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FLASH FLOOD (Δ) RISK AND DAMAGE ASSESSMENT IN BATU, EAST JAVA

PENILAIAN RISIKO DAN KERUSAKAN BANJIR FLASH (Δ) DI BATU, JAWA TIMUR

Dekka Putra*, Bahrul Sofwany, Hukma Zulfinanda,* and *Iqbal Kamaruddin

School of Architecture, Planning, and Policy Development, Institut Teknologi Bandung
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ABSTRAK

Bencana hidrometeorologi menunjukkan tren yang meningkat di Indonesia. Banjir bandang merupakan bagian dari bencana hidrometeorologi yang terindikasi berdampak signifikan terhadap mata pencaharian. Banjir bandang dipicu oleh intensitas hujan yang ekstrim, beberapa tindakan mitigasi yang dapat dilakukan dengan sistem peringatan dini, pemetaan bahaya dan risiko, kesiapsiagaan masyarakat, dan adaptasi perubahan iklim. Berdasarkan peryataan tersebut, bagaimana pengaruh tata guna lahan ke depan, dan seberapa besar kerugian akibat bencana banjir bandang di Kota Batu? Salah satu bencana hidrometeorologi yang terjadi di Indonesia adalah Banjir Bandang Batu. Banjir Bandang Kota Batu terjadi pada tanggal 4 November 2021. Banjir bandang berdampak banyak di berbagai lokasi, antara lain di Kecamatan Bumiaji dan Kecamatan Junrejo. Berdasarkan catatan sejarah bencana, banjir bandang di Batu hanya terjadi satu kali, namun dampak yang ditimbulkan cukup besar karena banyaknya rumah terdampak yang berada di tengah-tengah Desa Bulukerto. Berdasarkan dampak yang ditimbulkan, hal tersebut dapat menjadi dasar upaya pengendalian pola tata ruang Kota Batu di masa yang akan datang. Metodologi yang digunakan dalam penelitian ini adalah risk assessment. Sedangkan kajian risiko terkait delta (Δ) kajian risiko banjir bandang dalam pencegahan spatiotemporal menggunakan rencana tata ruang 2030 untuk prediksi delta (Δ), yang nantinya dapat memprediksi akibat perubahan iklim dan bencana meteorologi dari banjir bandang di Batu. Hasil dari penelitian ini adalah delta (Δ) risiko banjir bandang dan penilaian kerusakan banjir bandang yang terjadi di Batu.

Kata Kunci: *Perubahan Iklim; Bencana Hidrometrologi; Banjir Bandang; Perubahan Lahan; Kajian Kerusakan.*

ABSTRACT

Hydrometeorological disasters are showing an increasing trend in Indonesia. Flash floods are part of a hydrometeorological disaster that has a significant livelihood impact. Flash Flood is triggered by the intensity of extreme rain, several actions of mitigation can be taken by early warning systems, hazard and risk mapping, community preparedness, and climate change adaptation. So, how does future land use have an impact, and how much loss will result from the flash flood disaster in Batu City? The hydrometeorological disaster that occurred in Indonesia was the Batu Flash Flood. The Flash Flood occurred on November 4, 2021. The flash flood has a lot of impact on many locations, including the Bumiaji District and Junrejo District. Based on the disaster history recorded, the flash flood in Batu has only happened once, but the impact was quite big because there are many houses in the midstream of Bulukerto. Based on the losses caused, this can be the basis for efforts to control the spatial pattern of Batu City in the future. The methodology used in this study is risk assessment. While the

*Corresponding author: 25421055@mahasiswa.itb.ac.id

risk study related to delta (Δ) the study of flash floods risk in spatiotemporal prevention uses the 2030 spatial plan for delta prediction (Δ), which can later predict the consequences of climate change and meteorological disasters from flash floods in Batu. The results of this study are the delta (Δ) of flash flood risk and the damage assessment of the flash flood that occurred in Batu.

Keywords: *Climate Change; Hydrometeorological Disasters; Flash Flood; Landuse Chang; Damage Assessment.*

INTRODUCTION

Climate change that occurs, can affect the high increase in rainfall [1]which is in northeastern China. From 1965 to 2014, there were twenty-four TCs ranging from severe tropical storm to super typhoon over Hadahe River basin in twenty years. General Circulation Models (GCMs. The increase in rainfall, which is the impact of climate change, can lead to disasters, one of which is flooding and flash floods [2]. A flash flood is a natural disaster phenomenon that has high destructive power and can cause damage to settlements and infrastructure, loss of property, and loss of life [3]. Flash floods are caused by high rainfall in a short time [4]in particular to buildings and infrastructure due to its fast occurrence and high magnitude in financial loss. Risk assessment of the flash flood identify the critically flood-prone areas and provide assistance in improving the resiliency of mitigation plans. In this study, we developed an assessment of flood susceptibility, vulnerability, the impact of socio-economic, and integrated flash flood index based on the historical data of flood events recorded in Kuala Lumpur. Data of rainfall characteristics, inundated location, and areas are extracted from the reports of flood events from the year 2005-2015. Each event is then segregated according to the place of incidence, providing point-based recurrence of flood at each identified location. Indicators of assessment include frequency and month of occurrence, rainfall characteristics (of intensity, duration, and depth which in increases water levels or water discharge in rivers. Flash floods are prone to occur in areas that are mountain water catchment areas [3].

