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# Study of Flood Management Due to Rainfall on Drainage Network System in Residential Area (Case Study: Cempaka Sub District, Banjarbaru City, South Borneo)

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***ABSTRACT :***
*The initial indication of this research was carried out by the occurrence of floods that was correlated with the conditions of the slum settlements in Cempaka Sub District, narrowing and silting of the river, as well as the rainfall that fell beyond the carrying capacity of the river geometry in that area. The goverment is concerned about the inability of existing drainage network system to accommodate and drain the water, causing a flood problem that impact to human settlements. A recommendation was given for the drainage channel design in the form of sodetan using box culvert in an effort to deal with flood problems that every year hit residential area in Cempaka Sub District. The work process is by dividing the planned flood discharge in the existing river channel with a cross sectional capacity of the Kuranji River of 24.912 $m^3/s$, which means that there is a runoff of 11.704 $m^3/s$. The runoff flood discharge is flowed through sodetan using box culvert with capacity of 13.032 $m^3/s$. From the results of the financial feasibility analysis using net present value, benefit cost ratio, and internal rate of return method with an interest rate of 9.90% based on cash flow obtained from the value of losses for flood affected humans that investment in the sodetan development project uses box culvert in the size 1.5 m × 1.5 m is declared feasible and enforceable.*
***KEYWORDS :****floods, sodetan, box culvert, technical analysis, financial analysis*

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## I. INTRODUCTION

So many effect of flooding on infrastucture[1]. However in general, the causes of flooding can be classified into two categories, namely floods caused by natural causes and flood caused by human activities[2]. Natural flooding is influenced by high rainfall, physiography, erosion and sedimentation, river capacity, drainage capacity, and tidal influence. Meanwhile, floods are caused by human activities that cause environmental changes [3] such as changes in the condition of the watershed, residential areas around the banks, damage to land drainage, damage to flood control, damage to forests, and improper planning of flood control systems. Floods most commonly occur in developing cities [4, 5]. The floods that occured in Banjarbaru city are usually caused by the water channels that drain rainfall from the road drainage to main river are not maintained. Many water channels especially in residential areas which are covered with sewage, even covered with settlements on the banks, so that their function as a water channel can not run properly, then puddles occur on the streets which cause flooding.

**Fig. 1.Settlements on a River Bank in Cempaka Sub District**

Floods that occured in Cempaka Sub District on the early 2020 that was correlated with the conditions of that slum settlements, narrowing and silting of the river, as well as the rainfall that fell beyond the carrying capacity of the river geometry in that area.The effects of flooding include loss of life and damage to infrastructures such as drainage network system [6], besides that it also causes environtmental dependence on comfort and disease prone. This process occurs because the high amounts of water flowing in streams and the drainage conditions are not good.

The government of Banjarbaru city is concerned about the inability of the existing drainage channels to accommodate and drain the water, causing flooding problem that will impact on human settlements [7]. So an effort to solve the problem is to provide recommendation for design the drainage system in the form of sodetan using box culvert. The handling plan is recommended because the normalization program in other ways such as widening the capacity of the drainage system [8] is inadequate or unable to accommodate the maximum water discharge from rainfall. Thus, the widening for the river channel can not be carried out because the land acquisition process is not possible, considering that the area along the river crosses a dense a residential area. The drainage system in the form of sodetan using box culvert can be a solution when viewed from the land and efficiency, as well as in terms of technical and financial aspect. By making a crossing channel known as sodetan, it can be reduce the potential for flooding in Cempaka Sub District, especially in the residential area of Kampung Kertak Baru.

