Study of Flood Disaster Risk Delta in Bojonegoro Regency

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A B S T R A K

Bencana adalah peristiwa yang tidak terduga dan seringkali tiba-tiba yang menyebabkan kehancuran, kerusakan serius, dan penderitaan manusia. Menurut Undang-Undang Republik Indonesia Nomor 24 Tahun 2007 tentang Penanggulangan Bencana, bencana disebabkan oleh faktor alam dan/atau nonalam dan faktor manusia sehingga bencana dapat mengakibatkan hilangnya nyawa, kerusakan lingkungan, kerugian harta benda, dan kerugian. dampak psikologis. Kabupaten Bojonegoro yang memiliki wilayah terluas yang dilintasi sungai Bengawan Solo dan luas wilayahnya 24.753 hektar merupakan daerah aliran sungai sehingga hampir setiap tahun Kabupaten Bojonegoro digenangi air saat sungai Bengawan Solo meluap. Banjir di Kabupaten Bojonegoro hampir terjadi setiap tahun. Dimana banjir yang terjadi di Kabupaten Bojonegoro disebabkan oleh luapan sungai Bengawan Solo. Sebanyak 63% dari total penduduk Kabupaten Bojonegoro terkena atau berisiko banjir pada tahun 2012 hingga 2020. Penelitian ini untuk mengetahui risiko Delta (Δ) kawasan rawan banjir di Kabupaten Bojonegoro berdasarkan tren perubahan penggunaan lahan. dengan perspektif multitemporal di Kabupaten Bojonegoro. Penelitian ini menggunakan metode terbaru khususnya dalam hal pemodelan spasial yaitu database TIN dan Raster. Langkah pertama adalah memprediksi tren penggunaan lahan di Kabupaten Bojonegoro. Yang kemudian dilanjutkan dengan mengidentifikasi bahaya banjir dan kerawanan penggunaan lahan. Daerah rawan bencana banjir setiap tahunnya diprediksi berdasarkan tahapan sebelumnya menggunakan proses hirarki Analytic yang kemudian menghasilkan risiko bencana pada setiap tahun prediksi. Langkah terakhir adalah menghitung besarnya perubahan atau Delta () Risiko Bencana Banjir di Kabupaten Bojonegoro. Hasil dari penelitian ini adalah Delta (Δ) Risiko Bencana Banjir Rendah: mengalami perubahan sebesar -1,62% atau menurun sebesar 49,66 Ha dari tahun 2020 hingga 2040. Delta (Δ) Risiko Bencana Banjir Sedang: mengalami perubahan sebesar 2,85% atau mengalami peningkatan 17,67 Ha dari tahun 2020 hingga 2040. Delta (Δ) Risiko Banjir Tinggi: mengalami perubahan sebesar 23,96% atau meningkat sebesar 31,99 Ha dari tahun 2020 hingga 2040.

Keywords:
Disaster
Flood
Risk Delta

A B S T R A C T

A disaster is an unexpected and often sudden event that causes destruction, serious damage, and human suffering. According to the Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management, disasters are caused by natural factors and/or non-natural and human factors so that disasters can result in loss of life, environmental damage, loss of property, and psychological impacts. Bojonegoro Regency which has the widest area crossed by the Bengawan Solo river and 24,753 hectares of its area is a watershed so that almost every year Bojonegoro Regency is flooded when the Bengawan Solo river overflows. Floods in Bojonegoro Regency almost occur every year. Where the flood that occurred in Bojonegoro Regency was caused by the overflow of the Bengawan Solo river. As much as 63% of the total population of

Bojonegoro Regency is exposed or at risk of flooding in 2012 to 2020. This study is to determine the Delta (Δ) risk of flood-prone areas in Bojonegoro Regency based on trends in land use change with a multitemporal perspective in Bojonegoro Regency. This study uses the latest methods, especially in terms of spatial modeling, namely TIN and Raster databases. The first step is to predict the trend of land use in Bojonegoro Regency. Which is then continued to identify flood hazards and land use vulnerabilities. Flood disaster-prone areas each year are predicted based on the previous stages using the Analytic hierarchy process which then produces disaster risk in each prediction year. The last step is to calculate the amount of change or Delta (Δ) of Flood Disaster Risk in Bojonegoro Regency. The results of this study are Delta (Δ) Low Flood Disaster Risk: experienced a change of -1.62% or decreased by 49.66 Ha from 2020 to 2040. Delta (Δ) Moderate Flood Disaster Risk: experienced a change of 2.85% or experienced an increase of 17.67 Ha from 2020 to 2040. Delta (Δ) High Flood Risk: experienced a change of 23.96% or an increase of 31.99 Ha from 2020 to 2040.

Introduction

A disaster is an unexpected and often sudden event that causes destruction, serious damage, and human suffering. According to the Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management, disasters are caused by natural factors and/or non-natural and human factors so that disasters can result in loss of life, environmental damage, loss of property, and psychological impacts. During the period 1980-2016, there were a total of 16,584 natural disaster events that caused $4.3 trillion in damage worldwide, of which 80% were hydrometeorological disasters and 20% were climatological or geophysical disasters.