Batu City is located at an average altitude of 862 mdpl, so most areas in Batu City have hilly/slope contours. Batu City is an area that has the potential to develop tourism, agriculture, plantations, settlements, services, and industry. The Batu City area is an area that has a role as a conservation area and a protected function area. The economy of Batu City is largely supported by the tourism and agriculture sectors. The residents of Batu City mostly work as farmers; the main agricultural products of Batu City are fruit, flowers, and vegetables. The mainstay plantation product, which is the main commodity of Batu City, is apples. Flash floods in Batu City occurred on November 4, 2021. Flash floods in Batu City occurred due to climate change factors and land conversion that occurred in Batu City where the water catchment area was decreasing, which resulted in insufficient rainwater being absorbed into the ground.

Research on flash floods has been carried out using hazard data based on topography, Aster DEM, meteorology, density river system and socio-economic vulnerability. After that, to know the weight of the multi-criteria hazard and socio-economic vulnerability, it is necessary to carry out an AHP analysis, which will then be overlayed and will produce a risk layer from the Bandung Flood disaster. The formulation of the problem in this research is to know the risk of the flash flood disaster in Batu City, East Java [5].

To assess the risk of flash floods in Yunan Province, using time series data obtained based on crawling satellite image data based on the time of the disaster, which is then compared with existing images. Then to identify the risk of flash floods, using the XGBoost Modebnadal by employing machine learning based on several variables, namely precision, recall, accuracy, F-Score and Kappa. Then later, the location of the risk of flash flood disaster will be obtained from Yunnan Province, China [6]a widely applied technology in preventing catastrophic flash flood disasters,

has become the current research hotspot. However, most existing machine learning methods for assessing flash flood risk rely on a single classifier, which is suitable for processing small sets of sample data, but the resulting prediction accuracy and generalization ability are insufficient. Meanwhile, machine learning methods that integrate multiple classifiers are thus far unknown. Extreme Gradient Boosting (XGBoost.

Because flash floods have high destructive power, a damage assessment is needed to assess how much damage is caused by flash floods. Damage Assessment is a process to assess losses and damage caused by disaster events that have occurred [7]. Damage assessment can also be used as a consideration in making decisions. Damage Assessment contains information on the losses generated by disasters [8].

This research was conducted based on the research problem that has been formulated, namely the occurrence of the phenomenon of climate change in Batu City. In addition, several research questions remain, such as how to describe the risk of flash floods in Batu City based on hazard conditions, the sensitivity and exposure, the vulnerability of flash floods that occur in Batu City, and the risk of flash floods in Batu City itself and how much loss will result from the flash flood disaster in Batu City.

METHOD

This research uses the risk assessment method or risk analysis method. This risk assessment is a method that combines several characteristics and frequency of danger from a certain place or potential losses caused by flash floods. Hazard is a variable that tends to be constant, therefore vulnerability and capacity are variables that can be managed so that the risk value can be small. The calculation of risk assessment can be assessed using the following equation:

$$R = \frac{H\ x\ V\ (E + S)}{C}$$

R = Risk
H = Flood Disaster Hazard
V = Vulnerability (Exposure + Sensitivity)
AC = Adaptive Capacity [9].

This research began with the collection of secondary data in the form of land use map data for the Spatial Planning [10] in 2021 and flash flood hazard data obtained from InaRisk. The required land use data is in the form of shapefiles while flood hazard data is in the form of maps in .tiff format. The primary data collection is carried out by interviewing local experts regarding the weight of vulnerability.

