



UTILIZING GOOGLE EARTH ENGINE FOR FLOOD-PRONE AREAS USING THE THRESHOLD METHOD IN PASAMAN REGENCY, WEST SUMATRA PROVINCE

Ananda Q-to Paguno¹, Dian Adhetya Arif², Helfia Edial³, Eva Purnamasari⁴

¹ Diploma 3 Student in Remote Sensing Technology, Padang State University

^{2,4} Lecturer in Diploma 3 Program in Remote Sensing Technology, Padang State University

³ Lecturer in Geography Department, Padang State University

email : qtopaguni@mail.com

Abstract: This study aims to utilize Google Earth Engine and Sentinel-1 image data to map flood areas using the Threshold method, which is expected to provide accurate information to support flood mitigation and management in the Pasaman region. This study also aims to determine the results of the area affected by disaster-prone areas. Based on the results of the study, researchers have obtained a flood hazard map in 2024 in Pasaman Regency by processing Sentinel-1 image data using the Threshold algorithm which has produced an area in the Vulnerable classification with an area of 4,225 Ha, a Moderately Vulnerable classification with an area of 9,102 Ha and a Safe classification of 3,818 Ha for Pasaman Regency. From the results of data processing for the flood hazard map in Pasaman Regency, it can be concluded that in 2024 Pasaman Regency experienced quite vulnerable floods.

Keywords: *Sentinel-1 Imagery, Google Earth Engine, Flood Risk*

1. INTRODUCTION

Floods are natural disasters that can occur at any time and often result in the loss of life and property. Losses caused by floods can include damaged buildings, lost valuables, and even lost time, disrupting daily activities. Floods are not preventable, but their impact can be controlled and minimized [1]. Floods accounted for 51.6% of the total damage caused by natural disasters globally in 2021 [2]. As of October 10, 2022, 2,740 natural disasters had occurred in Indonesia from January 1 to October 10, 2022. Of this data, floods were the most frequent natural disaster, with a total of 1,096 occurrences [3]. Total material damage from natural disasters in Pasaman throughout 2024 was approximately IDR 18,839,450,000. Most of the affected areas experienced damage to infrastructure. "We always report this material damage to the Central BNPB so that it can be followed up," explained the Head of the Rehabilitation and Reconstruction Division of the Pasaman BPBD, Donny, Wednesday. Flooding is defined as a condition in which land or an area is submerged due to increasing water volume. [4].

Pasaman Regency is one of the areas in West Sumatra that has a high potential for disasters because it has many natural disasters and various types of disasters. Based on the potential threat of disasters, Pasaman Regency is considered to have a high level of vulnerability to disasters [5]. The Pasaman Regency area has many rivers, at least 10 large rivers and 197 small rivers spread across each sub-district. In addition, the average rainfall in Pasaman Regency is also quite high. (2016 Pasaman Regency Government Agency Performance Report) In [6]. This flood occurred because of rain that occurred overnight which caused the Batang Panapa River and Batang Pangariang River to overflow. This flood also resulted in the submergence of residents' homes in three hamlets, namely Hamlet Tampang, Hamlet Kampung Lua, and Hamlet Lintang. This flood has occurred 15 times in 2024 [7]. Google Earth Engine (GEE), GEE offers the ability to access and analyze various satellite data sources, including Sentinel-1, quickly and easily. [8]. This study aims to utilize Google Earth Engine and Sentinel-1 image data to map flooded areas using the Threshold method, Based on the ability of Sentinel-1 synthetic aperture radar (SAR) imagery to penetrate clouds and rain, which optical imagery such as Sentinel-2 cannot do. This makes Sentinel-1 very useful for detecting floods even in bad weather conditions. Sentinel-1 can penetrate easily, which is expected to provide accurate information to support flood mitigation and management in the Pasaman area.

2. RESEARCH MATERIALS AND METHODS

2.1 Research Location

This type of research uses quantitative methods, which focus on the collection and analysis of numerical data. The primary goal of this quantitative approach is to measure variables, test hypotheses, and discover patterns or relationships between variables through the use of statistics. This quantitative research can provide significant insights into flooding patterns in Pasaman Regency and aid planning and decision-making processes.

