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Analysis The Influence of Hydrometeorological Disaster in Kera River Wajo Regency

M R Pratama[1], F Maricar[2], R Karamma[2] and R T Lopa[2]

[1]Magister Student Department of Civil Engineering, Faculty of Engineering, Hasanuddin University, Makassar, Indonesia
[2]Lecturer Department of Civil Engineering, Faculty of Engineering, Hasanuddin University, Makassar, Indonesia

E-mail: ryanryanpratama1@gmail.com

Abstract. Recently, Indonesia has been dominated by hydrometeorological disasters which include landslides, tornadoes, droughts and floods. Hydrometeorological disasters cannot be separated from the consequences of climate change that occur. The purpose of this study is to examine the influence of climate change on hydrometeorological disasters in the Kera River of Wajo Regency. This research uses quantitative methods. The data used are primary data in the form of field surveys and secondary data in the form of river topographic data and TRMM rainfall. The climate change greatly affects the increase in rainfall in the watershed, and flooding in the Watershed. Changes in rain characteristics in the watershed, in the form of annual rain height and maximum daily rain tend to increase, resulting in flooding around the Kera River area. The highest discharge that occurs at 2 year return period is 147.1 m^3/s, 5 year return period is 212.5 m^3/s, 10 year return period is 251.3 m^3/s, 25 year return period is 296.1 m^3/s. Therefore, it is necessary to carry out flood disaster mitigation with structural methods shown, by normalizing rivers, building flood embankments respectively. The results of this study found that climate change that occurred in the Kera River had an effect on the number of hydrometeorological disaster events, especially floods.

1. Introduction

A disaster is an event or series of events that threatens and disrupts people's lives and livelihoods caused by natural and/or non-natural factors as well as human factors, environmental damage, property losses, and psychological impacts. Flood is the natural disasters that often occur in Indonesia. Climate can encourage the potential for this hydrometeorological disaster to occur is climate. In the era of global warming, Indonesia has experienced quite drastic temperature changes. The timing of the transition of the seasons is increasingly difficult to detect due to the presence of global warming which changes the intensity of rainfall[1]. There are two climatic elements that are commonly used as parameters of climate change, ie air temperature and rainfall[2]. Changes in rain patterns that occur can have an impact on the lives of people around the watershed. A major flood event can significantly change the morphology of a river in the sedimentary channel of a stream. Therefore, previous flood disaster events cause losses, and can be used as a study to determine the potential for disasters that occur in the future[1].

Flood hydrometeorological disasters are the dominating disasters in Indonesia in 2010 – 2020 in addition to landslides, and tornadoes. Hydrometeorological disasters cannot be separated from the current climate change in all regions of the world including Indonesia[3]. Indications of global climate change in the form of rising surface temperatures, changes in precipitation patterns, evaporation, sea level rise and surpluses or deficits in water availability can threaten life anywhere sustainable development policy strategy like land use is needed. Land use change will bring serious problems according to soil and water conservation rules and the land capability classes. Climate change will have an impact on the existence of water use in several watersheds , especially on meteorological, hydrological and land water supplies. From a hydrological aspect, changes in land use will have a direct effect on the characteristics of land cover so that it will affect the water system in each watershed.

Climate change that occurs today, is also thought to cause an increase in hydrometeorological disasters such as floods, landslides and tornadoes. Currently flooding is a problem that is also a major concern in many regions of many countries. This problem is further exacerbated due to global climate change[4].

To determine the type of distribution that will be used in determining the return period (frequency analysis), statistical parameters are sought from regional rainfall data both normally and logarithmically. To estimate the amount of rainfall with various re-periods, a frequency analysis of rainfall data is carried out.

Frequency analysis of hydrological data aims to determine the value of the magnitude of extreme events related to the frequency of occurrence through the application of probability distributions. Frequency analysis using random variables and probability distributions is part of the statistical method. In the statistical analysis of data, there are parameters that can help in determining the right type of distribution. These parameters are divided into 4 (four) large parts of measurement, namely, central tendency measurement, variability measurement, skewness measurement and kurtosis measurement. The types of distributions used are Normal Distribution, Normal Log Distribution, Gumbel Distribution, Pearson III Log Distribution[5].

