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Case-based Article

The flood points distribution in Dibal Village from 2019 to 2023

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ABSTRACT

Floods are natural disasters that commonly occur in tropical countries like Indonesia. Floods often happen in low-lying areas densely populated by residents. The amount and intensity of rainfall have a significant impact on the occurrence of floods at specific points. Population growth and urban development have led to rapid construction, reducing areas for rainwater absorption. This study was conducted in Dibal Village, Ngemplak District, Boyolali Regency, which directly borders Surakarta City. The area has three important facilities as supporting facilities for the region. This research aims to determine the distribution and causes of floods in Dibal Village over the past five years.This research utilized spatial data, analyzed qualitatively using a descriptive approach. Research data were obtained from in-depth interviews and presented in a flood distribution map of Dibal Village. The results of this study identified flood points in Beran Hamlet, North Dibal Hamlet, Central Dibal Hamlet, South Dibal Hamlet, and North Wangkis Hamlet. Among these hamlets, the most severely affected by floods is Beran Hamlet, with flood depths ranging from 30-50 cm and a receding time of 5-9 hours. Meanwhile, North Dibal Hamlet experienced flood depths of 10-30 cm with a receding time of 3-7 hours, Central Dibal Hamlet had flood depths of 10-20 cm with a receding time of 3-5 hours, South Dibal Hamlet had flood depths of 15-25 cm with a receding time of 3-5 hours, and North Wangkis Hamlet had flood depths of 10-25 cm with a receding time of 3-9 hours.

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1. INTRODUCTION

As a tropical country with high rainfall, Indonesia is no stranger to flooding disasters (Sugandi, 2016). These disasters can be influenced by environmental factors, both physical and social. Floods occur in areas with high rainfall and high population density, as well as in regions located in basins or lower than the surrounding areas. These events have adverse impacts on humans, such as loss of life and damage to infrastructure, settlements, and the natural environment (Arrighi et al., 2023; Setiawan et al., 2020). Population density and human activities have led to extensive construction, resulting in a reduction of rainwater absorption areas (Afrianto et al., 2016). Floods continue to be a recurring disaster that causes significant social and economic losses to communities.

Floods usually occur during periods of heavy rainfall (Weday et al., 2023; Mardikaningsih et al., 2017). In certain areas, water accumulation gradually increases, leading to flooding. Areas with dense populations and low-lying terrain are prone to this type of disaster. The density of settlements in a region is influenced by the development of settlements along riverbanks and other constructions in the area. Riverbanks refer to areas on the right or left side of a river.

In recent years, there has been a significant increase in rainfall intensity and frequency throughout Indonesia. This increase in rainfall is a primary factor contributing to floods in specific regions (Rosyidie, 2013; Nora, 2023). Dibal Village is located in the Ngemplak District of Boyolali Regency, directly adjacent to Surakarta City. This area has undergone rapid development due to the expansion of Surakarta City. The conversion of land use has become more extensive, particularly in peripheral urban areas (Iemaaniah et al., 2023; Qodriyatun, 2020). Most of the converted areas were previously undeveloped land used for agriculture, gardens, or vacant land (Iemaaniah et al., 2023). In this village, there is a river that marks the boundary between Dibal Village and Manggung Village. Over the past five years, the village has frequently experienced flooding in its residential areas, particularly during the rainy season, with flooding reaching into houses in several locations.

Building on previous research, this study relies on spatial descriptions presented in the form of mapping the flood points that have occurred in Dibal Village. Previous studies (Sugandi, 2016) focused on flood management models and employed qualitative research methods by combining flood theories to analyze and develop flood management models. Similarly, Rosyidie (2013) analyzed flood issues using descriptive analysis of specific parameters, while Qodriyatun (2020) focused on the emergence of spatial planning policies.

