Equivalent : Journal Of Economic, Accounting and Management
Vol. 4, No. 1, 2026, 1445-1454
Publisher: CV. Doki Course and Training
E-ISSN: 2985-8089 | P-ISSN: 2986-8777

OPTIMIZATION OF DRAINAGE SYSTEM ON JALAN SISINGAMANGARAJA TO OVERCOME FLOODING IN TIGALINGGA VILLAGE, DAIRI REGENCY

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ARTICLE INFO

Article History
Submission : 08/05/2026
Received : 08/05/2026
Revised : 15/05/2026
Accepted : 19/05/2026

Keywords
Drainage, Flooding, Sisingamangaraja Road, Tigalingga Village, Qualitative, Sustainable Infrastructure

ABSTRACT

Tigalingga Village is one of the areas that, geographically, has a relatively low-lying topography with fairly flat terrain, making it prone to waterlogging, especially during the rainy season. High rainfall, combined with an inadequate drainage system, causes routine flooding at several locations, one of which is along Sisingamangaraja Road. Frequent flooding not only disrupts residents' daily activities but also causes damage to road infrastructure, hampers transportation, and increases the risk of waterborne diseases. One of the main causes of flooding on Sisingamangaraja Road is the limited capacity of the drainage channels to accommodate heavy rainfall. Many drainage channels are clogged with waste, sedimentation, and other deposits, preventing water from flowing smoothly into rivers or disposal channels. This condition is further exacerbated by the growth of settlements around the road, which increases surface runoff and reduces water infiltration areas. This flooding problem requires structured and sustainable management. One effort that can be undertaken is the construction or improvement of the drainage system along Sisingamangaraja Road by considering flow capacity, channel slope, and the final disposal system. With the development of an effective drainage system, it is expected that waterlogging can be minimized, community mobility will not be disrupted, and the risk of infrastructure damage can be red reduced. In addition, improving drainage quality also plays a role in maintaining environmental quality and public health in Tigalingga Village as a whole. Therefore, the development of the drainage system along Sisingamangaraja Road is not only an infrastructure necessity but also a strategic step in flood risk management and improving the quality of life of the community. This research is important to formulate appropriate technical solutions to address flooding, as well as to serve as a reference for the development of a sustainable drainage system in the village.

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Introduction

Tigalingga Village is one of the areas that geographically has a low topography and relatively flat plains, so it is prone to waterlogging, especially in the rainy season. High rainfall, coupled with an inadequate drainage system, causes routine flooding to occur at several points, one of which is along Jalan Sisingamangaraja. Frequent floods not only disrupt people's daily activities, but also cause damage to road infrastructure, hinder transportation, and increase the risk of spreading waterborne diseases. One of the main causes of flooding on Jalan Sisingamangaraja is the limited capacity of drainage channels to accommodate heavy rainwater. Many channels are clogged with garbage, sedimentation, and other sediments so that water cannot flow smoothly into rivers or sewers. This condition is exacerbated by the growth of settlements around the road which increases the volume of runoff water and minimizes water catchment areas.

This flood problem requires structured and sustainable handling. One of the efforts that can be made is the construction or repair of the drainage of Jalan Sisingamangaraja by paying attention to the flow capacity, channel slope, and final disposal system. With effective drainage development, it is hoped that waterlogging can be minimized, community mobility will not be disrupted, and the risk of infrastructure damage can be reduced. In addition, improving the quality of drainage also plays a role in maintaining the quality of the environment and the health of the people of Tigalingga Village as a whole. Thus, the construction of drainage on Jalan Sisingamangaraja is not only an infrastructure need, but also a strategic step in managing flood risk and improving the quality of life of the community. This research is important to formulate the right technical solutions in dealing with floods, as well as a reference for the development of a sustainable drainage system in the village.

Table 1. Drainage Conditions of Sisingamangaraja Road

Aspek	Kondisi Saat Ini	Keterangan
Lebar saluran	40–60 cm	Tidak sesuai kapasitas air limpasan
Kedalaman saluran	30–50 cm	Banyak sedimentasi dan sampah
Titik tersumbat	6 titik utama	Hampir semua saat hujan deras
Material saluran	Beton dan tanah	Beton sebagian retak, tanah mudah longsor

The current drainage condition along Jalan Sisingamangaraja shows a number of limitations that are one of the main factors for flooding in the area. The width of the drainage channel, which only ranges from 40 to 60 cm, is considered insufficient to accommodate the volume of runoff water during heavy rains. This condition causes the

flow of water to be limited so that it is prone to overflowing to the road surface. In addition, the depth of the channel which only ranges from 30 to 50 cm is also a problem, as many channels are filled with sedimentation, mud, and garbage. The accumulation of this material further narrows the flow capacity, hinders the smooth drainage of water, and triggers inundation at certain points. From the identification results, there are six main points that are often clogged, especially during heavy rains, causing local flooding that disrupts community mobility and economic activities along the way.