According to the definition of disaster risk by the United Nations International Strategy for Disaster Reduction (UNISDR), disaster risk is the potential loss of life, injury, destruction or damage to assets, which can occur to a system, society or community over a period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. This means that the magnitude of a regional disaster is influenced by several factors such as local hazards, exposure, vulnerability, and emergency and recovery capabilities. Because flood disasters are the most frequent natural disasters today, disaster risk floods are characterized by uncertainty, losses, and other factors. Flood risk assessment involves uncertainty and multiple and conflicting criteria, which make it more difficult to determine [1].

The impact of flood risk is expected to increase due to population growth, economic development and climate change [2]. Flood exposure and flood frequency are expected to increase, especially in low latitudes Asia and Africa [3]. Foll owing a risk-based approach, flood risk assessment is widely applied at three scales: local scale [4], regional scale and global scale [5]. This assessment aims to identify risk locations at different levels, namely: set as a basis for establishing mitigation and adaptation actions [6]. In most cases, catastrophic flooding is caused by excessive rainfall in a certain area over a relatively short period of time. Therefore, the level of risk is closely related to changes in the amount and intensity of rainfall in the future [7].

Indonesia is one of the countries in the ASEAN region that is prone to hydrometeorological disasters due to the climate in Indonesia which is strongly influenced by the location and geographical characteristics that stretch between the Pacific Ocean and the Indian Ocean. Indonesia has three basic climate patterns, namely monsoon, equatorial, and local climate systems which cause dramatic differences in rainfall patterns. This condition is increasingly complex due to the challenges of global warming and the effects of climate change, such as rising

temperatures and sea levels in Indonesia, which is located at the equator. Hydrometeorological disasters that can occur include floods, flash floods, droughts, extreme weather, extreme waves, abrasion, and forest and land fires.

Bojonegoro Regency which has the widest area crossed by the Bengawan Solo river and 24,753 hectares of its area is a watershed so that almost every year Bojonegoro Regency is flooded when the Bengawan Solo river overflows. The distribution of flood events in East Java Province in 1908 – 2012 based on districts/cities shows that Bojonegoro Regency is the area with the highest frequency of flood events. As much as 63% of the total population of Bojonegoro Regency was exposed to or at risk of flooding in 2015 to 2019. During the last 10 years, flooding has become a disaster with the highest frequency of the four other types of disasters, namely 40.21% of flood events in Bojonegoro Regency in 2015. 2010 to 2019. Bojonegoro Regency has 28 sub-districts with 14 sub-districts located in the Bengawan Solo watershed, namely Margomulyo, Ngraho, Padangan, Kasiman, Purwosari, Malo, Kalitidu, Trucuk, Dander, Bojonegoro, Kapas, Balen, Kanor, and Baureno sub-districts. Based on the Rapid Health Assessment of Floods in Bojonegoro Regency in 2008, Kanor District is one of the sub-districts in Bojonegoro Regency which has the most affected villages when the largest flood disaster occurred due to overflowing of the Bengawan Solo river during the last 50 years, namely in December 2007 with a height of 0.5 up to 1.2 meters which submerged 17 villages for 4-5 days.

From these problems, a study is needed to identify the risk of flood-prone areas in Bojonegoro Regency based on a multitemporal perspective. Where it is necessary to predict changes in land use based on trends so that in the future we can direct development in locations affected by low flood disasters. This inquire about is anticipated to include knowledge for perusers almost which regions have a tall hazard of flooding in Bojonegoro Rule. This inquire about can moreover be utilized as a reference for the nearby government of Bojonegoro Rule for the improvement of the watershed zone improvement, taking under consideration the drift of arrive utilize changes to suit the characteristics and items of the Bojonegoro Regency spatial arranging arrange. Typically because this strategy is developing and once in a while utilized, and in this strategy there's approval of arrive utilize information. Already, arrive utilize alter investigation as it were utilized the overlay procedure, with the improvement of cellular automata examination, it can analyze arrive utilize patterns with arrive utilize approval inside a certain time.

The aim of this study about was to determine the Delta (Δ) chance of flood-prone ranges in Bojonegoro Rule based on patterns in arrive utilize alter with a multitemporal viewpoint in Bojonegoro Rule. To realize the targets of this think about, three interrelated goals were defined. The targets in this ponder are to distinguish changes in arrive utilize in Bojonegoro Rule from 2019 to 2039 (Utilizing Cellular Automata), distinguish flood-prone hazard in Bojonegoro Rule, define Delta (Δ) chance for flood-prone ranges in Bojonegoro Rule based on a multitemporal viewpoint beginning from from 2019 to 2039.

Method

The type of research conducted is a type of combination research or a combination of qualitative and quantitative research. Where there are several explanations that can be described in sentences but there are also problems that must be explained mathematically. In this study, the data collection method consisted of two primary data (observations and interviews) and secondary data (institutional surveys and literature surveys). This research uses descriptive analysis method, AHP and Geographic Information System Analysis Method). Analytical Hierarchy Process (AHP) Has the ability to solve multi-objective and multi-criteria problems based on the comparison of preferences of each element in the hierarchy.

The Analytical Hierarchy Process (AHP) was originally developed by Thomas L. Saaty. Analytical Hierarchy Process (AHP) is a decision support model that describes a hierarchy. Analytical Hierarchy Process (AHP) can too be deciphered as a strategy utilized to fathom a complex unstructured circumstance into a few components in a progressive course of action. By doling out a subjective esteem to the relative significance of each variable, and deciding which variable has the most elevated need in impacting the result of the circumstance.

