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PLANNING THE CONSTRUCTION OF DRAINAGE ALONG THE ROAD FROM BALUNIJUK VILLAGE TO JADA BAHRIN VILLAGE TO PREVENT WATER PONDING

Kartini[1], Aulia Puspita Sari[2] , Izam Zamali[3] ,Eveline[4]
[1,2,3,4,5]Fakultas Ekonomi dan Bisnis, Universitas Bangka Belitung, Indonesia
E-mail: kartinibly@gmail.com, aulpsptsr@gmail.com, zamzmli12903@gmail.com, eveline20190713@gmail.com

Abstract: This project aims to plan the construction of a drainage system along the road from Balunijuk Village to Jada Bahrin Village, Bangka Regency, to prevent waterlogging that often occurs during the rainy season. An adequate drainage system is expected to reduce road damage and minimize negative impacts on the environment, health, and activities of the local community. Financial studies show that this project is feasible to implement with a positive Net Present Value (NPV) of IDR4,777,274,281 at a 10% discount rate, and IDR4,226,951,979 at a 15% discount rate. The project's Internal Rate of Return (IRR) reaches 12.65%, while the Benefit-Cost Ratio (BCR) is 3.57, indicating that this project is very profitable.

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Introduction

The drainage system is an important infrastructure that plays a role in maintaining the stability of the environmental ecosystem, especially in addressing the issues of waterlogging and flooding that often occur during heavy rainfall. In various regions, especially in areas experiencing rapid development, this problem often arises due to inadequate drainage infrastructure. This condition also occurs along the road from Balunijuk Village to Jada Bahrin Village, where waterlogging often becomes a serious problem affecting the community, infrastructure, and the smoothness of daily activities. Poorly managed waterlogging will cause various negative impacts, such as damage to road surfaces, disruption of transportation access, and increased health risks due to the emergence of disease sources from stagnant water. The issue of waterlogging in this area is not a new problem. Every time the rainfall increases, especially at the peak of the rainy season, residents along the road from Balunijuk Village to Jada Bahrin Village have to deal with waterlogged streets. This condition is exacerbated by the lack of maintenance and updates to the existing drainage infrastructure. As a result, rainwater that should be able to flow directly into the drainage system instead pools on the road surface due to the inadequate drainage system. The flooded roads not only disrupt community activities but also accelerate the deterioration of road infrastructure, which in turn increases the maintenance costs that must be borne by the government and the public. In the long term, this condition can lower the quality of life for the community due to various disruptions caused, ranging from transportation, economic, to health

issues.
In addition, climate change, which causes increased rainfall, is also a factor that exacerbates this condition. Heavy rain that occurs in a short period but with a large volume of water cannot be accommodated by the non-existent drainage system. As a result, waterlogging occurs more frequently and the duration of the flooding becomes longer. If this condition is left unaddressed, the problem of waterlogging will continue to recur, further deteriorating the environmental conditions and damaging the road infrastructure.

Therefore, careful planning is needed to build a drainage system to address the waterlogging issue along the road from Desa Balunijuk to Desa Jada Bahrin. The construction of this drainage system must be designed by considering various factors, such as topographic conditions, rainfall, and water flow patterns in the area, so that the drainage system built can function optimally in the long term. With good planning and proper drainage construction, it is hoped that the waterlogging problem that has been a nuisance can be resolved, allowing the community to carry out their activities smoothly and the road infrastructure to be well-maintained.