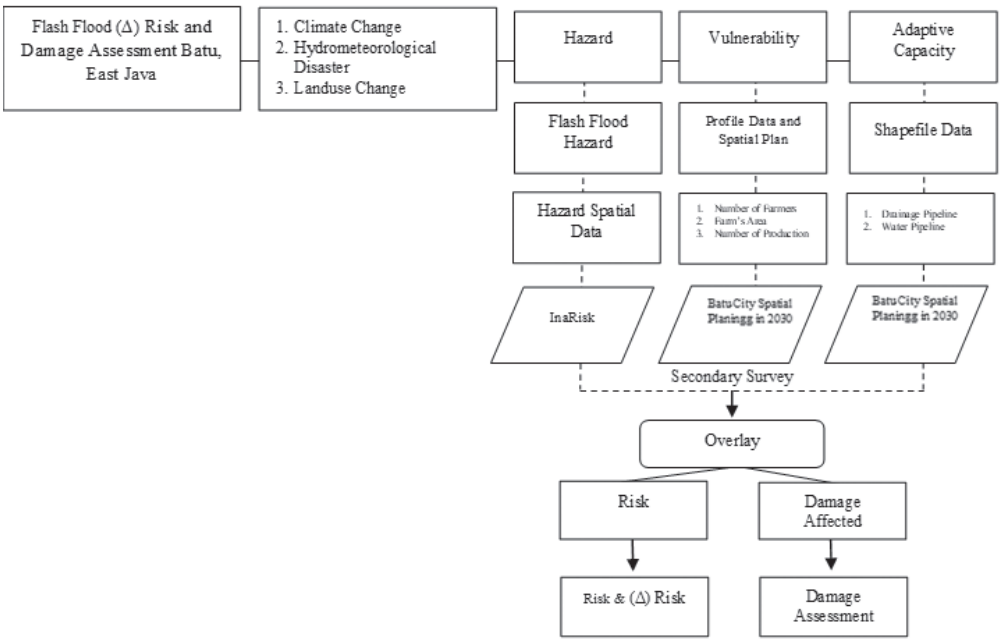
In calculating (Δ) risk, using projected vulnerability data, the vulnerability data in this study is taken from the 2030 Batu City spatial planning, which is used to predict the increase in risk and impact of flash flood disasters. If it is not studied, the risk of flash floods in Batu City will be able to make the impact of flash floods higher in the future.

$$(\Delta)R = \frac{DHx\ SP}{AC}$$

(Δ) R = Delta Risk
H = Disaster History (Flash Flood in November 2021 Batu City)
SP = Vulnerability based on Spatial Planning Batu City 2030
C = Adaptive Capacity [9].

The obtained primary and secondary data will then be subjected to several stages of analysis:

Table 1.
Workflow



Hazard

In the hazard analysis, flash flood hazard data from InaRisk will be classified into three classes ranging from high, low, and medium. Each of these classifications will be given weight and will produce a Flash Flood Hazard Map in Batu City.

Vulnerability

Vulnerability is the level of insecurity or inability to cope with climate change due to climate variability and climate extremes[11]. The variable components and vulnerability analysis indicators will be assessed.

Table 2.
Vulnerability Indicator

No.	**Variables**	**Indicator**
1.	Exposure	Agricultural Land Area
		Number of Farmers
2.	Sensitivity	Types of Agriculture
		Number of Workers
		Agricultural Production
3.	Capacity	Drainage Availability
		Availability of Clean Water

Source: Secondary Data (2022)

Adaptive Capacity

Capacity Analysis describes adaptive capacity as the ability of communities, locations, and infrastructure to adapt to climate change[12]. Adaptive capacity in Batu City as a form of risk reduction for flash flood disasters in the study will be assessed based on the availability of drainage and the availability of clean water.

Risk Assessment

Risk analysis is the last analysis of a series of analyses that have been carried out, including Hazard, Vulnerability, and Capacity analysis. The data that has been generated from the three analyses are then calculated and overlayed to see the classification of the level of risk caused by the Flash Flood disaster in Batu City in 2022.

Damage Assessment

The last is calculating the damage and loss assessment. At this stage, it is to calculate the number of buildings and land, as well as the prediction of losses caused by flash flood risk and (Δ) flood risk. The calculation in the damage assessment uses the overlay method

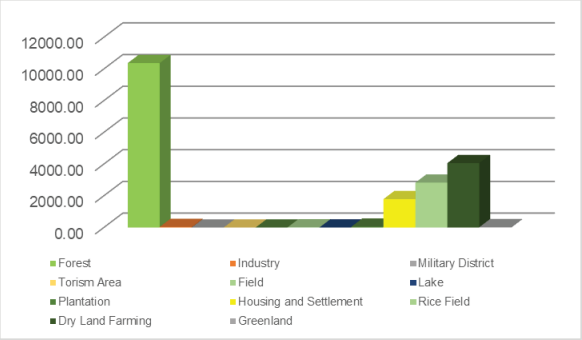
from ArcGIS to find out how much impact it has, and then the value of the loss is calculated based on the standard selling price of land in Batu City in 2022. Damage and Loss Assessment (DaLA) is a methodology for obtaining accurate data on damage and loss caused by a disaster[7]. The position of the DaLA is very important in post-disaster management. The success of a post-disaster recovery program is largely determined by good recovery planning. Good planning begins with accurate data and information. The main objective of post-disaster needs assessment is to measure the scale of the impact of the disaster as soon as possible [13].

