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Spatial Analysis of Modeling Potential Flood Areas in Padang City using Google Earth Engine

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ABSTRACT

Flooding in Indonesia tends to increase from year to year, and one of the causes is high rainfall. Padang City is one of the areas that has high rainfall intensity which can trigger flooding. This research aims to present spatial information on flood-prone areas by processing data in Google Earth Engine (GEE) and determine the level of flood vulnerability in Padang City. GEE is a platform capable of processing geopatial data on a large scale using multi-temporal imagery and utilizing cloud computing technology that allows solving large problems in a short time. This research uses CHIRPS Dayli data: Climate Hazard Group Infrared Precipitation, NASA SRTM Digital Elevation 30 m, Sentinel 2-A and research administrative boundaries. This study uses rainfall, elevation, TPI, NDWI and NDVI parameters. Data analysis and processing in this study were fully carried out in GEE. The results showed that the area very prone to flooding has an area of 5569.46 ha or 8.03%. The prone area is 28064.57 ha or 40.46% and the non-prone area is 35726.20 ha or 51.51%. The results of this research are expected to help the government in flood mitigation in Padang City.

Keywords: *Padang; Flooding; Google Earth Engine; Geopatial; Imagery Satellite*

INTRODUCTION

One of the natural disasters that often occurs in Indonesia is flooding. Indonesia is a country that has a variety of different landforms (relief). This causes some areas in Indonesia to experience frequent floods that can cause losses, both life and property. Floods in Indonesia tend to increase from year to year [1]. With the increase in flood disasters, the losses that will be incurred will also increase.

Padang City is one of the areas that has high rainfall intensity. This is because Padang City is located in the western part of Bukit Barisan, where this area has a wet climate, compared to the climate of Bukit Barisan in the east [2]. The very high rainfall and the topographical condition of the Padang City area, which is mostly very steep, can trigger landslides and floods. These potential hazards, if not realized from the start, will cause huge losses, both life and material.

The use of GEE in analyzing flood vulnerability can provide real-time information that is critical for dealing with flood threats. One of the benefits of GEE is that it provides easy access to a variety of regularly updated data and satellite images that can be used to monitor areas in real-time. In addition, GEE can create flood simulations and has open data access

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where the results of the analysis can be shared more easily with the public [3].

METHODS

This research was conducted in Padang City, West Sumatra Province. In this study using CHIRPS daily data: Climate Hazard Group Infrared Precipitation, NASA SRTM Digital Elevation 30 m, Sentinel-2 MSI: MultiSpectral Instrument, Level 2-A and research administrative boundaries in SHP format. CHIRPS (Climate Hazards Group Infrared Precipitation with Stations) is a type of combined satellite data from multi-satellite and ground station rainfall observations developed by the United States Geological Survey (USGS) and the University of California, Santa Barbara. CHIRPS satellite data is available from 1981 to the present. CHIRPS is a dataset that measures global rainfall with a high resolution of 0.05° or 5.56 km [4]. CHIRPS is used to explore the spatial and temporal variability of rainfall over different types of land cover.

SRTM DEM (Shuttle Radar Topography Mission DEM) is a data product released by NASA (National Aeronautics and Space Administration) in collaboration with NGA (National Geospatial Intelligence Agency). The SRTM Digital Elevation 30 m dataset has a 1-arc (30 m) resolution that provides data on the elevation of the earth's surface [5]. The SRTM Digital Elevation 30 m data was also explored to obtain information on land elevation and TPI (Topographic Position Index), which shows the relative location of a pixel to the surrounding elevation, whether lower or higher.

Imagery data produced by Sentinel-2 is very useful for remote sensing applications such as vegetation monitoring, land use mapping, water quality monitoring and others. MSI sentinel-2 level 2A satellite imagery has undergone radiometric and atmospheric corrections resulting in higher quality images. The sentinel-2A satellite data has been calibrated and corrected based on factors such as illumination, atmosphere and geometry which provides more accurate results that can be used for mapping analysis. This satellite data is publicly available and can be accessed through the Google Earth Engine platform. This data is used for NDWI (Normalized Difference Water Index) and NDVI (Normalized Difference Vegetation Index) analysis. Details of the data can be seen in the image below:

Figure 1 . a) CHIRPS daily: Climate Hazard Group Infrared Precipitation, b) NASA SRTM Digital Elevation 30 m, c) Sentinel-2 MSI: MultiSpectral Instrument, Level 2-A

The three types of data were fully processed and analyzed using the Google Earth Engine platform. This study used the following parameters: rainfall, elevation, TPI, NDWI and NDVI. All parameters were then scored and weighted, which were then overlaid. The results of the analysis of flood areas in Padang City were then classified into three classes, namely the classes of not prone, prone and very prone.