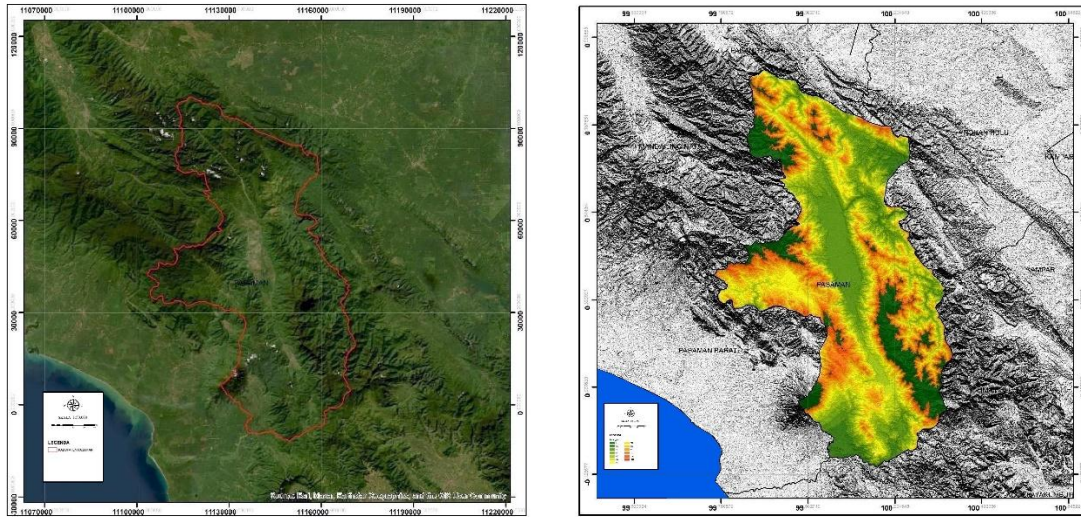


Figure 1 Research Location and Topography of Research Location

2.2 Research Method

The type and source of data required for this research is Sentinel-1. Sentinel-1 is a radar satellite mission part of the Copernicus Program, managed by the European Space Agency (ESA). This mission is designed to provide remote sensing data to support environmental monitoring, disaster monitoring, and resource management.

2.2.1 Specifications and Data Types:

Table 1 Specifications and Data Types

DATA TYPE	NAMA DATA	SUMBER DATA
	Administrative Data	INA GEOPORTAL
Secondary Data	Sentinel-1 Grd Data, Copernicus Inarisk Data	Google Earth Engine Inarisk.Bnpb.Go.Id

2.2.2 Data Processing Stages

In general, the steps recommended by UN-SPIDER, 2019 consist of three stages of data processing: The first stage is pre-processing, which is performed on images before and during the flood to create an image mosaic ready for further processing. Data from the GRD Sentinel-1 SAR Level-1 Ground Range Detected Catalogue of Earth Engines image data has undergone a pre-processing process, including the application of orbit files, thermal noise cleaning, radiometric calibration, ground correction, and backscatter-to-decibel transformation. After that, the data is filtered. This concept determines the type of instrument mode, limitations, polarization, trajectory direction, and spatial resolution of the area that has been used.

For the device mode used is the Interferometric Wide Swath (IW) type. The type of polarization used is VH (cross-polarization). This VH polarization has advantages in distinguishing objects that have certain geometric structures, such as tree branches or tree crowns, and is also useful for forest monitoring and biomass estimation compared to HH polarization. The processing carried out in this study is :

2.2.2.1 Filter Bounds

The purpose of the bounds filter is to filter an ImageCollection (a collection of images) and display only images whose geometry (the area covered by the image) intersects with a specified area. In other words, this function helps select only images to be analyzed within the research area.

```
Imports (1 entry)
var roi: Table projects/ee-bapakberkuda3122/assets/KABUPATEN_PASAMAN
1 var datasar = ee.ImageCollection("COPERNICUS/S1_GRD")
2 .filter(ee.Filter.listContains('transmitterReceiverPolarisation', 'VH'))
3 .select('VH')
4 .filter(ee.Filter.eq('instrumentMode', 'IW'))
5 .filterBounds(roi)
6 ;
7
8
9
```

