Journal of Data Analytics, Information, and Computer Science (JDAICS)
Volume 1, No 2 – April 2024
e-ISSN : 3032-4696

APPLICATION OF REMOTE SENSING DATA AND GEOGRAPHIC INFORMATION SYSTEM FOR FLOOD MODELING IN WAI RUHU WATERSHED AMBON CITY BASED ON GEOGLE EARTH ENGINE

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Received: 15-04- 2024	Revised: 20-04-2024	Approved: 29-04-2024

ABSTRACT
Flood hazard modeling in watersheds is an important step in natural disaster risk mitigation, especially in vulnerable areas such as Ambon City. This research focused on the Wai Batu Gantung, Wai Batu Gajah, Wai Tomu, Wai Batu Merah, and Wai Ruhu watersheds, using JRC Global Surface Water Mapping Layers data, NASA SRTM Digital Elevation 30 m data, and USGS Landsat 8 Level 2, Collection 2, Tier 1 data analyzed on the Google Earth Engine (GEE) platform. Prediction of built-up land in flood-prone areas was conducted by utilizing flood history analysis, hydrological modeling, and flood zone mapping. The results show that flood hazard modeling provides a better understanding of flood risk, assists in the development of safer land use planning, and increases public awareness of flood risk in Ambon City. It is hoped that the results of this research can contribute to flood risk management and sustainable regional development in the future.
Keywords: *Flood, Wai Ruhu Watershed, Google Earth Engine*

INTRODUCTION

Climate change in Indonesia, including an increase in the frequency of hydrometeorological disasters such as floods, is a serious phenomenon that requires serious attention from the government, academics or researchers as well as from the community [1]. Indonesia, which is located in the tropics with a climate that already tends to be wet, increased rainfall intensity can result in more frequent flooding [2]. Heavier and longer rains can cause rivers to overflow, drainage channels to clog, and waterlogging in urban and rural areas [3], [4].

The history of flooding in Ambon City shows that flooding is a frequent problem in the city, especially during the rainy season [5]. Flooding occurs almost every year and the intensity of its impact has increased rapidly in recent decades [6]. Ambon City has a potential flood extent that is in the medium class and the potential exposed population is in the high class, so the flood risk in this city is quite significant [7]. By understanding the history of flooding and the factors that influence it, it is expected that flood mitigation and management measures in Ambon City can be continuously improved to protect the community and city infrastructure from the impact of flood disasters [8].

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In Ambon City, the Wae Ruhu watershed has experienced severe flooding over the past three years (2021, 2022, 2023), resulting in major damage to infrastructure and houses. Based on reports, there were at least 7 flood points and 13 landslide points that occurred, causing damage to 79 houses and 2 residents died. In addition, there were broken walls and fallen trees in several locations, showing the considerable impact of these natural disasters. Flood and landslide casualties in Ambon include damage to infrastructure, such as bridges and girders, as well as damage to people's homes, demonstrating the importance of effective and rapid disaster management efforts.

Factors affecting flood risk in the Wai Ruhu watershed are complex. These include topographic conditions, land use patterns, rainfall intensity, and suboptimal drainage [9]. The limited data and information available is often an obstacle in conducting an in-depth analysis of the flood dynamics in the area [10]. Flooding in the Wai Ruhu watershed, Ambon City is often caused by high rainfall [11]. High rainfall above normal can cause the drainage system, which consists of natural rivers and creeks as well as drainage channel systems and artificial flood storage canals, to be unable to accommodate the accumulated rainwater. As a result, there is an overflow of water that covers the surrounding environment.

In addition to natural factors, human influence also contributes to the occurrence of floods [12]. For example, siltation of rivers at certain points on both rivers can result in overflows in most river areas, especially downstream [13], [14]. Technological advances, especially in the fields of remote sensing and geographic information systems (GIS), provide new opportunities for flood modeling and mapping with higher accuracy [15]. Google Earth Engine is a cloud-based platform developed by Google that allows users to analyze and visualize large amounts of geospatial data [16]. The platform provides access to a wide range of satellite imagery and other Earth observation data, allowing users to perform sophisticated geospatial analysis at a large scale [17].