Flood disaster mitigation is an effort to reduce the risk due to flood disasters According to Yulia S. (2015) "Flood disaster mitigation is an effort made to prevent or reduce the risk of flood disasters.

Mitigation in flood disasters is also divided into 2 types, namely structural mitigation and non-structural mitigation. Structural Mitigation is an effort made to minimize disasters such as by building special canals to prevent flooding and by making technical engineering of disaster-resistant buildings, as well as waterproof building infrastructure. Meanwhile, non-structural mitigation is an effort made in addition to structural mitigation such as with regional planning and &ing insurance. In this non-structural mitigation, we really expect from the development of increasingly advanced technology. The hope is that technology can predict, anticipate & reduce the risk of a disaster occurring[6].

The SCS Synthetic Unit Hydrograph is a hydrograph dimensionless unit, where this method calculates the influence of soil type and land use patterns and can be calculated using HEC-HMS software[7]. HEC-HMS (Hydrologic Engineering Center's Hydrologic Modeling System) is software developed by the U.S Army Corps of Engineering. HEC-HMS is used for hydrological analysis by simulating rainfall processes and run off from a river basin.

HEC-RAS stands for Hydraulic Engineering Center-River Analysis System. The program was created by the Hydrologic Engineering Center (HEC) which is a division within the Institute for Water Resources, under the US Army Corps of Engineers (USAGE). HEC-RAS is a permanent and non-permanent flow one-dimensional model (steady and unsteady one dimensional flow model).

2-D modeling using HEC RAS software for unsteady flow conditions uses input data in the form of longitudinal cross sections (long section) and cross section (cross section), boundary condition data upstream and downstream, channel base slope data, manning coefficient and DEM (Digital Elevation Model) data to describe the topographic conditions of the watershed[8]. HEC-RAS software is a hydrodynamic model used in this study. HEC-RAS 5.03 was used to model river hydraulics so that flood flow profiles could be simulated including their inundation characteristics[8].

2. Research Method

Kera River in Wajo regency, is located in the central part of South Sulawesi Province with a distance of 242 km from Makassar which is the capital of South Sulawesi Province. The area of Wajo Regency is 2,506.19 km2 or 4.01% of the area of South Sulawesi Province.

Floods occurred in Wajo Regency in 2020 affecting 9 (nine) sub-districts and 78 villages/kelurahan, where one of the sub-districts affected by severe floods was Keera District. The inability of the Kera River to accommodate and drain the flood discharge that occurred resulted in runoff which affected settlements, agricultural land and community ponds in the area. Based on information obtained from the community, the worst flooding incident that has ever occurred reached a height of ± 2 m in residential areas and inundation on national roads which also resulted in the interruption of transportation access in the area.

Figure 1 shows the research location is in Kera river, Wajo Regency, South Sulawesi Province. Hydraulic tracing for flood analysis was carried out along 32 km with a watershed area of 172.37 km^2, namely in the upstream area towards the estuary or at coordinates 3°51'2.04" LS; 120°21'46.87 BT to 3°48'58.93" LS; 120°13'24.11 BT.

