



# Urban Flood Modeling using Remote Sensing Technology and 3D Simulation: An Innovative Approach to Risk Management

Fahrul Agus<sup>1\*,2</sup> , Muhammad M.N. Rahman<sup>1</sup>, Zanu A. Kamil<sup>2</sup>, and Okta I. Gifari<sup>2</sup>

<sup>1</sup> Informatics Department, Engineering Faculty, Mulawarman University, Samarinda-Indonesia

<sup>2</sup> GIS and Environment Modeling, Geomatics Research Group, Mulawarman University, Samarinda-Indonesia

fahrulagus@unmul.ac.id

**Abstract.** The phenomenon poses the most insidious demands of urban administration, referred to as urban flooding, which usually causes extensive damage and disruption. Therefore, it is crucial to use sophisticated modeling methodologies that suit current technologies to reduce the potential of these risks. This study reports a novel method of predicting urban inundation utilizing remote sensing and 3D simulation. Remote sensing allows collecting specific spatial data to produce high-resolution floodplain maps of urban spaces. In contrast, the 3D simulation enables dynamic visualization of flood scenarios to obtain a whole sense depending on diverse conditions. However, combining both approaches improves the accuracy and depth of flood risk evaluation. It provides meaningful developments for urban designers in response to policymaking regarding how they can effectively increase their potential for increasing levels of functional resilience. The model was tested in Samarinda Seberang District (Samarinda City, Indonesia). The research resulted in developing a 3D flood model based on open-source Digital Elevation Model (DEM) data. Secondly, the results show that our model is also accurate in flood prediction and flood protection planning. The page <https://zenodo.org/records/13336376> provides access to a three-dimensional video that simulates the movement of water puddles during inundation in Samarinda Seberang.

**Keywords:** Urban Flood, Modeling, Remote Sensing, 3D Simulation, Samarinda-Indonesia.

## 1 Introduction

Urban flooding has become a critical problem in almost all world cities yearly, exacerbated by rapid urbanization, climate change, and poor infrastructural development. Most growth in cities is due to converting natural landscapes into impervious surfaces made of impermeable materials like concrete and asphalt, leaving no space for soil where rainwater can be absorbed. As a result, more water runs off the surface, raising

flood risk at times of rainfall. Urban flooding is a significant challenge for urban administration and planning because of increasing damage to property, disruption of transportation systems, and severe human health risks and safety [1-3].

However, traditional flood management approaches based on historical data and limited hydrological models are progressively less capable of addressing the complexities of urban flooding. These tools generally do not consider the feedback of urban infrastructure activities with land use or natural water system processes. In addition, they tend to be coarse and often do not have the required precision for urban areas that are densely populated. There is an increasing demand for more advanced modeling methods with modern technologies, such as remote sensing and 3D simulation, etc. to achieve higher precision and efficiency in urban flood management [4, 5].

Remote sensing technology is essential in contemporary flood modeling since it can provide high-resolution spatial and temporal data across extensive areas. Satellites, drones, and other remote sensing platforms provide urban planners with detailed maps of cities that can help identify areas vulnerable to floods and changes in land use or topography. This technology also offers a real-time data flow, particularly useful in producing the latest flood risk assessments for informed decision-making. Furthermore, remote sensing data can be combined with other parts of the geographic information system (GIS) to establish holistic models that cover complicated transactions in urban ecosystems [6-8].

This paper aims to implement three-dimensional urban flood modeling using remote sensing data and 3D simulation tools. 3D simulations provide a dynamic and interactive view of the simulation, which is much better than traditional 2D models. Flood modeling in this study was applied to the Samarinda Seberang area, Samarinda City, East Kalimantan Province, Indonesia. The area is infamous for getting waterlogged during rains because the topography is predominantly flat, poor land use practices, and a dysfunctional drainage system. However, researchers combined remote sensing data of the urban environment in that district with a 3D flood simulation model and predicted distinct inundation patterns for different flooding scenarios. The DEM data is publicly available, and the 3D model was built with these data to provide all topographic elevation information for an accurate flood simulation.