Literature Review

To support the drainage construction planning proposal, the researchers seek comparisons as references from published studies. Here are some previous studies related to drainage planning that have been conducted:

1. A previous study conducted by (Miftakhul Huda et al., 2021) in the research titled "Drainage System Planning Along the Mayong – Bakalan Highway, Jepara Regency." This study was motivated by the issue of waterlogging and flooding along the Mayong – Bakalan highway in Jepara, which cannot be separated from the road widening and pavement projects. Physical developments such as housing and industry have also occurred very rapidly, accompanied by an increase in the population and the volume of vehicles on the highway. Meanwhile, the factor of rain is a natural event that cannot be avoided or prevented. Rainwater that should seep into the ground turns into runoff and causes flooding. Based on the results of the survey and hydrological analysis using HEC-RAS 5.0.7 software, it was found that the planned flood discharge for 2024 reaches 69.52 m^3/s, while the capacity of the existing drainage channel can only flow an average of 2.44 m^3/s. Therefore, a redesign of the drainage system is necessary with a solution in the form of a U-ditch channel with dimensions b = 1 m and h = 1 m. This channel was chosen because it can meet the planned discharge capacity and is safe to accommodate water runoff, thereby reducing the risk of flooding along the road. This improvement is considered effective in increasing drainage capacity and maintaining smooth water flow, as well as preventing road damage and traffic disruptions in the future.
2. Previous research conducted by (Fajar Muhammad Sidiq et al., 2019) in the study titled "Drainage System Planning in the Pemenang Village Area, North Lombok Regency" was motivated by the fact that the Pemenang area is one of the regions facing road problems that cannot accommodate flood discharge due to rainwater runoff. Problems arise when the water does not infiltrate into the ground and there is no proper drainage system, causing surface runoff or water to become trapped, leading to flooding. The current existing condition is that several sections of the drainage channels are already filled with sediment or garbage and are damaged. This can lead to various problems, resulting in discomfort, a dirty environment, the emergence of various diseases, and other negative impacts. Another cause is the lack of proper drainage system management. In addition to the issues with the drainage system arrangement, there are still many roads or alleys that do not have drainage channels.
3. Previous research conducted by (Nasfi, et al., 2020) in the study titled "Drainage Development Affecting User Rights, Road User Problems, and Economic Development" was motivated by the fact that road construction, one of the important aspects, is the construction of

water drainage. This ensures that the rights of road users in Bukit Tinggi are not disturbed in their daily activities due to drainage construction or poorly functioning drainage. The geography of Bukittinggi will not allow water to accumulate on the main roads, and even the occurrence of floods during heavy rain is beyond reason, while the handling of sanitation or drainage issues has become a national target in 2019. The city's drainage system is not yet fully capable of controlling the problem of waterlogging in several areas, which will impact the condition of those areas. Thus, resolving the drainage issues in Bukit Tinggi needs to be prioritized to achieve universal access and improve sanitation services in Bukit Tinggi City. Everyone has the right to a good and healthy living environment, to report alleged environmental destruction, which is regulated by the constitution and protected by law based on the principles of justice and balance for individuals or groups in their interactions with the environment.

4. Previous research conducted by (Yohanna Fabiola Pane, et al., 2016) in the study titled "Drainage Planning for the Semarang - Bawen Highway Km 12+400 - Km 16+600 (Jamu Jago - Balai Pelatihan Transmigrasi Dan Penyandang Cacat Jateng)" was motivated by the problem of flooding or puddles on the Semarang - Bawen Road. During the rain, puddles occur along the road, disrupting road users and causing damage to the pavement. The flooding that occurs is caused by an inefficient drainage system due to sedimentation at the curb inlets and in the side channels. Therefore, to determine the performance of the drainage system, a hydrological analysis was conducted to calculate the planned discharge with a recurrence interval of 5 years, in accordance with the total area of the drainage basin and the city's typology, and then compared with the existing channel and culvert discharges. The results of the comparison between the planned discharge and the existing discharge indicate that the existing side channels and culverts cannot accommodate the planned discharge, necessitating a redesign of the dimensions of the side channels and culverts. The cross-section of the side channel is planned to be rectangular due to land constraints, while the culverts are planned to be circular and rectangular. (u-ditch). The inlet kerb is planned in two types: (1) perforated kerb with dimensions of 13/16 x 30 x 50 cm and kerb holes of 15 x 30 cm for slopes < 6%, (2) concrete kerb with an inlet dimension of 10 x 15 for slopes ≥ 6%.
5. Previous research conducted by (Ardianto Wibowo, et al., 2014) in the study titled "Drainage Channel Planning for the OASIS Area of PT. DJARUM Kudus in Kudus Regency" was motivated by the transformation from a natural landscape to a built environment, which increases impervious surfaces such as roads, parking areas, sidewalks, and residential areas. The impact of the landscape change in the OASIS area of PT. Djarum Kudus is the increase in direct surface runoff while reducing the water that seeps into the ground, potentially causing waterlogging. In its planning, a hydrological analysis was conducted using 15 years of rainfall data from Sta. Kedung Gupit. In this planning hydrological analysis, the Log Pearson type 3 probability distribution was used, and with the EPA SWMM program, a 10-year flood recurrence interval was applied, resulting in a maximum flood discharge of 9.05 m^3/second before construction and a maximum flood discharge of 16.69 m^3/second after construction. With the results of the analysis, drainage channel planning was carried out. In the planning, the drainage channels used are new drainage channels built in the OASIS area of PT. Djarum Kudus. The dimensions of the drainage channels used vary. Next, to determine the effectiveness of the drainage channels, they were modeled using the HEC RAS program. In the calculations using this program, all the channels planned in the OASIS PT. Djarum area are currently capable of accommodating water during a 10-year return period flood event.

