Analyzing the Impact of Environmental and Behavioral Factors on Flood Risk

Abstract

This study aims to analyze the impact of environmental conditions and community behavior on flood risk using OLS regression.Extreme weather changes that occur on Earth have had a significant negative impact on various aspects of life. One of the main disasters caused by extreme weather is flooding. Flooding is exacerbated by neglectful behavior towards the environment. This study uses environmental data and community behavior in waste management as independent variables. In addition, this study uses flood disaster index data as the dependent variable. This study uses descriptive analysis and inferential analysis (Ordinary Least Square-OLS). Through OLS, it will be known how big the role and significance of the independent variable is on the dependent variable. Community participation is needed in managing waste and awareness of the dangers of living on riverbanks. The government also needs to discipline people who litter and provide waste disposal sites close to settlements in reasonable amounts. The government also needs to relocate people who still live on riverbanks, because indirectly community activities on riverbanks will trigger flooding.

Keywords : Flood; environment; community behavior; Indonesia

1. Introduction

Extreme weather changes occurring on Earth have had a significant negative impact on various aspects of human life, ecosystems, and the environment as a whole(Ebi et al., 2021; Meierrieks, 2021). This phenomenon is characterized by an increase in the frequency of natural disasters such as floods, droughts, storms, and extreme heat waves, which are not only economically damaging but also threaten human safety and well-being. In addition, unpredictable weather changes have a direct impact on the agricultural sector, with crop yields declining due to prolonged droughts or irregular rainfall patterns. The health sector is also affected, with an increase in cases of climate-related diseases, such as malaria, dengue fever, and respiratory diseases due to deteriorating air quality. Furthermore, natural ecosystems are under great stress, with many species of flora and fauna losing their habitats or being unable to adapt quickly to changing temperatures and weather patterns.

One of the major disasters caused by extreme weather is flooding, which is a significant threat in many parts of the world, including tropical and subtropical regions. Flooding can occur due to very high rainfall in a short period, river overflows, or rising sea levels due to heavy storms and climate change phenomena such as melting ice at the poles(Mimura, 2013; Trenberth, 2011; Walsh et al., 2020). The impact of flooding is not only felt physically with damaged infrastructure, such as roads, bridges, and buildings, but also socially and economically, with many people losing their homes, livelihoods, and access to necessities such as clean water and food. In addition, flooding also carries serious health risks, including the spread of water-based diseases such as leptospirosis, diarrhea, and skin infections. In the context of climate change, the intensity and frequency of flooding are expected to increase, thus requiring more effective mitigation and adaptation measures. These measures include building resilient infrastructure, improving drainage systems, conserving forests as water reservoirs, and increasing public awareness of the importance of disaster preparedness.

Floods occur when the water discharge resulting from rainfall exceeds the capacity of the earth's surface, either through rivers, drainage channels, or natural catchment areas. This condition is often exacerbated by various factors, including unplanned land use changes, such as massive urbanization, deforestation, and narrowing of river basins due to sedimentation or human activity(Acreman & Holden, 2013; Balasubramanian, 2017; Matthai, 1990). In urban areas, the low capacity of the drainage system to drain rainwater is often the main cause of widespread flooding. In addition, the lack of water catchment areas, such as green spaces or open land, also reduces the ability of the soil to absorb water naturally, increasing the risk of flooding(Cea & Costabile, 2022; Gavrilescu, 2021; Keesstra et al., 2021).

Floods are not solely caused by high rainfall but are also influenced by people's behavior towards the environment, which often worsens the risks and impacts. One of the main factors is poor waste management in many areas, where domestic and industrial waste is often disposed of carelessly, including into waterways, rivers, and drainage. The accumulation of this waste causes blockages in water flow, which ultimately reduces the capacity of the drainage system and increases the risk of inundation and flooding. In addition, the presence of settlements on riverbanks is also a significant cause, where people living in this area tend to face a higher risk of flooding due to riverbank erosion and narrowing of waterways. Unplanned development activities along rivers also often ignore the natural capacity of rivers to accommodate rainwater, thus worsening the potential for flooding during heavy rain.