In this analytical hierarchy process, to make decisions in determining the priority of weighting the physical vulnerability of land use, the tool used is Expert Choice version 11. Where Expert Choice is a software that supports decision collaboration and a hardware system that facilitates group decision making that is more extensive. efficient, analytical, and justifiable.

Analysis The data that is processed in GIS basically consists of spatial data and attribute data from various sources. Most of the data that will be handled in a GIS is spatial data, which is geographically oriented data, has a certain coordinate system as a reference base and has two important parts that make it different from other data, namely location information (spatial) and descriptive information (attributes) that described below:

1. Location information (spatial), relating to a coordinate both geographic coordinates (latitude and longitude) and XYZ coordinates, including including datum information and projections, generally in the form of maps.
2 Descriptive information (attribute) or non-spatial information, a location that has some information related to it. Attribute data is table data that serves to explain the existence of various objects. For example: type of vegetation, population, area, zip code, and so on.

In this study there are 3 stages of analysis starting from the analysis of hazard, vulnerability and risk delta. The method used in the analysis is the latest method, especially in terms of spatial modeling. This spatial modeling is carried out in the TIN and Raster databases so that it can accurately determine the magnitude and direction of the model. The initial stage in this research is in flood hazard analysis, using the hydrodynamic model method which is analyzed using a spatial analysis TIN database then in vulnerability analysis this research also uses cellular automata analysis in determining and predicting future vulnerability conditions.

This cellular automata analysis will also be supported by several logistic regression analyzes, neural networks and simweights to increase validation in the process of determining transition models in the analysis of determining future susceptibility conditions. The advantage of this research is in making future predictions with spatial analysis, both projected flood conditions and future vulnerability conditions projections to formulate risk deltas, namely the overlay results of current risks and future risks that are spatially projected.

Results and Discussion

Based on the analysis of land use change, it is known that in 2012 the area of the built-up area was 25,117 ha where the area was only 10.9% of the total land use area of Bojonegoro Regency as a whole in 2012. For more details, see the following table and map image.

Table 1 Land Use of Bojonegoro Regency in 2012

No	Landuse	Area (Ha)	Percentage (%)
1	Mixed Settlements	25,116,90	10.87%
2	Other Waters	347.63	0.15%
3	Forest	1,259.81	0.55%
4	Meadow	2,059.83	0.89%

No	Landuse	Area (Ha)	Percentage (%)
5	Plantation	78,586.11	34.01%
6	Irrigation Paddy	75131.24	32.52%
7	Rainfed Rice	23,335.18	10.10%
8	Shrubs	7,872.60	3.41%
9	River	2,075.51	0.90%
10	Field	15,273.17	6.61%
11	Green Open Space	4.27	0.0018%
	Total	**31,062.25**	**100%**

Source: Indonesia Landscape Bojonegoro Regency 2019

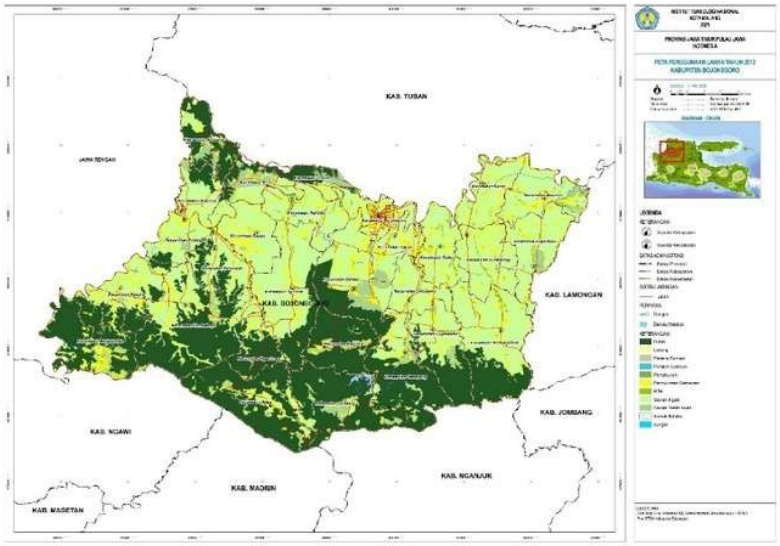


Image 1 Land Use Map for 2012

In addition, it is also known that the development of residential land looks quite large, this can be seen from the 2012 area which was only 25,116.90 Ha, increasing in 2020 by 27,258.17 Ha. Land use in Bojonegoro Regency until 2020 is dominated by Irrigation Rice land use, which is 99,477.03 Ha or 42.95% of the total land area. For more details can be seen in the following table and map image.