## **2 Materials and Methods**

This study uses tools or technology for remote sensing and 3D simulation to predict urban flood conditions in the Samarinda Seberang District (Samarinda City), Indonesia. The approach is split into three significant steps: data acquisition, processing of acquired data, or feature extraction, followed by simulating and validating models.

### **2.1 Data Acquisition**

Remote Sensing involves collecting high-resolution spatial data using remote sensing technology such as satellite imagery and aerial drones [9]. Among the significant data

sources were multispectral satellite images that provided rich land cover and usage information and detailed topographic maps from Light Detection and Ranging (LiDAR) scans [10]. Further, publicly available Digital Elevation Model (DEM) data was used to create the DEM for each flood model. DEM data (from public databases such as the United States Geological Survey - USGS) provided global coverage and a scale resolution large enough for urban-scale analysis [11].

Considering the wide availability of data and sufficient resolution for analysis, this study used DEM data sourced from USGS and DEMNAS (official DEM of the Indonesian government) [12]. According to research by Fakhruddin & Harintaka, based on the base map accuracy standards, the National DEM is included in the 1:25,000 class 2 scale accuracy, while TerraSAR-X and SRTM are included in the 1:25,000 class 3 scale accuracy. Analysis of the National DEM hydrological network shows that the hydrological network formed by the National DEM can display the hydrological network according to actual conditions [13].

## 2.2 Data Processing

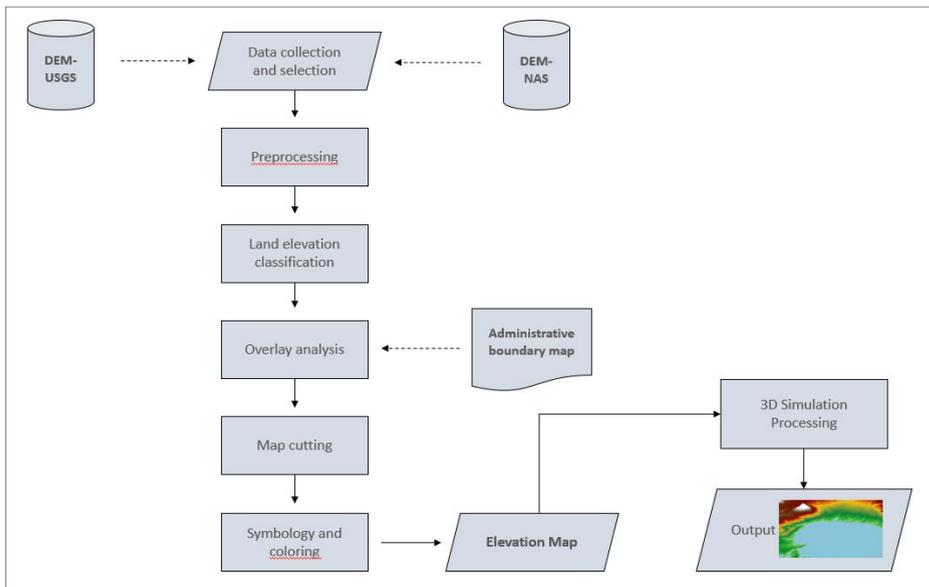


Fig. 1. Spatial analysis processing and 3D simulation stage flow

The spatial data we gathered were preprocessed and analyzed using the GIS software to generate elevation prediction profiles. Further, the DEM data was preprocessed and categorized into different elevation zones to delineate several flood-prone regions of a district. A spatial analysis was conducted to generate a 3D simulation of the flood situation in the Samarinda Seberang District by implementing stage flow illustrated as shown in Fig. 1. The procedure suggests transforming digital elevation data into maps and 3D simulations of topography. As with top-down models, the first step is gathering

and prioritizing data from DEM-USGS and DEMNAS. A method for preprocessing data and then land elevation classification. The second phase is overlay analysis concerning the boundary maps. Then, as necessary, the map is sliced and symbolized using graduated symbols to generate an elevation map. These elevation maps are further processed in 3D simulation rendering, which gives the final result as a visualization of elevations on a map from all three dimensions.