Figure 2 Filter Bounds

2.2.2.2 Filter Date

Filter date The aim is to filter data based on a specific date range, thus simplifying the data visualization and analysis process.

```
var before = datasar.filterDate('2024-04-01', '2024-04-30').min();
var after = datasar.filterDate('2024-05-01', '2020-05-31').mean();
```

Gambar 1 Filter Date

2.2.2.3 Smoothing Radius

Smoothing radius this calculates the image difference with the subtraction operation `after.subtract(before)`. The difference results are visualized with a color palette of blue for areas of deterioration, white for minimal changes, and red for improvements.

```
18 var SMOOTHING_RADIUS = 100;
19 var DIFF_UPPER_THRESHOLD = -3;
20 var diff_smoothed = after.focal_median(SMOOTHING_RADIUS, 'circle', 'meters')
21 .subtract(before.focal_median(SMOOTHING_RADIUS, 'circle', 'meters'));
22 var diff_thresholded = diff_smoothed.lt(DIFF_UPPER_THRESHOLD);
23 Map.addLayer(diff_smoothed.clip(roi), {min:-10,max:0}, 'diff smoothed', 0);
24
25 var flood = diff_smoothed.lt(-1)
26 .selfMask()
27 .rename('Fase9');
28
```

Gambar 2 Smoothing Radians

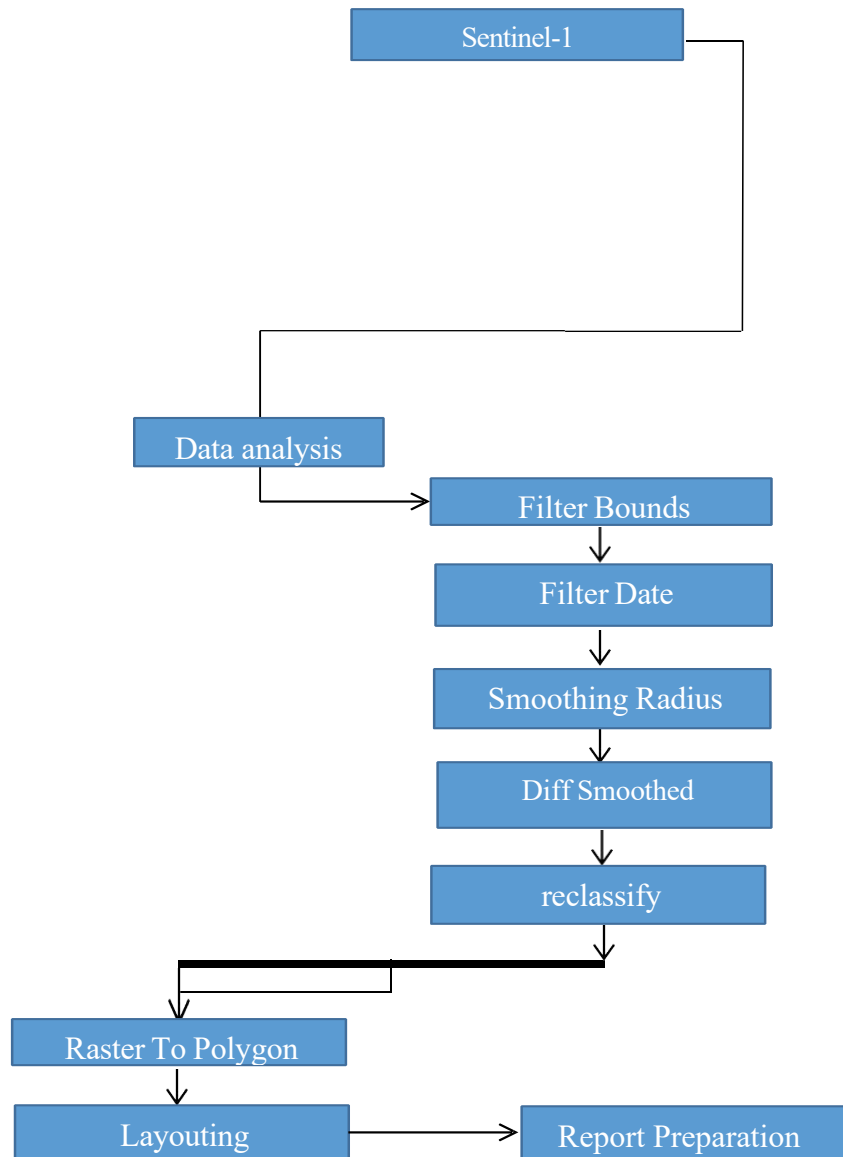
2.2.2.4 Diff Smoothed

Diff smoothed this is to smooth spatial data that has previously undergone differentiation (change). It is used to reduce noise or unwanted variations, and to identify trends or patterns in the data more clearly.



```
var flood = diff_smoothed.lt(-1)  
.selfMask()  
.rename('fase9')
```

Figure 5 Diff Smoothed





3. RESULTS

Identification of the distribution of areas affected by flooding in Pasaman Regency Based on The first objective of this research is to utilize Google Earth Engine platform to generate Flood Prone Areas in Pasaman Regency, West Sumatra Province using Sentinel 1 imagery, the following Flood Area research results were obtained: In this flood prone area process, there will be 2 stages of the process, where the first stage is the selection of the study area, which is the initial step in this research. The Indonesian Administrative Map will be entered into GEE. The data process uses a script directly from the GEE code editor itself. On the GEE website that has been opened tampilannya, klik 1 Assets dan pilih Upload the Pasaman Regency boundary shapefiles. Ensure the shapefile data set is in a single zipped archive. Also, be sure to include the .dbf and .shx files, as the shapefiles depend on them.