Table 2 Land Use of Bojonegoro Regency in 2020

No	Land Use	Area 2020	Percentage (%)
1	Mixed Settlements	27,258,17	11.77%
2	Other Waters	571.23	0.25%
3	Forest	86,738.74	37.45%
4	Meadow	8.66	0.00%
5	Plantation	2,059.83	0.89%
6	Irrigation Paddy	99,477.03	42.95%
7	Rainfed Rice Fields	12310,28	5.32%
8	Shrubs	792.77	0.34%
9	River	2,075.51	0.90%
10	Field	311.52	0.13%
11	Green Open Space	3.94	0.002%
	Total	**231,607.68**	**100%**

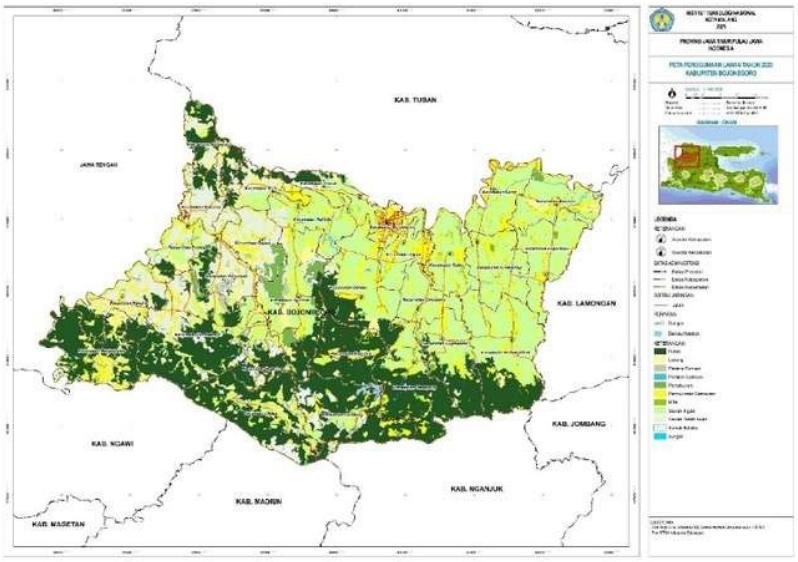
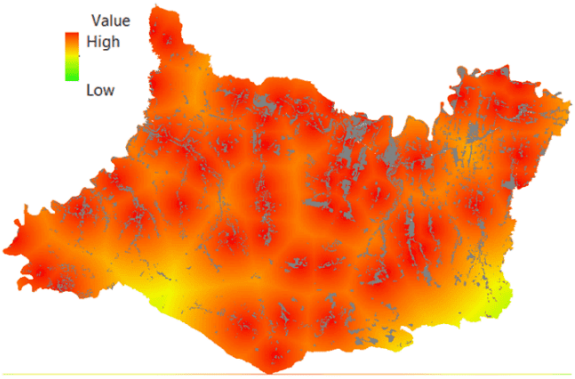
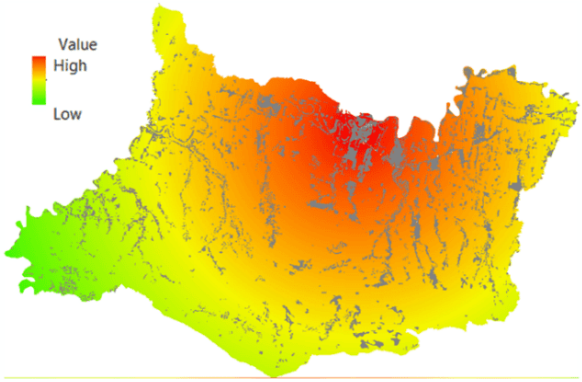


Image 2 Kediri Regency Land Use Map 2020

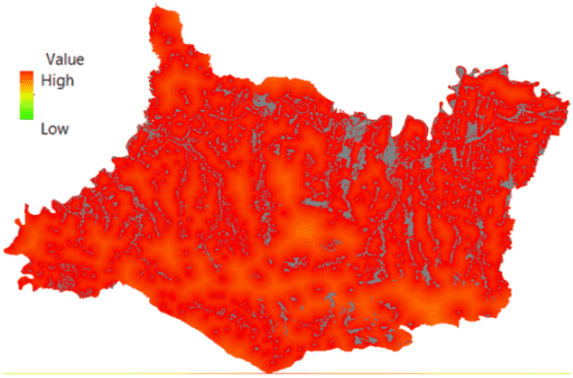
Based on the results of the analysis of the driving factor analysis by means of a change analysis of land use in Bojonegoro Regency in 2012 to 2020, it was found that the transition from plantation land use to forest land use was the largest land use transition where plantation land use turned into forest land use of 70,106.73 Ha. . Meanwhile, the smallest land use transition is the land use transition from settlements to pasture use, which is 0.02 Ha. From the simulation results, there are three scenarios in regional development, namely a trend scenario, a target scenario without constraints, and a target scenario with a trend. For more details, see the following image.