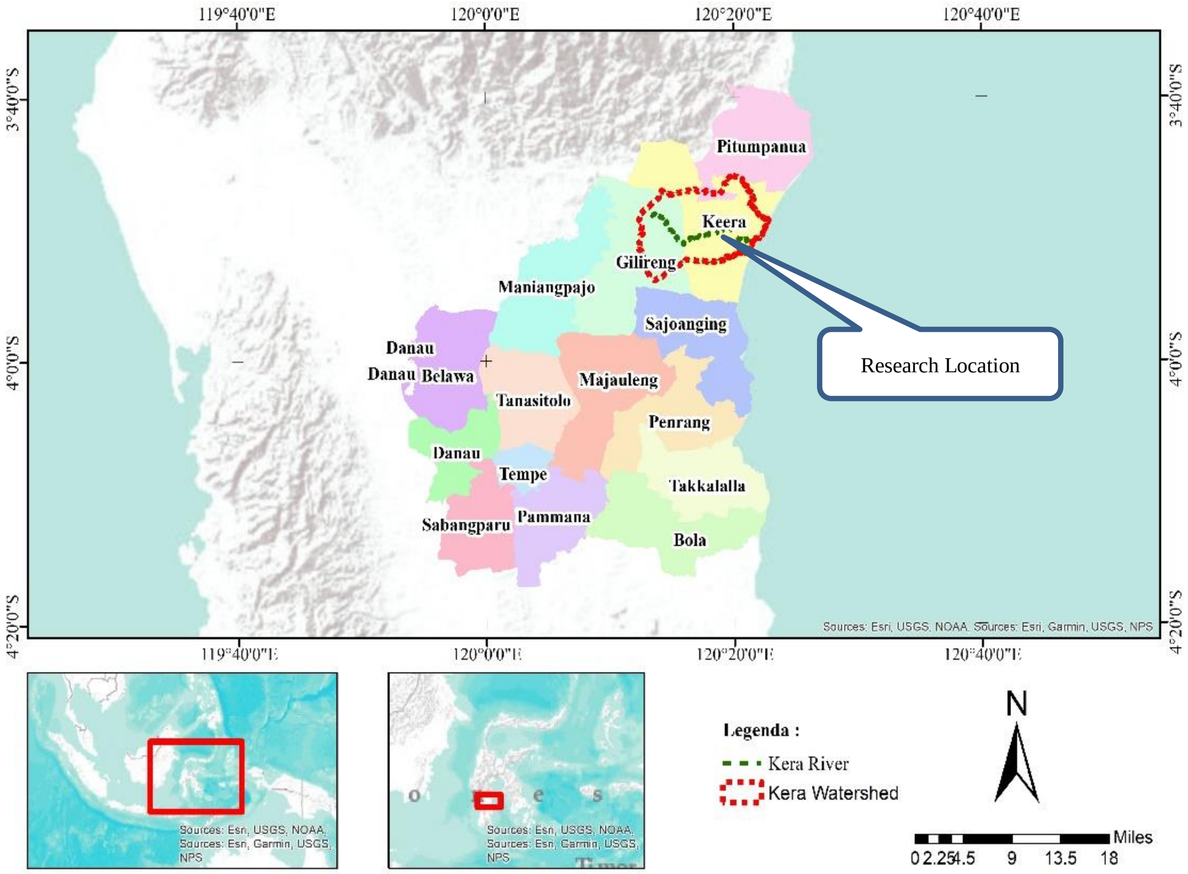

Figure 1. Research Location Map.

Primary data is obtained from survey results to collect information related to flood events while secondary data is obtained from related agencies. Information data retrieval techniques are 1). Prepare everything that will be used for surveys to the field so that the research runs smoothly, 2). Seeing and paying attention to the condition of buildings in the field, 3). Coordinating/communicating to relevant agencies for data collection, 4). Collect data and input into Microsoft Office which will be used to analyze.

The method to determine the flood-prone areas of The Kera River in Wajo Regency is carried out based on the flood discharge plan resulting from hydrological analysis which has previously been verified with discharge data at the time of Q2, Q5, Q10, Q20, Q25 in accordance with the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia concerning the Determination of the River Boundary Line and Lake Boundary Line No. 28 / PRT / M / 2015 for the regency / city capital to flow the plan discharge (Q10 - Q20). Furthermore, the flood discharge data of the selected plan and the cross-sectional data of the river are used as input data for 2D modeling using the HEC-RAS application to see the flood distribution area. From this modeling, it can be known the extent of inundation, the speed of flood flow, and the duration of floods which are then overlayed using the Arcgis 10.5 Application to analyze the determination of flood-prone areas based on the Regulation of the Head of the National Disaster Management Agency Number 02 of 2012 concerning General Guidelines for Disaster Risk Assessment and making maps of flood-prone areas. From the results of regional modeling, it is continued by mitigating flood disasters with structural methods to minimize the impact of floods.

