



Analysis of Prediction of Economic Losses due to Flood Disaster Hazards in Industrial Estates in Karawang Regency

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Abstract

Based on the National Disaster Management Agency, there was an increase in the total number of disasters from 2020 to 2022, which was initially 1,296 to 5402 disasters, with the highest percentage of disaster events being flood disasters with the highest frequency being in the West Java and DKI Jakarta areas (BNPB, 2022). The high frequency of floods that occur in the West Java region can certainly increase economic losses that are pretty high. On the other hand, West Java Province also contributes the third most significant national GDP. The sector that contributes the most to West Java's GRDP is the processing industry sector (BPS, 2017). Karawang Regency is one of West Java's destination areas for industrial development. In Karawang Regency, industrial areas are developing quite rapidly and are concentrated in the southern part of Karawang Regency (Telukjambe Barat, Telukjambe Timur, Ciampel, Pangkalan, Klari, and Cikampek districts). However, based on research conducted by the ITB Climate Change Center (2022), several points have a relatively high level of flood hazard in the area. That can bring considerable losses if the disaster occurs in an industrial area, so an analysis of losses due to flooding is needed at the location of the existing industrial site, which is currently in Karawang Regency. Therefore, this research was conducted to determine the condition of existing industrial land in flood-prone areas and to find predictions of economic losses that will be obtained in the event of a flood disaster on existing industrial land today. The research used secondary data in shapefiles (.shp) maps of Karawang Regency, planning documents, and related journals. Then, the analysis method that will be carried out is mapping disaster-prone areas in industrial estates and predicting economic losses due to flood disasters which will be carried out with a Geographic Information System (GIS). Based on the results of the analysis, it was found that 34.69% of the existing industrial land is located in flood-prone areas, which are predicted to impact the economic losses of IDR 65,049,705,681,272,-. That shows a need for a flood mitigation plan and the suitability of proper allocation of industrial estates to reduce the possibility of economic losses to be borne by the government.

Keywords: economic losses; flood hazard; industrial estates; karawang regency

Introduction

From 1970 to 2005, there were drastic changes to physical, biological, and human systems related to climate change (IPCC, 2014). The main focus in this regard is the increasing temperature of the earth's surface, characterized by extreme rainfall, cold heat waves, droughts, extreme tropical cyclones, and the emergence of unprecedented natural disasters. This phenomenon impacts all countries, such as floods, droughts, crop failures, and sea level rise.

Climate change has often been a concern for governments in making their policies since the Paris Agreement. Indonesia's involvement in the Paris Agreement certainly adds to its obligation to reduce the use of greenhouse gases. In addition, disaster events that often occur in Indonesia are also a catalyst for consideration of the impacts of climate change in the policies made by the current government. Efforts to reduce losses due to the impacts of climate change are now an indicator of Indonesia's realization of climate change adaptation.



This loss reduction effort will significantly affect the region's spatial arrangement. Spatial planning must ensure that the economic losses due to the impacts of climate change are not so significant. A comprehensive study is needed to determine how much impact it will have on a threatened area and what strategies must be implemented to minimize these losses.

Backgrounds

Based on data obtained from the National Disaster Management Agency, it was found that there was an increase in the total number of disasters from 2020 to 2022, which was initially 1,296 to 5402 disasters, of which in those two years, the highest percentage of disasters events were flood disasters. In one year, there was an increase in the number of flood disasters by 1,299 events, with the highest frequency being in the West Java and DKI Jakarta areas (BNPB, 2022).

The high frequency of floods that occur in the West Java region can certainly increase economic losses that are pretty high. On the other hand, West Java Province also contributes the third most significant national GDP. The sector that contributes the most to West Java's GRDP is the manufacturing industry sector (accounting for around 42.29% in 2016) (BPS, 2017). That shows a relatively high concentration of West Java industrial sectors in the national strategic industry. One of the regencies/cities with high industrial potential is Karawang Regency.

Karawang Regency is located in the northern part of West Java Province, which is geographically situated between 107° 02' – 107° 40' East Longitude and five° 56' – 6° 34' South Latitude. Bekasi Regency borders the regency in the West, Bogor Regency in the Southwest and South, the Java Sea in the North, Subang Regency in the East, and Purwakarta Regency in the Southeast and South. Karawang has an area of 1,652.00 km² consisting of 30 sub-districts, 297 villages, and 12 urban villages, with a population in 2021 of 2,406,895 people and a population density of 1,457 people per km². The location of Karawang Regency is very strategic because the Java Island Pantura Regional Route traverses it, the Jakarta–Bandung Toll Road, and the 3 PKN meeting node (Bodebek–Bandung–Cirebon), so currently, Karawang Regency is a destination area for industrial development by several companies from within and outside the country.