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RESULTS AND DISCUSSION

Rainfall

Rainfall has a high influence on the occurrence of flooding because it can trigger the overflow of river water which can cause inundation of water in low absorption areas.

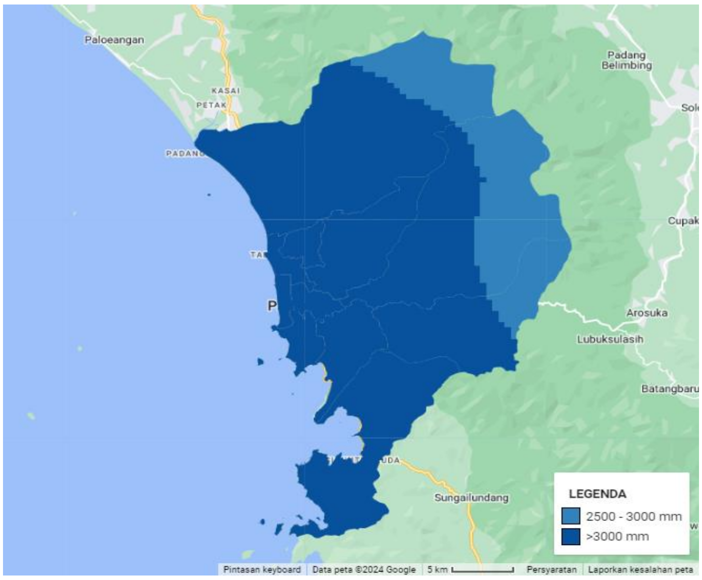

Figure 2. Rainfall of Padang City

Padang City has a very high rainfall intensity category with an average rainfall > 3000 mm / year with an area of 53623 ha or 77%. And rainfall 2500 - 3000 mm with an area of 15725 ha.

Elevation

Elevation refers to the height of a particular location above sea level. Elevation has a profound influence on the likelihood of flooding.

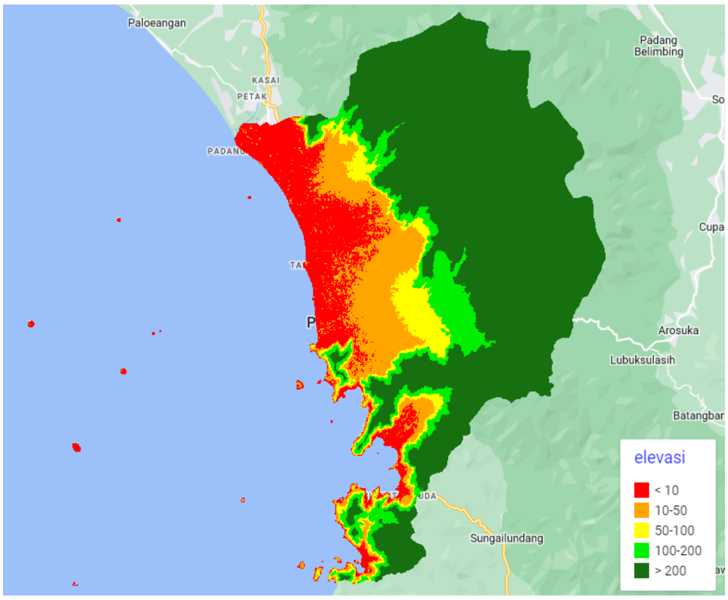

Figure 3. Elevation of Padang City

Table 1. Elevation data

No	Elevation	Area (ha)
1	< 10	8679
2	10-50	8781
3	50-100	4089
4	100-200	6079
5	>200	41805

From the classification results, elevation shows that 60% of the Padang City area has a high elevation of more than 200m. Areas that have low elevation have a high potential to trigger flooding. This is due to the water flow that tends to flow to lower areas. Based on this finding, it can be concluded that Padang City is dominated by high areas where the water flow rate is faster in this area during the rainy season, causing inundation of water in the lowlands.