3. Result and Discussion

Based on TRMM rainfall data for 1998-2021 shows that the rainfall in the watershed averages more than 90 mm / month. A positive increase in annual rainfall will increase the availability of water resources if they can be managed. Rainfall in the watershed has increased and decreased every year (Figure 2) shows that climate change does affect hydrometeorological disasters , especially floods. However, if there is successive rains with high intensity, the flood event will be even greater. In addition, high-intensity rains will also cause more flood overflow events beyond river embankments.

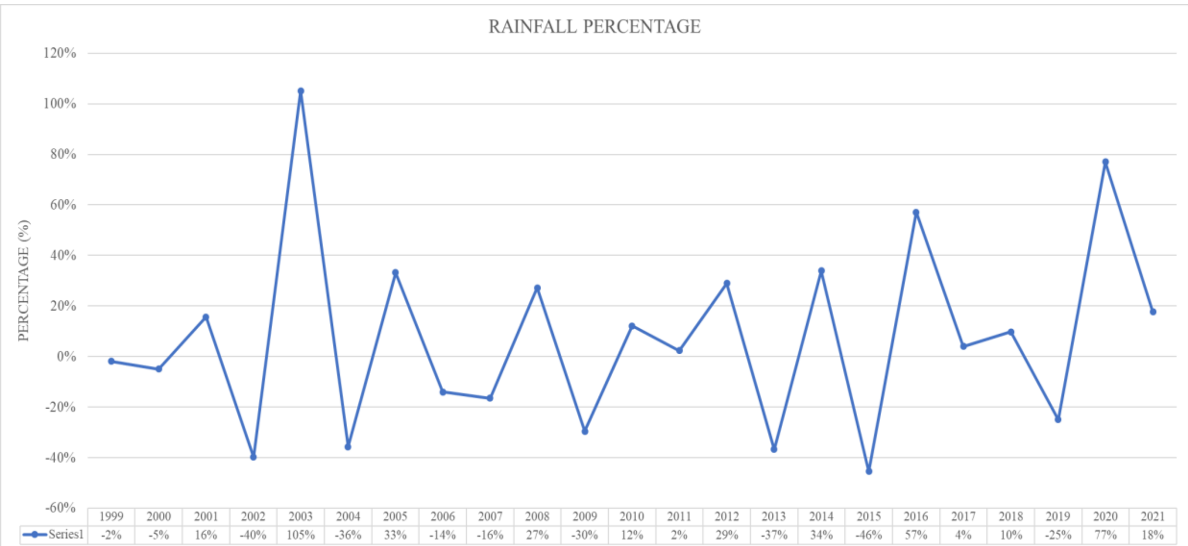

Figure 2. Rainfall Percentage

The trigger for flooding in the Watershed area is due to the high intensity of rainfall. Based on TRMM rainfall data in 1998-2021, the maximum rainfall that occurred in the Kera river was 122 mm/day in June 2001, 140 mm/day in April 2003, 128 mm/day in May 2005, 146 mm/day occurred in December 2021. The results of the rainfall analysis that has been carried out by the rainfall data in the category of very heavy rain in accordance with the threshold of the rain intensity value :

a. 0 mm/day (gray) : Cloudy
b. 0.5 – 20 mm/day (green) : Light rain
c. 20 – 50 mm/day (yellow) : Moderate rain
d. 50 – 100 mm/day (orange): Heavy rain
e. 100 – 150 mm/day (red) : Very heavy rain
f. >150 mm / day (purple) : Extreme rain

Figure 3 shows that the hydrograph of floods due to climate change greatly affects the peak of floods. Discharge with a high re-time, quantitatively experienced a higher increase than the discharge with a lower re-time. The highest discharge that occurs at 2 year return period is 147.1 m^3/s, 5 year the return period is 212.5 m^3/s, 10 year return period is 251.3 m^3/s, 25 year the return period is 296.1 m^3/s.