There are several National Strategic Projects located in Karawang Regency, namely the Jakarta - Cikampek II South Side Toll Road, South Sentul - West Karawang Toll Road, TOD and the Jakarta - Bandung Fast Train Line, the Nambo - Cikarang - Tanjung Priok Cross Railway Plan, the International Airport Plan, and the Cilamaya PLTGU and contained in the transportation and energy network plan in the Karawang Regency Rencana Tata Ruang Wilayah (RTRW) Revision which can increase investment value.

The Industrial Sector is the sector of choice in the Karawang Regency Government. The direction of industrial development has been described in the SKPD Strategic Plan of the Karawang Regency Industry and Trade Office, which aligns with the Rencana Pembangunan Jangka Menengah Daerah (RPJMD) of the Karawang Regency. The industrial sector is also included in the industry that plays an essential role in West Java, supporting the province's economy. In addition, the direction for the development of the industrial sector in Karawang Regency, as well as contextual directions on the issues discussed, can be seen in the following table.

In Karawang Regency, industrial areas are developing quite rapidly and are concentrated in the southern part of Karawang Regency (Telukjambe Barat, Telukjambe Timur, Ciampel, Pangkalan, Klari, and Cikampek districts). However, based on research conducted by the ITB Climate Change Center (2022), several points have a relatively high level of flood hazard in the area, especially in the districts of Telukjambe Barat, Telukjambe Timur, Ciampel, Pangkalan, and Klari. That can bring considerable losses if the disaster occurs in an industrial area, so analysis is needed to check the suitability of the land and losses due to flooding at the location of the existing industrial site, which is currently in Karawang Regency.

Therefore, this research was conducted to determine the condition of existing industrial land in flood-prone areas and to find predictions of economic losses that will be obtained in the event of a flood disaster on existing industrial land today. Then it will be compared whether the losses experienced in other areas, such as residential and agriculture, will be smaller / the same / greater than in industrial areas. This research will then reference disaster mitigation plans at existing industrial sites and as a tool to consider land use in disaster-prone regions of Karawang Regency.

Flood Impact

Based on the article "Flood Impact Assessment Literature Review," there are generally two flood impacts based on the impact's shape and the measurement type. The form of influence is divided into direct impact and indirect impact. Meanwhile, based on the type of measurement, it is divided into measurable and unmeasured effects.

The difference between direct and indirect damage impacts is caused directly/indirectly by flooding. According to Jonkman et al. (2008), direct impacts occur during floods, while indirect impacts are felt after floods occur. At the same time, the difference between measurable and unmeasured impacts is in a particular form or economic value. Measurable impacts are impacts that can be assessed with the economy, but those that are not measurable are impacts that are difficult to determine economically.

The estimation of the magnitude of the impact can be divided into two, namely ex-ante and ex-post. Impact forecasting on ex-ante is done before the disaster occurs with what-if analysis. Meanwhile, ex-post impact forecasts are carried out after or before a disaster occurs. Both approaches aim to provide assumptions on the damage and losses from disasters. Ex-ante estimates will be used in this study.

The role of spatial planning in climate change adaptation

Historically, spatial planning has been considered necessary for overcoming the impacts or sources of climate change. The need to integrate climate change adaptation into spatial planning has been discussed for a long time. Meanwhile, climate change adaptation is an adjustment to actual climate stimuli in natural and human systems to moderate losses or explore beneficial opportunities (IPCC, 2007).

The role of planners is not only to ensure that climate change adaptation is integrated into spatial planning, but planners can also provide interventions regarding the use of zones by permitting or preventing specific land uses (Carter & Sheriff, 2011). In addition, the essence of planning practice is knowledge of current conditions and a continuous orientation to seek future improvements while avoiding emerging problems. It highlights the potential for planning to deal with adaptation to the impacts of climate change (Hurlimann and March 2012). The spatial configuration of cities and towns and how land is used and developed significantly impact cities' vulnerability to climate change's effects and will be central to adaptive responses to these changes (Davidse et al., 2015).