Google Earth Engine (GEE) has outstanding capabilities for flood analysis by providing access to various satellite image datasets such as Landsat and Sentinel, advanced geospatial analysis tools, and large-scale data processing capabilities [18]. With GEE, users can map submerged areas, monitor changes in flood extent over time, develop flood prediction models, and perform flood risk analysis with multi-source data integration [15]. The platform also enables interactive visualization of flood analysis results in the form of maps that facilitate interpretation and communication of flood-related information [19]. With the combination of these features, Google Earth Engine becomes a very effective tool in helping stakeholders to better understand, manage and respond to floods. Based on the above background, this research aims to determine the results of flood modeling of the Wai Ruhu watershed in Ambon City using Google Earth Engine.

RESEARCH METHODS

This research was conducted in the Wai Ruhu watershed, Ambon City. This research uses JRC Global Surface Water Mapping Layers data, v1.4, NASA SRTM Digital Elevation 30m data, and USGS Landsat 8 Level 2, Collection 2, Tier 1 data analyzed on the Google Earth Engine (GEE) platform. Google Earth Engine is a cloud computing platform developed by Google for large-scale geospatial data analysis and processing [20].

By providing access to a wide range of satellite image datasets and powerful geospatial analysis tools, Google Earth Engine enables users to perform modeling, mapping, and monitoring of the earth's environment with high efficiency [21]. The platform facilitates temporal and spatial analysis, predictive model building, and interactive visualization of geospatial data, making it a very useful tool for researchers, scientists, and practitioners in various fields to run complex geospatial analyses without the need to download or process data locally.

The variables used in this study consisted of distance from river, Normalized Difference Water Index (NDWI), elevation, Topographic Position Index (TPI) and Normalized Difference Vegetation Index (NDVI), all of which were analyzed on the Google Earth Engine (GEE) platform; https://earthengine.google.com.

JRC Global Surface Water Mapping Layers data in Google Earth Engine (GEE) can generate Normalized Difference Water Index (NDWI) data which is very important for flood analysis [22]. NDWI is an index used to monitor and identify water surfaces, including rivers, lakes and other bodies of water [23]. By utilizing NDWI data from JRC, researchers and practitioners can accurately and quickly identify waterlogged areas during flood events. This information is essential for flood monitoring, mapping and risk management, enabling relevant parties to respond quickly and effectively in emergency situations and plan appropriate mitigation measures to reduce the impact of future floods [24].

NASA SRTM Digital Elevation 30m data and USGS Landsat 8 Level 2 data are used to generate elevation and TPI (Topographic Position Index) which are important in flood analysis. Elevation data from SRTM allows for accurate topographic modeling, while Landsat 8 Level 2 data can be used to extract information on land texture and structure that affect surface water flow [25]. By utilizing both, users can identify low areas susceptible to inundation during floods and determine the relative topography of an area to its surroundings through TPI, thus providing more comprehensive insights in anticipating and managing flood risks [24].

USGS Landsat 8 Level 2, Collection 2, Tier 1 data in Google Earth Engine (GEE) provides Normalized Difference Vegetation Index (NDVI) data that is critical for flood analysis. NDVI is an index used to measure the amount and quality of vegetation in an area based on the reflectance of near infrared and red light from the ground surface. Using NDVI data from Landsat 8, researchers and practitioners can evaluate the state of vegetation before and after flooding, which provides valuable insights into the impact of flooding on ecosystems [26]. This information can be used to evaluate environmental damage, plan habitat restoration, and identify areas that may experience soil erosion or flooding after a flood event, enabling more precise and effective mitigation and adaptation efforts [27].