2. METHODS

This research was conducted in Dibal Village, Ngemplak District, Boyolali Regency, which is directly adjacent to Surakarta City. The research employed a survey method and spatial analysis using ArcGIS 10.3. It is a qualitative study with a descriptive approach. Research data were obtained through interviews and presented in the form of mapping by overlaying the data obtained from the image data collection of Dibal Village. The survey method was used to cross-check and determine flood points in the hamlets that experienced flooding, considering physical environmental indicators such as elevation, population density, building density, and distance between flood points and the river. In-depth interviews were conducted with affected community members, including the village head, local neighborhood association (RT) leaders, and local residents.

3. RESULTS AND DISCUSSION

3.1 The Condition of Dibal Village

Dibal Village is located on flat terrain. Its elevation is 150 meters above sea level (masl). The village benefits from its fertile land, formed through fluvial processes, making it suitable for habitation. The total area of the village is 279.96 hectares, with a population of 6,553 individuals (BPS Boyolali, 2019). The population density in the village is relatively low, with 23 people per square kilometer. Based on this population density, the village is considered to have a low population density. The land use in the village is predominantly agricultural, accounting for over 50% of the total area, with paddy rice as the main crop. The rainfall intensity in Dibal Village is recorded at 2,645 mm per year or 106 mm per day (BPS Boyolali, 2019). With such high rainfall intensity, floods can occur at specific points.

Figure. 1 (a) Riverbank Area; (b) Flood in Dibal Utara Hamlet; (c) Flood in Beran Hamlet; (d) Flood in Agricultural Land of Beran Hamlet

3.2 Rivers and Riverbank Areas

Dibal Village is crossed by a river that serves as the border between Dibal Village and the village located to the north, Manggung Village. Additionally, the southern part of the village is also bordered by a river, which serves as the administrative boundary with Donohudan Village. These rivers function as drainage channels during periods of heavy rainfall. As the population grows and the need for housing increases, the areas around the river, known for their fertility and low land prices, have witnessed the development of residential areas. Riverbank areas are supposed to be reserved for non-residential purposes and should not be used for human activities or settlements (Ministry of Public Works and Public Housing of the Republic of Indonesia, 2015). However, these river areas are often used as

dumping grounds for waste and residential settlements. Rivers should serve as catchment areas for surface water runoff that cannot penetrate the ground. The elongated pattern of settlements along the river has disrupted the natural function of the river itself.

3.3 Land Use Change

In the past 10 years, this village has undergone land use changes. Some paddy fields, yards, settlements, and plantations have been converted into developed land for government projects such as toll roads and railway tracks. The rapid development can reduce vacant land and green open spaces that previously served as rainwater catchment areas. Moreover, paddy fields, which consist of clayey soil make it difficult for water to penetrate the soil particles and cause waterlogging. The soil type in productive agricultural land belongs to the vertisol type, which expands during the rainy season, allowing it to retain water and have a slow water infiltration rate. This condition results in the formation of puddles or surface water unable to seep into the soil, requiring a longer time compared to sandy soils (Utomo, 2016).

Land use changes occur due to urban development in the Surakarta city area. Surakarta, being a rapidly developing city, has experienced urban expansion, including in the outskirts of the city where this village is located. Public facilities built in this village include the airport railway, Solo-Kertosono toll road, and the expansion of the Adi Sumarmo Airport Area. During the land conversion process for these three development projects, there were demolitions of settlements, paddy fields, gardens, and other vacant lands. Displaced settlements seek new residential areas nearby by purchasing vacant lands in the village. Consequently, open land continues to diminish due to these land use changes.

Figure. 2 Solo-Kertosono Toll Road in Dibal Village

During periods of heavy rainfall, the areas surrounding the toll road experience floods of 10 to 20 cm in depth. These areas around the toll road are densely populated and predominantly built up. The occurrence of floods in this area is due to a decrease in rainwater absorption areas and the interruption of water drainage flowing towards the Cengklik Reservoir. The vicinity of the toll road includes two densely populated hamlets, namely Dibal Selatan Hamlet and Dibal Tengah Hamlet.