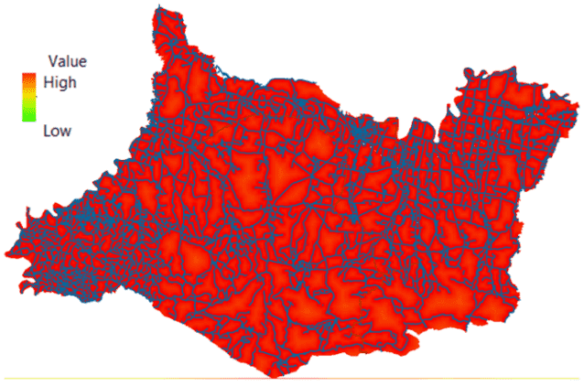
Proximity to Facilities



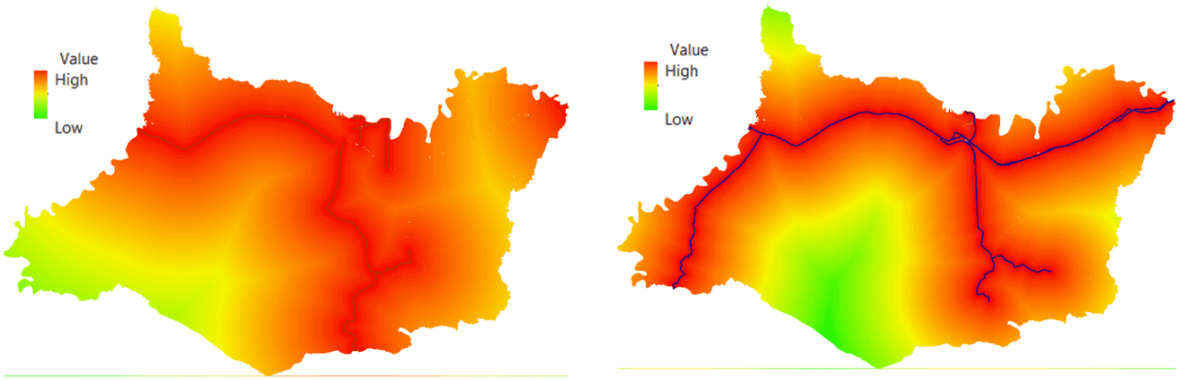
Proximity to Activity Center



Proximity to Existing Settlement



Proximity to District Road



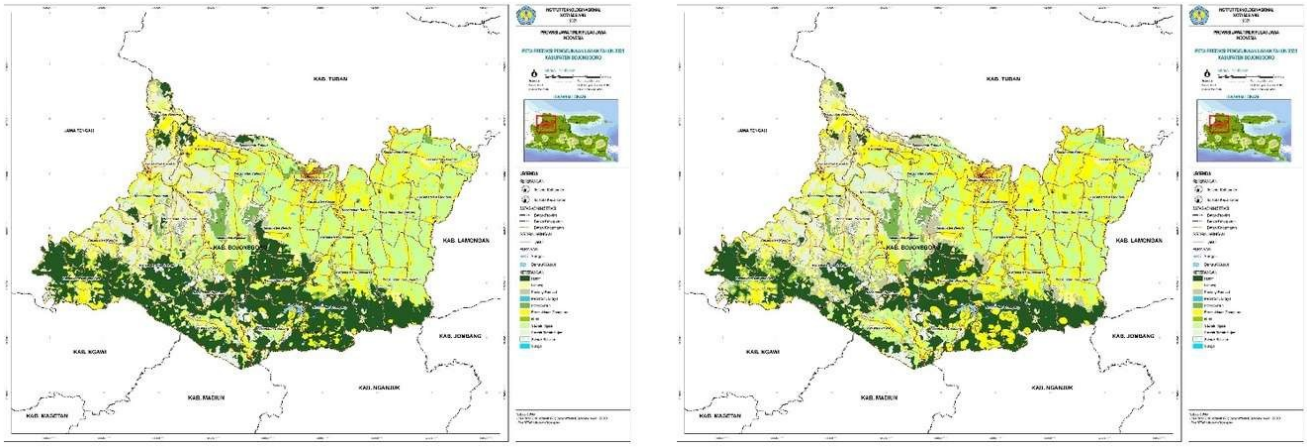
Proximity to Provincial Road Proximity to National Road

Image 3 Euclidean Distance Driving Factors

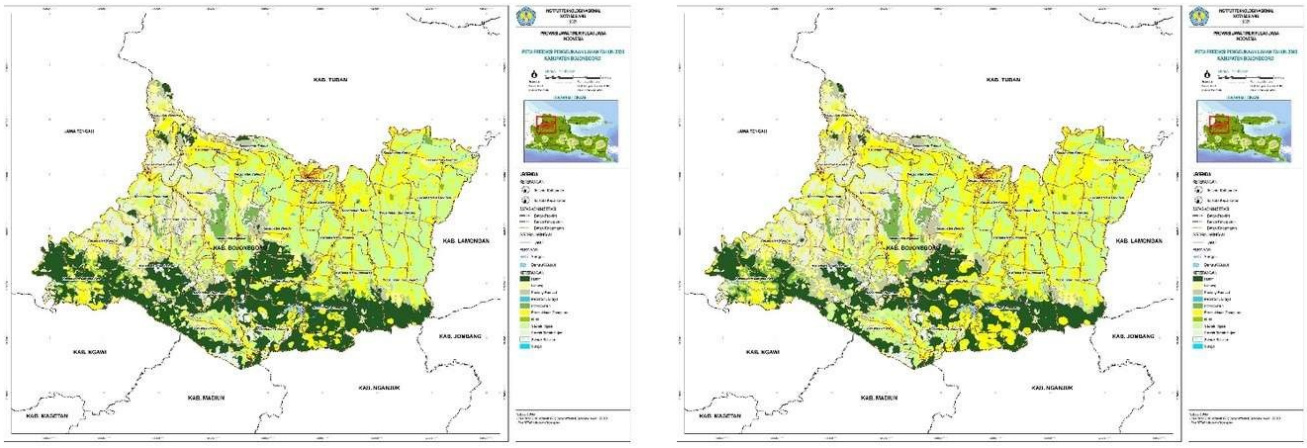
From the simulation results, there are three scenarios in regional development, namely a trend scenario, a target scenario without constraints, and a target scenario with a trend. The following are the results of the land use simulation in 2023, 2028, 2033, 2038. The data can be seen in the following table.

