

UNDERGRADUATE THESIS

**EFFECTS OF GRADUALLY CONSTRUCTED
LEVEES ON THE FLOOD CHARACTERISTICS IN
MAEN VILLAGE, NORTH SULAWESI, INDONESIA**



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ABSTRACT

The flood occurring in 2015 in the Maen Village, North Sulawesi, was caused by high-intensity rainfall, which exceeded the capacity of the Maen River to accommodate and convey the water to the sea. Therefore, to prevent the occurrence of extreme flood events, it is necessary to construct levees along the Maen river. In this regard, 2D hydrodynamic simulation was conducted using HEC-RAS 6.1 to investigate the effects of gradually constructed levees (upstream-downstream or downstream-upstream) on the flood characteristics (depth and velocity) in the Maen village. The purpose of this study is to provide an overview of whether the upstream or downstream locations should be prioritized for the levee construction, which was done based on the analysis of flood hazard index. First, 2D simulation was carried out with the levees entirely constructed along the river (approximately 2.8 km). It was shown that the levees were able to anticipate the flood with 25-year return period. Afterwards, the 2D hydrodynamic analysis was performed with the levees partially constructed upstream or downstream of the river. The results suggest that the levees should be constructed from upstream to downstream of the river showing a lower value of flood hazard index. The finding of this study is expected to provide a new perspective for the planning of levee construction especially when gradual construction must be accounted for.

Kata Kunci: Downstream, Levees, Flood, Hazard, Upstream

DAMPAK PEMBANGUNAN TANGGUL YANG DILAKUKAN SECARA BERTAHAP TERHADAP KARAKTERISTIK BANJIR DI DESA MAEN, SULAWESI UTARA, INDONESIA.

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ABSTRAK

Banjir yang terjadi di Desa Maen, Sulawesi Utara pada tahun 2015 disebabkan oleh curah hujan yang sangat tinggi, sehingga melebihi kapasitas Sungai Maen untuk menampung dan mengalirkan air ke laut. Oleh karena itu, untuk mencegah terjadinya banjir ekstrem, diperlukan pembangunan tanggul di sepanjang Sungai Maen. Dalam hal ini, dilakukan simulasi hidrodinamika 2D menggunakan HEC-RAS 6.1 untuk menyelidiki efek dari pembangunan tanggul secara bertahap (dari hulu ke hilir atau dari hilir ke hulu) terhadap karakteristik banjir (kedalaman dan kecepatan aliran) di Desa Maen. Tujuan dari penelitian ini adalah untuk memberikan gambaran apakah lokasi hulu atau hilir harus diutamakan untuk pembangunan tanggul, yang ditentukan berdasarkan analisis indeks bahaya banjir. Pertama, dilakukan simulasi 2D dengan tanggul yang dibangun sepenuhnya sepanjang sungai (sekitar 2,8 km). Hasilnya menunjukkan bahwa tanggul mampu mengantisipasi banjir dengan periode ulang 25 tahun. Selanjutnya, dilakukan analisis hidrodinamika 2D dengan tanggul yang dibangun secara parsial dari hulu atau hilir sungai. Hasilnya menunjukkan bahwa tanggul sebaiknya dibangun dari hulu ke hilir sungai dengan nilai indeks bahaya banjir yang lebih rendah. Temuan dari penelitian ini diharapkan dapat memberikan pandangan baru untuk perencanaan pembangunan tanggul terutama ketika pembangunan secara bertahap harus dipertimbangkan.