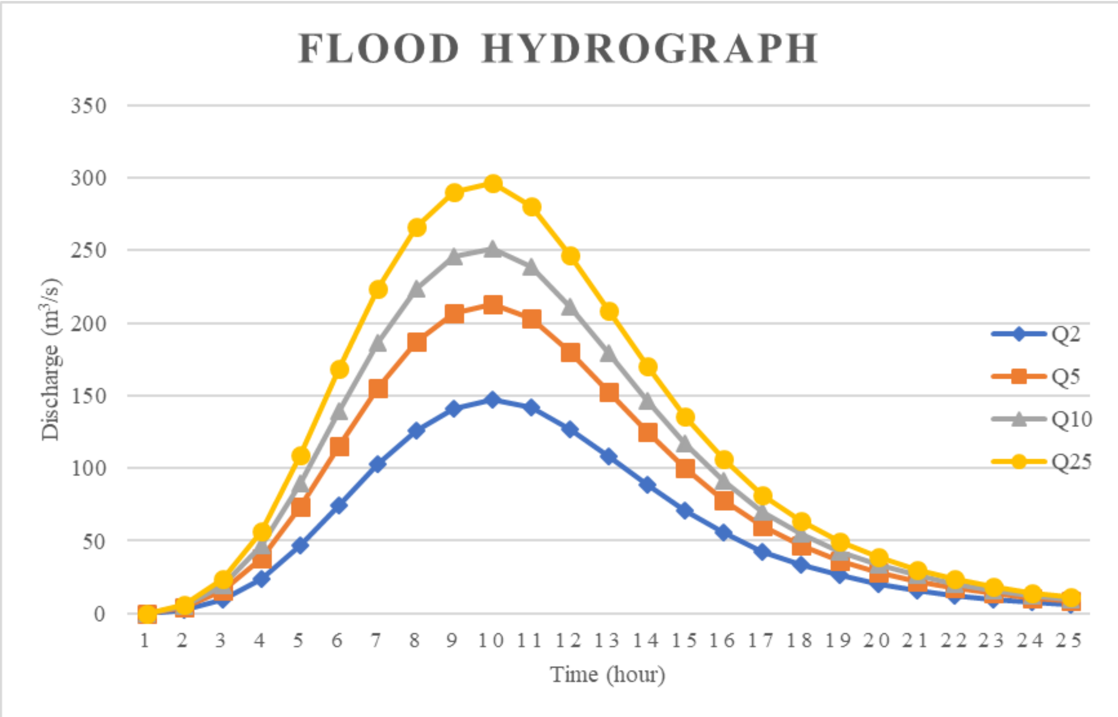

Figure 3. Flood Hydrograph

This study presents a flood-prone map of the River (Figure 3), where typical land characteristics and the potential for flooding can provide information about a flood-prone condition related to these geomorphological and hydrological characteristics.

