Model of settlement environment for flood prone areas on the bank of Cimanuk river Garut

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Abstract. Settlements along the river are dwellings that are vulnerable to flooding. It is not easy to move residents from the area because of the strategic and economic value of the area for urban residents. The purpose of this study is to find solutions for flood-prone areas by making settlement plans to minimize the impact of flood disasters. The study was conducted in Rw.10 and Rw.19 in Cimacan, Haurpanggung Village, Tarogong Kidul District, Garut Regency. Research data were collected using the interview survey method. To get a history of floods that have been experienced by residents, a questionnaire was used with the snowball method. Respondents taken were 22 respondents who had lived in 2 RWs for at least 5 years. Based on the results of the study note the average flood height of 40-50 cm with the distance of water entering the settlement 50-60 meters from the river bank. The average number of houses submerged by floods is 40-50. To minimize the impact of losses from flood disasters, it is necessary to re-arrange the settlement space in Cimacan Village by setting green land in the no-go zone for building settlements, making infiltration wells, and modifying house building models.

1. Introduction

Flooding is one of the natural disasters that greatly destroys the socioeconomic conditions of the affected area [1]. Floods that occur in Indonesia is a relationship between natural factors and anthropogenic factors [2]. The main cause of the flooding is rain with high intensity and for a long period of time. Other factors that have an impact on flood disasters, namely the weak supervision of land use in zones prone to flooding. Managing flood risk is important because many people live in flood-prone areas [3]. Eviction and relocation of residents in flood-prone areas usually create new problems for cities [4,5]. The effectiveness of flood disaster mitigation and mitigation depends on the conditions of the regional characteristics [6,7].

Flood disaster, although it poses a relatively lower risk than volcanic eruptions, earthquakes and, tsunamis, but has a relatively higher frequency, so that when compared to this disaster also causes losses that are not less far from the other three disasters [8]. Floods that occurred in Cimacan Garut Regency came from the overflow of Cimanuk River water caused by high rainfall for a long duration, and the inability of the river area to store large amounts of water so that the water overflowed and entered residential areas [9]. Flood events cause loss of property and can allow casualties or can also cause various types of diseases originating from flood disasters [10,11]. To reduce the risk of such disasters, adaptation is needed in structuring the settlement environment on the banks of the Cimanuk Garut river.
2. Methods

The focus of this research study is human interaction with the environment to produce a model of community interaction with the environment in which they live. The research location is a settlement on the banks of the Cimanuk river, precisely in RW 10 and RW 19, Cimacan, Haurpanggung Village, Tarogong Kidul District, Garut Regency (figure 1).

![Figure 1. Location map (source: google map).](image)

Research data were collected using survey and interview methods. Respondents taken were 22 respondents who had lived in the area for at least 5 years. To get a history of floods that have been experienced by residents, a questionnaire was used with the snowball method. The snowball sampling technique is a method for identifying, selecting, and taking samples through a rolling process from one respondent to another. Based on the Environmental Research and Design method, namely by taking a map of settlements in Cimacan from Google Earth to be re-planned according to an analysis of the environmental characteristics of the settlements on the banks of the Cimanuk river. The settlement structuring model aims to minimize the risk of material loss due to flood disasters.

3. Results and discussion

3.1. History of floods in Cimacan

Floods that occurred in Cimacan were caused by runoff of river water coming from upstream of the river due to high rainfall, so that water overflowed from the Cimanuk River [10]. Another factor causing floods is the backflow of water, namely the backflow of water caused by runoff from the upstream of the Cimanuk River being held by the Copong Dam, so that the water experiences a backflow and the runoff increases, causing flooding around the Copong weir.

The most frequent flood height in Cimacan area ranged from 40-50 cm and was able to inundate around 17 houses. The closer the house is to the river, the higher the risk of flooding. Based on the analysis of the history of floods collected from the results of interviews with residents living in Cimacan RW 10 and RW 19 the following results were obtained:

| NO | Length of stay (year) | sum | Average Flood Altitude Occurring (cm) | The average house affected by flooding |
|----|----------------------|-----|--------------------------------------|--------------------------------------|
|    |                      |     | 15-20cm | 20-30cm | 30-40cm | 40-50cm | 20-30 | 30-40 | 40-50 |
| 1. | 5 – 10               | 5   | -       | -       | 1       | 4       | -     | -     | 5     |
| 2. | 10 – 15              | 3   | -       | -       | 2       | 1       | -     | 1     | 2     |
| 3. | 15 – 20              | 6   | 1       | 1       | 1       | 3       | 1     | 2     | 3     |
| 4. | 20 – 25              | 5   | 1       | 1       | 1       | 2       | -     | 1     | 4     |
| 5. | > 25                 | 3   | -       | -       | 1       | 2       | -     | -     | 3     |
| Sum|                      | 22  | 2       | 2       | 6       | 12      | 1     | 4     | 17    |
Apart from the interview results, the history of flooding in the village of Haurpanggung was also obtained from the BPBD office. Floods in the Haurpanggung Village area occur almost every month, especially from the wet months of January to April. One of the areas that are flooded is Cimacan area, especially in RW 10 and RW 19. During 2019 the flood events that occurred in Haurpanggung Village can be seen in Table 2.