Keywords: Bahaya Banjir, Banjir, Hilir, Hulu, Tanggul,

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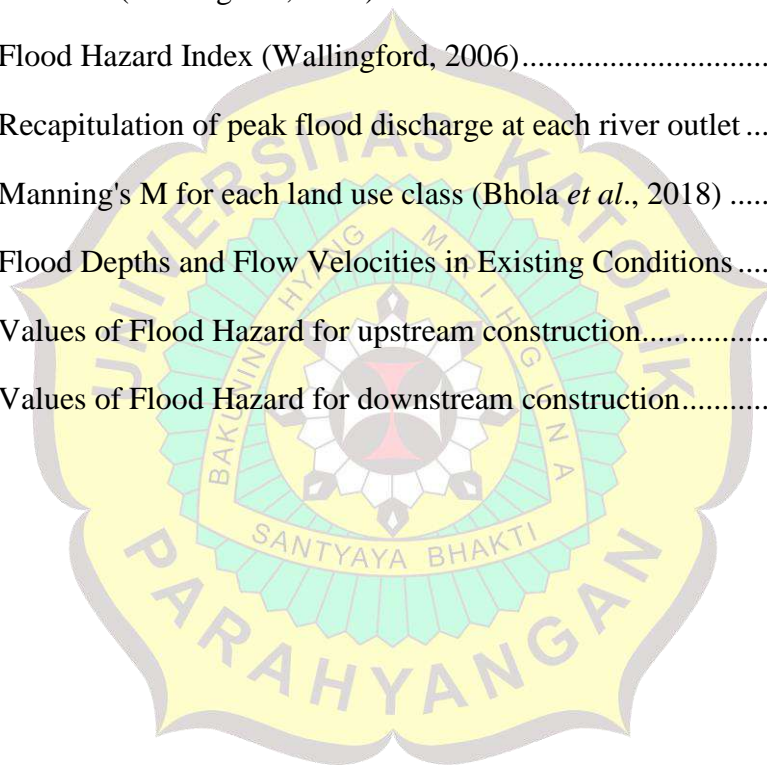
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CHAPTER 1

INTRODUCTION

1.1 Background

Flood is one of several natural disasters often occurring during rainy season. In general, floods occur due to the insufficient capacity of the channels to accommodate large discharge (Marinto *et al.*, 2018). Consequently, the water will overflow and inundate the surrounding areas causing several losses in terms of economics and even human life (Adimas and Hadi, 2018).

One of several flood events in Indonesia is the 2015 flood in the Maen village, North Sulawesi. Generally, the Maen village located in Likupang subdistrict has low terrain contours and is near the coastal area, making it vulnerable to flooding (Rifay *et al.*, 2021). Therefore, floods frequently occur there.

Efforts to prevent future floods for the Maen village are crucial, and flood control structures such as levees are necessary to accommodate the water overflow from rivers to the residential areas. In the previous study of (Makahinsade *et al.*, 2020), it was recommended to build levees along both sides of the Maen River, for which good planning is needed to ensure that the levees can deliver the optimal results. Also, the construction of levees should be done efficiently regarding several aspects such as technical hydraulics, cost, social, etc.

As shown in **Figure 1.1**, Maen village is located in the northern part of the Maen River Basin with an area of 73.53 km². The length of the main river is approximately 23 km. In addition, there is also a small Maen River on the eastern side of the main Maen River. For several cases, the levee construction on rivers may become more complicated due to several reasons, for example, if it is not feasible to build the levees simultaneously along the rivers because of budget limitations. Hence, knowing the priority of the river parts on which the levees are constructed is of importance and must be thoroughly investigated by the engineers and the related stakeholders.



Figure 1.1 Maen River Basin (PT Aditya Engineering Consultant, 2021)

This thesis focuses on investigating the effects of gradually constructed levees on the flood characteristics in the Maen village. The author assumes that the levee construction in the Main village somehow cannot be conducted entirely along the rivers at the same time. The general idea of this study will be performed as follows. First, the simulation of the flood discharge of the river is conducted in order to provide an overview in terms of river levee planning. Afterwards, the author will investigate how the levee can be spatially developed along the river: from upstream to downstream or downstream to upstream, such as the one conducted by (Koma *et al.*, 2022). In this regard, several simulations will be carried out to compare which plan is better to implement.

To simulate the floods and investigate the impact of upstream-downstream or downstream-upstream levee construction, HEC-RAS (Hydrologic Engineering Center River Analysis System) model is used. HEC-RAS is a free-license software developed by the United States Army Corps of Engineers (USACE). HEC-RAS software is specifically designed to assist in solving flood inundation modeling problems (Sholikha *et al.*, 2022).

1.2 Objective

The objectives of this thesis are:

1. To simulate the existing flood in the Maen Village with 2D simulation.
2. To plan the location for the river levee along the Maen river.
3. To analyze and compare the results for the construction phase of the levees either from upstream-downstream or downstream-upstream.

1.3 Scope of Study

The scope of this study are:

1. The location of the case study is the Maen Village, North Sulawesi.
2. The software used to investigate the hydraulic behaviors due to the levee construction is HEC-RAS 6.1.
3. This thesis only focuses on studying the height dimensions of the levees.