Table 3 Land Use Prediction 2025-2040

Land Use	Area (Ha)			
	2025	2030	2035	2040
Forest	60,106,89	50,745.18	43,024.76	36,657.18
Field	18,239.02	19,412.98	19,909,70	20.116.57
Meadow	5,331.17	9,069.39	11,506.43	13,014.07
Other Waters	343.45	343.48	343.53	342.40
Plantation	7,918,50	8,163.15	8,864.42	9,332.74
Mixed Settlements	43,432.45	52,168,51	57,954.01	67,250.31
Green Open Space	4.02	4.03	4.07	4.02
Irrigation Paddy	66,052.82	60,887.20	58,802.49	53,291.01
Rainfed Rice Fields	19,015,70	19,609.52	19.992.03	20,379.41
Shrubs	7,706.92	7,707,66	7,706.93	7,707,19
River	2,747.39	2,796.60	2,803.47	2,821.90



Land Use Prediction in 2025 Land Use Prediction in 2035



Land Use Prediction in 2030 Land Use Prediction in 2040

Image 4 Land Use Prediction in 2025-2040

From the simulation results table above, it can be seen that the area of mixed settlements in 2023 increased rapidly from 2020. The increase from the original area of 27,258.17 Ha to 43,432.44 Ha. This indicates that the settlement simulation results in a period of 5 years from 2020 to 2025 will increase to an area of 16,174.27 hectares. Then the area of mixed settlements in 2030 will increase rapidly from 2020. The addition of the original area of 27,258.17 hectares to52,168,51Ha. This indicates that the settlement simulation results in a period of 10 years from 2020 to 2030 will increase by 24,910.34 hectares. The largest reduced land in the 2030 simulation is forest land, where the forest area has decreased from 9,361.71 Ha in 2025, from an area of 60,106.89 Ha in 2025 to 50,745.18 Ha in 2030.

In 2035, the largest land use change from 2020 based on the above simulation is the change in forest land use, namely a forest decline of 17,082.13 Ha, followed by a decrease or conversion of agricultural land, which is 7250.32 Ha. Meanwhile, in 2035 for settlements there was an addition of 30,695.84 Ha from 2020. Based on the simulation results, settlements experienced a fairly large increase, which was 39,992.14 Ha. Of course this also has an impact on the reduction of forest land and agricultural land, each of which is reduced by 50,081.57 Ha for forest land and 46,186.03 for irrigated agriculture from 2020 to 2040.

The results of the simulation of land use in 2023, 2028, 2033, 2038, namely that the area of mixed settlements in 2023 is growing rapidly from 2020. The increase from the original area of 27,258.17 Ha to 43,432.44 Ha. This indicates that the settlement simulation results in a period of 5 years from 2020 to 2025 will increase to an area of 16,174.27 hectares. Then the area of mixed settlements in 2030 will increase rapidly from 2020. The increase from the original area of 27,258.17 hectares to 52,168.51 hectares. This indicates that the settlement simulation results in a period of 10 years from 2020 to 2030 will increase by 24,910.34 hectares. The largest reduced land in the 2030 simulation is forest land, where the forest area has decreased from 9,361.71 hectares in 2025, from 60,106 hectares in 2025.

Flood-prone locations in Bojonegoro Regency according to the RTRW of East Java Province are in Kasiman District, Padangan, Kalitidu, Bojonegoro. Some areas of Bojonegoro Regency which are located in the Bengawan Solo watershed are flood-prone areas. Meanwhile, flood-prone areas caused by the Bengawan Solo watershed are along the river where the downstream the higher the flood intensity. The areas that have the potential for flooding are the Districts of Padangan, Kalitidu, Malo, Trucuk, Bojonegoro, Kapas, Sumberrejo, Kanor, Baureno. Results of Identification of Vulnerability Factors for

Floods in Bojonegoro Regency in 2020. For more details, please see the following table and diagram.

Table 4 Flood Prone Areas of Bojonegoro Regency (RTRW of Bojonegoro Regency, 2021)

Flood Danger	Area (Ha)	Percentage (%)
Low Level Flood	1,769.52	71.77%
Intermediate Flood	681.00	27.62%
High Level Flood	15,13	0.61%
Total	**2,465.65**	**100%**