TPI (Topography Position Index)

The range of TPI values varies from positive to negative. If the TPI value is close to 0, then the area can be considered flat, and for TPI values greater than 0 (positive value), the area tends to be hilly. Areas with TPI values less than 0 (negative values) tend to be valleys [6].

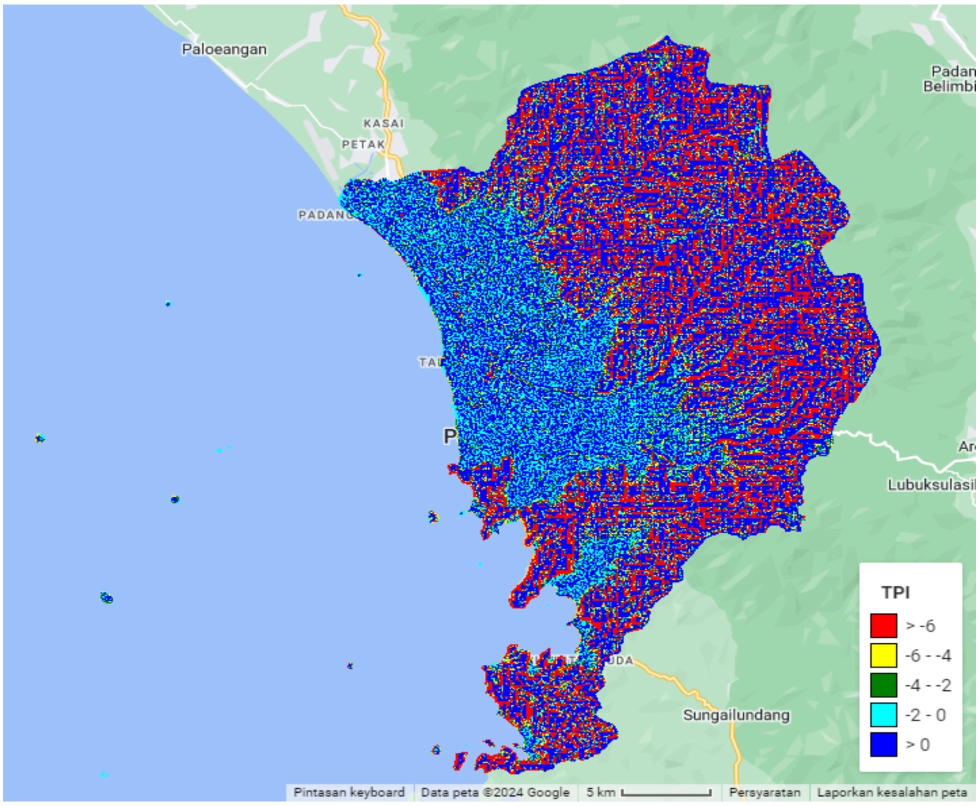

Figure 4. TPI of Padang City

In the figure it can be seen that the topographic position index > 0 which shows that Padang City is dominated by hills with an area of 33,354 ha or 48%.

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Table 1. TPI

No	TPI	Area (ha)
1	> 0	33354
2	-2 - 0	9965
3	-4 - -2	6771
4	-6 - -4	4357
5	< -6	14807

NDWI

NDWI can help in identifying wet areas that have a high degree of presence. NDWI values range from -1 to +1 where values from -1 to 0 indicate areas with vegetation or no water content, while values greater than 0 indicate the presence of water objects.

Table 2. NDWI Classification

Class	NDWI value	Wettness level
1	-1 < NDWI < 0	Non-water body
2	0 < NDWI < 0.33	Moderate wetness
3	0.33 < NDWI < 1	High wetness

From the results of NDWI processing, Padang City is classified into three classes: high wetness class with a coverage area of 69 ha or 0.099%, followed by medium wetness of 134 ha or 0.193% and non-water bodies covering 69230 ha or 99.708%.