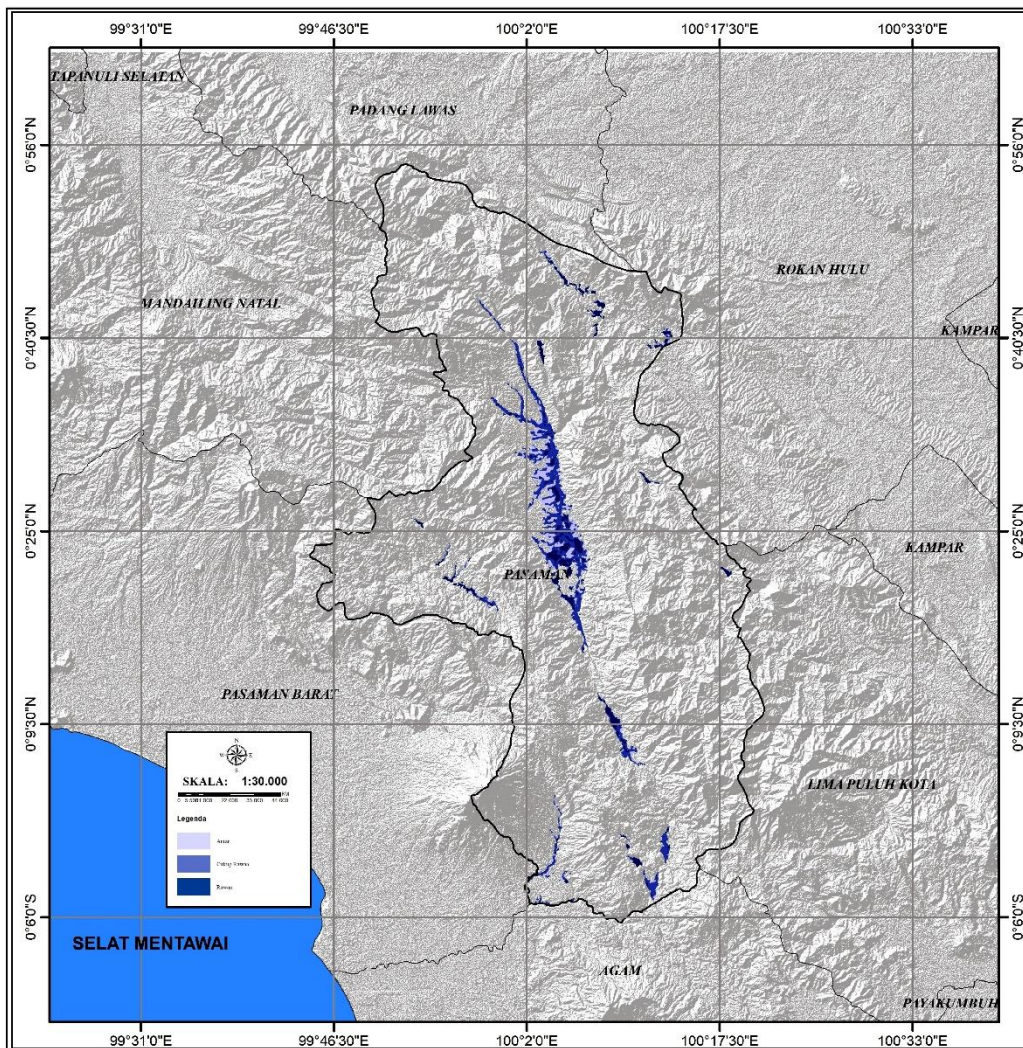


Figure 6 Map of Flood-Prone Areas

3.1. Measuring the Flood Area of Pasaman Regency

Attribute tables can be used to view the total area directly, or statistics can be used to calculate it. The following table and graph show the flooded area.



Table 2

No	Area (Ha)	Classification
1	4225	Prone
2	9102	Quite vulnerable
3	3818	Safe

Flood Area

Table 2 is a table of flood area areas where in the classification class the area of inundation that is prone to flooding is around 4225 Ha while for the moderately vulnerable classification area there are 9102 Ha, in the safe classification there is an area reaching 381 Ha. If looked closely the area that has a higher value is the classification of Somewhat Vulnerable this is very vulnerable to the increase in the expansion of the flood prone area.