Throwing garbage into water channels is one of the main factors that can cause flooding(Echendu, 2023; Ijaz et al., 2021; Tharani et al., 2021). When waste, be it plastic, paper, or other materials, is thrown into water channels, it can block the flow of water that should flow smoothly. Blockage of water channels due to accumulation of waste reduces the capacity of the channels so that water cannot flow optimally. As a result, the volume of water that is blocked will overflow and cause flooding, especially during high rainfall. In addition to the impact on the environment, flooding caused by waste also has the potential to cause economic losses, damage infrastructure, and threats to the health of the affected community(Abubakar et al., 2022; Crawford et al., 2022; Hussain & Reza, 2023).

In Indonesia, many people live along riverbanks, especially in rapidly developing urban and rural areas. Although these areas offer easy access to natural resources and transportation, the presence of settlements along riverbanks increases their vulnerability to flooding. One of the main causes is changes in nature and human behavior that worsen river flow conditions, such as deforestation, land conversion, and ineffective water channel control. In addition, residents living in these areas tend to build houses informally, without considering disaster mitigation aspects, such as building height or environmental carrying capacity. As a result, when heavy rain occurs or the volume of river water increases, these residential areas are very vulnerable to overflowing water which can cause flooding. This phenomenon not only threatens life safety but also causes great material losses and worsens the quality of life of the affected community.

There have been many studies examining the influence of climate on flood disasters(Atanga & Tankpa, 2021; Shi et al., 2021; Wang et al., 2021). However, there are still limited studies that examine other aspects that can affect flooding, especially community behavior toward the environment. Through this study, it will be known how waste management affects flooding in an area. In addition, through this study, it will be known the impact caused by the existence of community residences on riverbanks on flooding.

2. Data and Methodology

The data used in this study comes from the results of the 2021 Village Potential data collection related to the environment and community behavior in waste management, obtained from the Central Statistics Agency. In addition, this study uses 2023 flood disaster index data from the National Disaster Management Agency. The availability of flood index data is only available at the district/city level, while environmental data is available up to the village level. Therefore, flood index data will be the same for each village in the corresponding district/city.

This study uses descriptive analysis and inferential analysis (Ordinary Least Square-OLS). Through OLS, it will be known how big the role and significance of the independent variable is on the dependent variable(McKelvey & Zavoina, 1975). The dependent variable used in this study is the flood index by district/city. The independent data used in this study are waste disposal to the trash can then transported, waste disposal into holes or burned, waste disposal into rivers/irrigation channels/lakes/seas, the existence of temporary waste disposal sites, the existence of settlements on riverbanks, the number of settlement locations on riverbanks, and the number of houses on riverbanks.

3. Results and Discussion

Table 1 shows the number of villages based on household waste disposal sites, reflecting waste management patterns in Indonesia. Most villages (78.41%) have waste bins that are then collected by relevant parties, indicating awareness and the existence of adequate waste management infrastructure in many areas. However, there are still 21.59% of villages that do not have this facility, which is most likely located in remote or hard-to-reach areas.

Most villages (87.39%) also do not burn or dump waste into holes, with only 12.61% still using this method. This phenomenon reflects the increasing public awareness of the dangers of burning waste to the environment and health. However, the use of this method in certain villages indicates that there is still limited access to more modern waste management services. On the other hand, around 28.81% of villages still dump waste into water bodies such as rivers, irrigation channels, lakes, or the sea, although the majority of villages (71.19%) have avoided this practice. Disposal of waste into water bodies remains a major challenge, especially in areas that do not have temporary waste disposal sites (TPS) or waste transportation facilities.