NDVI (Normalized Difference Vegetation Index)

Vegetation is also influential in flood vulnerability modeling. Areas with dense vegetation are less vulnerable than areas that are barren, or unable to absorb water. Vegetation can be evaluated using NDVI (Normalized Difference Vegetation Index). The output for NDVI ranges from -1 to 1, where high green vegetation has a value between 0.8-0.9. The absence of green vegetation has a value close to 0 and water has a value close to -1 [8]. Positive values indicate the presence of denser vegetation while negative values indicate the presence of water or open land.

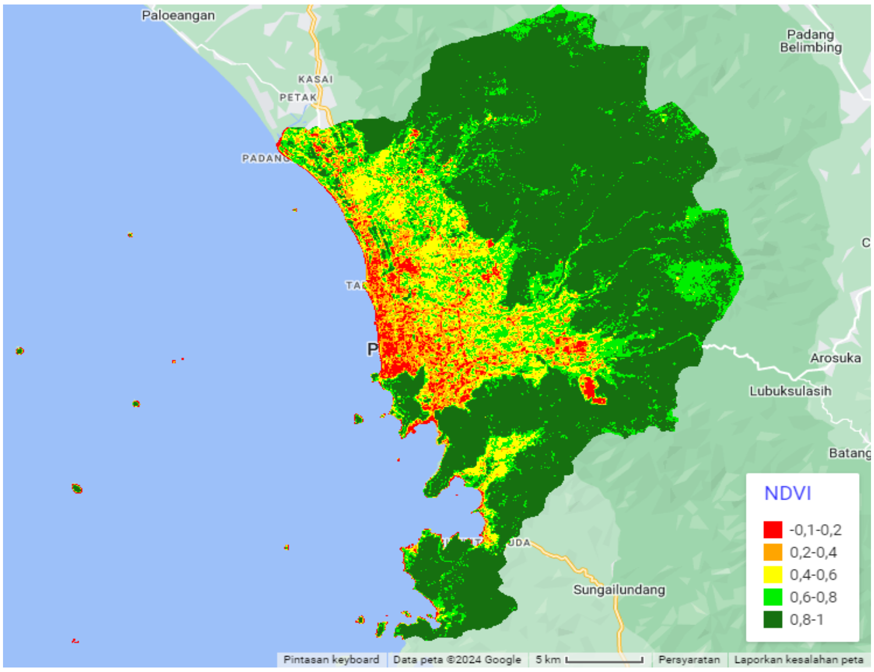

Figure 5. NDVI of Padang City

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The NDVI results show that most of Padang City is dominated by very dense vegetation covering an area of 45414 ha or 65%, followed by areas of dense vegetation of 16%, moderate vegetation 8%, sparse vegetation 5% and non-land cover 6%.

Table 3. NDVI

No	class NDVI	Area (ha)
1	< 0,2	45414
2	0,2 - 0,4	10710
3	0,4 – 0,6	5754
4	0,6 – 0,8	3530
5	> 0,8	4025