1.4 Research Methodology

The research methodology used in this thesis is explained as follows:

1. Literature Study

The literature study is conducted to broadly understand the issues related to the levee construction along the Maen river.

2. Flood Modeling

This stage will show the results of flood simulation carried out using HEC-RAS and validate the occurrence of floods that had happened.

3. Result Analysis

This stage is to analyze and compare all existing simulations of the levees construction.

The research methodology is also shown in **Figure 1.2** below.

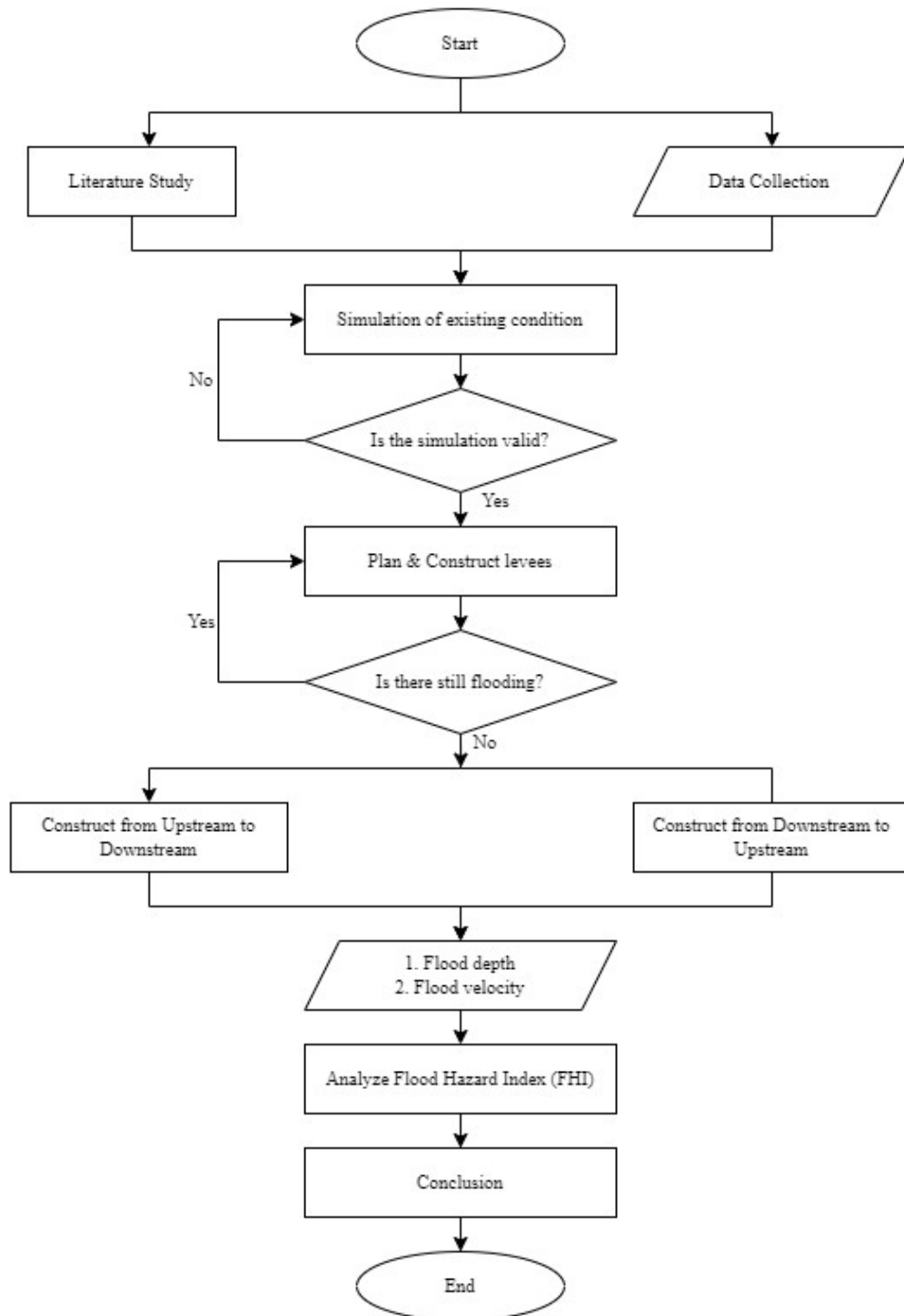


Figure 1.2 Flow Chart