6. Previous research conducted by (L. Tanudjaja, E. M. Wuisan, et al., 2013) in the study titled "Drainage System Planning in the City Center Area of Amurang" was motivated by the negative impacts of waterlogging that occurs every time it rains, including road damage and disruption of residents' activities in the area. To address the frequent flooding issues, a well-planned drainage system is needed in the city center area. To identify the problem of waterlogging, direct observations were made in the research area, followed by the design of the drainage system layout plan. Hydrological analysis was conducted to obtain the planned discharge based on the rainfall data that had been collected, followed by hydraulic analysis to determine the existing capacity of the channels relevant to the drainage system layout plan. The layout plan for the drainage system was designed by first determining the interceptor channel on the southern side of the Trans Sulawesi road so that the flow load from outside the research area would not enter the review location. From the analysis results, it is necessary to change the layout of the drainage system. There are 48 sections of existing channels that are still relevant to the drainage system layout plan and 10 culverts that are still suitable. For the existing channels, 9 sections do not meet the requirements, so the dimensions of the channels were changed. As for the culverts, there are 4 sections that do not meet the requirements. The recommendation for the new channels consists of 17 sections and 5 culverts.
7. Previous research conducted by (Suhudi, et al., 2020) in the study titled "Drainage System Planning for Istana Safira Housing on Jalan Jambu Semanding Sumber Sekar, Dau, Malang Regency" was motivated by issues identified during the problem identification process, specifically the planned flood discharge for the drainage channel with a 5-year return period, the planned drainage network scheme for Istana Safira Housing, and the planned dimensions of the drainage channel. This study aims to obtain the maximum annual daily rainfall and the design flood discharge for a 5-year return period; to obtain the drainage network scheme from the measurement results; and to obtain the dimensions of the channel that can effectively convey the planned flood discharge. This study aims to plan the drainage system for the Istana Safira Housing in Dau, Malang Regency, which has generally not been fully planned. The analysis and thought process for data management used the rational method to calculate the planned flood discharge and the channel dimensions for the specified discharge. The results of the hydraulic analysis obtained the dimensions of the primary channel as the channel bottom width (b) = 0.50 m and channel depth (h) = 0.50 m. The dimensions of the secondary channel are the channel width (b) = 0.40 m and channel depth (h) = 0.40 m. Meanwhile, the dimensions of the tertiary channel are (b) = 0.30 m and (h) = 0.30 m, with the guard height of each channel being 3% of the planned channel depth. The cross-section of the channel is rectangular.
8. Previous research conducted by (Renndy Heska Desrian Habibullah, 2021) in the study titled "Drainage Channel Planning in Overcoming Flooding in Padang Tanggung Pangean Village" was motivated by the fact that the road section in Padang Tanggung Pangean Village frequently floods during rain. The flooding on the road section disrupts road users who use that road section for their activities. Flooding or ponding that occurs can be caused by several factors, but the more dominant ones are usually due to changes in land use and the dimensions of the drainage channels not meeting the requirements. If the ponding issue is not resolved, it could lead to more significant problems that would disadvantage road users. The purpose of this research is to plan the Drainage Dimensions on the Road Section of Padang Tanggung Pangean Village. The data used are secondary data obtained from the Agriculture Office of Kuantan Singingi Regency and primary data obtained from direct field surveys. The data processing method uses manual

