Assessment of the level of drainage services in Damai settlement area (Ampal River Watershed), Balikpapan, Indonesia

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Abstract. Flood is a major disaster in Balikpapan City. One of the locations experiencing high flooding is in the Damai settlement area (Ampal River Watershed), especially in Mayor Polisi Zainal Arifin Street. One of the causes of this flood-prone area is the suboptimal drainage conditions. This study aimed to assess the drainage services in the Damai settlement area (Ampal River Watershed), of Mayor Polisi Zainal Arifin Street to observe the drainage services and overcome flood problems. Achieving such goals was done by analyzing the service level of the drainage channel by using the scoring and weighting method. The scoring and weighting method produced classifications of drainage services in the Damai settlement area (Ampal River Watershed) on Mayor Polisi Zainal Arifin Street, namely, medium and bad drainage services. There is segment 2 channel 2A, segment 3 channel 3A, segment 4 channel 4A, and segment 5 on channel 5A and 5B classified as having bad service level and there are 13 channels classified as having moderate service levels.

1. Introduction
Flood is a major disaster in Balikpapan City [1]. Since 2015, flooding has become a priority environmental issue for the Balikpapan City Government. Moreover, from 2009 to 2015, there has been an increase in land cover for settlement areas in Balikpapan City by 13.34%, with only 70% of the drainage capacity able to accommodate the volume of inundation each year [2]. The increased flood inundation area in Balikpapan City in 2014 did not have flooded areas. However, the inundation area increased to 11.34 Ha in 2016 [3]. When it rains, the City of Balikpapan can experience floods of up to 1.5 meters in depth due to the rain occurring for 5 hours [4]. The flood disaster certainly impacts property losses, damage to facilities and infrastructure, public facilities, and may ultimately cause casualties [5].

Throughout 2016, 88 incidences of floods hit Balikpapan City with 22 flood points [3] Then, in 2017, there was an increase in flood incidences as many as 89 with 51 flood locations, in which one of the locations that have a high level of flood vulnerability is the Damai settlement area (Ampal River Watershed). It is mainly located on Mayor Polisi Zainal Arifin Street where there is a flood with water levels reaching 1.5 meters, which submerged the main roads and settlements from 3 hours to 12 hours with high rainfall [6]. This high flood-prone area is caused by the fact that there are still many suboptimal drainage conditions [7]. Climatological conditions due to high rainfall that can reach up to
54.9 mm are the cause of drainage problems in the Damai settlement area (Ampal River Watershed) along the Mayor Polisi Zainal Arifin Street [8]. Due to the impact of floods that occurred in the area, 172 houses were flooded and suffered losses of up to approximately Rp. 87,000,000. The flood conditions that occurred have caused losses for the residents who live and, even, claimed their lives.

Flood mitigation efforts have been carried out, such as implementing flood control programs and constructing drainage channels or ditches. However, according to the BAPPELITBANG Work Plan 2018, the flood control program planned for 2017 to 2018 has not been achieved. Therefore, the government program has not been able to handle the flood problem [9]. The government carried out flood management in Balikpapan City by constructing drainage channels and ditches. However, the handling has not been carried out at the research location, so floods still occur frequently. Therefore, after identifying and analyzing the drainage services in the Damai settlement area (Ampal River Watershed), it is necessary to take action on drainage service problems in that area, especially along the Mayor Polisi Zainal Arifin Street so that they no longer pose more significant threats on the community. Hence, this study attempted to provide assessment of the drainage service level to identify problems concerning drainage service and flood in the Damai settlement area (Ampal River Watershed), especially on Mayor Polisi Zainal Arifin Street, Balikpapan City.

2. Methods

2.1 Data collection method
In collecting data to assess drainage services, field observations were carried out. In addition, the assessment was carried out by looking at the existing conditions of the research location, i.e., the population and sample studied. The research location was divided into 10 segments and was then assessed based on the right and left channels.

2.2 Analysis Method

2.2.1 Analysis of the Assessment of Drainage Service Levels in the settlement areas of Mayor Polisi Zainal Arifin Street, Balikpapan City

Scoring and weighting are a decision-making, which is carried out by assessing each variable, providing a score multiplied by the weight. The weight can be seen in Table 1.