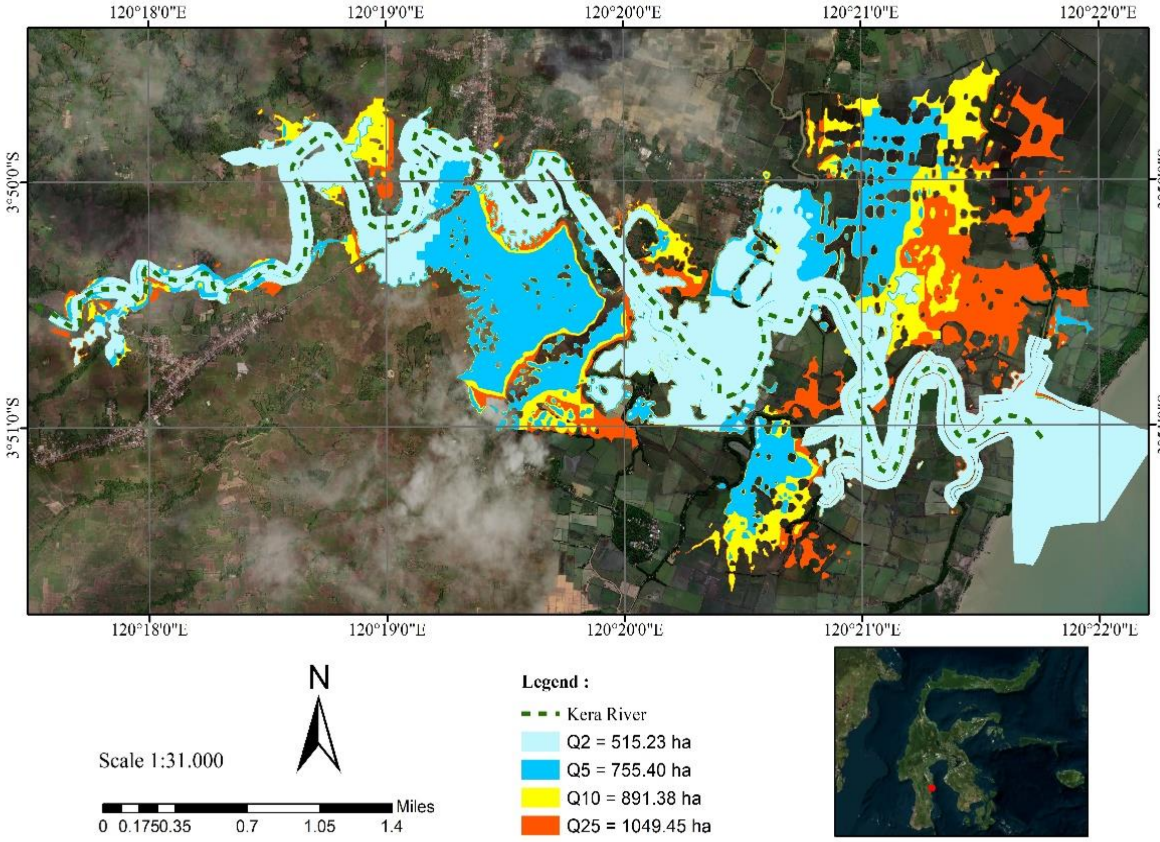

Figure 4. Map prone to Flooding of the Ape River with Various return period

Based on the simulation results, it describes a model of the distribution of flood inundation, so that information on the affected areas is obtained. Efforts to overcome river problems and damage due to flooding that can be applied to the Watershed according to the location and causes can be carried out disaster mitigation, by structural methods. Flood control efforts with the structural method in question are to prevent flood runoff to a certain height with flood embankments.

Based on the flood simulation study above, the structural flood control alternatives for the Watershed are as follows:

3.1 Flood Embankment

The embankment is one of the flood control buildings that serves to prevent the overflow of floodwaters, generally made from landfills, but under certain conditions it can be made of stone or concrete pairs. The soil used to form the embankment body at least meets the requirements, including high imperviousness, high cohesion value, and in a water-saturated state the inner shear angle is high, concentrated and the pore number is low. A mixed soil between sand and loam with a proportion of ± 1/3 part of sand and ± 2/3 part of clay is a fairly adequate embankment material.

In general, flood embankments are planned to follow the existing flow of the river. Except for the parts of the river channel that are hostage, the flood embankment is made straight (it does not always follow the flow of the river so that the alignment of the embankment becomes shorter).