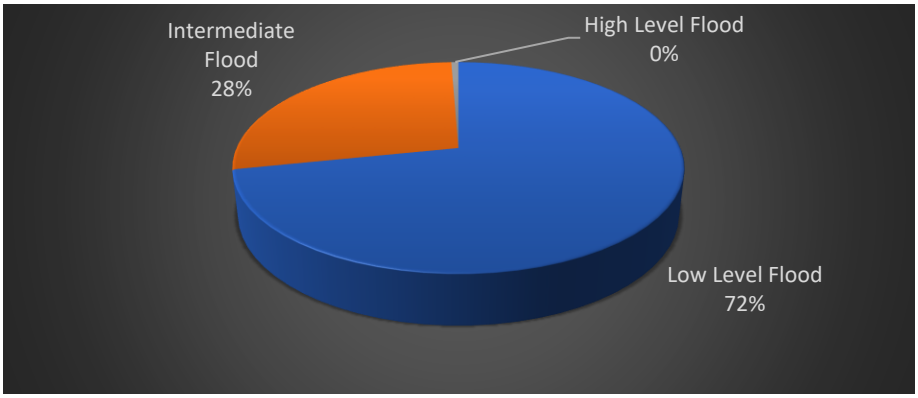


Image 5 Bojonegoro Regency Flood Prone Area Diagram

Based on the results of the physical vulnerability assessment of Land Use with indicators of Mixed Settlements, Irrigated Rice Fields, Rainfed Rice Fields, Plantations, Green Open Space, Fields, Grasslands, Forests, Shrubs, Rivers, Other Waters. all indicators use the reclassify method in Arcgis. In the scoring map, the weighting of each indicator is based on the results of the AHP analysis. For more details can be seen in the following table.

Table 5 Flood Vulnerability Area of Bojonegoro Regency in 2020

Vulnerability	Area (Ha)	Percentage (%)
Tall	105,164.11	45.38%
Currently	28,950,36	12.49%
Low	97,613.63	42.12%
Total	**231,728.10**	**100%**

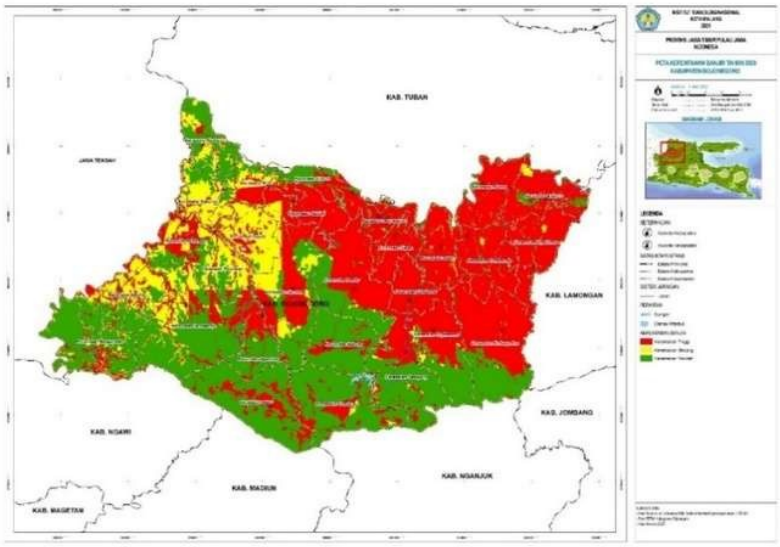


Image 6 Map of Bojonegoro Regency Flood Vulnerability in 2020

Based on the results of the scoring analysis of the physical vulnerability map of land use with indicators of Mixed Settlements, Irrigated Rice Fields, Rainfed Rice Fields, Plantations, Green Open Space, Fields, Grasslands, Forests, Scrub, Rivers, Other Waters, it was found that in the research area, physical vulnerability of land use fall into the category of high vulnerability, medium vulnerability and low vulnerability.

Based on the results of the analysis of flood risk zones in Bojonegoro Regency, it is known that there is an area of 165.48 Ha or 4.34% in the High Risk category, 637.37 Ha or 16.73% in the Medium Risk category and 3,007.3 Ha or 78 ,93% fall into the Low Risk category.

Delta () flood disaster risk in Bojonegoro Regency sees the difference in changes from the flood risk in Bojonegoro Regency from 2020-2040. The purpose of this analysis is to find out whether the current and future changing trends in use can minimize the risk of flooding in Bojonegoro Regency or even increase the risk of Bojonegoro Regency. If there is an increase, it can be used as a reference for the local government in managing future development. The following is the change or delta of the flood risk zone of Bojonegoro Regency from 2020 to 2040 seen every 5 years.

Table 6 Area of the Bojonegoro Regency Flood Risk Zone

Vulnerability	Area (Ha)				
	2020	2025	2030	2035	2040
Tall	133.49	139.10	153.46	164.59	165.48
Currently	619.70	630.50	632.49	633.23	637.37
Low	3056.96	3,040,55	3,024,20	3,012.33	3,007,30
Total	**3,810,15**	**3,810,15**	**3,810,15**	**3,810,15**	**3,810,15**

Table 7 Percentage of Flood Risk Zoning in Bojonegoro Regency

Vulnerability	Percentage (%)				
	2020	2025	2030	2035	2040
Tall	3.50%	3.65%	4.03%	4.32%	4.34%
Currently	16.26%	16.55%	16.60%	16.62%	16.73%
Low	80.23%	79.80%	79.37%	79.06%	78.93%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Based on the data above, the risk of flood disaster in Bojonegoro Regency is every projected land use that continues to change. Where high disaster risk increases every year starting from 2020 - 2040. Meanwhile, disaster risk is experiencing an increase in 2020 - 2040. Low disaster risk decreases in 2020 - 2040. To see the difference in changes in flood disasters in Bojonegoro Regency can be seen in the following table 8.