### **2.3 Model Validation**

The simulation included surface runoff, drainage capacity of infrastructure from 3D sources, and elevation changes for a wide range of potential flood areas. It also described how entities could get critical flooded areas by examining flood dynamic visualization and a 3D model. Model validation was accomplished concerning the simulated flood extents after comparing historical flash flood records and field observation in several locations throughout Samarinda Seberang District. This validation showed them that their model correctly predicted floods, wherein some conclusions were found regarding excellent or bad fare in coping with floods.

## **3 Results**

### **3.1 Samarinda Seberang District Profile**

Geographically, Samarinda City is located on the equator at a position between 0°21'18" and 0°9'16" South Latitude and 116°15'16" and 117°24'16" East Longitude. The city is divided by the Mahakam River and has a total area of 71,800 Ha. The town comprises ten sub-districts, including the Samarinda Seberang Sub-district, located across the Mahakan River from the city center. The topography of Samarinda City is flat and hilly, with an altitude of around 10–200 meters above sea level. Based on the table of altitude classes and area, it can be seen that 42.77% of the land area of Samarinda City is located at an altitude of 7-25 meters above sea level. The climate is tropical wet, causing rain throughout the year with air temperatures between 20° and 34°C, an average annual rainfall of 1,980 mm, and an average air humidity of 85%. The population density in Samarinda City in 2018 was 1,195 people/km<sup>2</sup>, with the highest density in Samarinda Seberang District of 5,845 people/km<sup>2</sup>. Samarinda District has five sub-districts, namely Mangkupalas, Mesjid, Tenun, Baqo, Sungai Keledang, and Gunung Panjang, with a total area of 1,246 hectares. The administrative boundary map of Samarinda Seberang District is presented on Fig. 2.

Samarinda Seberang District is one of the districts with a high potential for flooding, especially in lowland and riverbank areas, namely in Mesjid and Tenun Villages. These two areas have a high risk of flooding due to the lowland topography, with very few hills, and located on the edge of the Mahakam River. So, if the river water rises and is supported by high rainfall, it causes puddles of water everywhere. Two other sub-districts, namely Baqo and Sungai Keledang, are also areas with quite worrying risks, so that at any time, if the intensity of rain is high and the water is high, it will cause the flow of waste into the river is blocked and cause flooding. It is slightly different in the

two sub-districts, namely Mangkupalas and Gunung Panjang, which have hilly areas, causing these two areas to have a relatively lower risk of flooding. The potential for flooding in this district covers an area of 609 hectares or 52.11% of the district's area [14].

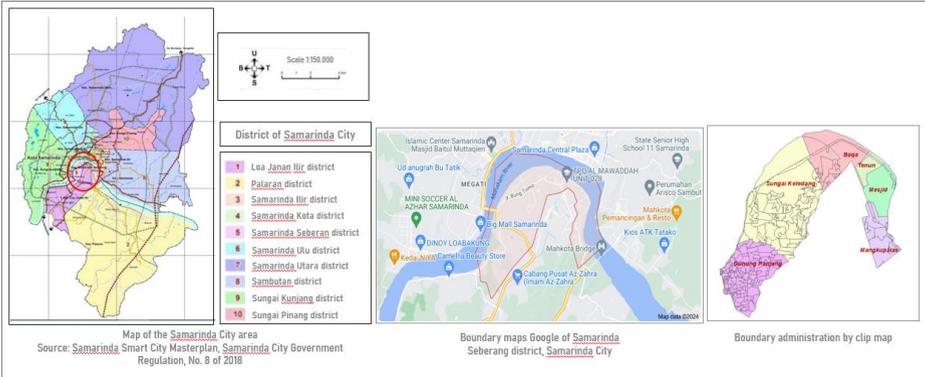


Fig. 2. Map of the Administrative Boundaries of Samarinda Seberang District, Samarinda City

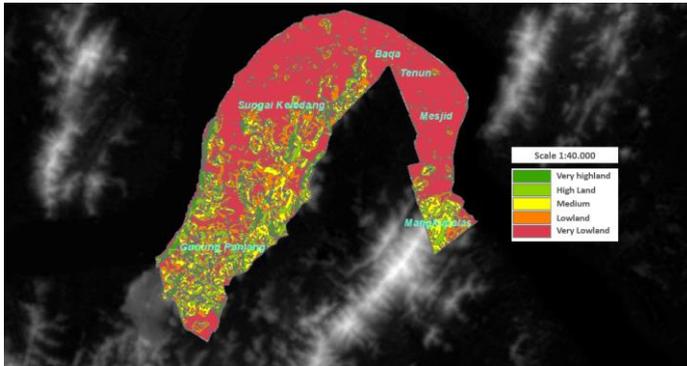
### 3.2 Three Dimension Flood Simulation