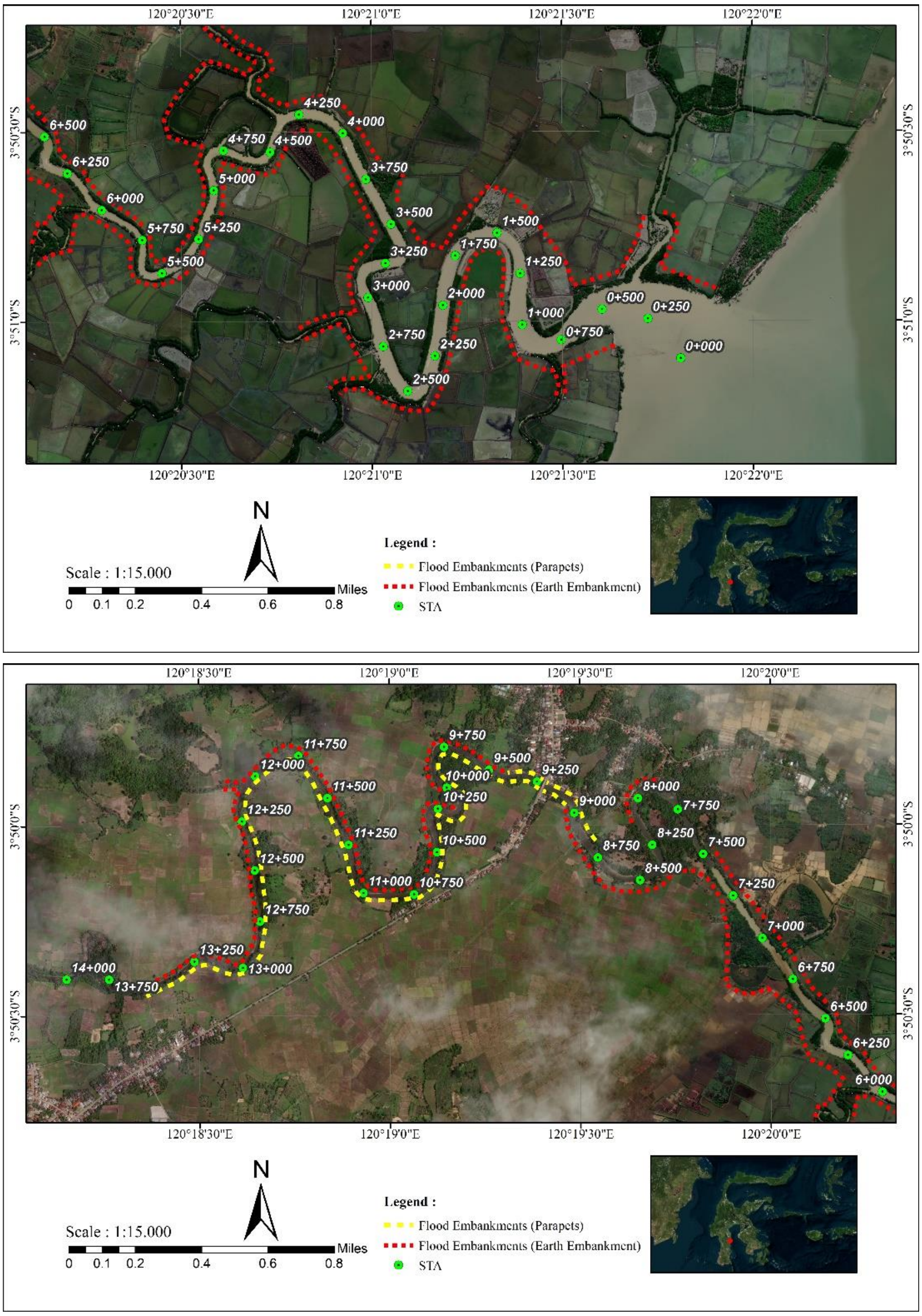

Figure 5. Location Layout of Flood Control and Ape River Safety Buildings

Based on figure 5, it can be seen that the installation of flood embankments (earth embankments) at Sta 0+000 – Sta 13+500, while at Sta 8+750 - Sta 13 +500 , flood embankments (parapets) are installed so as to reduce the impact of floods due to climate change that occurs in the Kera River.

4. Conclusion

Climate change greatly affects the increase in rainfall in the watershed, and flooding in the watershed. Changes in rain characteristics in the watershed, namely the annual rain height and maximum daily rain tend to increase causing inundation, resulting in flooding around the Ape River area. The highest discharge that occurs at 2 year return period is 147.1 m^3/s, 5 year return period is 212.5 m3/s, 10 year return period is 251.3 m3/s, 25 year return period is 296.1 m3/s respectively. The simulation results for 2 year return period have an inundation area is 515.23 ha, 5 year return period is 755.40 ha, the the return period 5 year is 891.38 ha, the the return period 5 year 1049.45 ha. It is necessary to carry out flood disaster mitigation with structural methods, building flood embankments. Therefore, it can be concluded that climate change that occurs in the Ape River affects the number of hydrometeorological disaster events, especially floods

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