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Utilization of Geogle Earth Engine for Flood Hazard Analysis in DKI Jakarta Province

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Abstract

This research describes the use of Google Earth Engine as a key tool in analyzing flood vulnerability in DKI Jakarta Province. By combining high-quality satellite data, detailed city surface mapping, and advanced geospatial analysis capabilities, this technology has opened the door to a deeper understanding of the factors that influence flood risk in this densely populated region. This research uses the variables distance from river, elevation, TPI (Topographic Position Index) and NDVI (Normalized Difference Vegetation Index). Processing and analysis in this research was carried out in Google Earth Engine. The results of this study indicate that the area at the low flood vulnerability level has an area of 14,735.61 ha or 22.53%, the area at the medium vulnerability level is 32,512.94 ha or 49.71% and the area at the high flood vulnerability level is 18,153.42 ha or 27.76%. The results of this research are expected to help the DKI Jakarta Provincial Government in flood mitigation.
Keywords: *Flood Hazard, Geogle Earth Engine, Jakarta*

Abstrak

Penelitian ini menjelaskan pemanfaatan Google Earth Engine sebagai alat utama dalam menganalisis kerawanan banjir di Provinsi DKI Jakarta. Dengan menggabungkan data satelit berkualitas tinggi, pemetaan permukaan kota yang rinci, dan kemampuan analisis geospasial yang canggih, teknologi ini telah membuka pintu untuk pemahaman yang lebih mendalam tentang faktor-faktor yang mempengaruhi risiko banjir di wilayah yang padat penduduk ini. Penelitian ini menggunakan variabel jarak dari sungai, elevasi, TPI (Topographic Position Index) dan NDVI (Normalized Difference Vegetation Index). Pengolahan dan analisis pada penelitian ini dilakukan diGoogle Earth Engine. Hasil penelitian ini menunjukan bahwa daerah yang berada pada tingkat kerawanan rendah banjir memiliki luas 14.735, 61 ha atau sebesar 22,53 %, daerah yang berada pada tingkat kerawanan sedang seluas 32.512,94 ha atau sebesar 49.71% dan daerah yang berada pada tigkat kerawanan banjir tinggi seluas 18.153,42 ha atau sebesar 27,76 %. Hasil penelitian ini diharapkan dapat membantu pemerintah Provinsi DKI Jakarta dalam mitigasi banjir.
Kata kunci: Bahaya Banjir, Geogle Earth Engine, Jakarta

Introduction

Flooding is one of the most frequent natural disasters in many parts of the world and has a significant impact on human life, the environment, and the economy (Antony et al., 2021; Rakuasa et al., 2022; Latue et al., 2023). DKI Jakarta Province, as the capital of Indonesia and one of the most populous urban areas in the world, has experienced flooding problems repeatedly over the past few decades (Tambunan, 2017). Factors such as rapid urbanization, global climate change, and land use change have been the main causes of flooding in the region (Sugandhi et al., 2023). DKI Jakarta, as the economic and political center of Indonesia, faces persistent flooding problems, which require a multidisciplinary approach for effective flood risk mitigation and management (Klipper et al., 2021; Sugandhi et al., 2023). In the face of these challenges, a deep understanding of flood vulnerability and the use of technology for flood vulnerability analysis and mitigation is becoming increasingly important (Muin & Rakuasa, 2023)

In the last decade, geospatial technologies have undergone significant advances and enabled a better understanding of flood vulnerability (Rakuasa et al., 2023; Manakane et al., 2023; Manakane et al., 2023). One of the most useful tools is Google Earth Engine (GEE), a powerful geospatial analysis platform that allows access and analysis of satellite imagery and geospatial data on a global scale (Cui et al., 2023). GEE is a powerful platform that allows users to access and analyze a wide range of geospatial data, including satellite imagery, weather data, and topographic data, on a global scale (Muntaga, 2019; Rakuasa, 2022; Muin & Rakuasa 2023). This enables researchers, stakeholders and governments to conduct in-depth analysis of flood vulnerability by utilizing accurate and up-to-date data (Manakane et al., 2023)