RESULT AND DISCUSSION

Batu City is one of the newly formed cities in 2001 as a part of Malang Regency. Previously, the Batu City area was part of the Subunit for Development Area 1, North Malang. The beautiful natural panorama and cool air make Batu City an attractive tourist destination so that the tourism sector is relied on to increase regional income. Batu City residents mostly work as farmers work as farmers and the main agricultural products from Batu City are fruit, flowers, and vegetables. The mainstay plantation product, which is the main commodity of Batu City, is apples. The economy of Batu City is largely supported by the tourism and agriculture sectors. Most of Batu City's GDP growth is supported by the location, which is in a mountainous area, and the rapid development of tourism.

Land Use 2022

Since the city of Batu has been designated as an administrative area and has developed very rapidly since 2021, many agricultural and forest lands are now developed into built-up areas, settlements, and tourism, and have undergone very rapid changes to date.



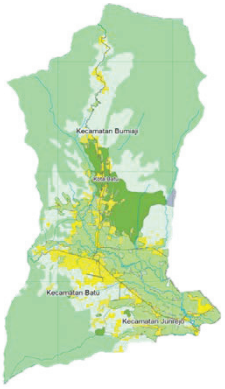
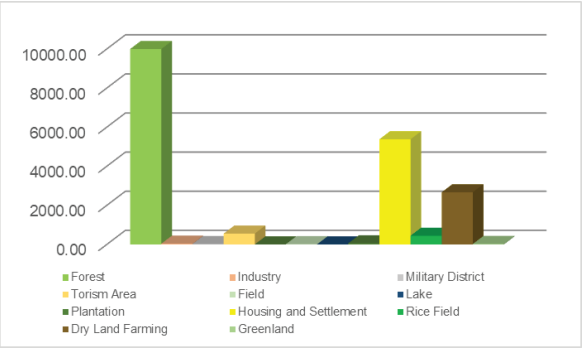


Figure 1.
Batu City Land Use in 2022
Source: Land use (2022).



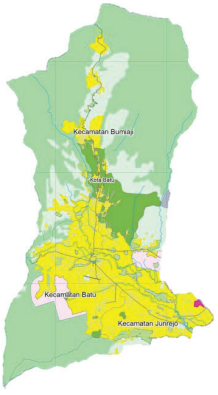
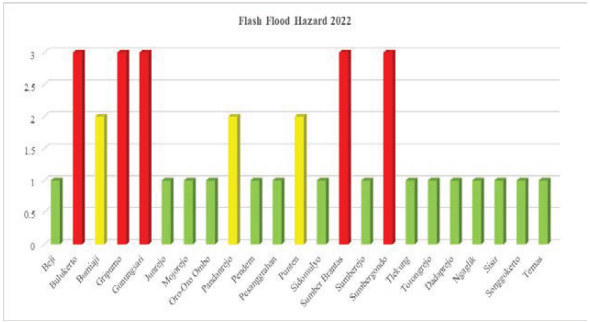


Figure 2.
Batu City Spatial Planning in 2030
Source: Spatial Planning Pattern (2022)

Spatial Planning 2030

The rapid development of Batu City is also stated and planned in the spatial planning of 2030. Many have experienced changes in land use from agriculture and plantations to residential areas and the centre of activities of Batu City.

Climate hazards in an area will be different due to differences in geographical conditions, types of settlements, demographics, and types of infrastructure. The first option is to conduct hazard analysis based on secondary data in the form of disaster maps from authorized agencies, and the second option is to conduct qualitative hazard analysis based on primary data. Based on the results of taking data from InaRisk as a baseline for the Danger of Flash Floods in Batu City, while to get projections of the dangers of flash floods in Batu City, elaboration was carried out by combining the historical data of the last flash flood, namely on November 4, 2021. The extent and classification of flash flood hazards.



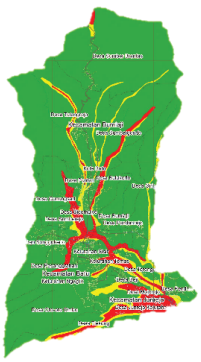
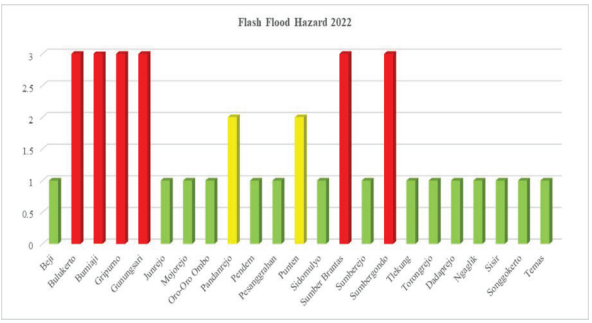


Figure 3.
Flash Flood Hazard 2022
Source: InaRisk 2022



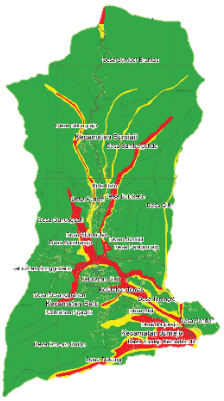


Figure 4.
Flash Flood Hazard 2030
Source: Historical Flash Flood Disaster in November (2021)

High Flash Flood Hazard Classification, located in Bulukerto, Giripurno, Gunungsari, Sumber Brantas, Bumiaji and Sumbergondo; medium classification, Pandanrejo, and Punten. while the rest are in the low classification of flash flood hazards in Batu City.