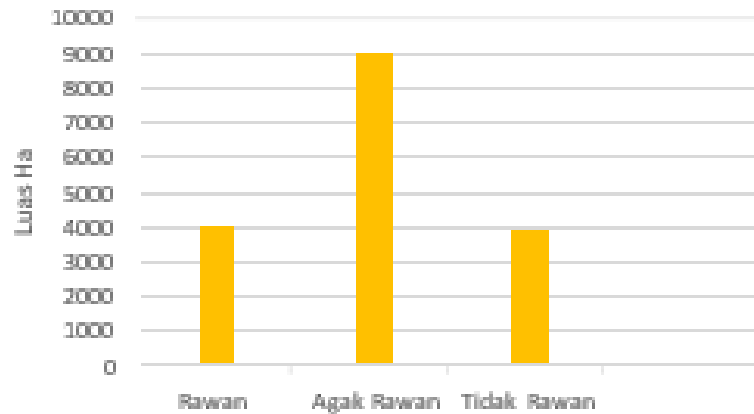


Figure 7 Bar Graph of Flood-Prone Areas

Figure 7 is a bar graph of Flood Prone Areas, which has 3 types of flood area classifications, namely Prone, Somewhat Prone, and Not Prone. The area of the very vulnerable flood area in Pasaman Regency has an area of 4,255 hectares, while the area of the moderately vulnerable flood area has an area of 9,102 hectares, while for luas area The flood zone classified as safe covers an area of approximately 3,818 hectares. This places the Pasaman area at high risk of flooding, as the moderately flood-prone area covers a larger area than the safe area.