Over the past few decades, DKI Jakarta has seen an increasing number of damaging floods, causing significant economic losses and social impacts (Tambunan, 2018). Traditional analysis based on limited data is often unable to address the complexity of this issue. Therefore, more advanced approaches, such as the utilization of GEE, are needed to provide a more comprehensive and in-depth picture of flood patterns as well as the interactions between factors that contribute to flood risk (DeVries et al., 2020). The utilization of GEE technology in the analysis of flood-prone areas in DKI Jakarta is expected to provide more detailed solutions in planning flood mitigation and more sustainable regional development. GEE's ability to integrate data from multiple sources and design accurate simulation models will enable experts, researchers, and decision-makers to take more effective measures in managing flood risks (Phongsapan et al., 2019)

In the context of global climate change, DKI Jakarta is also at additional risk from extreme rainfall surges and sea level rise (BNPB, 2021). In the face of these challenges, analysis using GEE can provide insights into how climate change may affect flood patterns and assist in the development of adaptation strategies (Phongsapan et al., 2019). With so many interacting factors, analyzing flood-prone areas using GEE will provide a more comprehensive understanding of flood vulnerability and risk in DKI Jakarta. The information obtained from this analysis can assist the government and other stakeholders in formulating policies, programs, and projects that focus on flood risk reduction, community protection, and sustainable development in this region. Based on the above problems, this research aims to determine the level of flood vulnerability in DKI Jakarta Province.

Research Method

This research was conducted in DKI Jakarta Province, Indonesia, This research uses Landsat 8 Level 2, Collection 2, Tier 1 data to generate distance from rivers through NDWI (Normalized Difference Water Index) index analysis. Landsat 8 Level 2, Collection 2 data can also be analyzed to produce Vegetation Index or NDVI variables. SRTM Digital Elevation 30m data can be further analyzed to produce land elevation variables and TPI (Topographic Position Index) or the relative location of a pixel to the surrounding elevation (whether lower or higher). The three data are processed and analyzed in Google Eearth Engine. Details of the data can be seen in Figure 1.

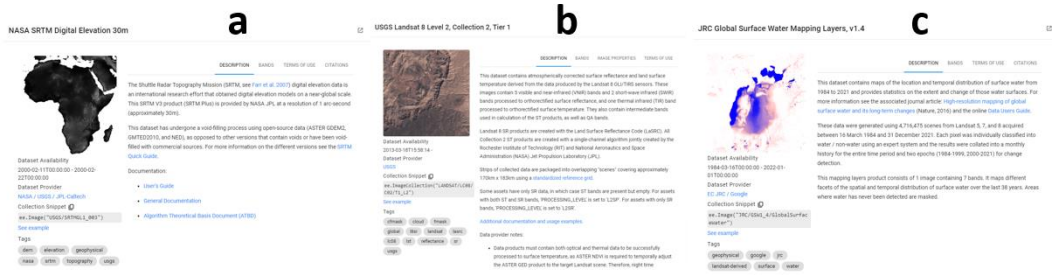

Figure 1.a) NASA SRTM Digital Elevation 30m, b) USGS Landsat 8 Level 2, Collection 2, Level 1, c) JRC Global Surface Water Mapping Layer, v1.4

Modeling flood vulnerability in DKI Jakarta is done by creating a value from a combination of variables that support flooding. For example, using distance from permanent water or rivers. The closer a point is to a river, the higher the possibility of vulnerability. Besides distance from the river, elevation can also be used. If the elevation is low, it is more likely to be flooded than those at high elevations. Elevation is actually not enough as there are other topographic factors such as TPI (Topographic Position Index) which is a value that states the position of a point relative to the surrounding elevation. Vegetation is also sometimes used in flood vulnerability modeling where areas with dense vegetation are less vulnerable than those that are barren or unable to absorb water. Vegetation can be modeled with NDVI. Using all of these variables, it is possible to mark the area to determine the level of flood vulnerability:

Table 1. Ranking of Flood Vulnerability Variables

No	Variables	Description	Score
1	Distance From River	>.200 meters	1
		150 – 200 meters	2
		100 – 149 meters	3
		50 – 99 meters	4
		< 20 meters	5
2	Elevation	>.20 meters	1
		15 – 20 meters	2
		10 – 14 meters	3
		5 – 9 meters	4
		<. 5 meters	5

3	TPI	>.0 0 – -0.25 -0.25 – -0.5 -0.5 – -0.75 <.0.75	1 2 3 4 5
4	NDVI	>.0.5 0.25 – 0.5 0 – 0.25 -0.25 – 0 <-0.25	1 2 3 4 5

Source: (Phongsapan et al., 2019)

Table 2: Flood Vulnerability Score

No	Total Variable Score	Flood Vulnerability Score	Description
2	> 8	1	Low Vulnerability
3	9 – 12	2	Medium Vulnerability
4	13 – 16	3	High Vulnerability

Source: (Phongsapan et al., 2019)

After all variables have been assessed. Then flood vulnerability can be modeled by summing up all variable values and re-harrowing them to determine the level of vulnerability. The determination of the flood vulnerability hierarchy refers to Table 2. The whole process of analyzing flood-prone areas was carried out at https://code.earthengine.google.com/ using a modified script based on previous studies (Phongsapan et al., 2019). The flood analysis process in Google Earth Engine can be seen in Figure 2.

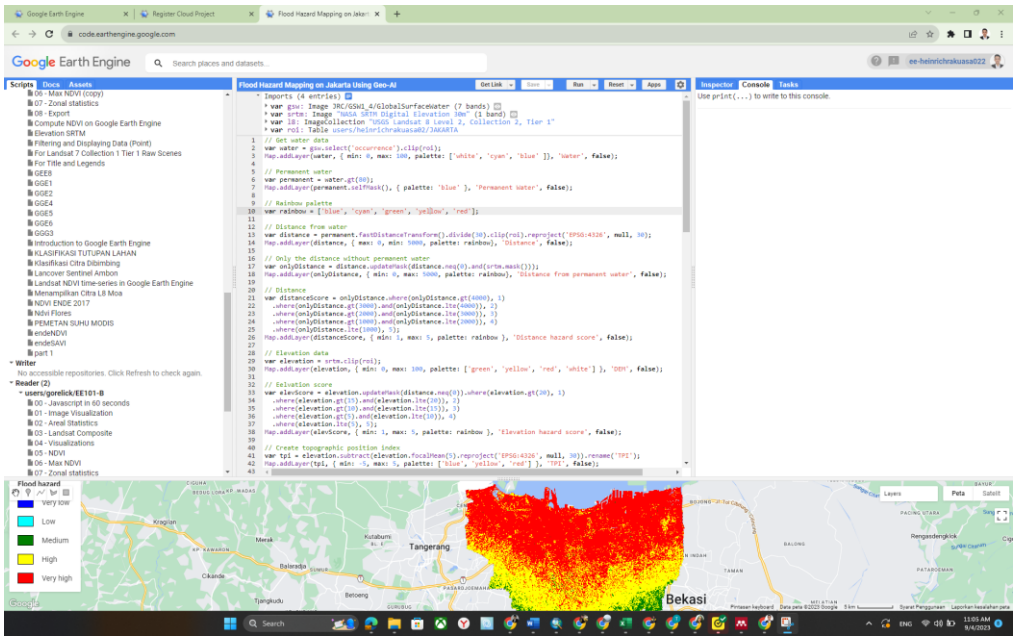

Figure 2. Display of Flood Analysis Process in Google Earth Engine

Results and Discussion

The results of the analysis of flood vulnerability in DKI Jakarta using Geogle Earth Engine, show that the area at the low vulnerability level is 14,735.61 ha or 22.53%, the area at the medium vulnerability level is 32,512.94 ha or 49.71% and the area at the high flood vulnerability level is 18,153.42 ha or 27.76%. Details of the level of flood vulnerability in DKI Jakarta can be seen in Figure 2.