The existence of TPS in most villages (82.04%) shows that efforts to provide basic infrastructure for waste management have been made, although there are still 17.96% of villages that do not have it. Villages without TPS are likely to face budget constraints or lack of priority in infrastructure development.

Problems such as waste disposal into water bodies that still occur indicate the need for further intervention. The government needs to increase access to sanitation services in remote villages and conduct ongoing environmental education to change people's habits(Herdiansyah et al., 2021; Kohlitz & Iyer, 2021; Tan, 2021). In addition, investment in infrastructure such as TPS and regular waste transportation is essential to create a sustainable and equitable waste management system. With these steps, it is hoped that the waste problem in Indonesia can be handled more effectively so that negative impacts on the environment and public health can be minimized.

Table 1. Number of Villages Based on Family Waste Disposal Sites

Description	Option	Freq.	Percent
Trash bin then transported	Yes	53,123	78.41
	No	14,626	21.59
In a hole or burned	Yes	8,541	12.61
	No	59,208	87.39
River/irrigation canal/lake/sea	Yes	48,231	71.19
	No	19,518	28.81
There is a temporary rubbish dump	Yes	55,578	82.04
	No	12,171	17.96

Based on Table 2, as many as 83.03% of villages in Indonesia have settlements located on riverbanks, while only 16.97% of villages do not have settlements in that location. The high percentage of villages with settlements on riverbanks reflects a phenomenon that often occurs in Indonesia, where rivers are often the center of community activities, both for domestic needs such as bathing and washing and as a source of livelihood through activities such as fishing or transportation.

However, the existence of settlements on riverbanks also poses several major challenges. One of them is the risk of flooding, which often occurs especially during the rainy season, considering that many rivers in Indonesia experience shallowing or narrowing due to sedimentation and waste disposal. In addition, settlements on riverbanks are often poorly organized and have poor sanitation, which contributes to water pollution and an increased risk of water-based diseases such as diarrhea and dengue fever.

This phenomenon shows that spatial planning in rural areas still needs to be improved, especially to prevent the development of settlements in flood-prone areas such as riverbanks. Educating the community about the risks of living on riverbanks, coupled with relocation efforts to safer areas and adequate infrastructure development, are important steps in overcoming this problem. The government also needs to increase supervision of activities on riverbanks to reduce environmental impacts and minimize disaster risks. With a more integrated approach, it is hoped that the management of riverbank areas in Indonesia can be carried out more sustainably and safely for the community.

Table 2. Number of Villages Based on the Existence of Settlements on Riverbanks

Description	Option	Freq.	Percent
The existence of settlements on riverbanks	Yes	56,250	83.03
	No	11,499	16.97

Based on Table 3 regarding the number of settlement locations on riverbanks per province, it can be seen that West Java has the largest number of locations with 1,257 villages or 10.93% of the total. This is followed by South Kalimantan with 1,035 villages (9.00%) and East Java with 862 villages

(7.50%). These three provinces have a significant contribution to the total settlements on riverbanks in Indonesia, reflecting the large population and high activity in the river basins in the region.

Provinces such as West Nusa Tenggara (23 villages, 0.20%), Gorontalo (16 villages, 0.14%), and Bangka Belitung Islands (27 villages, 0.23%) have the fewest number of settlement locations on riverbanks. This can be attributed to the geographical and demographic characteristics of these areas, where the existence of large rivers as centers of community activity is relatively more limited compared to other provinces.