The channel material used in the form of a combination of concrete and soil also poses additional problems. Concrete channels at some points have cracked, while earthen channels are easy to landslide when hit by heavy water. This condition not only reduces drainage function, but also increases the risk of damage to road infrastructure that has an impact on the safety of road users. Based on these conditions, this research is important to carry out because the construction or repair of drainage on Sisingamangaraja Road will be a strategic solution in overcoming flooding. This research can formulate drainage designs that are appropriate to the capacity of water flow, pay attention to more durable materials, and identify critical points that require special attention. Thus, the results of the research are expected to be able to provide effective and sustainable technical recommendations to reduce inundation and improve the quality of infrastructure in Tigalingga Village.

The flood problem on Jalan Sisingamangaraja, Tigalingga Village, arises due to a combination of several factors, including high rainfall, limited drainage channel capacity, and a lot of sedimentation and garbage that clog the water flow. This condition not only causes waterlogging on the road, but also disrupts people's mobility, damages infrastructure, and has the potential to cause health impacts due to floodwater. The common thread of this research is an effort to identify the limitations of existing drainage systems and design technical solutions that can reduce the impact of flooding. By analyzing the physical conditions of drainage, clogged points, and water flow capacity, this study will link actual problems occurring in the field with appropriate and sustainable drainage improvement solutions. Thus, every step of research related to drainage development has a direct relationship with the flood problems experienced by the community, so that the results of the research can be applied in real terms. This research has high urgency because flooding on Jalan Sisingamangaraja occurs regularly every rainy season and has a significant impact on the lives of the people of Tigalingga Village. These impacts include disruption of transportation activities, damage to road infrastructure, deterioration of environmental quality, and increased health risks.

Problem Identification

Based on field observations and secondary data, some of the problems that occurred on Jalan Sisingamangaraja, Tigalingga Village, include:

1. Inadequate drainage capacity
   The width of the drainage channel is only 40–60 cm and the depth is 30–50 cm, so it is not able to accommodate the volume of runoff water during heavy rains.
2. Blocked drainage channels
   Many points are clogged due to sedimentation, mud, and garbage, especially at six main points, which slows the flow of water and causes inundation.
3. Damage to drainage material

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Cracked concrete channels and landslides are easy to undertake, lowering drainage function and accelerating the deterioration of road infrastructure.

4. Impact of floods on communities
   Standing water disrupts the mobility of residents, damages infrastructure, and increases health risks due to stagnant water.
5. Lack of sustainable drainage planning
   The existing drainage has not taken into account the water flow capacity according to rainfall and the area affected, so that the flood problem recurs every rainy season.

Problem Formulation

Based on the above problem identification, the formulation of this research problem is:

1. What is the current physical condition and drainage capacity of Jalan Sisingamangaraja in handling rainwater runoff?
2. What are the factors that cause the blockage of drainage channels on Jalan Sisingamangaraja?
3. How will the flood impact the community and infrastructure around Jalan Sisingamangaraja?
4. How is the development planning or effective drainage repair to overcome flooding on Jalan Sisingamangaraja in a sustainable manner?

KAJIAN THEORITIS

Definition and Function of Drainage

Drainage is a system designed to drain or remove excess water from an area to prevent inundation and damage to infrastructure. According to Humairo et al. (2022), urban drainage functions to dispose of excess water with high volumes through surface drainage and subsurface drainage, so that it can go to rivers, lakes, and seas.

Types of Drainage

Based on its function, drainage is divided into two types:

1. Surface Drainage: Channels that are above the ground level and function to drain surface runoff water.
2. Subsurface Drainage: Channels that are below the ground surface and function to drain water that seeps into the soil.

Humairo et al. (2022) also mentioned that urban drainage needs to be integrated with sanitation, waste management, and flood control to achieve an effective system.

Floods and Their Causes

Flooding occurs when the capacity of drainage channels is not able to accommodate high rainwater discharge, so water overflows and inundates the surrounding area. Rohman and Mardiah (2021) stated that urban drainage floods often occur due to piles of garbage that clog channels, thereby hindering the flow of water.

Drainage System Planning

Drainage system planning should consider several factors, including:

1. Return Period: The time period used to plan the channel capacity, for example 10 years, 25 years, or 50 years. According to Edisono et al. (1997), the minimum re-

release time is used to determine the flood discharge that should not exceed the capacity of the channel.
2. Discharge Calculation Method: A method used to calculate rainwater discharge, such as the rational method or the Gumbel method.
3. Channel Capacity: The dimensions and types of channels designed to accommodate rainwater discharge according to the plan.