Vulnerability

Exposure

Vulnerability is a picture of urban internal conditions in the face of the impacts of climate change. This analysis is carried out by determining indicators of indicators and components of regional vulnerability, namely exposure indicators (E), sensitivity (S), and adaptive capacity (AC). Due to data limitations, this analysis uses baseline statistical data in 2022 and uses assumptions from plans made by the Batu City Government as a reference in the 2030 projections.

Based on the location of the hazard and the use of land within the inundation area, it

can be seen in the use of land in 2022 if it has a lot of impact on the agricultural sector. This is the basis for studies in determining the sectors that impact climate change most. The indicators used to identify vulnerabilities are exposure and sensitivity.

Exposure consists of Agricultural Land Area, Number of Farmers. As for the sensitivity of the type of agriculture, the number of workers, and agricultural production. Exposure is a component that depends on the physical conditions of the location or geography based on climatic variations that can be the cause of disaster.

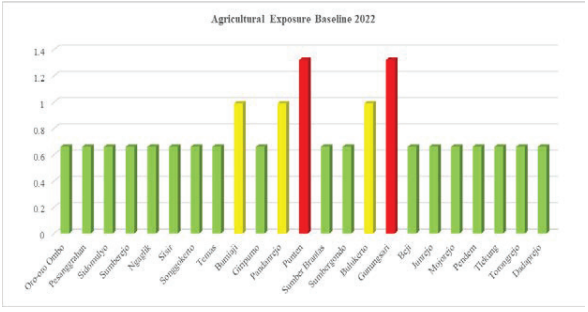


Figure 5.
Agricultural Exposure Baseline 2022
Source: Data Analysis (2022)

The classification of total exposure to the agricultural sector to flash flood disasters in Batu City, for areas with a high classification, consists of Gunungsari and Sumbergondo; for areas with a medium classification, consists of Bulukerto and Giripurno; the rest are in the medium exposure classification.

Meanwhile, the projection of total exposure to flash flood hazards is based on the planned spatial pattern in 2030, which is relatively reduced agricultural land and is projected to become a settlement.

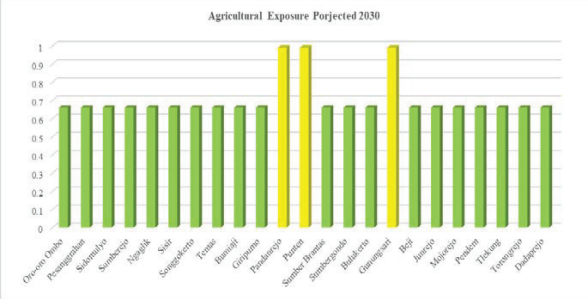


Figure 5.
Agricultural Exposure Projected 2030
Source: Data Analysis (2022).

The classification of the total projected exposure of the agricultural sector to flash flood disasters in Batu City, for areas with a high classification is not identified, while the medium classification consists of Giripurno, Gunungsari, and Sumbergond, and the rest are in the low class.

Sensitivity

Calculations are carried out to determine the level of climate change sensitivity in the agricultural sector in Batu City using agricultural labor indicators and the dominance of agricultural land types.

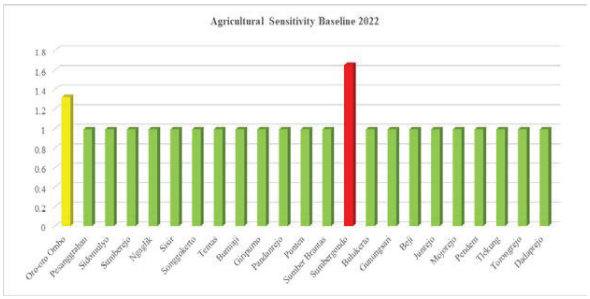
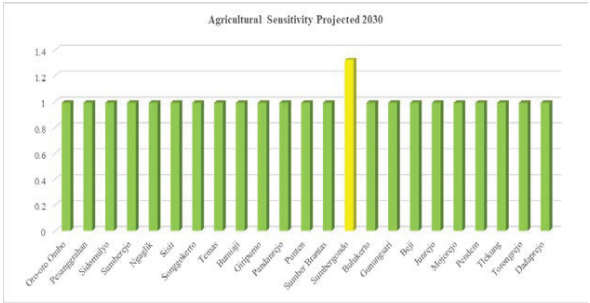


Figure 6.
Agricultural Sensitivity Baseline 2022
Source: Data Analysis (2022).