In a project activity funded by the central and regional governments, it always requires financial analysis. This is done to determine the financial feasibility [9] of a project whether it can provide sufficient economic benefits, advantages, and disadvantages of this project for the community and possibility of returning investment cost to creditors if the project uses loan funds. A cost and benefit analysisis designed to assess the economic feasibility of a project [10] by comparing its implementation costs (initial investment and operating costs) to damage it prevents [4]. The choice of investment alternative to assess the financial feasibility of this government project is not based on the amount of profit that the project can generate but rather on the benefits or general welfare of the humans. There are several techniques that can be used in comparing these alternative investments [11], including:

1. Benefit Cost Ratio
   Benefit cost ratio is a comparison between present value benefit and present value cost. If the project has a benefit cost ratio greater than 1, the project is expected to deliver a positive net present value to a community and possibility of returning investment cost to creditors if the project uses loan funds.
2. Net Present Value
   Net present value is the difference between present value of the benefit and present value of the cost. This method is based on all future benefits and costs associated with a project being discounted to the present value using a discounted interest rate. Net present value is used in capital budgeting and investment planning to analyze the profitability of a projected invesment or project.

3. Internal Rate of Return

Internal rate of return is the rate of return based on the determination of the value of the interest rate, where all future benefits that are valued now at a certain interest rate are equal to the present value of the total cost of capital.

Damage and loss assessment [11] is usually made after a disaster occurs. In simple terms, damage and loss assessment is a comprehensive method to assess the economic impact of a disaster, based on a country's economic calculations and individual livehood needs to determine recovery and reconstruction.

- Damage is calculated as a replacement for the value of physical assets that were totally or partially damaged.
- Economic losses arising from temporarily damage assets.

This methodology produces a preliminary estimate of the impact or physical assets that must be repaired and replaced, as well as on flows that will not be produced until the asset is repaired and built. The forecast analyzes there main aspects:

- Damage (direct impact) refers to the impact on assets, shares, property, which are valued at the agreed unit price replacement (not reconstruction). The estimate must take into account the level of damage (wether the asset can still be recovered or repaired, or has been completely destroyed).
- Loss (indirect impact) refers to the flows that will be affected such as reduced income and increased expenses during the period of time until the asset is recovered. All of these will be added up based on the present value. The determination of time period is very important. If the recovery lasts longer than expected, the losses can increase excessively.
- Economic effects (sometimes called secondary impacts) include physical impacts and others. This analysis can also be applied at the sub-national level.

**Location of the study area**

The selection of the study area was based on secondary data with a flood area approach in Cempaka Sub District of 14.15 hectare, which was obtained from the 2020 inundation data.

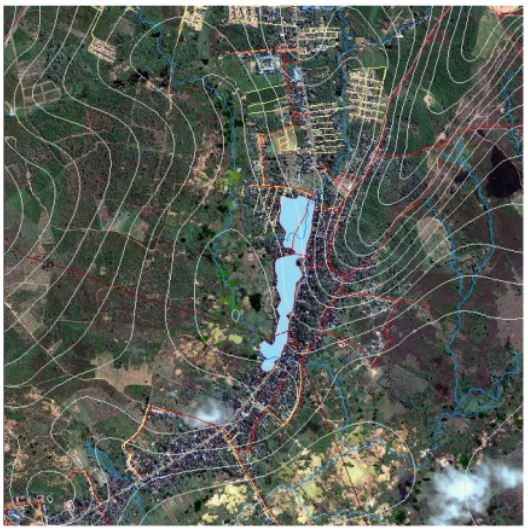

**Fig.2.The Study Location with Flood Area in Cempaka Sub District, adapter from Google Earth**

## II. RESEARCH METHODS

### 2.1 Overview of Technical Aspects

Analysis data based on technical aspects includes hydrological analysis and hydraulic analysis. From overview of hydrological analysis, in relation to the plan to constructa design cross sectionusing box culvert that is able to accommodate the planned flood discharge, one of the plans that must be obtained through hydrological analysis is the calculation of rainfall to estimate the amount of the planned flood discharge. The data for determining the planned flood discharge in this study is rainfall data, where rainfall is one of several data that be used to estimate the amount of planned flood discharge.