3.4 Flood Points and Causes

Over the past five years, the Dibal village has experienced several flood points due to exceptionally high rainfall. In 2019, after the construction of the toll road and railway tracks in the village, floods occurred, inundating residential areas, paddy fields, and other vacant lands. In both 2019 and 2020, flood points were observed in various locations, including Dibal Tengah Hamlet (RT 01/05), Dibal Selatan Hamlet (RT 03/08), Dibal Utara Hamlet (RT 04/06), Beran Hamlet (RT 03/06), agricultural land,

and the village's field. The floods during these years were caused by high rainfall and intense rainfall events. Additionally, these flood-prone areas are densely populated residential areas directly adjacent to the river (Beran Hamlet rt 03/06), resulting in the overflow of the river waters into the settlements. The flood points in Dibal Tengah Hamlet (RT 01/05), Dibal Selatan Hamlet (RT 03/08), agricultural land, and the village's field are directly adjacent to the railway tracks and the Solo-Kertosono toll road. The flood points in these areas occurred due to the lack of reconstructed drainage systems, as the previous ones were disrupted by the construction of the toll road and railway tracks.

In 2021, 2022, and 2023, floods recurred, inundating specific residential areas. The high rainfall and intensity during certain periods directly impacted the communities residing near or adjacent to the river. In the past three years, floods only affected the areas of Beran Hamlet (RT 03/06), Dibal Utara Hamlet (RT 04/06), agricultural land, and the village's field. The flood points in Dibal Tengah Hamlet (RT 01/05) and Dibal Selatan Hamlet (RT 03/08) did not experience floods during the past three years. This is attributed to the fact that the intensity of rainfall during these years was not as high as in 2019 and 2020. The floods in the village ranged from approximately 10 cm to 50 cm in depth, with a duration of inundation lasting around 5-9 hours during each flood event along the river. The distribution of flood points over the past five years is presented in map images 6 and 7 below.

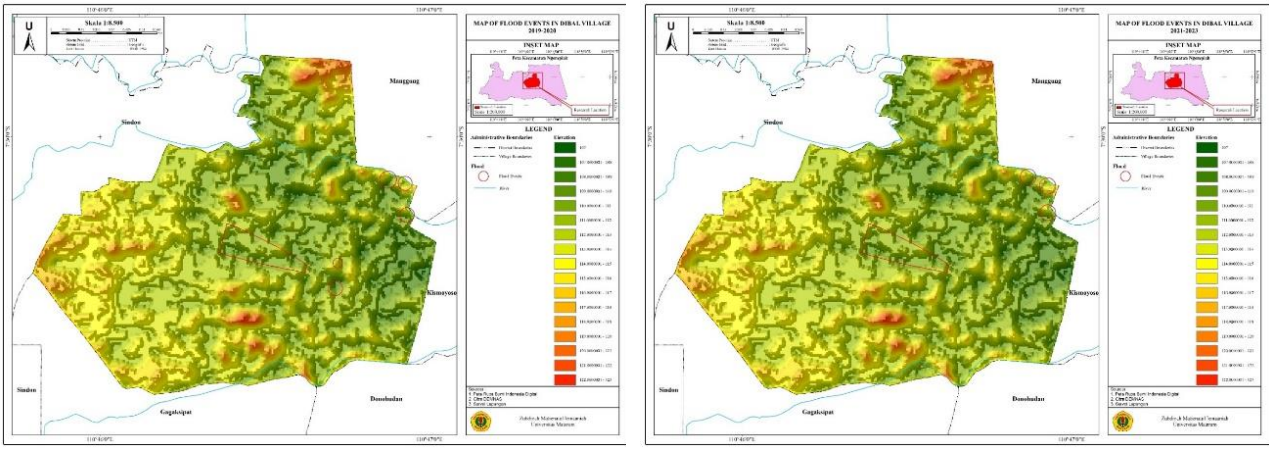

Figure. 3 (a) Map of Dibal Village flooding area from 2019 to 2020; (b) Map of Dibal Village flooding area from 2021-2023