Methods

The research used secondary data in shapefiles (.shp) maps of Karawang Regency, planning documents, and related journals. The data needed to analyze the prediction of economic losses due to flooding disasters is a flood hazard map in Karawang Regency. The data was obtained from research by the Center for Climate Change of the Bandung Institute of Technology (2022) in the Study of Hydrometeorological Hazards in West Java Province. Hence, this data is relevant for use in this study.

The analysis method that will be carried out in this study is a spatial analysis using ArcGIS software. The analysis carried out is an overlay analysis of flood-prone maps with land-use maps in Karawang Regency which will then calculate each area of flood-prone areas in each type of land use to be studied, namely: industry, agriculture, and residential. The land area will then be multiplied by the predicted land value per type of land use, which is assumed to be the economic loss that Karawang Regency will bear in the event of a flood disaster at that location.

Area of Study

The area of this research study was conducted in Karawang Regency. Karawang Regency is astronomically located at coordinates 107° 02' BT - 107° 40' East Longitude and 5° 56' LS - 6° 34' South Latitude. It has an area of 1,753.27 km² or about 4.95% of the area of West Java Province and coastal and sea areas along 75 km with the authority of 4 miles from the outermost coastline, which is included in the scope of the district RTRW area. Karawang Regency is divided into 30 sub-districts, 297 villages, and 12 districts, with a population of 2,505,247 people in 2022 and a population density per km² of 1,286.76 people.

For the last five years (2018-2022), Karawang's economic structure has been dominated by four categories of business fields, namely: processing industry; wholesale and retail trade, repair of cars and motorcycles; construction; and agriculture (BPS, 2022).

The study area used in this study is specific to industrial, residential, and agricultural areas located in disaster-prone areas in Karawang Regency. Based on writings by Suroso et al. (2009), vulnerability studies can be divided into three scales, namely macro, meso, and micro, which are divided based on the size of the research area, data used in the study, planning level, accuracy, and expenditure per area. In this regard, the area that will be the study is on a microscale, with the size of the study region being local and using quantitative data and analysis. The result of this study can become a good input for Detailed Spatial Planning in considering the economic losses due to floods.

Mapping Flood Prone Areas in several types of land use

Flood-prone areas are being mapped in various areas (including residential, industrial, and agricultural) by placing a flood-prone disaster map over the area's current map. Then the number of areas affected will be obtained. This area will be used as data input to predict the number of losses that Karawang Regency will experience in each type of area (residential, industry, and agriculture). The analysis results will also be the subject of discussion in this study.

Prediction of economic losses due to flooding in several types of areas

The approach used in this study is the one developed by ELDI (Economic Land Degradation Initiative) in 2015. The calculation of economic value in this study only focuses on the land use value based on the market value of each land use type. There are three types of land use: residential, industrial, and agricultural. The standard weight for residential is based on the 2010 market value taken from DBS Research Group (2016), which amounted to Rp23.6 billion per Ha. The industrial land use market value is based on Bachdar data (2017), and this paper uses industrial land prices of Rp 21.1 billion per Ha. The standard value of agricultural land is IDR 0.9 billion, in Ward et al. (2010). However, the above values are then projected, assuming that the fixed interest rate is 4.75% based on the Governor's Decree (Setiawan, 2017). The standard values for calculating economic value are presented in Table 1.

The analysis of economic loss predictions due to floods will focus on identifying loss predictions based on flood hazard areas in residential, industrial, and agricultural regions in Karawang Regency. The total economic loss is obtained by multiplying the standard value by the total area of each land use type in flood-prone areas. In addition, the impact of failures is estimated or calculated based on the use value of residential, industrial, and agricultural land listed in the Suroso article (2017), as follows:

Table 1. Economic Value Standards per Land Use Type

Types of Land Use	Value per ha (in Rupiah)
Residential	81.040.335.284,79
Agriculture	3.116.935.972,49
Industry	49.870.975.559,87