### 2.2 Overview of Financial Aspects

In analyzing data based on the financial aspects of flood management in Cempaka Sub District, the calculation of the cost of losses caused by flooding is carried out in the form of asset damage and inefficiency costs due to traffic congestion due to flooding, as well as the cost required for handling drainage channels by taking into account cost and benefit components.

Investments costs are calculated from planning costs, construction costs, supervision costs, as well as operating and maintenance costs on a regular basis. Project benefit are calculated from direct and indirect impacts. The direct impacts consist of reduced costs for the construction and repair of damaged drainage network systems, reduced costs for construction and repair of damaged infrastructure and facilities, reduced costs for overcoming inudation and flooding. Meanwhile, the indirect impacts consists of social costs due to flooding such as health and costs of reducing economic costs that must be borne by the community due to flooding such as trade.

## III. RESULTS AND DISCUSSION

### *A. Analysis of Technical Aspect*

**Hydrology Analysis**

The data collected are a set of annual maximum daily rainfall for the period 2008 up to 2019 taken from Banjarbaru Climatology Station Banjarbaru and the Meteorological Station Syamsudin Noor, the methodological choice was to focus on frequency analysis as a method prediction [12]. The average of annual maximum daily rainfall for over 11 years is 113.17 mm. The rainfall design is then calculated to determine the rainfall design that occurs in the return period of 25 years.

A frequency distribution analysis carried out to find distribution in accordance with the data available from the stations. The selection of rain distribution calculated using statistical parameters as shown in the table below.

**Tab. 1. The Distribution of the Annual Maximum Rainfall**

| Return Period of 25 Years | | | |
|---|---|---|---|
| Normal Distribution (mm) | Log Normal Distribution (mm) | Gumbel Distribution (mm) | Log Pearson Type III Distribution (mm) |
| 181.707 | 178.203 | 222.365 | 203.293 |

After obtaining the distribution of the annual maximum rainfall value, the calculation of the frequency analysis is carried out, as shown in Table 2 summarizes. The value of this frequency analysis can be seen which distribution is suitable for use in this research.

**Tab. 2. General Guidelines for the Spread of Distribution Method**

| Distribution Type | Terms | The Results | Conclusions |
|---|---|---|---|
| Normal | $Cs = 0$<br>$Ck = 0$ | $Cs = 2.133$<br>$Cv = 0.346$ | Disqualify |
| Log Normal | $Cs = 3$<br>$Cv + Cv^3 = 0.758$ | $Cs = 1.784$ | Disqualify |
| Log Pearson Type III | $Cs \neq 0$ | $Cs = 1.784$ | Qualify |
| Gumbel | $Cs \leq 1.1396$<br>$Ck \leq 5.4002$ | $Cs = 2.133$<br>$Ck = 0.708$ | Disqualify |

From these results, the distribution that qualify the terms is the Log Pearson Type III distribution with the condition $Cs \neq 0$ and the results obtained are $Cs = 1.784$. After obtaining the distribution to be used, the next step of analysis is to calculate the value for Chi-Square. The calculation results obtained the degree of confidence (DK) = 2, coefficient of significant ($\alpha$) = 5%, $X^2 = 2.564$, and $X^2cr = 5.991$. The results obtained are $X^2 < X^2cr$ so that the Chi-Square analysis for Log Pearson Type III distribution is fullfilled.

The planned flood discharge for the return period 25 years is calculated by entering the rainwater runoff's coefficient, the reduction coefficient of the area for watershed rainfall, the maximum rainfall intensity, the area of the watershed, and the rainfall design for the 25 years return period. The results of the calculation of the planned flood discharge is calculated by Rational method with maximum daily rainfall intensity using the Mononobe method. The results can be seen in the following Table 3.