Evaluation and Optimization of Drainage Systems

An evaluation of the drainage system is needed to find out whether the existing channels are still able to accommodate rainwater discharge as planned. According to research in Sengkang City, GIS can help in the evaluation and planning of drainage networks to optimize drainage utilization in flood management.

Research Method

Types and Approaches to Research

This study uses a qualitative approach with an exploratory descriptive research type. The qualitative approach was chosen because this study aims to understand social phenomena in depth, such as drainage conditions, flood-causing factors, and their impact on the community in Tigalingga Village. According to Sutopo (2006), qualitative research focuses on understanding the meaning and experience of research subjects in their social context.

Research Location and Time

This research was carried out in Tigalingga Village, Tigalingga District, Dairi Regency, North Sumatra. The research period lasted for 3 months, starting from January to March 2025, with consideration to observe drainage conditions in the rainy and dry seasons.

Data Sources and Types

Data Primer

Primary data is obtained through:
1. Field Observation: Direct observation of the physical condition of drainage, clogged points, and the impact of flooding at the research site.
2. In-Depth Interviews: Interaction with key informants such as village heads, technical officers, and local communities to dig up information related to drainage problems and solutions.

Data Seconds

Secondary data were collected from:
1. Village Government Documentation: Annual reports, drainage network maps, and other technical data.
2. Literature Studies: References to books, journals, and articles relevant to the research topic.

Data Collection Techniques

The data collection techniques used include:
1. Participatory Observation: Researchers are directly involved in community activities to understand social dynamics related to drainage.
2. Semi-Structured Interview: Open-ended questions that allow the informant to provide more in-depth answers.

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3. Documentation Study: Analysis of documents related to drainage infrastructure in Tigalingga Village.

Data Analysis Techniques

The collected data was analyzed using qualitative descriptive analysis techniques. According to Miles and Huberman (2014), qualitative data analysis involves three main steps: data reduction, data presentation, and conclusion/verification.

Data Validity and Reliability

To ensure the validity of the data, the following are carried out:

1. Source Triangulation: Comparing information from different sources to test the consistency of the data.
2. Member Checking: Confirming research findings with informants to ensure data accuracy.
3. Audit Trail: Documenting the entire research process for easy verification by other parties.

Results and Discussion

What is the current physical condition and drainage capacity of Jalan Sisingamangaraja in handling rainwater runoff

The physical condition of drainage along Jalan Sisingamangaraja currently shows a number of significant limitations in handling rainwater runoff. The existing drainage channels are between 40 to 60 cm wide and 30 to 50 cm deep, which is technically considered insufficient to accommodate the volume of water produced during heavy rains. This limited channel capacity causes the flow of water to be stalled and prone to overflow to the road surface.

In addition, drainage channels experience many obstacles due to flow blockage by sedimentation, mud, and garbage. Identification in the field shows that there are six main points that are often clogged, especially during heavy rains, thus worsening waterlogging. The conduit material consisting of a combination of concrete and soil also poses an additional problem; Concrete at some points is cracked, while earthen channels are easy to landslide when hit by heavy water. This condition not only reduces the effectiveness of drainage, but also accelerates the damage to road infrastructure and increases the risk of disruption to community mobility.

Drainage capacity that does not match rainwater runoff discharge indicates the need for more effective drainage system replanning. Increasing the width and depth of the channel, improving more durable materials, and regular cleaning and maintenance are important steps for drainage to function optimally. Thus, the construction or repair of the drainage of Jalan Sisingamangaraja is an urgent need to reduce the risk of flooding and negative impacts on the community and infrastructure in Tigalingga Village.

Flood Photo

What are the factors that cause the blockage of drainage channels on Jalan Sisingamangaraja

The blockage of drainage channels on Jalan Sisingamangaraja is one of the main factors in flooding in Tigalingga Village. Based on field observations and interviews with local communities, there are several factors that cause drainage channels to not function optimally.

First, the accumulation of household waste and solid waste is the main block. Many residents throw garbage carelessly, both on the side of the road and directly into the drainage channel. This accumulation of garbage impedes the flow of water and causes water to stagnate at some points, especially during heavy rains.

Second, sedimentation and soil sedimentation also contribute significantly to blockage. Drainage channels that are partly made of soil are prone to sedimentation of mud, sand, and erosion materials from settlements or roads. These deposits gradually narrow the channel and decrease the capacity of the water flow.

Third, physical damage to drainage channels, such as cracks in concrete or landslides, make water not flow smoothly. This damage often occurs due to a lack of regular maintenance and a water load that exceeds the capacity of the channel, thus triggering blockages at certain points.

Fourth, improper drainage planning is also a factor causing channel clogging. Narrow, inadequate, or poorly equipped channels with a good final disposal system cause runoff to build up and speed up the clogging process.