Flood vulnerability

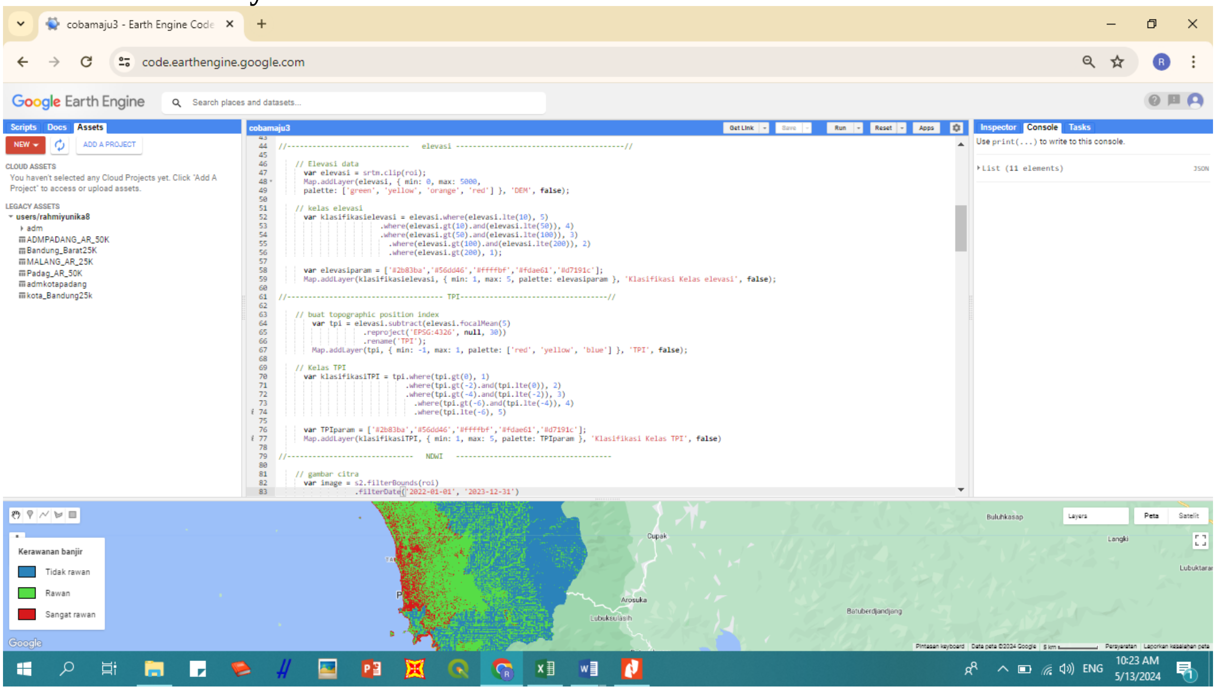

Figure 6. Display of Data Analysis Process in Google Earth Engine

The flood prone map is obtained from the overlay and weighting of each parameter. Rainfall parameters (30% weight), elevation (20% weight), TPI (20% weight), NDWI (15% weight) and NDVI (15% weight). The results of flood vulnerability analysis in Padang City using Google Earth Engine show that the area in the non-vulnerable class is 35726.2 ha or 51.51%, the area in the vulnerable class is 28064.57 or 40.46%, the area in the highly vulnerable class is 5569.46 ha or 51.51%. Details of the level of flood vulnerability can be seen in the figure below.

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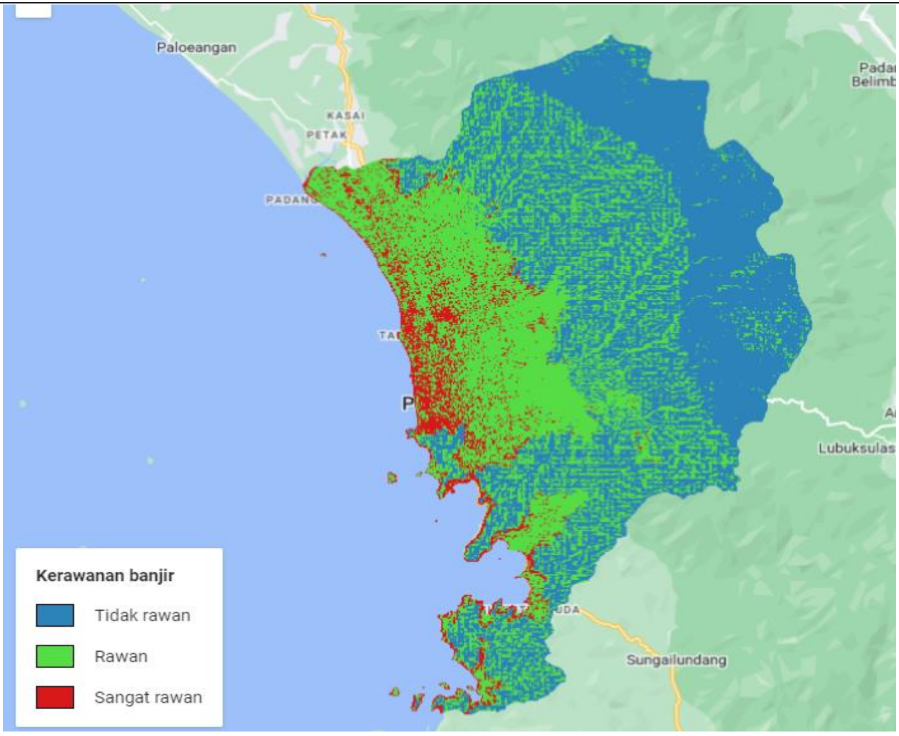

Figure 7. Level of Flood Vulnerability in Padang City

Based on the flood prone class level, Koto Tangah sub-district is the sub-district with the largest flood hazard level of 1639.699 ha, West Padang sub-district of 375.25 ha, Pauh sub-district of 46.17 ha, Kuranji sub-district of 557.369 ha, Lubuk Kilangan sub-district of 73, 12 ha, East Padang sub-district covering 339.80 ha, South Padang sub-district covering 441.10 ha, Lubuk Begalung sub-district covering 488.13 ha, Bungus Teluk Kabung sub-district covering 766.07 ha, North Padang sub-district covering 473.39 ha, Nanggalo sub-district covering 399.32 ha.