**Tab. 3. The Calculation Results of the Planned Flood Discharge**

| Return Period(year) | $R_{24}$(mm) | Velocity (km/h) | Tc | Rainfall Intensity, I (mm/h) | Runoff's Coefficient | Watershed Area ($km^2$) | Flood Discharge, Q($m^3$/s) |
|---|---|---|---|---|---|---|---|
| 25 | 203.293 | 1.930 | 1.296 | 59.301 | 0.85 | 2.613 | 36.616 |

**Hydraulic Analysis**

From the result above, the 25 years return period obtained a planned flood discharge of 36.616 $m^3$/s.The discharge in the cross section of the existing flow is 24.912 $m^3$/s, so the flood discharge flows to the sodetan is 11.704 $m^3$/s.

**Tab. 4. The Calculation of Box Culvert Capacity**

| Runoff Discharge($m^3$/s) | B(m) | Y(m) | A($m^2$) | P(m) | R | V(m/s) | Q($m^3$/s) |
|---|---|---|---|---|---|---|---|
| 11.704 | 1.5 | 1.5 | 2.25 | 4.5 | 0.5 | 5.79 | 13.032 |

Where the results of the above calculations obtained an economic cross sectional capacity, box culvert with dimensions of 1.5 m × 1.5 m with a flood discharge (Q) of 13.032 $m^3$/s.

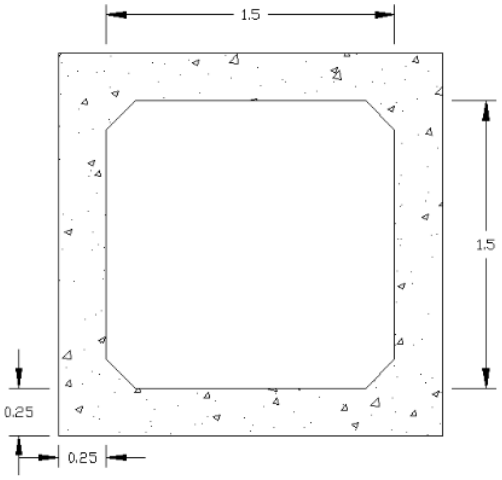


**Fig. 3. Design Plan Sketch of Box Culvert 1.5 m × 1.5 m**

***B. Analysis of Financial Aspects***

**Costs**

Based on the results of the calculation of the unit price analysis, the total cost of IDR 6,349,269.75, was obtained for the work of the reinforced K-250 precast box culvert 1.5 m × 1.5 m length 100 cm and thick 25 cm. Then a budget plan can be prepared for making, the following is a recapitulation construction cost of the sodetan development plan.

**Tab. 5. Construction Cost of Sodetan Development Plan**

| No. | Description/Type of Work | Unit Price |
|---|---|---|
| 1 | Preparatory Work | IDR 23,925,000.00 |
| 2 | Ground Work | IDR 207,849,924.68 |
| 3 | Concrete Work | IDR 2,979,368,027.15 |
| 4 | Installation Work | IDR 21,384,587.04 |
| 5 | Others Work | IDR 48,922,500.00 |
| Amount | | IDR 3,281,450,038.87 |
| Rounded Off | | IDR 3,280,000,000.00 |

The amount of the project cost for the initial investments can be detailed as follows:

1. The planning cost for the construction of this drainage channel in the form of sodetan IDR 100,000,000.00, in accordance with the government project budget ceiling for sodetan construction project in the 2020 fiscal year activities.
2. Construction costs based on the recapitulation of the calculation of the above budget plan is IDR 3,280,000,000.00, as shown in Table 5.
3. The cost of supervising for the construction of the drainage channel in the form of sodetan is at IDR 100,000,000.00, according to the goverment project budget ceiling for supervisory work.
4. Operational and maintenance costs are at 4% of the periodic construction costs, due to budget constraints for the government projects.