Creating a 3D flood simulation in the case of Samarinda Seberang District begins with processing the land elevation contained in the selected DEM image. Several images in TIF format sourced from USGS and DEMNAS were successfully collected during this study experiment. We decided to use DEM images from DEMNAS because, based on visual observation of the existing images, DEMNAS images tend to be of better quality with a high resolution of around 8.1 meters/pixel for coverage throughout Indonesia [15]. Compared to the resolution of DEM-USGS, which has a resolution of 30 meters per pixel with global coverage [16].

By using the reclassify feature in the spatial analysis application, the DEM image data is classified based on the land height zone and analyzed by overlay with the administrative map data of the Samarinda Seberang District. The administrative boundary map can be freely accessed on the website <https://tanahair.indonesia.go.id>. Furthermore, the spatial coordinate adjustments between the DEM image and the boundary map are carried out using the Universal Transverse Mercator zone 50 South, abbreviated as UTM 50S. Then, the image-cutting process is carried out using the clip feature. This process's end is converting data from pixels/raster to polygons. The conversion process uses the raster to polygon feature.

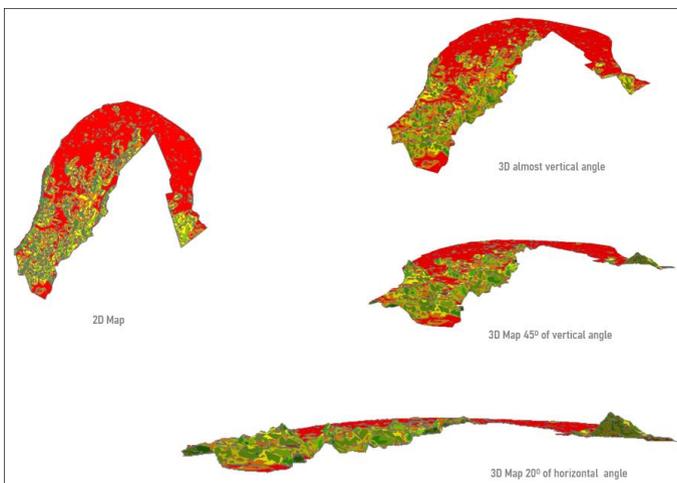
Fig. 3 illustrates the overlay analysis between DEMNAS imagery and the administrative boundary and elevation class map of Samarinda Seberang District. The classified image data shows five color codes with their respective meanings. Very highlands (dark green) represent the highest areas in the region. High land (light green) is slightly lower than the highland areas. Medium (yellow) areas have moderate elevations, and lowland (orange) areas have lower elevations. The last class is very lowland (red), the

lowest area, likely flat or near the river. This map includes specific locations marked with names such as Gunung Panjang, Sungai Kledang, Baqa, Tenun, Mesjid, and Mangupalas, which indicate landmarks or boundaries of each sub-district in Samarinda Seberang District.



**Fig. 3.** Overlay map of DEMNAS imagery with administrative boundaries and elevation class of Samarinda Seberang District before the map-cutting process

Next, the scene feature is applied to create a three-dimensional effect on the simulation of the occurrence of waterlogging. It begins by adding a DEM image layer cut according to the administrative boundaries and creating a polygon-shaped layer representing the water that will inundate the area during the simulation. These two layers will be processed as material to create a 3D flood simulation in the animation feature. This study forms as many as 13 keyframe layers in the animation manager so that the illustration of the occurrence of flooding can be perfectly depicted and cover the Samarinda Seberang area.