The determination of flood-prone areas in Dibal Village is based on the flood incidents that occurred over the past five years. According to the flood point map in Dibal Village in images 6 and 7 above, the flood-prone areas in the village are influenced by the elevation of the land. The areas that frequently experience floods have low to moderate elevations. To determine the flood points based on environmental indicators, factors such as the distance of the area from the river, densely populated residential and building areas, and areas with limited rainwater absorption are taken into account. From the floods that occurred in the five points in Dibal Village, it can be observed that the most severe flood-prone areas are located near the river on the village border. These flood points include Beran Hamlet and Dibal Utara Hamlet. Meanwhile, the points in Dibal Selatan Hamlet, Dibal Tengah Hamlet, and Wangkis Utara Hamlet are situated around the toll road and railway tracks. With the construction of these mega projects, the rainwater absorption areas in these areas have decreased significantly, making them highly susceptible to heavy rainfall. Table 1 below shows the results of interviews with the community regarding the flood incidents that have occurred over the past five years.

Table 1. Interview Results

Year	Flood Points	Water Level	Recession Period
2019-2020	Dibal Selatan Hamlet	15-25 cm	3-5 hours
2019-2023	Dibal Utara Hamlet	10-30 cm	3-7 hours
2019-2023	Beran Hamlet	30-50 cm	5-9 hours
2019-2023	Wangkis Utara Hamlet	10-25 cm	3-9 hours
2019-2020	Dibal Tengah Hamlet	10-20 cm	3-5 hours

Interview Results, 2023

Based on the table above, the most severe flood point is located in Beran Hamlet. Geographically, this area is situated in a floodplain due to the presence of residential areas near the river. In Beran Hamlet, floods occur not only once a year, and this hamlet is always prone to flooding. During periods of high rainfall and intensity, the surface water level rises rapidly and can persist for a considerable duration, typically around 5-9 hours. Besides the geographical conditions and the influence of natural phenomena, the occurrence of floods is also influenced by human activities in the vicinity (Rosyidie, 2013). One of the factors is the expansion of settlements in the river areas and the indiscriminate disposal of waste into the river. The floods in Beran Hamlet not only affect residential areas but also inundate the rice fields in the hamlet, causing farmers to be cautious during the rainy season as it significantly affects their agricultural yields.

Meanwhile, a similar situation is observed in Dibal Utara Hamlet. The flooding in this area is caused by the fact that these two hamlets are directly adjacent to the river at the border between Dibal Village and Manggung Village. In Wangkis Utara Hamlet, the flood points are located on agricultural land and a soccer field area. The floods in this hamlet occur due to the clogging of drainage systems caused by the construction of the toll road and railway tracks surrounding the area. According to the Village Head of Dibal, Mr. Sulistyanto, drainage systems will be constructed in this area to prevent inundation during the rainy season.

The floods from 2019 to 2020 that affected Dibal Selatan Hamlet and Dibal Tengah Hamlet were due to extremely high rainfall intensity in Ngemplak Sub-district. These two hamlets are directly adjacent to the Solo-Kertosono toll road and Adisumarmo Airport railway tracks. The floods in these two hamlets directly affected the residential areas. The floods around these infrastructure facilities did not reach the interior of houses but inundated roads and residents' yards. This situation was exacerbated by the disruption of drainage flow around the residential areas due to the construction of the toll road, the lack of rainwater absorption areas, and the absence of proper water storage facilities for surface runoff during heavy rainfalls

4. CONCLUSION

Flood is a natural disaster that can occur both naturally and due to human activities. Changes in land use, high intensity, and rainfall can cause floods in certain areas. The floods that occur in Dibal Village are caused, among other factors, by construction activities that disrupt the drainage system, the reduction of water absorption areas in the surrounding settlements, and the development of settlements along the river.

Based on the above discussion, the most severe flood occurs in Beran Hamlet, particularly in RT 03/06. This is because the settlement in this village is directly adjacent to the river at the border between Desa Dibal and Desa Manggung, coupled with very heavy rainfall. The flood in this village takes a considerable amount of time to recede, around 5-9 hours. On the other hand, in Dibal Selatan Hamlet, Dibal Utara, Dibal Tengah, and Wangkis Utara Hamlet, the flood is not as severe as in Dusun Beran. The frequency of flooding in these villages is not as frequent as in Dusun Beran, where almost every heavy rainfall causes a flood.

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