**Benefits**

The benefits in this analysis are explained by the reduced value of population losses as a positive impact of the drainage construction in the form of a sodetan. The financial analysis carried out includes the calculation of NPV, BCR, and IRR using the following data:

1. The useful life of the project is set for 20 years.
2. Construction time is in one year.
3. Value of losses due to flooding with an increase of 1.40% every year, the rate of increase obtained is based on a comparison of the value of losses with the amount of people in 2020 and 2019.
4. Project analysis activities that will carry out cost calculations using an interest rate on investment for the loan interest rate of PT. BPD South Borneo in November 2020.

**Tab. 6. Annual Total Project Cash Flow**

| Years | Planning Cost(IDR) | Construction Costs(IDR) | Supervising Cost(IDR) | Operational & Maintenance Costs (IDR) | Benefits (IDR) | Accumulated Cash Flow (IDR) |
|---|---|---|---|---|---|---|
| 0 | 100,000,000.00 | 3,280,000,000.00 | 100,000,000.00 | | | -3,480,000,000.00 |
| 1 | | | | | 763,056,425.00 | 763,056,425.00 |
| 2 | | | | | 773,708,936.83 | 773,708,936.83 |
| 3 | | | | | 784,510,161.12 | 784,510,161.12 |
| 4 | | | | | 795,462,173.97 | 795,462,173.97 |
| 5 | | | | 108,141,600.00 | 806,567,080.42 | 698,425,480.42 |
| 6 | | | | | 817,827,014.91 | 817,827,014.91 |
| 7 | | | | | 829,244,141.70 | 829,244,141.70 |
| 8 | | | | | 840,820,655.22 | 840,820,655.22 |
| 9 | | | | | 852,558,780.58 | 852,558,780.58 |
| 10 | | | | 118,847,618.40 | 864,460,773.93 | 864,460,773.93 |
| 11 | | | | | 876,528,992.90 | 876,528,992.90 |
| 12 | | | | | 888,765,574.10 | 888,765,574.10 |
| 13 | | | | | 901,172,998.49 | 901,172,998.49 |
| 14 | | | | | 913,753,661.87 | 913,753,661.87 |
| 15 | | | | 130,613,532.62 | 926,509,955.34 | 795,896,422.72 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16 | | | | | 939,444,330.74 | 939,444,330.74 |
| 17 | | | | | 952,559,274.17 | 952,559,274.17 |
| 18 | | | | | 965,857,306.40 | 965,857,306.40 |
| 19 | | | | | 979,340,983.41 | 979,340,983.41 |
| 20 | | | | 143,544,272.35 | 993,012,896.87 | 993,012,896.87 |

The financial feasibilty calculation as shown in tabel below shows a positive results, it means the project are economically and financially are worth doing, and the project earns more than its cost of capital each year.