Table 1. Drainage service level aspect variable assessment criteria

| Variable                          | Weight | Assessment Criteria                                                                 | References |
|----------------------------------|--------|-------------------------------------------------------------------------------------|------------|
| Condition and function of drainage | 0.089  | 1. Natural or artificial drainage conditions are filled with sediment and vegetation. | [10][11]  |
|                                   |        | 2. Natural or artificial drainage conditions are partially filled with sediment and vegetation | [12][14]  |
|                                   |        | 3. Natural or artificial drainage conditions are completely devoid of sediment and vegetation; it can drain water |           |
| Building density                  | 0.042  | 1. > 100 units/ha                                                                   | [12][13]  |
|                                   |        | 2. 80 – 100 units/ha                                                                | [14]       |
|                                   |        | 3. <80 units/ha                                                                     |            |
| Completeness of waste facilities | 0.040  | 1. No waste facilities                                                               | [13][14]  |
|                                   |        | 2. There are some waste facilities                                                  |            |
|                                   |        | 3. Complete waste facilities are available, such as trash cans, waste collection points (TPS) or 3R TPS, garbage carts or garbage trucks, and TPST | [13][14]  |
| Contour height                    | 0.056  | 1. <10 m 2. <10 – 50 m 3. >50 m                                                   | [13][14]  |
| Garbage that accumulates in the drainage channel | 0.084 | 1. Volume >50%                                                                      | [10][11]  |
|                                   |        | 2. Volume 1% - 50%                                                                 | [12][14]  |
|                                   |        | 3. Volume does not exist                                                            |            |
| Fund for routine maintenance      | 0.050  | 1. None 2. In progress 3. Exists                                                    | [10][13]  |
| Procurement of capital fund       | 0.019  | 1. None 2. In progress 3. Exists                                                    | [10][13]  |
### Variable Weight Assessment Criteria References

| Variable                                      | Weight | 1. | 2. | 3. | References |
|----------------------------------------------|--------|----|----|----|------------|
| There are community activities in maintaining drainage | 0.080  | None | 1 or >1 time/month | 1 or >1 time/week | [10][13][14] |
| Active community participation               | 0.226  | None | 2. part of society | 3. all society | [10][13][14] |
| Drainage Regional Regulation                 | 0.086  | None | 2. In progress | 3. Exists | [11][13][14] |
| Standard procedure management and supervision of drainage | 0.086  | None | 2. In progress | 3. Exists | [11][13][14] |
| The existence of a drainage infrastructure management agency | 0.071  | None | 2. Not clear | 3. Exists | [13][14] |
| Optimizing human resources in agencies in handling drainage | 0.071  | 1. | Does not take care of drainage at all | 2. | Does handle drainage but still finds problematic drainage | 3. | Has dealt with the drainage and found no drainage problems | [11][14] |

### 3. Result and Discussions

#### 3.1 Overview of Research Sites

The location in this study is the drainage system located in the Damai settlement area of Mayor Polisi Zainal Arifin Street, administratively bordering six urban villages. Mayor Polisi Zainal Arifin Street spans 2,434.3 meters [15]. The research location was divided into 10 segments (Figure 1)

![Figure 1. Map of study site segment channel [15]](image)

#### 3.1.1 Condition and function of drainage

In the settlement area of Mayor Polisi Zainal Arifin Street, there are 9 artificial channels with channel conditions filled with vegetation and sediment and, thus, the drainage function cannot drain water, 7 natural or artificial channels where the channel conditions were partially filled with greenery, and sediment and 2 tracks which were in good condition and able to drain water.

#### 3.1.2 Building Density

The number of buildings in the research area was 187 buildings. The highest building density was in segment 2, channel 2A, with a building density of 71.9 units/ha. On the other hand, the lowest building density was in segment 1, channel 1B, and segment 4, channel 4B, with a building density of 7.4 units/ha.
3.1.3 Completeness of waste facilities

Based on field observations, we did not find any completeness of waste facilities in Mayor Polisi Zainal Arifin Street.

3.1.4 Contour height

In the settlement area of Mayor Polisi Zainal Arifin Street, the lowest contour height was found in segments 1 to segment 5 with a contour height of 2–8 meters; whereas, for the highest contour height, it was located in segment 9 and segment 10 with a contour height of 40–75 meters.

3.1.5 Garbage that accumulates in the drainage channel

From the field observations, the authors observed that the highest percentage of the waste was in segment 3 on channel 3A with 34.57% of waste. The lowest rate was in segment 4 on channel 4B with a percentage of 0.00%.