Table 3. Number of Residential Locations on Riverbanks

Province	Freq.	Percent
Aceh	480	4.17
Sumatera Utara	589	5.12
Sumatera Barat	228	1.98
R i a u	373	3.24
J a m b i	411	3.57
Sumatera Selatan	565	4.91
Bengkulu	62	0.54
Lampung	321	2.79
Kepulauan Bangka Belitung	27	0.23
Jawa Barat	1,257	10.93
Jawa Tengah	715	6.22
DI Yogyakarta	47	0.41
Jawa Timur	862	7.50
Banten	564	4.90
Nusa Tenggara Barat	23	0.20
Nusa Tenggara Timur	305	2.65
Kalimantan Barat	718	6.24
Kalimantan Tengah	824	7.17
Kalimantan Selatan	1,035	9.00
Kalimantan Timur	300	2.61
Kalimantan Utara	51	0.44
Sulawesi Utara	63	0.55
Sulawesi Tengah	272	2.37
Sulawesi Selatan	465	4.04
Sulawesi Tenggara	116	1.01
Gorontalo	16	0.14
Sulawesi Barat	130	1.13
Maluku	141	1.23
Maluku Utara	153	1.33
Papua Barat	138	1.20
Papua	248	2.16
Total	**11,499**	**100.00**

This phenomenon reflects the geographical and socio-economic patterns of Indonesia, where settlements on riverbanks tend to be more common in areas with large rivers that are centers of economic and transportation activities, such as in Java and Kalimantan. However, the existence of settlements on riverbanks also poses major challenges, such as the risk of flooding that often occurs in densely populated areas such as West Java and East Java, as well as river pollution due to domestic and industrial waste disposal.

The government needs to pay special attention to areas with high concentrations of settlements on riverbanks, especially to manage the risk of disasters and environmental pollution. Relocation of settlements to safer locations, better spatial management, and the development of adequate sanitation infrastructure and waste management systems are strategic steps that need to be taken. With an integrated approach, the negative impacts of settlements on riverbanks can be minimized, while improving the quality of life of the people living in the area.

Table 4. Number of House Buildings on Riverbanks

Province	Freq.	Percent
Aceh	480	4.17
Sumatera Utara	589	5.12
Sumatera Barat	228	1.98
R i a u	373	3.24
J a m b i	411	3.57
Sumatera Selatan	565	4.91
Bengkulu	62	0.54
Lampung	321	2.79
Kepulauan Bangka Belitung	27	0.23
Jawa Barat	1,257	10.93
Jawa Tengah	715	6.22
DI Yogyakarta	47	0.41
Jawa Timur	862	7.50
Banten	564	4.90
Nusa Tenggara Barat	23	0.20
Nusa Tenggara Timur	305	2.65
Kalimantan Barat	718	6.24
Kalimantan Tengah	824	7.17
Kalimantan Selatan	1,035	9.00
Kalimantan Timur	300	2.61
Kalimantan Utara	51	0.44
Sulawesi Utara	63	0.55
Sulawesi Tengah	272	2.37
Sulawesi Selatan	465	4.04
Sulawesi Tenggara	116	1.01
Gorontalo	16	0.14
Sulawesi Barat	130	1.13
Maluku	141	1.23
Maluku Utara	153	1.33
Papua Barat	138	1.20
Papua	248	2.16
Total	**11,499**	**100.00**

Table 4 shows the distribution of the number of houses on riverbanks in various provinces in Indonesia. In total, there are 11,499 houses on riverbanks, with varying distributions in each region. West Java Province is in the top position with 1,257 houses (10.93%), followed by South Kalimantan with 1,035 houses (9.00%) and East Java with 862 houses (7.50%). Meanwhile, several provinces such as West Nusa Tenggara (23 houses, 0.20%) and Gorontalo (16 houses, 0.14%) have a very small number of houses on riverbanks.

This distribution reflects the geographic and socio-economic dynamics in Indonesia. West Java, as the province with the highest number, is likely influenced by the high population density and urbanization in the region, which drives the expansion of settlements to riverbank areas. On the other hand, South Kalimantan, which is ranked second, shows the influence of community adaptation patterns to geographical conditions, considering that this region is known for its many large rivers that serve as transportation routes and economic activities for the community.