**Tab. 7. The Results of Financial Feasibility**

| Years | Accumulated Cash Flow (IDR) | DF 9.90% | Net Present Value (IDR) | DF 22.45% | Net Present Value (IDR) |
|---|---|---|---|---|---|
| 0 | -3,480,000,000.00 | 1.000 | -3,480,000,000.00 | 1.000 | -3,480,000,000.00 |
| 1 | 763,056,425.00 | 0.910 | 694,318,858.05 | 0.817 | 623,157,554.10 |
| 2 | 773,708,936.83 | 0.828 | 640,593,058.65 | 0.667 | 516,012,276.79 |
| 3 | 784,510,161.12 | 0.753 | 591,024,515.65 | 0.545 | 427,289,484.09 |
| 4 | 795,462,173.97 | 0.686 | 545,291,544.11 | 0.445 | 353,821,626,78 |
| 5 | 698,425,480.42 | 0.624 | 435,643,875.70 | 0.363 | 253,703,306.80 |
| 6 | 817,827,014.91 | 0.568 | 464,168,108.08 | 0.297 | 242,610,009.90 |
| 7 | 829,244,141.70 | 0.516 | 428,251,176.86 | 0.242 | 200,895,813.19 |
| 8 | 840,820,655.22 | 0.470 | 395,113,467.07 | 0.198 | 166,353,926.52 |
| 9 | 852,558,780.58 | 0.428 | 364,539,924.91 | 0.162 | 137,751,147.86 |
| 10 | 864,460,773.93 | 0.389 | 290.092,591.55 | 0.132 | 98,384,269.98 |
| 11 | 876,528,992.90 | 0.354 | 310,307,044.17 | 0.108 | 94,453,828.75 |
| 12 | 888,765,574.10 | 0.322 | 286,295,750.49 | 0.88 | 78,213,503.00 |
| 13 | 901,172,998.49 | 0.293 | 264,142,430.18 | 0.072 | 64,765,527.58 |
| 14 | 913,753,661.87 | 0.267 | 243,703,314.84 | 0.059 | 53,629,787.72 |
| 15 | 795,896,422.72 | 0.243 | 193,148,422.88 | 0.048 | 38,148,257.97 |
| 16 | 939,444,330.74 | 0.221 | 207,447,388.11 | 0.039 | 36,773,114.89 |
| 17 | 952,559,274.17 | 0.201 | 191,395,286.64 | 0.032 | 30,450,371.04 |
| 18 | 965,857,306.40 | 0.183 | 176,585,283.05 | 0.026 | 25,214,755.38 |
| 19 | 979,340,983.41 | 0.166 | 162,921,264.88 | 0.021 | 20,879,347.84 |

| | | | | | |
|---|---|---|---|---|---|
| 20 | 993,012,896.87 | 0.151 | 128,585,943.01 | 0.017 | 14,790,115.90 |
| Amount | | | 3,533,569,248.86 | | -2,701,974.74 |

So from the financial feasibility analysis, it is resulted that the researcher generated a capital budgeting outcome about current condition. The funding and financial condition of the project was good and feasible to develop. These are finacial summaries of the following conditions:

- Net Present Value = IDR 3,533,248.86 greater than 0
- Benefit Cost Ratio = 1.02 greater than 1
- Internal Rate of Return = 22.44% greater than minimum attractive rate of return 9.90%

## IV. CONCLUSION

From the results obtained through the analysis of technical aspects it can be concluded that:

1. The cross sectional capacity of the existing drainage is not sufficient to accommodate the design flood discharge for the 25 years return period. With water discharge 36.616 $m^3/s$, the cross sectional capacity of the existing drainage can only accommodate a water discharge of 24.912 $m^3/s$, so there is a runoff discharge of 11.704 $m^3/s$ which will be flowed to sodetan using box culvert in the size 1.5 m × 1.5 m.
2. Planning of drainage channel using box culvert with the size 1.5 m × 1.5 m which can accommodate a water discharge 13.032 $m^3/s$ with velocity of 5.79 m/s of flow in box culvert cell.

Based on the result of the evaluation of the financial feasibility in the sodetan development project using box culvert, it is obtained as follows which cash flow for the sodetan construction project using box culvert in Cempaka Sub District Banjarbaru city consists of initial investment costs which are planning costs, operational and maintenance costs, as well as the cost benefits from the project which are obtained from the losses before the project is implemented, it can be concluded that:

1. Financial feasibility analysis using the net present value method obtained a positive value of IDR 3,533,248.86 at an interest rate of 9.90% per year for government projects. If it has a net present value is greater than 0, so the investment in the sodetan development project using the box culvert is declared feasible and can be implemented.
2. Financial feasibility analysis using the benefit cost ratio method obtained value of 1.02, which means that the value of the benefit cost ratio is greater that 1. So the investment in the sodetan development project using the box culvert is declared feasible and can be implemented.
3. Financial feasibility analysis using the internal rate of return method obtained a value 22.44%, the value of the internal rate of return was obtained from the results of trial and error. Thus, the internal rate of return, so the investment in the sodetan development project using the box culvert is declared feasible and can be implemented.

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