| Month | Disaster Location District area | Date of Occurrence | Disaster type | Frequency |
|-------|---------------------------------|--------------------|---------------|-----------|
| January | Tarogong Kidul Haurpanggung | 1/19/2019 | flood | 1 |
| February | Tarogong Kidul Haurpanggung | 2/22/2019 | flood | 2 |
| | | 2/23/2019 | | |
| March | Tarogong Kidul Haurpanggung | 3/27/2019 | flood | 1 |
| April | Tarogong Kidul Haurpanggung | 4/4/2019 | flood | 1 |

(Source: Garut Regency BPBD).

Even though they have the potential to experience property losses and threaten life safety, respondents' interviews in Cimacan area show that people living on the banks of the Cimanuk river are used to flooding. Most respondents chose to remain there rather than relocated. For the Cimacan village community, the location of the settlement is considered strategic. The settlement is only about 0.5 km from the Ciawitali Garut wholesale market and terminal, while most of the people living in Cimacan are informal sector workers in the Ciawitali terminal or market. Relocating people in flood-prone areas is often ineffective because it creates new problems [12]. Communities in Cimacan generally anticipate the arrival of floods by temporarily displaced during a flood.

3.2. Model of environmental settlement in flood prone areas
A green infrastructure approach is needed to manage flooding that often occurs in riverbanks [13]. Planning for settlements in flood-prone areas is done by arranging, designing, or replacing existing objects from the initial map and designing a settlement that can minimize the impact of flooding. Required risk management about climate information in decision making given the increased risk of flooding in the area in wet months [14]. The situation map of Cimacan, Haurpanggung Village, Tarogong Kidul District, Garut Regency can be seen in the following figure 2.

Figure 2. Situation map of Cimacan area.

Based on the analysis of the river border space, the flood-prone settlement planning in Cimacan Area needs to add some supporting elements such as infiltration wells and the determination of green open
land in the area around settlement at Cimacan. Based on Attachment III of the Minister of Environment Regulation No. 05 of 2012, river borders fall into the category of protected areas that are established with the main function of protecting the sustainability of life which includes natural and man-made resources. Determination of the river border is at least 10 m from the left and right bank of the river trough along the river channel, in the case that the river depth is less than 3 m. Outside these lines, no building is allowed. Land along the river is planned as a Green Open Space and can also be used as an open space for social activities such as parks and sports fields.

Apart from Green open spaces, another element that needs to be planned is the creation of infiltration wells [15]. Determination of the number and placement point of the infiltration well considers the condition of the areas in RW 10 and 19 Cimacan Village, Haurpanggung Village, Garut Regency. Based on the consideration of the area of the settlement and the minimum safe distance of the infiltration well with the surrounding residential buildings, it is determined that the infiltration well is built with a distance of 3 meters from the nearest house, and is 10 to 20 meters from the river mouth.

Based on the high flood inundation that often occurs in Cimacan area, a stage settlement design is deemed to be able to minimize material losses in the event of a flood (figure 3). The various causes of flooding all have consequences on the need for attention to human interaction and the environment in a complex social-ecological system [16]. Examples of home building designs are shown in the following figure 4.
This research does not take into account the structural resilience of the building so that further research is needed by calculating the flow velocity and flood volume [17]. Determination of the average area of house building is based on the average size of houses in Cimacan area itself. In planning the building space planning adjusts the general space requirements. Drawings of flood-prone houses for housing in Cimacan, planned with size:

- Floor area of the house = 63.75m² (P x L = 7.50m x 8.50m)
- Main bedroom area = 3.50m x 2.50m
- The area of bedrooms 1 & 2 = 2.50m x 2.50m
- Bathroom area / Wc = 1.50m x 2.50m

Repeated experiences of flood events in the community have enabled residents to adapt to environmental conditions along the river banks [18]. Food management strategies cause respondents' perceptions of floods to change. As a result, individuals in a community respond to flood risks very differently [19].

4. Conclusion
Floods that hit settlements on the banks of the Cimanuk river Garut regency became a routine disaster. The strategic location of settlements is a strong magnet for the community to remain in flood-prone settlements. Minimizing the risk of loss can be done by structuring and selecting flood-prone settlement designs. Nevertheless, the protection of the river border protection function must still be considered as a no-go zone and is functioned as a green open space.

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