4. DISCUSSION

Based on the topography of the Pasaman Regency area, it was formed through tectonic processes due to plate collisions, volcanic activity, erosion, sedimentation, and the influence of tropical climates, therefore Pasaman Regency is prone to disasters such as earthquakes, landslides, and floods. The affected areas are the districts of South Rao, Pantı Mapat, and Lubuk Sikaping. Educational facilities in these 3 districts were paralyzed due to the flood, for example, educational facilities in South Rao were submerged by the flood, not only that, damage occurred to the building. This flood also paralyzed businesses owned by local residents which hampered the economy of the surrounding community. On the other hand, in addition to damaging and inundating school buildings, the flood also destroyed several public facilities, such as suspension bridges and several other facilities. The Lubuk Sikaping sub-district also suffered enormous losses, not only were residents' homes submerged in floodwaters, resulting in casualties in the Lubuk Sikaping sub-district, but also affected vehicles and agricultural land of the surrounding community. Meanwhile, the Pantı Mapat area suffered significant losses, including damage to educational facilities



such as schools, bridges caused by flooding, and several houses. Of the three sub-districts most affected by the flood, all three have lowlands, with an elevation of only 100 meters above sea level. In the results of flood area processing in ArcGIS, researchers provide 3 classification classes which will later be useful for seeing the division of areas prone to flooding. In the Vulnerable classification, the area is approximately 1.07 km² of the total area of Pasaman Regency. The affected sub-districts include South Rao, Panti Mapat, and Lubuk Sikaping. In the Moderately Vulnerable classification, the area is approximately 2.30 km² of the total area of Pasaman Regency. The affected sub-districts are in the sub-districts of Mapat Tunggul, South Rao, Padang Gelugur, Panti Mapat, South Tunggul, Lubuk Sikaping, Tigo Nagari, Bonjol, and Simpang Alahan Mati.

5. CONCLUSION

From the research conducted, it can be concluded that the area of the disaster-prone area has an area of approximately 1.07 km² of the area of Pasaman Regency. Meanwhile, the moderately vulnerable area covers approximately 2.30 km², while the non-vulnerable area covers approximately 0.96 km² of Pasaman Regency. The moderately vulnerable area is larger than the vulnerable and safe areas.

6. REFERENCES

- [1] Adityawarman, A., Sultan, I., & Supratomo. (2015). Analisis Komunikasi Partisipatif Masyarakat Pada Pelaksanaan Musyawarah Perencanaan Pembangunan (Musrenbang) Desa Resapan Banjir. *Jurnal Komunikasi KAREBA*,4(3),226–238.
- [2] <http://journal.unhas.ac.id/index.php/kareba/article/view/623%0Ahttp://journal.unhas.ac.id/index.php/kareba/article/download/623/443>
- [3] Aghajani, H., & Tatem, A. J. (2020). Satellite-based flood detection using SAR and optical imagery in Google Earth Engine. *International Journal of Remote Sensing*, 41(21), 8221-8238.
- [4] Assidiq dan Rokhmana (2021) Polarisasi pemancaran gelombang microwave sensor
- [5] BNPB, keursakan akibat bencana banjir indonesia (2022)
- [6] Buchhorn, M., Langers, F., & Tellman, B. (2019). Automated flood detection in near real-time using satellite imagery. *ISPRS Journal of Photogrammetry and Remote Sensing*, 153, 30-40.
- [7] Budiarto, F. A. (2023). Analisis Spasial Wilayah Banjir dan Area Terdampak Menggunakan Citra Sentinel-1 SAR dan Change Detection Approach Berbasis Platform Google Earth Engine (Studi Kasus: Banjir Kabupaten Aceh Utara 2022). Institut Teknologi Sepuluh Nopember.
- [8] Bioresita, F., Ngurawan, M. G. R., & Hayati, N. (2021). Identifikasi Sebaran Spasial area Banjir Memanfaatkan Citra Sentinel-1 dan Google Earth Engine (Studi Kasus: Banjir Kalimantan Selatan). *Geoid*, 17(1), 108-118.
- [9] Elachi & van Zyl (2006) Synthetic Aperture Radar Understanding technology
- [10] Fadillah, A. (2022). Deteksi area Banjir Menggunakan Google Earth Engine pada Daerah Aliran Sungai Serayu. Universitas Jenderal Soedirman.
- [11] Ghosh, S., et al. (2020). Remote sensing for flood monitoring using Sentinel-1 SAR data. *Journal of Hydrology*