calculations according to the rational method to calculate flood discharge, and the Manning formula to calculate channel velocity. After calculations were performed, the economic dimensions for the main drainage channel were obtained, with a base width of B = 0.80 m and a channel height of H = 0.80 m, with a cross-sectional area of the channel in the shape of a rectangle. The cost required for the construction of the drainage system is Rp.132,180,000.

9. Previous research conducted by (Nanda Aprilian, 2021) in the study titled "Drainage Channel Planning in Pulau Komang Sentajo Village to Address Flooding" was motivated by the fact that in the residential area on Karak Road, Pulau Komang Sentajo Village, there are points that frequently experience flooding when it rains. The flooding disrupts the community's economic activities. Flooding can be caused by several factors, but the most dominant one is usually due to changes in land use, leading to flooding in the area. Floods or inundation that occur can be caused by several factors, but the more dominant one is usually due to changes in land use, resulting in flooding in that area. The purpose of this research is to plan the Drainage Dimensions in Pulau Komang Sentajo Village, Sentajo Raya District, Kuantan Singingi Regency. The data or information used are secondary data obtained from the Agriculture Office of Kuantan Singingi Regency and primary data obtained from direct field surveys, which include points/coordinates of the channels and points of the catchment area coefficients. The data processing method uses manual calculations according to the rational method to calculate flood discharge, and the Manning formula for channel velocity. After calculating the 5-year return period flood discharge, the economic dimensions for the main drainage channel were obtained with a bottom width B = 0.75 m and a channel height H = 1.21 m, with a cross-sectional shape of a rectangle.
10. Previous research conducted by (Tri Suhardi, 2019) in the study titled "Drainage Channel Planning for Senaken Village and Jone Kota Tana Paser Village, Paser Regency" was motivated by the current poor drainage system in Paser Regency. During the rainy season, flooding often occurs in some areas of the regency, especially in regions with relatively low topography, such as in the areas of Senaken Village and Jone Kota Tana Paser Village, Paser Regency. This is caused by high sedimentation and the existing network system, which is still not functioning well. Therefore, permanent drainage channels were constructed in Senaken Village and Jone Kota Tana Paser Village, Paser Regency. In terms of drainage planning, especially for roads in urban and rural areas, what must be carried out meticulously is in accordance with the standards and systems of urban drainage planning, which involves flow direction patterns, the situation and condition of the city, planning steps by considering hydrological aspects that include: the hydrological cycle, rainfall characteristics, rainfall data, rainfall data processing, design discharge, as well as hydraulic aspects concerning water flow in channels, flow properties, water flow formulas, and channel dimension analysis.

Method

A. Research Methodology

This research uses a quantitative descriptive method. The quantitative descriptive method is a research approach used to describe or explain a phenomenon by collecting and analyzing data in numerical form. This method is used to measure, analyze, and describe the characteristics of a population or phenomenon without seeking cause-and-effect relationships. The aim is to provide a clear and measurable description based on the results of quantitative data collection.

The descriptive method is a research approach aimed at providing an overview of a phenomenon or specific condition without making generalizations or cause-and-effect conclusions. This method is used to objectively describe conditions or situations based on existing facts, whether through the collection of qualitative or quantitative data.