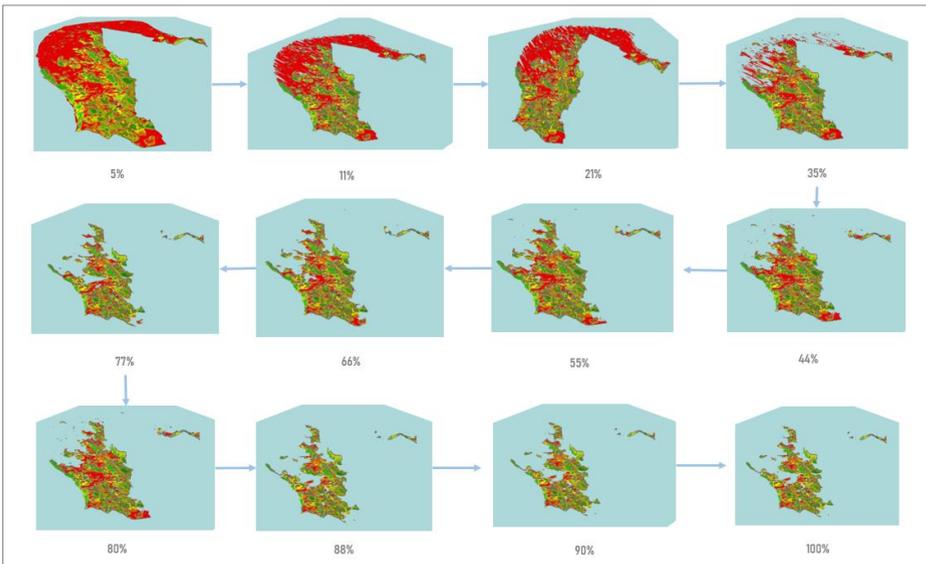


**Fig. 4.** 2D and 3D Visualization of Elevation Maps with Multiple Viewpoints

Fig. 4 illustrates the visualization of the elevation map in 2D and various 3D view-points. The map on the left is a 2D view, with elevation classifications represented by different colors. On the right are three 3D map views showing the same area at different slope angles: nearly vertical, 45°, and 20° from the vertical. This visualization shows how the same elevation map can be viewed from different perspectives to better understand the topography and elevation variations in the Samarinda Seberang area. The different viewpoints help in a more detailed analysis, especially in understanding how elevation affects the area's physical characteristics.

Fig. 5 shows a series of 3D simulations that visualize the stages of the flooding process in the Samarinda Seberang area. Each map represents a frame from the simulation with a certain percentage that shows the progress of the flood from start to finish.

- 5% to 35%: The initial simulation stage shows the area starting to be inundated. This progress shows how the flood spreads from the starting points, most likely from a water source or river, and begins to inundate the surrounding area.
- 44% to 77%: At this stage, the inundation is getting wider, covering a larger area. These maps show how the flood moves to lower areas, with water continuing to flow and inundating more areas.
- 80% to 100%: The simulation's final stage shows the flood's state when it reaches its peak, where almost the entire area has been inundated. This simulation visualizes the worst-case scenario of a flood, providing a complete picture of the impact and scope of the affected area.



**Fig. 5.** Three-Dimensional Simulation Process of Inundation Stages in Flood Model

In addition, we have created a 40-minute 3D video that vividly depicts the flood occurrence, including the flow of water that submerges low-lying regions like the Mesjid and

Tenun Sub-districts before spreading further to the Baqo Sub-district and subsequently reaches the Sungai Keledang. The flood then proceeds towards hilly areas such as Mangkupalas and Gunung Panjang Sub-districts. The video showcasing the flood occurrence can be viewed at the following link: <https://zenodo.org/records/13336376>.