3.1.6 Routine maintenance fund

In the interview results, Mrs. Faridah (Head of Development and Improvement of Natural Resources and Drainage of Balikpapan City) and head of neighbourhood of each channel in the segment said that there were no funds for routine maintenance of drainage in Mayor Polisi Zainal Arifin Street.

3.1.7 Procurement capital fund

From the interview results with Mrs. Faridah as the head of the Development and Improvement of Natural Resources and Drainage Section of Balikpapan, she explained that the capital fund for drainage in Mayor of Polisi Zainal Arifin Street was Rp. 5,000,000,000, and the fund was only for drainage planning along the length of 400 meters located in segment 1 in channel 1B, segment 2 in channel 2B, and segment 3 in channel 3B. For the rest, there was no procurement capital fund related to drainage planning.

3.1.8 There are community activities in maintaining drainage

From the interviews with the head of neighbourhood in each channel in the segment, it was stated that community activities in maintaining drainage were carried out about 1–2 times a month.

3.1.9 Active community participation

Based on the interview results from the head of the neighbourhood on each channel in the segment, active participation by the whole community was found in segment 7 on channel 7A and segment 8 on channel 8A. Apart from this segment, active participation was only undertaken by some people.

3.1.10 Drainage Regional Regulation

The interview results from both the head of the neighbourhood for each channel in the segment and Mrs. Fairidah (Head of the Development and Improvement of Natural Resources and Drainage Section of Balikpapan City) revealed that there were no regional regulations related to drainage.

3.1.11 Standard procedures management and supervision of drainage

In the interview results from both the head of neighbourhood in each channel in the research segment and Mrs. Faridah (Head of Development and Improvement of Natural Resources and Drainage of Balikpapan City) said that there were no standard procedures for management and supervision of drainage.
3.1.12 The existence of a drainage infrastructure management agency
Based on the interview results with the head of the neighbourhood in each channel in the segment, an agency manages the infrastructure of all drainage channels in the settlement area on Mayor Polisi Zainal Arifin Street, namely the Public Works Department.

3.1.13 Optimizing human resources in agencies in handling drainage
In the settlement area of Mayor Polisi Zainal Arifin Street, the optimality of human resources in the agency in handling drainage can be seen from the drainage planning carried out in segment 1 of channel 1B. The agency has carried out optimal drainage planning work on segment 2, channel 2B, and segment 3, channel 3B, such as selecting the appropriate drainage materials so that drainage can function correctly. Meanwhile, in addition to the drainage segment mentioned earlier, we can say that the agency has not carried out optimal handling because drainage planning has not been carried out.

3.2 Analysis Results
3.2.1 Analysis of the Assessment of Drainage Service Levels in the settlement areas of Mayor Polisi Zainal Arifin Street Balikpapan City
To analyze the level of drainage services on Mayor Polisi Zainal Arifin Street, this study carried out outscoring and weighting through the assessment of each variable by giving a score according to the existing conditions, then multiplied by the weight [14]. In calculating the drainage service level assessment, interval calculations were carried out with the following equation:

\[
\text{Interval} = \frac{\text{Highest total score} - \text{Lowest total score}}{\text{class}}
\]

\[
= \frac{3000 - 1000}{3} = 0.667
\]

The obtained classification of each level can be seen in Table 2:

| Interval     | Description |
|--------------|-------------|
| 1.00 – 1.666 | Bad         |
| 1.667 – 2.333| Moderate    |
| 2.334 – 3.000| Good        |

The results of the service level qualification for each channel can be seen in Table 3:

| Segment | Code | Total Score | Drainage service level | Service conditions |
|---------|------|-------------|------------------------|--------------------|
| 1       | 1A   | 1.705       | Moderate               | No complete waste facilities were found. The contour height was less than 10 meters, there were no routine maintenance funds and procurement capital funds. There were no drainage regulations and standard procedures management and supervision of drainage, and there was no handling of drainage. |
| 1B      |      | 1.974       | Moderate               | No complete waste facilities were found. The contour height was less than 10 meters, there were no routine maintenance funds. There were no drainage regulations and standard procedures management and supervision of drainage. |
| 2       | 2A   | 1.663       | Bad                    | No complete waste facilities were found. The contour height was less than 10 meters, there were no routine maintenance funds and procurement capital funds. There were no drainage area regulations, standard procedures management, and supervision of drainage. There was no handling of drainage. |
| Segment | Code | Total Score | Drainage service level | Service conditions | Existing condition |
|---------|------|-------------|------------------------|--------------------|-------------------|
| 2B      | 1.974| Moderate    | No complete waste facilities were found. The contour height was less than 10 meters. There were no routine maintenance funds, no drainage area regulations, standard procedures management, and supervision of drainage. |
| 3A      | 1.616| Bad         | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities. The contour height was less than 10 meters. There were no routine maintenance funds and capital procurement funds. There were no drainage area regulations, standard procedures management, and supervision of drainage. There was no drainage treatment. |
| 3B      | 1.885| Moderate    | No complete waste facilities were found. The contour height was less than 10 meters. There were no routine maintenance funds. There were no drainage area regulations, standard procedures management, and supervision of drainage. |
| 4A      | 1.616| Bad         | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities. The contour height was less than 10 meters. There were no routine maintenance funds and capital procurement funds. There were no drainage area regulations, standard procedures management, and supervision of drainage. There was no drainage treatment. |
| 4B      | 1.705| Moderate    | No complete waste facilities were found. The contour height was less than 10 meters. There were no routine maintenance funds and procurement capital funds. There were no drainage regulations, standard procedures management, and supervision of drainage. There was no handling of drainage. |
| 5A      | 1.616| Bad         | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities. The contour height was less than 10 meters. There were no routine maintenance funds and capital procurement funds. There were no drainage area regulations, standard procedures management, and supervision of drainage. There was no drainage treatment. |
| 5B      | 1.616| Bad         | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities. The contour height was less than 10 meters. There were no routine maintenance funds and capital procurement funds. There were no drainage area regulations, standard procedures management, and supervision of drainage. There was no drainage treatment. |
| 6A      | 1.672| Moderate    | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities. There were no routine maintenance funds and capital procurement funds. There were no drainage regulations, standard procedures management, and supervision of drainage. There was a drainage treatment. |
| 6B      | 1.761| Moderate    | There were no complete waste facilities. There were no routine maintenance funds and procurement capital funds. There were no drainage regulations, standard procedures management, and supervision of drainage. There was no treatment for drainage. |
| 7A      | 1.987| Moderate    | There were no complete waste facilities. There were no routine maintenance funds and procurement capital funds. There were no drainage regulations, standard procedures management, and supervision of drainage. There was no treatment for drainage. |
| 7B      | 1.761| Moderate    | There were no complete waste facilities, routine maintenance funds, and procurement capital funds. There were no drainage regulations, standard procedures management, and supervision of drainage. There was no treatment for drainage. |
| Segment | Code | Total Score | Drainage service level | Service conditions | Existing condition |
|---------|------|-------------|------------------------|--------------------|-------------------|
| 8       | 8A   | 1.898       | Moderate               | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities, routine maintenance funds, and capital procurement funds. Moreover, there were no drainage area regulations, standard procedures management, and supervision of drainage. There was no drainage treatment. |
| 8       | 8B   | 1.672       | Moderate               | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities, no routine maintenance funds, and no capital procurement funds. There were no drainage area regulations, standard procedures management, and supervision of drainage. There was a drainage treatment. |
| 9       | 9A   | 1.728       | Moderate               | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities, routine maintenance funds, and capital procurement funds. Moreover, there were no drainage area regulations, standard procedures management, supervision of drainage. There was no drainage treatment. |
| 10      | 10A  | 1.728       | Moderate               | Drainage channels were filled with vegetation and sediments, and were not able to drain water. There were no complete waste facilities, routine maintenance funds, and capital procurement funds. Moreover, there were no drainage area regulations, standard procedures management, and supervision of drainage. There was no drainage treatment. |

The values and results of the level of drainage services in each channel on Mayor Polisi Zainal Arifin Street Balikpapan City are grouped into 2 classifications: bad and moderate classes.

**Figure 2.** Map of drainage service levels in the settlement areas of Mayor Polisi Zainal Arifin Street Balikpapan City [author’s document]

### 4. Conclusions
The level of drainage services in Damai settlement area (Ampal River Watershed), Balikpapan City has two classifications, which are moderate and bad, obtained from the assessment analysis results, particularly on the Mayor Polisi Zainal Arifin Street. At the bad service level, there are 5 channels,
namely in segment 2 on channel 2A, segment 3 on channel 3A, segment 4 on channel 4A, and segment 5 on channel 5A and 5B; whereas, there are 13 channels for moderate service levels.

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