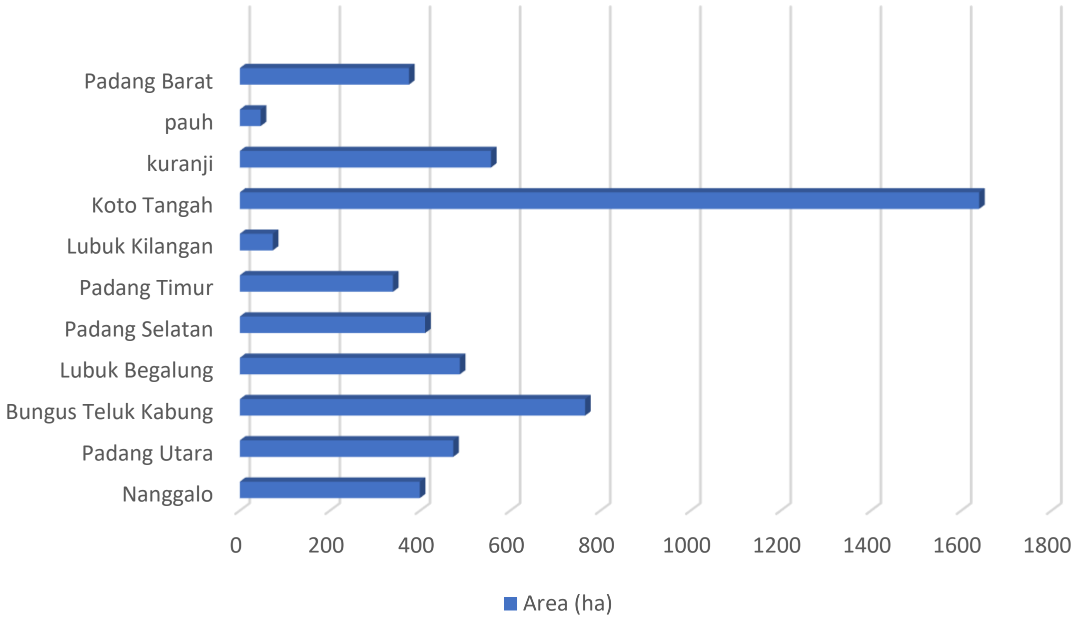

Figure 8. Graph of Very Prone Flood Vulnerability Level in Padang City

Flood vulnerability is a measure of how prone an area is to flooding. It is important in flood disaster management, and helps the government to understand how an area is affected by flooding. The use of GEE can provide information for the Padang City government to take action in the face of flood threats, as well as assist in planning spatial planning, flood management and flood disaster mitigation.

Google Earth Engine is one of the sophisticated and useful tools in flood mitigation. In flood vulnerability analysis Google Earth Engine provides easy access to regularly updated satellite imagery data, including high-resolution imagery for real-time monitoring, which is critical for understanding environmental changes that can affect flood ranges. In addition, it can also be used for the development of flood early warning systems by utilizing real-time weather data and flood modeling.

CONCLUSION

Based on the results of the analysis using Google Earth Engine, the following conclusions can be drawn:

1. Padang City is grouped into three classes of flood hazard vulnerability levels, namely: very vulnerable, vulnerable, not vulnerable. From the grouping results, the highly vulnerable class is 8.03% with an area of 5569.46 ha, followed by a vulnerable area of 40.46% or 28064.57 ha, not vulnerable by 51.51% or 35726.2 ha.
2. Koto Tangah sub-district is the most vulnerable area to flooding with an area of 1639.69 ha.
3. The use of Google Earth Engine makes work faster and provides real-time information for the government or stakeholders in flood mitigation.

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