Source: Suroso, 2017

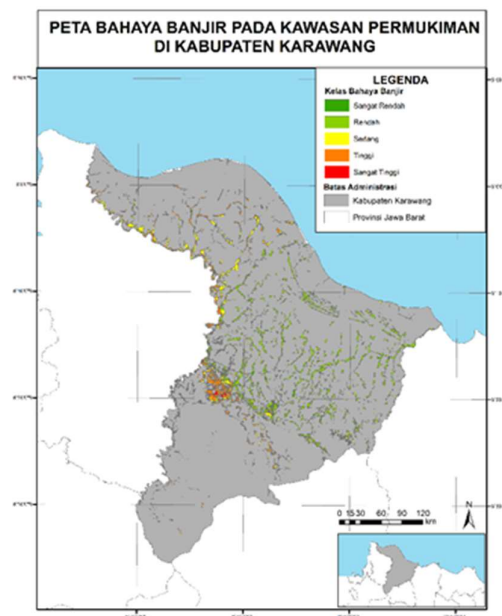
Analysis of economic loss predictions is carried out to indicate future economic losses. The economic value of built-up areas is undoubtedly higher than that of non-developed areas, but in this study, the possibility of a loss of damage will be interpreted as a potential economic loss (Ward et al., 2010; Purnama et al., 2015). Ward et al. (2010) simulated that changing from non-built-up areas to built-up areas would increase exposure to damage caused by inundation because built-up areas, such as industry and settlements, have higher land values than non-built-up areas.

Results

Mapping Flood Prone Areas in several types of land use

There are three mappings of flood-prone areas, including residential land use, industrial land use, and agricultural land use. Based on the analysis results, it was found that the size of residential land in flood-prone areas was 14,193.07 ha, the size of agricultural land in flood-prone areas was 104,560.89 ha, and the location of industrial land in flood-prone areas was 1,304.36 ha.

The following is a map of the distribution of disaster-prone areas in residential, agricultural, and industrial land use types:

**Figure 1.** Flood Hazard Map in Residential Areas

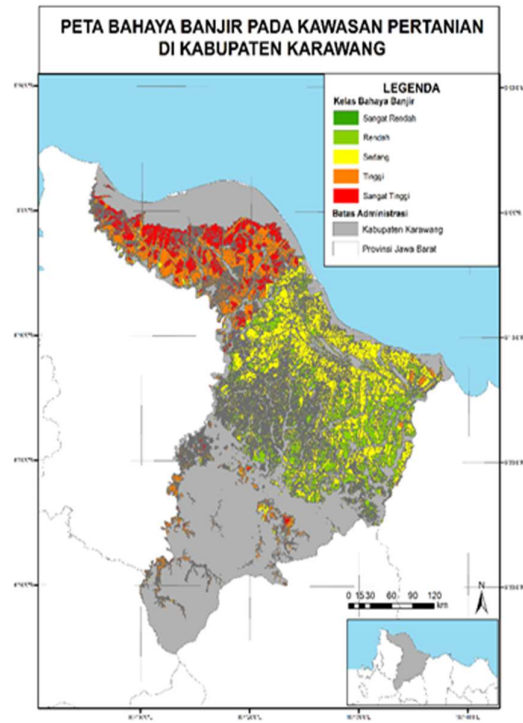


Figure 2. Flood Hazard Map in Agricultural Areas

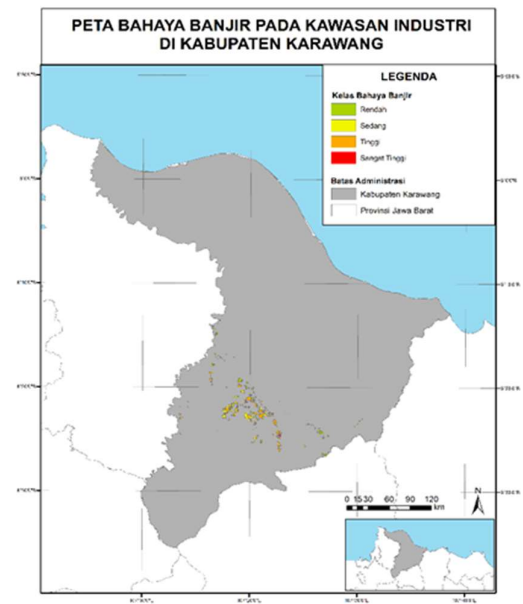


Figure 3. Flood Hazard Map in Industrial Areas

Prediction of economic losses due to flooding in several types of areas

The following is a table of the analysis of financial loss predictions due to flood disasters in industrial areas in Karawang Regency, including the size of hazard per class, the percentage of the hazard area, and forecasts of economic losses covered.

Table 2. Area and Percentage of Existing Land Use Area Threatened by Floods and Prediction of Economic Losses to be Obtained.