B. Data collection methods

Secondary data is data that is collected, recorded, and published. Secondary data is data that is collected, recorded, and published by third parties for purposes other than the actual research. This data is taken from existing sources and reused to answer research questions or solve problems.

a. Observation
   During the survey, observations were made for the research purpose to understand the initial condition of the drainage along the road from Balunijuk Village to Jada Bahrin Village to avoid waterlogging.
b. Documentation
   The documentation is used to collect data, specifically the length and edges of the left and right sides of the highway, to plan the construction of drainage along the road. Documentation is used to collect data, specifically the length and edges of the left and right sides of the highway for the planning of drainage construction along the road.

C. Financial Analysis Methods

1. Data processing is the process of conducting a feasibility analysis of a development project. The data processing technique used in financial analysis employs parameters such as Net Present Value (NPV), Internal Rate of Return (IRR), Benefit Cost Ratio (BCR), and Payback Period (PP).
   Net Present Value (NPV)
   Net Present Value is a capital budgeting technique that measures the profitability of an investment project plan using the time value of money factor. NPV is a method for evaluating projects based on the timing of the generated cash flows. The present value of future cash flows is discounted to the present value using an appropriate discount rate.

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t} - C_0 \ldots\ldots\ldots\ldots\ldots\ldots$$

Explanation:
〖CF〗_t = Cash flow in period t
r = Discount rate
n = Number of Years (economic life) of the project
C_o = Initial Investment

2. Internal Rate of Return (IRR)
   The internal rate of return or tingkat pengembalian internal is the interest rate of a project over a certain period. The Internal Rate of Return (IRR) method measures the feasibility of an investment based on the interest rate that can make the present value of the expected profits equal to the present value of the capital costs (NPV = 0). In this method, the time value of money has been taken into account, so the cash flows received have been discounted based on the capital cost or the interest rate applied. Projects with an internal rate of return that exceeds the discount rate or the company's financial policy are considered profitable.

   IRR=i_t+ 〖NPV〗_1/(〖NPV〗_1+ 〖NPV〗_2)×(i_2-i_1)……..
   Explanation:
   〖NPV〗_1 = NPV at Interest Rate i_1
   〖NPV〗_2 = NPV at Interest Rate i_2
   i_1 = Discount Rate that Results in 〖NPV〗_(1)
   i_2 = Discount Rate that Results in 〖NPV〗_2

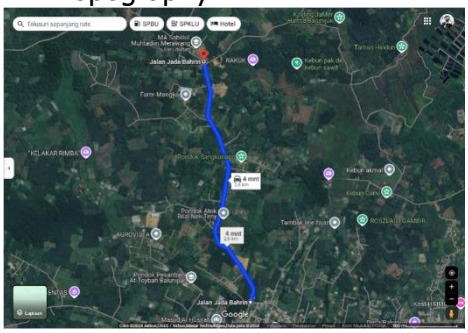
3. Benefit Cost Ratio (BCR)
   The benefit cost ratio (BCR) is a ratio used in economic analysis to compare the benefits of a project. BCR is a common project selection analysis because it is simple, involving a comparison between benefit and cost.

   BCR=(Total Benefit)/(Total Cost)……..

Total benefit: The value of benefits generated from the project
Total cost: The total cost incurred to implement the project
If BCR > 1, the project is feasible to use.
If BCR < 1, the project is not feasible to use.
If BCR = 1, it means the benefits equal the costs, so the project is "break-even" in economic terms.

Results and Discussion

A. Overview of the Study Area Topography



Balunijuk is a village located in the Merawang District, Bangka Regency, Bangka Belitung Islands, Indonesia. If you travel the road connecting Balunijuk Village with Jada Bahrin Village in Merawang District, there is still no water drainage or drainage system along that road. When it rains, it will cause water puddles that can erode the road surface and damage the road.