Overall, the combination of community behavior factors, the physical condition of the channel, and drainage planning that is not optimal makes the drainage channel on Jalan Sisingamangaraja often clogged. This emphasizes the importance of drainage improvement efforts which include increasing channel capacity, routine maintenance, and public awareness in maintaining environmental cleanliness to prevent flooding.

How does the flood impact the community and infrastructure around Jalan Sisingamangaraja

The flood that occurred on Jalan Sisingamangaraja, Tigalingga Village, had a significant impact on people's lives and the condition of the surrounding infrastructure. From the community's perspective, waterlogging interferes with daily activities, such as children's mobility to school, residents' trips to work, and access to public facilities. Residents are forced to wait until the inundation recedes or look for alternative routes, thus reducing time efficiency and causing inconvenience in daily activities.

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In addition, floods also have an economic impact on the community. Some houses were damaged by water entering the house, furniture and household appliances were damaged, and small business owners operating along the road suffered losses due to the disruption of business activities. This condition can reduce the quality of life of the community if floods occur regularly every rainy season.

In terms of infrastructure, waterlogging causes damage to the road and the drainage itself. Roads that are often submerged in water have cracks, damaged surfaces, and reduce the lifespan of the road. Drainage channels that are clogged or physically damaged further worsen the condition, resulting in decreased flow capacity and worsening flooding. In addition, public facilities such as sidewalks, street lights, and small bridges around the road also experienced a decrease in function due to prolonged submersion in water.

These impacts emphasize the importance of the construction or improvement of the drainage of Jalan Sisingamangaraja as a whole. With optimally functioning drainage, waterlogging can be minimized, community mobility is not disrupted, infrastructure damage can be reduced, and health risks due to flooded water can be prevented. Therefore, this research is important to formulate effective technical solutions in dealing with floods and improving the quality of life of the people in Tigalingga Village.

How to plan for effective development or drainage repair to overcome flooding on Jalan Sisingamangaraja in a sustainable manner

Planning for the construction or repair of drainage on Jalan Sisingamangaraja must be carried out systematically and continuously in order to effectively overcome flooding. The first step is to increase the capacity of drainage channels, which includes expanding the width and adding the depth of the channel according to the maximum rainwater discharge recorded in the Tigalingga Village area. This capacity adjustment aims to ensure that runoff water flows smoothly without overflowing to the road surface, so that waterlogging can be minimized. Furthermore, the selection of durable channel materials is an important aspect of planning. High-quality concrete channels or more stable material combinations can prevent cracks and landslides, thereby extending the life of the channel and reducing long-term maintenance costs. In addition, drainage channels should be equipped with grates or covers that can prevent garbage from entering the channels, so that the risk of clogging can be minimized.

Effective drainage planning must also pay attention to flood-prone points and runoff water flows. Analysis of topography, settlement locations, as well as water flow patterns in the rainy season can be used to determine critical points that require additional channels or repair of old channels. In this way, the distribution of water flow becomes more even and the potential for inundation can be controlled. In addition to the technical aspect, routine maintenance and community participation are also the key to drainage sustainability. Regular cleaning of the channel and education of residents not to litter will keep the channel functioning optimally. The integration of technical planning, the use of quality materials, and public awareness will result in a drainage system that is not only effective in the short term, but also sustainable.

Thus, effective planning for the construction or improvement of Jalan Sisingamangaraja drainage requires a holistic approach that combines analysis of channel

capacity, appropriate materials, identification of vulnerable points, and ongoing management and maintenance. The implementation of this strategy is expected to reduce flood risk, improve the quality of infrastructure, and maintain the comfort and safety of the community in Tigalingga Village.

Conclusion

Based on the analysis and observations in this study, several conclusions can be drawn as follows:

1. Current physical condition and drainage capacity

   The drainage on Jalan Sisingamangaraja has a width of 40–60 cm and a depth of 30–50 cm, which is inadequate to accommodate rainwater runoff. Channels are often clogged due to garbage, sedimentation, and physical damage, resulting in reduced water flow capacity and inundation occurs every rainy season.

2. Drainage blockage factors

   The clogging of the channel is caused by a combination of household waste, soil and mud deposits, physical damage to the channel (cracked concrete and landslide channels), and suboptimal drainage planning.

3. Impact of floods on communities and infrastructure

   Floods cause disruption of community mobility, damage to houses and public facilities, and a decrease in the quality of roads and drainage itself. This causes economic losses and health risks for the local community.

4. Sustainable drainage planning

   Effective drainage repair or construction requires increasing channel capacity, selecting durable materials, identifying flood-prone points, and routine maintenance and community participation. This approach ensures that drainage functions optimally in a sustainable manner.

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