Table 8 Delta (Δ) Flood Disaster Risk in Bojonegoro Regency in 2020-2040

Year	Height (Ha)	Difference Change (%)	Medium (Ha)	Difference Change (%)	Low (Ha)	Difference Change (%)
2020	133.49		619.70		3056.96	
2025	139.10	4.21%	630.50	1.74%	3,040,55	-0.54%
2030	153.46	10.32%	632.49	0.32%	3,024,20	-0.54%
2035	164.59	7.25%	633.23	0.12%	3,012.33	-0.39%
2040	165.48	0.54%	637.37	0.65%	3,007,30	-0.17%
Average		5.58%		0.71%		-1.63%

So from the data above, it shows that from 2020 to 2040 the risk of flood disasters, both medium risk, low risk, and high risk will change with the difference as follows:

1. Delta (Δ) Low Flood Risk: experienced a change of -1.62% or decreased by 49.66 Ha from 2020 to 2040.
2. Delta (Δ) Moderate Flood Disaster Risk: experienced a change of 2.85% or an increase of 17.67 Ha from 2020 to 2040.
3. Delta (Δ) High Flood Risk: experienced a change of 23.96% or an increase of 31.99 Ha from 2020 to 2040.

Conclusion

According to the Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management, disasters are caused by natural factors and/or non-natural and human factors so that disasters can result in loss of life, environmental damage, loss of property, and psychological impacts. During the period 1980-2016, there were a total of 16,584 natural disaster events that caused $4.3 trillion in damage worldwide, of which 80% were hydrometeorological disasters and 20% were climatological or geophysical disasters. According to the definition of disaster risk by the United Nations International Strategy for Disaster Reduction (UNISDR), disaster risk is the potential loss of life, injury, destruction or damage to assets, which can occur to a system, society or community over a period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. This means that the magnitude of a regional disaster is influenced by several factors such as local hazards, exposure, vulnerability, and emergency and recovery capabilities. The impact of flood risk is expected to increase due to population growth, economic development and climate change (Xiao, Yi, & Tang, 2017). Therefore, the level of risk is closely related to changes in the amount and intensity of rainfall in the future (Shao-Hong, Tao, & Shan-Feng, 2012).

Indonesia is one of the countries in the ASEAN region that is prone to hydrometeorological disasters due to the climate in Indonesia which is strongly influenced by the location and geographical characteristics that stretch between the Pacific Ocean and the Indian Ocean. The distribution of flood events in East Java Province in 1908 – 2012 based on districts/cities shows that Bojonegoro Regency is the area with the highest frequency of flood events. As much as 63% of the total population of Bojonegoro Regency was exposed to or at risk of flooding in 2015 to 2019. From these problems, a study is needed to identify the risk of flood-prone areas in Bojonegoro Regency based on a multitemporal perspective. This inquire about is anticipated to include knowledge for perusers almost which regions have a tall hazard of flooding in Bojonegoro Rule.

The aim of this study about was to determine the Delta (Δ) chance of flood-prone ranges in Bojonegoro Rule based on patterns in arrive utilize alter with a multitemporal viewpoint in Bojonegoro Rule. To realize the targets of this think about, three interrelated goals were defined. In addition, it is also known that the development of residential land looks quite large, this can be seen from the 2012 area which was only 25,116.90 Ha, increasing in 2020 by 27,258.17 Ha. Based on the results of the analysis of the driving factor analysis by means of a change analysis of land use in Bojonegoro Regency in 2012 to 2020, it was found that the transition from plantation land use to forest land use was the largest land use transition where plantation land use turned into forest land use of 70,106.73 Ha.

Meanwhile, the smallest land use transition is the land use transition from settlements to pasture use, which is 0.02 Ha. The following are the results of the land use simulation in 2023, 2028, 2033, 2038. The data can be seen in the following table. From the simulation results table above, it can be seen that the area of mixed settlements in 2023 increased rapidly from 2020. The increase from the original area of 27,258.17 Ha to 43,432.44 Ha. In 2035, the largest land use change from 2020 based on the above simulation is the change in forest land use, namely a forest decline of 17,082.13 Ha, followed by a decrease or conversion of agricultural land, which is 7250.32 Ha. Based on the simulation results, settlements experienced a fairly large increase, which was 39,992.14 Ha. The results of the simulation of land use in 2023, 2028, 2033, 2038, namely that the area of mixed settlements in 2023 is growing rapidly from 2020. The increase from the original area of 27,258.17 Ha to 43,432.44 Ha.

Meanwhile, flood-prone areas caused by the Bengawan Solo watershed are along the river where the downstream the higher the flood intensity. The areas that have the potential for flooding are the Districts of Padangan, Kalitidu, Malo, Trucuk, Bojonegoro, Kapas, Sumberrejo, Kanor, Baureno. Based on the results of the physical vulnerability assessment of Land Use with indicators of Mixed Settlements, Irrigated Rice Fields, Rainfed Rice Fields, Plantations, Green Open Space, Fields, Grasslands, Forests, Shrubs, Rivers, Other Waters. For more details can be seen in the following table. Delta flood disaster risk in Bojonegoro Regency sees the difference in changes from the flood risk in Bojonegoro Regency from 2020-2040.

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