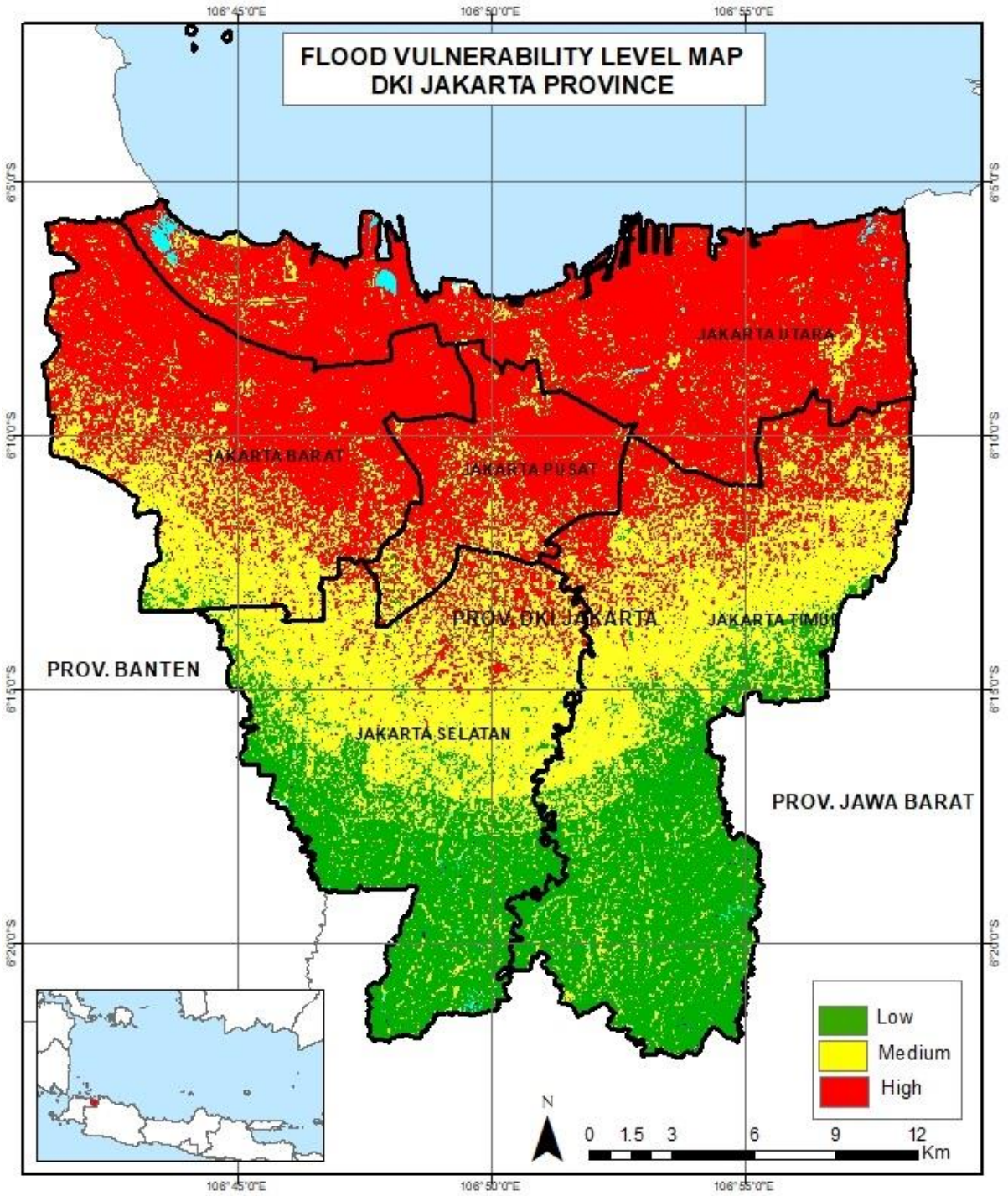

Figure 3: Level of flood vulnerability in DKI Jakarta

One of the variables used to analyze flood-prone areas in DKI Jakarta is the distance from the river. Areas that are close to the river have a very high level of vulnerability (Latue et

al., 2023). Other factors such as high rainfall intensity, poor drainage systems, and land use change can also affect flood risk (Rakuasa & Latue, 2023). In fact, some areas that are far away from rivers can remain flooded due to poor water flow, especially during severe rainy seasons. This suggests that flood mitigation in Jakarta is not only about distance from the river, but also requires attention to broader infrastructure and water management.