These variables are considered important in this study because, distance from the river is relevant as areas closer to the river tend to be more vulnerable to flooding. NDWI provides a clear visual indication of waterlogged areas, while elevation enables water flow modeling and identification of low areas prone to inundation [28]. TPI provides an understanding of the relative topography of an area, while NDVI provides information on vegetation that can affect drainage and water absorption. The use of GEE allows for efficient processing and analysis of these data, enabling faster and more informed decision-making in flood risk mitigation and adaptation.

All variables were then given weights and values before being overlaid on the Google Earth Engine (GEE) platform to produce flood-prone areas and then overlaid with data on the distribution of built-up land in the Wai Ruhu watershed to determine settlements that are predicted to be affected by flooding in the Wai Ruhu watershed, Ambon City. The whole process of analyzing flood-prone areas was carried out on the Google Earth Engine (GEE) platform with a modified script based on previous research [29].

RESULTS AND DISCUSSION

Flood Vulnerability Level

Flood vulnerability is defined as the level or severity of potential flood risks that can occur in an area. The level of flood vulnerability reflects how vulnerable the area is to flooding based on the physical, hydrological, social, economic and infrastructure characteristics of the area. Factors such as extreme rainfall, topography, land use, drainage systems and river conditions can affect the level of flood vulnerability of an area.

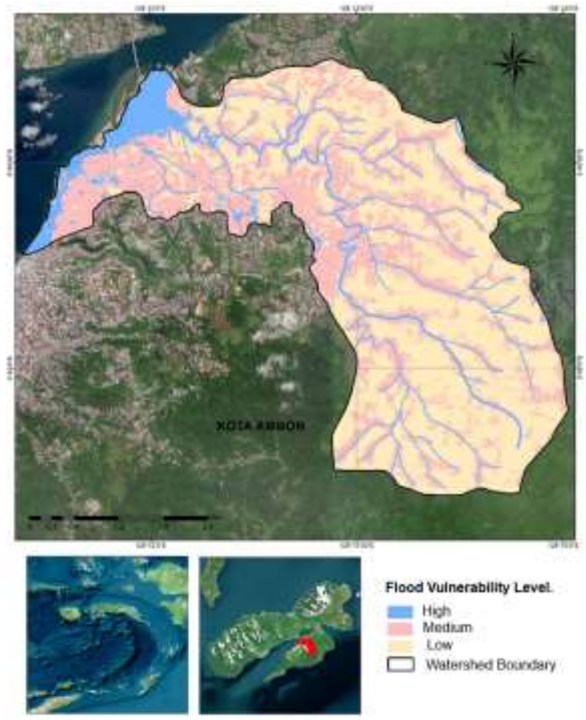

Figure 1. Map of the level of vulnerability in the Wae Ruhu watershed

The results of the analysis of the flood vulnerability level of the Wai Ruhu watershed on the Google Earth Engine (GEE) platform show that the area with high vulnerability level is 102.43 ha or 5.28%, the area with moderate vulnerability level is 761.66 ha or 39.30% and the high vulnerability level is 1074.07 ha or 55.42%. The map of flood vulnerability levels can be seen in Figure 1. Flood vulnerability assessments are important to assist in planning for flood risk mitigation, developing early warning systems, and improving flood preparedness. By understanding flood vulnerability, stakeholders can identify vulnerable areas and take preventive or adaptive measures to reduce the adverse impacts of flooding.

Prediction of built-up land located in flood-prone areas in the Wae Ruhu watershed

Prediction of residential areas affected by flooding is the process of estimating areas around rivers or other flood-prone areas that are likely to be inundated or affected during a flood. The results of the analysis of the flood vulnerability level of the Wai Ruhu watershed on the Google Earth Engine (GEE) platform are then overlaid with built-up land data extracted from Normalized Difference Vegetation Index (NDVI) data which shows that residential areas are located in flood-prone areas. The analysis results show that settlements predicted to be in high flood vulnerability areas are 95.85 ha or 22.54%, settlements predicted to be in moderate flood vulnerability areas are 263.78 ha or 62.02% and settlements predicted to be in low flood vulnerability areas are 65.71 ha or 15.45%. Spatially, built-up land areas located in flood-prone areas in the Wae Ruhu watershed can be seen in Figure 2.