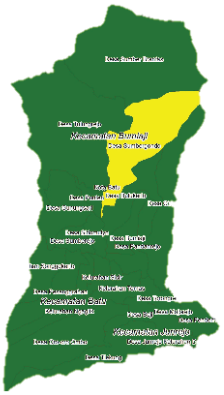
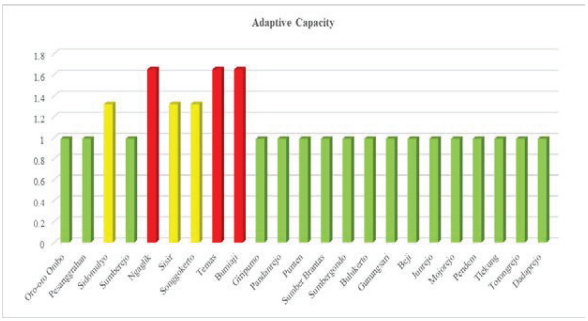


Figure 7.
Agricultural Sensitivity Baseline 2030
Source: Data Analysis (2022).



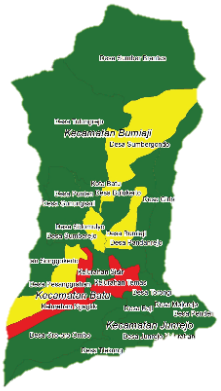


Figure 8.
Adaptive Capacity
Source: Data Analysis (2022)

The classification of total sensitivity of the agricultural sector to flash flood disasters in Batu City consists of Sumbergondo, the medium classification of Oro-Oro Ombo, and the rest are in the low classification. Meanwhile, the projection of total exposure to flash flood hazards based on the spatial pattern plan for 2030, obtained the total sensitivity of the projection with a reduced sensitivity classification compared to the baseline sensitivity. The classification of the total sensitivity of the projections to the agricultural sector to flash flood disasters in Batu City is not available for areas with a high classification, while areas with a medium classification are in Sumbergondo and the rest are in the low classification.

Adaptive Capacity

Adaptive capacity is influenced by all three factors. One of the factors may be dominant compared to the other. for adaptive capabilities in flash flood disasters in Batu City with the availability of drainage and

irrigation availability. The classification of adaptive abilities from flash flood disasters in Batu City is that there are villages with a high classification, namely Ngaglik, while the classification is in Sisir, Temas, Bumiaji, and Giripurno, while the rest are in the low classification.

Risk

The risk of climate change is the result of a study that considers physical, social, cultural, economic, and environmental factors. The risk study is a basis used to mitigate climate change and flash flood disasters in Batu City.

Table 3.
Risk Baseline 2022

No	Location	Subdistrict	Hazard Indeks	Exposure Indeks	Sensitivity Indeks	Capacity Indeks	Total Risk	Classification
1	Oro-oro Ombo	Batu	0,15	0,66	1,32	0,99	3,12	*Medium*
2	Pesanggrahan	Batu	0,33	0,66	0,99	0,99	2,97	*Low*
3	Sidomulyo	Batu	1,00	0,66	0,99	1,32	3,97	*High*
4	Sumberejo	Batu	1,00	0,66	0,99	0,99	3,64	High
5	Ngaglik	Batu	0,15	0,66	0,99	1,65	3,45	*Medium*
6	Sisir	Batu	0,15	0,66	0,99	0,99	2,79	*Low*
7	Songgokerto	Batu	0,15	0,66	0,99	0,99	2,79	*Low*
8	Temas	Batu	0,15	0,66	0,99	1,32	3,12	*Medium*
10	Bumiaji	Bumiaji	0,15	0,99	0,99	1,32	3,45	*Medium*
11	Giripurno	Bumiaji	0,15	0,66	0,99	0,66	2,46	*Low*
13	Pandanrejo	Bumiaji	0,15	0,99	0,99	0,99	3,12	*Medium*
14	Punten	Bumiaji	0,15	1,32	0,99	0,66	3,12	*Medium*
15	Sumber Brantas	Bumiaji	0,33	0,66	0,99	0,66	2,64	*Low*
16	Sumbergondo	Bumiaji	1,00	0,66	1,65	0,99	4,3	*High*
9	Bulukerto	Bumiaji	1,00	0,99	0,99	0,99	3,97	*High*
12	Gunungsari	Bumiaji	1,00	1,32	0,99	0,66	3,97	*High*
17	Beji	Junrejo	0,15	0,66	0,99	0,99	2,79	*Low*
18	Junrejo	Junrejo	0,15	0,66	0,99	0,66	2,46	*Low*
19	Mojorejo	Junrejo	0,15	0,66	0,99	0,99	2,79	*Low*
20	Pendem	Junrejo	0,33	0,66	0,99	0,99	2,97	*Low*
21	Tlekung	Junrejo	0,15	0,66	0,99	0,66	2,46	*Low*
22	Torongrejo	Junrejo	0,15	0,66	0,99	0,99	2,79	*Low*
23	Dadaprejo	Junrejo	0,15	0,66	0,99	0,99	2,79	Low

Source: Data Analysis (2022).