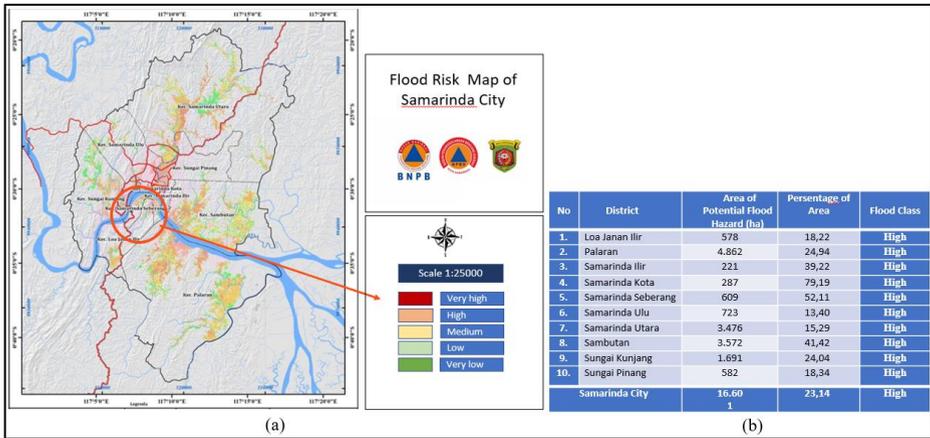
### 3.3 Model Validation

The created flood model is then validated to ensure its suitability with the actual conditions. Validation uses a qualitative method by comparing the visualization of water movement during a flood in Samarinda Seberang District with historical data on flood events published by an official institution, namely the Samarinda City Government, through the Regional Disaster Management Agency (BPPD). Historical data on flood events in Samarinda City, including maps of flood-prone areas and potential areas affected by flooding, are presented in Fig. 6.

According to the land elevation classification presented in Fig. 3, it can be observed that the red land class is mostly dominated in Mesjid, Tenun, Baqo, and Sungai Keledang Sub-districts, and areas with yellow, light green, and dark green colors are found in 2 sub-districts, namely Mangkupalas and Gunung Panjang. This observation is further clarified by the presentation of a three-dimensional image in Fig. 4 at a 20° angle from the horizontal view, that Mangkupalas and Gunung Panjang Sub-districts are areas that have hills and plateaus, which makes them different from the other 4 sub-districts which tend to be plains. This can also be observed in Fig. 5 of the 3D simulation process at portions 5 to 35%, that the first area affected by waterlogging during a flood is the area around Mesjid, Tenun, Baqo Sub-districts and a little in Sungai Keledang Sub-district. Then, in the process, 44 to 77% of these areas are increasingly submerged and are heading towards the Mangkupalas Sub-district area. Finally, in the 80 to 100% process, the only areas that were not flooded were Gunung Panjang Village and part of the Mangkupalas area.

The interpretation of the flood simulation results is then compared with historical flood data, as presented in Fig. 6. The areas stated to have high flood risk are the areas inset in orange, namely Mesjid, Tenun, Baqo Villages, and part of the Sungai Keledang area. The other 2 villages are classified as low. This grouping follows the conditions visualized by the 3D flood simulation model of Samarinda Seberang District.

There is a slight difference in the magnitude of the flood potential between BPPD predictions and simulation models. The potential area affected by flooding, according to BPPD estimates, is 609 hectares, covering 52.11% of the total area of Samarinda Seberang District. However, as in Fig. 5, the simulation model estimate is 100% process, and the affected area is more than 60%. The difference in validation results is still qualitative based on the apparent visualization. It is hoped that future research will be able to produce a simulation model with more accurate prediction results.



**Fig. 6.** Historical data for validation of 3D simulation model, (a) Flood vulnerability class map of Samarinda City, inset of Samarinda Seberang District, (b) Data on potential areas affected by flooding in Samarinda City

## 4 Discussion

Integrating remote sensing technology with 3D simulation tools significantly advances urban flood modeling. This study demonstrates that combining these two technologies provides a comprehensive approach to urban flood prediction and management, particularly in complex and rapidly changing urban environments like the Samarinda Seberang District in Samarinda City, Indonesia.

### 4.1 Accuracy and Precision in Flood Risk Mapping

Remote sensing technology has proven highly effective in acquiring detailed spatial data for accurate flood risk mapping. The ability to capture high-resolution imagery and topographical data through remote sensing allows for a precise assessment of the physical environment, which is critical in identifying flood-prone areas. This precision is further enhanced by integrating Digital Elevation Model (DEM) data, which provides a reliable foundation for understanding the terrain and how it influences water flow during flood events [17]. This study’s approach to utilizing freely accessible DEM data demonstrates that significant improvements in flood prediction accuracy can be achieved even with limited resources, which is crucial for resource-constrained urban settings.