However, this phenomenon also raises various challenges. The high settlements on riverbanks are often associated with the risk of flooding, river pollution, and environmental degradation. For example, areas in Kalimantan and Java, which often face seasonal flooding, reflect the impact of uncontrolled urbanization and the lack of effective spatial planning. Government programs such as "river normalization" or "relocation of riverbank communities" can be a solution, although their implementation requires an inclusive approach to maintain community welfare.

Provinces with low numbers, such as Gorontalo and West Nusa Tenggara, show a smaller potential for urbanization impacts on rivers, although they still need to be anticipated as the region develops. This analysis illustrates that the management of settlements on riverbanks requires cross-sectoral attention to reduce disaster risks and maintain the sustainability of river ecosystems.

Table 5. Community Behavior Regression Results Towards Floods

Independent Variable		**Coef.**	**Robust Std. Err.**	**t**	**P>|t|**	**[95 % Conf. Interval]**	
Waste is disposed of in:	The trash can is then transported	-1.23	0.09	-13.32	0.00	-1.42	-1.06
	In a hole or burned	-1.89	0.10	-17.94	0.00	-2.10	-1.69
	River/irrigation canal/lake/sea	0.41	0.07	5.55	0.00	0.26	0.55
The existence of a temporary waste disposal site		-1.60	0.10	-16.53	0.00	-1.80	-1.41
The existence of settlements on riverbanks		2.22	0.11	1.98	0.05	-0.00	0.43
Number of settlement locations on river banks		-0.05	0.03	-1.72	0.09	-0.11	0.01
Number of houses on the riverbank		-0.00	-0.00	2.72	0.01	-0.00	-0.00
Constant		24.05	0.11	219.18	0.00	23.84	24.26

Dependent Variable : Flood Disaster Index

The results of the regression analysis in Table 5 show that community behavior related to waste management, the existence of settlements on riverbanks, and waste management infrastructure have a significant influence on the flood disaster index. Waste that is managed properly, such as being thrown into a trash can and then transported, has a significant negative relationship with the flood disaster index, indicating that this behavior can reduce the risk of flooding. Conversely, throwing waste into rivers, irrigation channels, lakes, or the sea increases the flood disaster index(Bakti et al., 2024; Lamond et al., 2012; Tvedten & Candiracci, 2018). These results are in line with previous research. This phenomenon reflects conditions in Indonesia, where piles of garbage in rivers often cause blocked water flow and worsen the risk of flooding, especially in urban areas.

In addition, the existence of temporary waste disposal sites (TPS) also has a significant impact on reducing the flood disaster index, indicating the importance of waste management infrastructure development for flood risk mitigation(Amato et al., 2020). However, the existence of settlements on riverbanks has a positive relationship with the flood disaster index, indicating that settlements in this location increase vulnerability to flooding. However, the number of settlement locations on riverbanks does not have a significant relationship, while the number of houses on riverbanks has a very small but significant effect.

This context is very relevant to the conditions in Indonesia, where uncontrolled urbanization, the habit of throwing waste into rivers, and settlements on riverbanks are the main contributors to flood risk. Frequent flooding disasters, especially in big cities such as Jakarta and Bandung, show the need for a holistic approach that includes educating the public about waste management, building TPS, and rearranging settlements on riverbanks. This strategy can help reduce flood risk, preserve the environment, and improve the quality of life of the community.

4. Conclusion

This study shows that community behavior in waste management, the existence of waste disposal infrastructure, and settlements on riverbanks significantly affect the risk of flood disasters. Well-managed waste disposal is proven to reduce the flood disaster index, while waste disposal into water bodies significantly increases the risk. The existence of settlements on riverbanks also makes a positive contribution to increasing flood risk, indicating the importance of better spatial management. These results emphasize that a comprehensive mitigation approach, including improving waste management infrastructure, re-arranging riverbank areas, and community education, is essential to reduce flood risk sustainably. This study provides important implications for policymakers in designing evidence-based disaster mitigation strategies for flood-prone areas.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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