilling, which disrupts natural hydrological patterns and reduces the land's water retention capabilities, contributing to increased flood risks. Additionally, there has been a reduction in the amount of land filled but not yet developed, from 19.1 hectares (8.9%) in 2002 to 15.6 hectares (7.3%) in 2023, indicating continuous development pressure on the landscape.

The integration of high-resolution imagery with Google Street View offers a nuanced understanding of land use changes and their spatial patterns (Tang et al., 2022). The analysis reveals that while most areas were converted through landfilling, residential buildings around the Karang Mumus River were constructed as stilt houses, an adaptive response to the hydrological conditions. This adaptation helps to mitigate some flood risks by allowing water flow underneath the structures. The spatial clustering pattern shows commercial activities concentrated along P.M. Noor Street, with residential areas positioned behind these commercial zones. Planned residential settlements, typically found behind commercial areas, contrast with unplanned settlements around Pramuka Street and the Karang Mumus River, which lack adequate infrastructure and are more vulnerable to flooding. This spatial distinction underscores the varying degrees of flood resilience based on planning and management practices.

Further analysis of settlement patterns in the Sempaja alluvial plain reveals a stark contrast between planned and unplanned settlements. Planned settlements, predominantly located around Jl. PM. Noor, increased significantly from 175 buildings in 2002 to 742 buildings in 2023. In contrast, unplanned settlements saw a more dramatic increase, from 141 units in 2002 to 836 units in 2023. This rapid growth of unplanned settlements indicates a surge in informal housing development, often lacking essential infrastructure and proper drainage systems. The typology of buildings also shifted markedly, with modern buildings increasing from 262 units in 2002 to 1,343 units in 2023, primarily due to land reclamation efforts. Stilt houses, on the other hand, rose from 54 units in 2002 to 235 units in 2023, reflecting ongoing traditional adaptive strategies to the local flood-prone environment. These changes emphasize the need for comprehensive urban planning and management strategies to enhance flood resilience and accommodate future growth sustainably.

The observed land use and land cover changes in the Sempaja alluvial plain have significant implications for both theoretical understanding and practical applications in urban planning and flood management. The transformation of natural wetlands and rice fields into built-up areas not only highlights the dynamic nature of urban expansion but also underscores the critical need for integrating environmental considerations into urban development frameworks (Gu et al., 2019). This study contributes to the theoretical discourse by demonstrating the adverse effects of rapid urbanization on natural hydrological systems, thus reinforcing the necessity of sustainable land use practices in urban planning theories.

From a practical standpoint, the findings underscore the importance of employing high-resolution satellite imagery and integrating it with tools like Google Street View for detailed and

accurate land use analysis. Such integration provides a robust methodological approach for monitoring and managing urban growth, offering planners and policymakers precise data to inform decision-making processes. The distinct differences between planned and unplanned settlements, as well as between modern buildings and stilt houses, offer practical insights into the varying degrees of flood resilience. These insights can inform the development of targeted interventions aimed at enhancing the resilience of vulnerable areas, particularly unplanned settlements.

Moreover, the increase in impermeable surfaces and the associated rise in flood risk call for a reevaluation of current urban planning and flood management practices. This study supports the argument for preserving natural wetlands and implementing green infrastructure solutions, such as permeable pavements and urban green spaces, to enhance the natural absorption and drainage capacity of urban landscapes. The traditional practice of building stilt houses, which allows for water flow beneath structures, provides a valuable adaptive strategy that could be integrated into modern urban design, especially in flood-prone areas.

4. CONCLUSION

This study shows that land use and land cover changes in the Sempaja alluvial plain of Samarinda City from 2002 to 2023 have significant implications for flood risk. The conversion of natural wetlands and rice fields into residential and commercial areas has reduced the landscape's natural absorption and drainage capacity. GIS analysis revealed a sharp increase in built-up areas, resulting in the intensification of impermeable surfaces such as roads and buildings. This exacerbates surface runoff during heavy rains, increasing flood risk. The study also found that the construction of stilt houses around the Karang Mumus River is an effective adaptive strategy to local hydrological conditions, reducing some flood risk by maintaining natural drainage channels.

Settlement classification shows significant differences between planned settlements with better infrastructure and unplanned settlements that are more vulnerable to flooding. Modern buildings using impermeable materials contribute to increased runoff, while stilt houses offer a traditional adaptive response to flooding. Therefore, urban planning strategies that integrate various building types can enhance overall flood resilience.

REFERENCES

- Bell, D. M., Cohen, W. B., Reilly, M., & Yang, Z. (2018). Visual interpretation and time series modeling of Landsat imagery highlight drought's role in forest canopy declines. *Ecosphere*, 9(6). <https://doi.org/10.1002/ecs2.2195>
- Gu, Y., Qiao, X., Xu, M., Zou, C., Liu, D., Wu, D., & Wang, Y. (2019). Assessing the impacts of urban expansion on bundles of ecosystem services by DMSP-OLS nighttime light data. *Sustainability (Switzerland)*, 11(21). <https://doi.org/10.3390/su11215888>
- Khan, S., Qasim, S., Ambreen, R., & Syed, Z.-U.-H. (2016). Spatio-Temporal Analysis of Landuse/Landcover Change of District Pishin Using Satellite Imagery and GIS. *Journal of Geographic Information System*, 08(03), 361–368. <https://doi.org/10.4236/jgis.2016.83031>
- Liu, D., Toman, E., Fuller, Z., Chen, G., Londo, A., Zhang, X., & Zhao, K. (2018). Integration of historical map and aerial imagery to characterize long-term land-use change and landscape dynamics: An object-based analysis via Random Forests. *Ecological Indicators*, 95(July), 595–605. <https://doi.org/10.1016/j.ecolind.2018.08.004>
- Meshesha, T. W., Tripathi, S. K., & Khare, D. (2016). Analyses of land use and land cover change dynamics using GIS and remote sensing during 1984 and 2015 in the Beressa Watershed Northern Central Highland of Ethiopia. *Modeling Earth Systems and Environment*, 2(4), 1–12. <https://doi.org/10.1007/s40808-016-0233-4>
- Saha, T. K., Pal, S., & Sarda, R. (2022). Impact of river flow modification on wetland hydrological and morphological characters. *Environmental Science and Pollution Research*, 29(50), 75769–75789. <https://doi.org/10.1007/s11356-022-21072-6>
- Svatonova, H. (2016). Analysis of visual interpretation of satellite data. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 41(July), 675–681. <https://doi.org/10.5194/isprsarchives-XLI-B2-675-2016>
- Tang, Y., Chen, F., Yang, W., Ding, Y., Wan, H., Sun, Z., & Jing, L. (2022). Elaborate Monitoring of Land-Cover Changes in Cultural Landscapes at Heritage Sites Using Very High-Resolution Remote-Sensing Images. *Sustainability (Switzerland)*, 14(3). <https://doi.org/10.3390/su14031319>

- Tiede, D. (2014). A new geospatial overlay method for the analysis and visualization of spatial change patterns using object-oriented data modeling concepts. *Cartography and Geographic Information Science*, 41(3), 227–234.
<https://doi.org/10.1080/15230406.2014.901900>
- Tilahun, A. (2015). Accuracy Assessment of Land Use Land Cover Classification using Google Earth. *American Journal of Environmental Protection*, 4(4), 193.
<https://doi.org/10.11648/j.ajep.20150404.14>