Land Use Types	Total Hazard Area (ha)	Entire Land Use Area (ha)	Percentage of Hazard Area	Total Loss (Rp)
Residential	14.193,07	20.140,75	70,47%	1.150.211.151.520.494
Agriculture	104.560,89	112.495,50	92,9%	325.909.599.356.569
Industry	1.304,36	3759,62	34,69%	65.049.705.681.272

Discussion

Based on the results of the analysis that has been carried out, it was found that the percentage of danger areas in residential and agricultural areas exceeds half of the total area of existing land in Karawang Regency. That also provides a significant potential loss for Karawang Regency. The area of industrial land use included in the vulnerable zone reaches 34.69%. However, it can be seen that the amount of losses obtained in agricultural areas is much more significant than in industrial areas, even though the economic value is smaller than in industrial areas. That is due to the vast agricultural land in Karawang Regency, and 92.9% of the total area is in disaster-prone areas.

Residential areas are not the dominant area in Karawang Regency but can provide relatively high losses because most of the residential land is in disaster-prone areas (amounting to 70.47%). In addition, the economic value in residential areas is undoubtedly higher than in industrial areas. That needs to be a concern in the future in making flood disaster mitigation plans in Karawang Regency in residential areas.

Based on the results of the analysis, it was found that the total amount of losses incurred in the Karawang Regency Industrial Estate was smaller than in other areas. That is because the location of the Karawang Regency industrial estate still tends to be narrow/minor, and the percentage of flood-prone sites in the industrial area in Karawang is still minimal. That means that Karawang Regency is good enough to allocate Industrial Estates, not in flood-prone areas, so the losses experienced are less than in other areas.

Limitation

In compiling this research, several limitations need to be considered along with future suggestions. First, there are limitations to the data used, where land use data is not the latest. Therefore, it is recommended to use the most recent land use data at least one or two years before the research is conducted so that the results obtained can be more accurate.

Furthermore, there are limitations to data regarding loss of value based solely on land value data. For further research, it broadens the categories in calculating losses, such as involving the value of industrial buildings, infrastructure, industrial production, and other factors that can be measured in monetary value. Thus, it can provide a more comprehensive picture of losses arising from changes in land use.

Conclusions

Conclusion

This study aimed to assess the potential economic impact of flooding on industrial estates in Karawang Regency. Our analysis found that a small-significant portion of industrial land is located in flood-prone areas, which could result in substantial economic losses which were found that 34.69% of the existing industrial land is located in flood-prone areas, predicted to have an impact on economic losses of IDR 65,049,705,681,272-. However, the losses suffered in industrial estates in Karawang Regency are less significant than those obtained in residential and agricultural areas. That is because the size of industrial estates in Karawang Regency has not dominated, and the percentage of industrial estates in disaster-prone regions of Karawang Regency tends to be minimal.

Recommendations

Although in conclusion, the losses experienced in Industrial Estates are smaller than in other regions. However, the value of Rp65,049,705,681,272,- is not small. Disaster mitigation efforts are needed in existing industrial areas currently in flood-prone areas. Of course, seeing the potential of the industrial sector in Karawang Regency, the area of industrial estates will expand from the data I use today. Suppose the government's current allocation of industrial estates does not consider flood-prone areas. In that case, it does not rule out the possibility that the total amount of losses to be borne exceeds the current prediction results. Therefore, the government must be able to carry out careful utilization planning and control in developing industrial estates in the Karawang Regency.

Disaster mitigation in industrial estates can be carried out in various stages, including:

1. Flood Risk Management Plan: In this plan, companies must map flood risk by identifying areas prone to flooding. Then, companies can establish effective mitigation measures to reduce flood risk, such as improving drainage and irrigation systems, building dikes, and preparing tools for evacuation.
2. Monitoring System: Companies can install flood sensors and monitor water levels in nearby rivers in anticipation of flooding. By monitoring water levels in real-time, companies can prepare before floods occur and take the necessary steps to mitigate their impact.
3. Training Programs: Companies can train employees and staff to deal with flood disasters. This training can include instruction on how to avoid flooded areas, how to avoid strong water currents, and how to act in emergencies.
4. Evacuation and Recovery Plan: Companies must devise an effective evacuation and recovery plan. This plan should include clear evacuation procedures, post-disaster preparedness preparations, and detailed recovery measures to help companies and surrounding communities recover after a disaster.
5. Collaboration with Government and Community: Companies can collaborate with the government and surrounding communities to reduce flood risk. That can be done by helping to improve drainage and irrigation systems in the region and facilitating the exchange of information and resources to cope with disasters. The Methods should be described with sufficient details, especially for new methods and protocols, while well-established methods can be briefly described and appropriately cited. The author should add subsections and subsubsection so that other scientists are convinced enough that the works are replicable upon the published results.

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