### 4.2 Enhanced Visualization with 3D Simulation

The 3D simulation tools used in this study offer an innovative way to visualize potential flood scenarios dynamically. Unlike traditional 2D models, which may oversimplify

complex urban landscapes, 3D models provide a more realistic and detailed representation of how floodwaters interact with urban infrastructure. This dynamic visualization enables urban planners and decision-makers to understand better the potential impacts of flooding under various conditions, including extreme weather events exacerbated by climate change [18]. Simulating different scenarios allows for more effective planning and implementation of flood mitigation strategies tailored to the specific needs of each urban area.

### **4.3 Practical Implications for Urban Planning**

The successful application of this integrated model in the Samarinda Seberang District underscores its practical utility in urban flood management. The results indicate that this approach can significantly enhance urban resilience by providing detailed insights into flood risks and helping to prioritize areas for intervention. For instance, the model's identification of high-risk zones within the district enables targeted infrastructure improvements, such as upgrading drainage systems or implementing flood barriers in vulnerable areas [19]. Furthermore, the model's adaptability to various urban contexts suggests that it can be effectively applied in other cities facing similar flood risks, contributing to global urban resilience efforts.

### **4.4 Challenges and Future Directions**

While the results of this study are promising, some challenges need to be addressed to refine the model further. One of the critical challenges is integrating real-time data, such as live weather updates and river discharge measurements, into the model to enhance its predictive capabilities. Additionally, the model could benefit from incorporating socioeconomic data to understand better the human impacts of flooding, such as the potential displacement of populations or economic losses [20]. Future research should also explore the potential of further combining this approach with emerging technologies, such as machine learning and artificial intelligence, to improve the model's accuracy and adaptability [21].

So, integrating remote sensing and 3D simulation technologies represents a significant step forward in urban flood modeling. This study demonstrates that such an approach improves the accuracy of flood risk assessments and provides valuable insights for urban planners and policymakers in designing more resilient urban environments. As cities continue to expand and face increasing threats from climate change, adopting advanced modeling techniques like those presented in this study will be essential for safeguarding urban communities from the devastating impacts of flooding.

## **5 Conclusions**

This study showed that the integrated remote sensing and 3D simulation model can predict urban flooding in Samarinda Seberang. The model's three-dimensional nature enabled flood scenarios to be visualized in a way that other modeling tools could not,

and it provided helpful information about how mitigation measures might reduce this risk. The model pinpointed regions in the neighborhood that would face increased flooding risks, causing urban planners to target these areas first for flood protection.

Remote sensing technologies and 3D models for urban flood Modeling have shown that using DEM data improves flood inundation mapping due to their ability to estimate surface topography. The efficacy of this model in the Samarinda Seberang District demonstrates potential applicability in other urban areas, especially those that have been experiencing heavy floods every year for two decades ago, to help better construction for more sustainable and resilient cities, furthermore finding out if these measures can also produce optimistic planner. Given the trend of increasing urbanization and intensifying extreme climate events due to global warming, such advanced models will become indispensable for efficiently managing urban floods to limit risk.

A three-dimensional video simulating the movement of water puddles during flooding in Samarinda Seberang can be accessed via the page: <https://zenodo.org/records/13336376>.