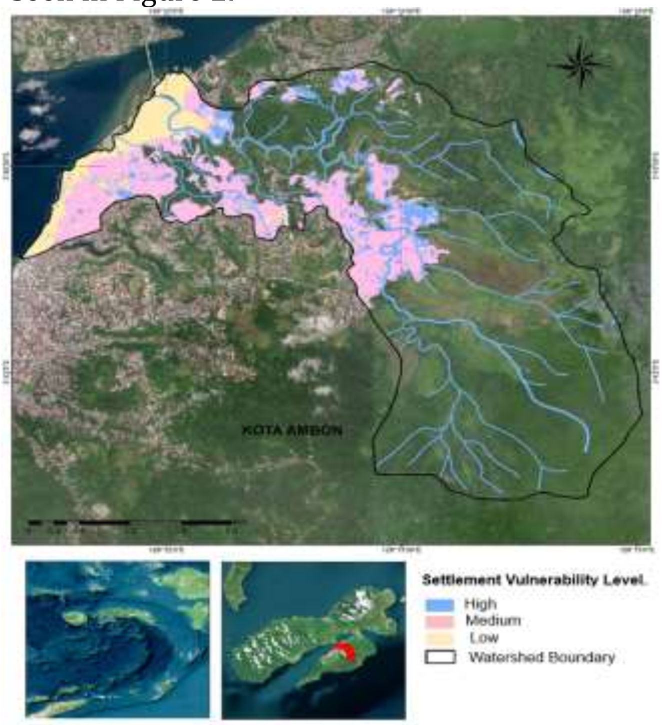

Figure 2. Map of Flood Affected Settlements

By utilizing geospatial data, satellite imagery, and mapping technologies such as Google Earth Engine, researchers and practitioners can develop prediction models that can estimate residential areas potentially affected by flooding. These predictions are important to assist stakeholders in planning flood risk mitigation, identifying areas that require special attention, and taking preventive measures to protect communities and critical assets from the impacts of flooding.

Flood modeling in the Wai Ruhu watershed in Ambon City using Google Earth Engine has several benefits. Here are some of the benefits:

1) Natural Resources Management: Flood modeling can assist in natural resource management by understanding the patterns and dynamics of land cover change [30],. This is important for planning sustainable land use and reducing the risk of flood damage.
2) Watershed Management Planning: By understanding the patterns and dynamics of land cover change, flood modeling can assist in more effective watershed management planning.
3) Raising Awareness and Understanding: Flood modeling can increase public awareness and understanding of flood risks and the importance of natural resource planning and management [31], [32]. This is important for reducing the negative impacts of flooding and improving people's quality of life.
4) Development of Risk Reduction Strategies: With the data and analysis obtained from flood modeling, governments and communities can develop more effective flood risk reduction strategies [33], [34]. This is included in the case study of Teluk Ambon Baguala Sub-district, Ambon City, which shows the importance of spatial analysis of flood vulnerability levels.
5) Infrastructure and Policy Development: Data and analysis from flood modeling can be used to develop better infrastructure and policies in dealing with and reducing flood risks [35]. This includes mapping flood-prone areas in Batumerah Village, Sirimau Sub-district, Ambon City using GIS.

Overall, flood modeling in the Wai Ruhu watershed of Ambon City using Google Earth Engine can provide significant benefits in natural resource management, watershed management planning, increasing awareness and understanding, developing risk reduction strategies, and developing better infrastructure and policies.

CONCLUSION

This research provides an in-depth understanding of flood vulnerability in the region, demonstrating that flood modeling can be an effective tool in planning flood risk mitigation, raising public awareness, and developing better risk reduction strategies and infrastructure. By utilizing geospatial and mapping technologies such as Google Earth Engine, researchers and practitioners can identify areas vulnerable to flooding, provide a basis for sustainable natural resource management planning, and assist in efforts to protect communities and critical assets from the impacts of flooding in Ambon City.

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