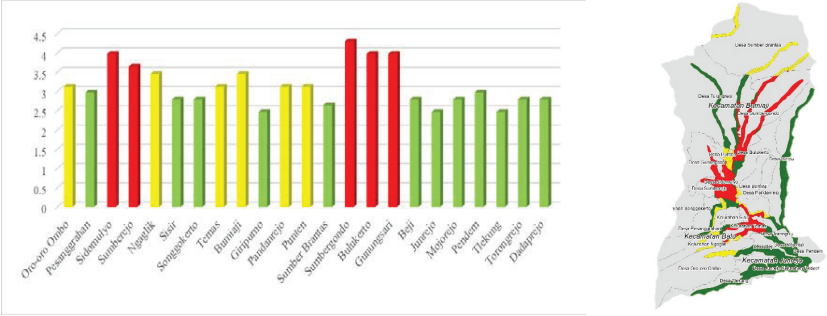


Figure 8.
Flash Flood Risk
Source: Data Analysis (2022)

Table 4.
Risk Projection 2030

No	Location	Subdistrict	Hazard Indeks	Exposure Indeks	Sensitivity Indeks	Capacity Indeks	Total Risk	Classification
1	Oro-oro Ombo	Batu	0,15	0,66	0,99	0,99	2,79	*Low*
2	Pesanggrahan	Batu	0,33	0,66	0,99	0,99	2,97	*Low*
3	Sidomulyo	Batu	1,00	0,66	0,99	1,32	3,97	*High*
4	Sumberejo	Batu	1,00	0,66	0,99	0,99	3,64	*High*
5	Ngaglik	Batu	0,15	0,66	0,99	1,65	3,45	*Medium*
6	Sisir	Batu	0,15	0,66	0,99	0,99	2,79	*Low*
7	Songgokerto	Batu	0,15	0,66	0,99	0,99	2,79	*Low*
8	Temas	Batu	0,15	0,66	0,99	1,32	3,12	*Medium*
10	Bumiaji	Bumiaji	0,15	0,66	0,99	1,32	3,12	*Medium*
11	Giripurno	Bumiaji	0,15	0,66	0,99	0,66	2,46	*Low*
13	Pandanrejo	Bumiaji	0,15	0,99	0,99	0,99	3,12	*Medium*
14	Punten	Bumiaji	1,00	0,99	0,99	0,66	3,64	*High*
15	Sumber Brantas	Bumiaji	1,00	0,66	0,99	0,66	3,31	*Low*
16	Sumbergondo	Bumiaji	1,00	0,66	1,32	0,99	3,97	*High*
9	Bulukerto	Bumiaji	1,00	0,66	0,99	0,99	3,64	*High*
12	Gunungsari	Bumiaji	1,00	0,99	0,99	0,66	3,64	*High*
17	Beji	Junrejo	0,15	0,66	0,99	0,99	2,79	*Low*
18	Junrejo	Junrejo	0,15	0,66	0,99	0,66	2,46	*Low*
19	Mojorejo	Junrejo	0,15	0,66	0,99	0,99	2,79	*Low*
20	Pendem	Junrejo	0,33	0,66	0,99	0,99	2,97	Low
21	Tlekung	Junrejo	0,15	0,66	0,99	0,66	2,46	*Low*
22	Torongrejo	Junrejo	0,15	0,66	0,99	0,99	2,79	*Low*
23	Dadaprejo	Junrejo	0,15	0,66	0,99	0,99	2,79	Low

Source: Data Analysis (2022)

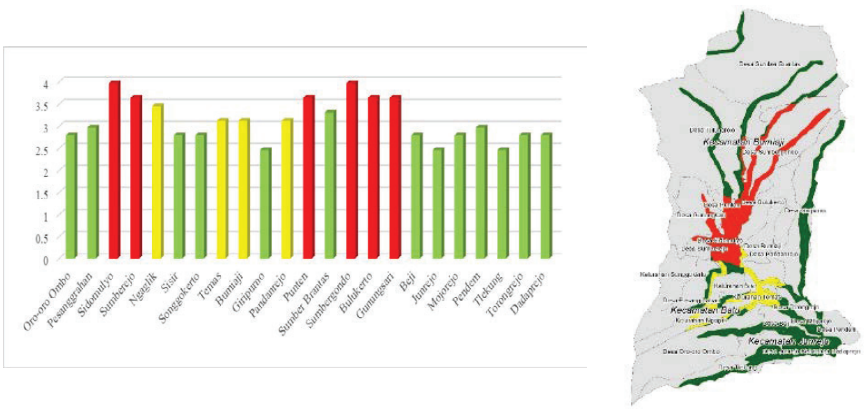


Figure 9.
Flash Flood (Δ) Risk
Source: Data Analysis (2022)