## References

1. Agus, F., Kamil, Z.A., Gifari, O.I.: Object Oriented Design Systems for WebGIS Flood Risk Classification in Samarinda, Indonesia. *IOP Conference Series: Earth and Environmental Science* **1282**(1) (2023).
2. Lu, S., Huang, J., Wu, J.: Knowledge Domain and Development Trend of Urban Flood Vulnerability Research: A Bibliometric Analysis. *Water (Switzerland)* **15**(10) (2023).
3. Woltjer, J.: Specifying floodwater characteristics in understanding human-mobility response: A comment to Tang et al. *National Science Review* **10**(8) (2023).
4. Zhu, W., Cao, Z., Luo, P., Tang, Z., Zhang, Y., Hu, M., He, B.: Urban Flood-Related Remote Sensing: Research Trends, Gaps and Opportunities. *Remote Sensing* **14**(21) (2022).
5. Mustafa, A., Szydłowski, M., Veysipanah, M., Hameed, H.M.: GIS-based hydrodynamic modeling for urban flood mitigation in fast-growing regions: a case study of Erbil, Kurdistan Region of Iraq. *Scientific Reports* **13**(1) (2023).
6. El Yacoubi, Y., Wahbi, M., Maatouk, M., El Kharki, O., Boulaassal, H., Alaoui, O.Y.: Towards Time Series Sensor Data to Accurately Map Flood Hazard and Assess Damages under Climate Change Using Google Earth Engine Cloud Platform and GIS – Case of the Cities of Tetouan and Casablanca (Morocco). *Ecological Engineering and Environmental Technology* **24**(5) (2023).
7. Wang, X.: Application of Remote Sensing Technology in Different Natural Disasters. *Highlights in Science, Engineering and Technology* **44** (2023).
8. Cerbelaud, A., Blanchet, G., Roupioz, L., Breil, P., Briottet, X.: Mapping Pluvial Flood-Induced Damages with Multi-Sensor Optical Remote Sensing: A Transferable Approach. *Remote Sensing* **15**(9) (2023).
9. Agus, F., Prafanto, A., Kamil, Z.A.: Detecting land use land cover using supervised maximum likelihood algorithm on spatiotemporal imagery in Samarinda, Indonesia. *IOP Conference Series: Earth and Environmental Science* **1266**(1) (2023).
10. Saifi, S., Anandakumar, R.M.: Web-based visualization and rendering of aerial LiDAR point cloud for urban flood simulation. *International Journal of Disaster Resilience in the Built Environment* **16**(2) (2024).

11. Fereshtehpour, M., Karamouz, M.: DEM Resolution Effects on Coastal Flood Vulnerability Assessment: Deterministic and Probabilistic Approach. *Water Resources Research* **54**(7) (2018).
12. Paramanandi, A.R.G., Sudaryatno, S., Rahardjo, N., Purwanto, T.H.: Spatial modeling of inundation flood using remote sensing and geographic information system in Bogowonto Watershed, Purwodadi and Bagelen, Central Java. In: Eighth Geoinformation Science Symposium 2023: Geoinformation Science for Sustainable Planet (2024).
13. Fakhruddin, A. W., Harintaka.: Vertical Accuracy Analysis of National Digital Elevation Model (Undergraduate Thesis). *Teknik Geodesi UGM-Indonesia* (2019).
14. Harun, A., Rusmasi, R.: Flood Management-Samarinda City Government (2021), <https://banjir.samarindakota.go.id/>.
15. Susetyo, D.B.: Vertical Accuracy Assessment of Various Open-Source DEM DATA: DEMNAS, SRTM-1, AND ASTER GDEM. *Geodesy and Cartography (Vilnius)* **49**(4) (2023).
16. Goyal, S.K., Seyfried, M.S., O'Neill, P.E.: Effect of digital elevation model resolution on topographic correction of airborne SAR. *International Journal of Remote Sensing* **19**(16) (1998).
17. Schumann, G., Giustarini, L., Tarpanelli, A., Jarihani, B., Martinis, S.: Flood Modeling and Prediction Using Earth Observation Data. *Surveys in Geophysics* **44**(5) (2023).
18. Rong, Y., Zhang, T., Zheng, Y., Hu, C., Peng, L., Feng, P.: Three-dimensional urban flood inundation simulation based on digital aerial photogrammetry. *Journal of Hydrology* **584** (2020).
19. Zhi, G., Liao, Z., Tian, W., Wu, J.: Urban flood risk assessment and analysis with a 3D visualization method coupling the PP-PSO algorithm and building data. *Journal of Environmental Management* **268** (2020).
20. Bryan-Smith, L., Godsall, J., George, F., Egode, K., Dethlefs, N., Parsons, D.: Real-time social media sentiment analysis for rapid impact assessment of floods. *Computers and Geosciences*, **178** (2023).
21. Saikh, N.I., Mondal, P.: GIS-based machine learning algorithm for flood susceptibility analysis in the Pagla river basin, Eastern India. *Natural Hazards Research* **3**(3), 420–436 (2023).

**Open Access** This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