B. Project Design

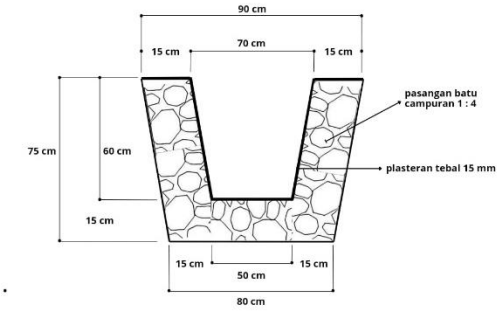


Figure 4.2 Drainage Design

The drainage construction plan along the road connecting Balunijuk Village to Jada Bahrin Village is 2600 M or 2.6 KM long. This drainage construction plan is made on both sides of the road, with a total overall drainage length of 5200 M or 5.2 KM from both sides.

C. Financial Analyses

a. *Net Present Value* (NPV) 10%

Year	***Cash Flow***	***Present value***
Year 0	IDR 1,397,730,000	IDR 1,397,730,000
Year 1	IDR 978,411,000	IDR 889,464,545
Year 2	IDR 950,456,400	IDR 785,501,157
Year 3	IDR 908,524,500	IDR 682,587,904
Year 4	IDR 936,479,100	IDR 639,627,826
Year 5	IDR 964,433,700	IDR 598,837,449
	Total PV	IDR 4,993,748,881
	NPV 10%	IDR 3,596,018,881

b. *Net present Value* (NPV) 15%

Year	***Cash Flow***	***Present value***
Year 0	IDR 1,397,730,000	IDR 1,397,730,000
Year 1	IDR 978,411,000	IDR 850,792,174
Year 2	IDR 950,456,400	IDR 718,681,588
Year 3	IDR 908,524,500	IDR 597,369,606
Year 4	IDR 936,479,100	IDR 535,434,965
Year 5	IDR 964,433,700	IDR 479,493,998
	Total PV	IDR 4,579,502,331
	NPV 15%	IDR 3,181,772,331

c. Internal Rate Of Return IRR

i_1 = 10% NPV_1 = IDR.3.596.018.881
i_2 = 15% NPV_2 = IDR. 3.181.772.331

$$IRR = i_t + \frac{NPV_1}{NPV_1 + NPV_2} \times (i_2 - i_1) \dots\dots\dots\dots$$

$$IRR = 10\% + \frac{IDR.3.596.018.881}{IDR.3.596.018.881 + IDR.3.181.772.331} \text{ x } (15\%-10\%)$$

$$IRR = 10\% + \frac{IDR.\ 3.596.018.881}{IDR.6.777.791.213} \text{ x } 5\%$$

$$IRR = 10\% + 0{,}53 \text{ x } 5\%$$

IRR = 10% + 2,65%
IRR = 12,65 %

d. *Benefit Cost Ratio (*BCR)

Benefit = Σ PV Manfaat (1-5)

= IDR. 4.738.304.700

Cost = IDR. 1.397.730.000

B/C $= \frac{Benefit}{Cost}$

B/C $= \frac{\text{IDR4.993.748.881}}{\text{IDR1.397.730.000}} = 3,5$

Conclusion

Proyek perencanaan pembangunan drainase di sepanjang jalan Desa Balunijuk hingga Desa Jada Bahrin bertujuan untuk mencegah genangan air yang sering terjadi di wilayah tersebut, terutama selama musim hujan. Sistem drainase yang direncanakan akan meningkatkan kualitas jalan dan mengurangi dampak negatif dari genangan air, seperti kerusakan infrastruktur, gangguan aktivitas masyarakat, dan potensi masalah kesehatan. Berdasarkan analisis finansial, proyek ini dianggap layak secara ekonomi dan finansial dengan NPV positif sebesar Rp 3.373.398.265 (10%) dan Rp 2.984.796.692 (15%), IRR 12,65%, dan BCR 3,57.

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All praise be to the presence of Allah SWT for His guidance that has guided our steps in completing the article titled "Planning the Construction of Drainage Along the Road from Balunijuk Village to Jada Bahrin Village to Prevent Water Accumulation." The authors would like to thank their friends and supervisors who have helped in the process of completing this article.

Conflict of Interest

The author conducts research as an effort to improve road infrastructure. In this case, the author, as the designer, provides a suitable infrastructure in the form of drainage.

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