This research also uses the variable elevation. According to Latue & Latue, (2023), The influence of elevation on flood-prone areas is one of the important aspects in flood risk analysis. Elevation refers to the height of an area above sea level or above the nearest riverbed. Elevation plays a significant role in determining the extent to which an area can be affected by flooding. A low elevation makes the area more likely to be inundated by floodwater, which can result in damage to property, infrastructure and even loss of life (Rakuasa & Rinaldi, 2023). River elevation also affects flood risk. Rivers with lower bottoms tend to have a greater risk of overflowing during heavy rains or snow melt (Latue, 2023). Areas located near low-elevation rivers can also be more severely affected by flooding when river water overflows and reaches higher elevations. In flood risk management, it is important to understand the relationship between elevation and various other factors that can affect flood risk, including rainfall, rivers, soil conditions and drainage systems (Muin & Rakuasa, 2023). By understanding this, governments and communities can take appropriate measures to protect vulnerable areas from potential flood hazards.

Flood vulnerability is a measure of how vulnerable or prone an area is to flood events. It is an important concept in flood risk management and helps experts, governments and other stakeholders to understand the extent to which an area or community may be affected by flooding. Using Google Earth Engine (GEE) to conduct an analysis of flood vulnerability levels in DKI Jakarta has a number of significant benefits. Here are some of the key benefits:

1. Access to Satellite and Imagery Data: GEE provides easy access to a wide range of regularly updated satellite data and imagery. This includes high-resolution satellite imagery that can be used to monitor the Jakarta area in real-time. This data is important for understanding environmental changes that may affect flood vulnerability
2. Powerful Spatial Analysis: GEE has strong spatial analysis capabilities, allowing researchers and stakeholders to conduct in-depth mapping and analysis of topography, drainage and river flow patterns in the Jakarta area. This helps in identifying areas that are vulnerable to flooding.
3. Flood Simulation: With GEE, you can use topographic and weather data to perform flood simulations. This allows modeling of how flooding may occur under various weather and topographic conditions. The results of these simulations can provide insights into the areas that are most at risk.
4. Early Warning: GEE can be used to develop flood early warning systems. By utilizing real-time weather data and flood modeling, these systems can provide warnings to communities and stakeholders when flood risks increase, allowing more time for evacuation and preparation.

5. Mitigation Planning: Flood vulnerability analysis with GEE can help in designing effective mitigation strategies. This includes infrastructure planning such as better drainage systems, levees, and improved urban planning.
6. Monitoring Environmental Change: GEE can also be used to monitor environmental changes over time. This is important as changes in land use, urban growth and climate change can affect flood vulnerability. With regular monitoring, stakeholders can respond to these changes in a timely manner.
7. Data Openness: GEE supports data openness, which means analysis results can be shared more easily with the public and other stakeholders, including governments, to increase awareness and collective action in managing flood risks.

In order to reduce flood vulnerability, GEE is a powerful and highly useful tool that can assist DKI Jakarta stakeholders in planning and implementing more effective flood mitigation measures.

Conclusion

The utilization of Google Earth Engine in the analysis of flood vulnerability in DKI Jakarta Province shows the great potential of geospatial technology in understanding, mitigating and managing flood risks in vulnerable areas. Through access to high-quality satellite data and advanced mapping capabilities, this technology provides invaluable real-time information for the government and stakeholders in taking more effective actions to deal with flood threats. This will assist DKI Jakarta in improving spatial planning, flood management, and prevention efforts to protect residents and vital assets in the region.

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