The risk classification for high vulnerability is in Sidomulyo, Sumberejo, Sumbergondo, Bulukerto, and Gunungsari. Meanwhile, the medium classification consisted of Oro-Oro Ombo, Ngaglik, Temas, Bumiaji, Pandanrejo, and Punten, while the rest were in the low classification. (Δ) The risk of climate change is the result of a study that considers the 2030 spatial pattern plan in Batu City to determine the prediction of the risk of flash flood disaster in Batu City until 2030.

Classification (Δ) Risks at high vulnerability are in Sidomulyo, Sumberejo, Punten, Sumbergondo, Bulukerto, and Gunungsari. Meanwhile, the medium vulnerability consists of Ngalik, Temas, Bumiajo, and Punten. While the rest are in the low classification. Based on the analysis, there is an increase in the projected risk of flash flood in Batu City, climate change that occurs can exacerbate the impact of damage due to flash floods if it occurs in the future and in the long term will threaten the environmental sustainability of the socio-economic status of the community.

Damage and Loss Assessment

Damage and Loss Assessment (DaLA) is a methodology for obtaining accurate data on damage and loss, an indicator of calculations based on available 2022 secondary data. In this calculation, the damage assessment is carried out based on the dominance of the affected land use in the 2022 baseline and the 2030 projection.

Table 5.
Damage Assessment Baseline 2022 in Agriculture Sector

No	Landuse	Land Price/m2	Area (m2)	Total Loss (Rp)
1	Farm	Rp 995.000,00	2.547.244,17	Rp 2.534.507.948.401,63
2	Ricefield	Rp 380.000,00	21.972.049,67	Rp 8.349.378.873.065,10

Source: Data Analysis (2022)

Damage & Loss Assessment in 2022 The affected area is mostly dominated by the agricultural sector. The highest affected land use is farms and rice fields. For farms, it has an impact of 2,547,244.17 m2 with standard land prices of Rp. 995,000.00 with accumulated losses of Rp. 2,534,507,948,401.63. Meanwhile, the farm has an impact of 21,972,049.67 m2 with a standard land price of Rp. 380.000,00, with an accumulated loss of Rp. 8,349,378,873,065.10, with a total loss of farm and rice field land cover of Rp. 8,351,913,381,013.73 for flash flood baseline risk 2022.

Table 6.
Damage Assessment Projection 2030 in Settlement Sector

No	Landuse	Land Price/m2	Spatial Pattern	Area (m2)		Total Loss
1	Occupied Land	Rp1.200.000,00	Settlement	21.629.097,19	Rp	25.954.916.628.000,00
			Tourism	166.752,42	Rp	200.10.904.000,00
			Industry	1.125.265,48	Rp	1.350.318.576.000,00

Source: Data Analysis (2022)

Damage & Loss Assessment in 2030 Based on the Batu City spatial planning, projections were obtained that previously had a lot of impact on the agricultural sector into built-up land. The affected area is mostly dominated by the built-up land sector, including the highest affected land use of settlement, tourism, and industry. For settlement has an impact of 21,629,097.19 m2 with the standard land price of Rp. 1,200,000 with an accumulated loss of Rp. 25,954,916,628,000. Meanwhile, tourism has an impact of 166,752.42 m2, with an accumulated loss standard of Rp 20,010,904,000. Then

the industry has an impact of 1,125,265.48 m2, with a standard accumulated loss of Rp. 1,350,318,576,000 with a standard with a total loss of Rp. 27,505,338,108,000 for the projected risk of flash flood 2030.

CONCLUSION

Batu City has a high risk of flash flood. Based on the analysis result in the baseline year, there are 5 villages which are classified as high risk to flash flood, 6 villages are classified as moderate, and the rest are classified as low. Meanwhile, based on the results of the delta analysis (Δ) of flash flood, there was an increase of 1 village with a high classification, where previously only 5 villages increased to 6 villages classified as high, 4 villages were classified as medium, and the rest were classified as low, with a total affected area and losses of baseline in 2022 of Rp. 8,351,913,381,013.73, as well as affected areas and projected losses in 2030 of Rp. 27,505,338,108,000

The flash flood that occurred in Batu City in 2021 resulted in considerable losses, especially to the agricultural sector. In this case, the Batu City government needs to take serious action to minimize the possibility of flash floods that can occur in the future.

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