Loss levels regarding flood affected areas in the upper Citarum Watershed

Fernandos, M P Tambunan and K Marko

Department of Geography, Faculty of Mathematics and Natural Science, Universitas Indonesia

E-mail: fernandos@ui.ac.id, mangapul.parlindungan@sci.ui.ac.id, kuswantoro@sci.ui.ac.id

Abstract. The Upper Citarum Watershed is an area that replaces the annual flood. The annual flooding experienced by the Upper Citarum watershed is influenced by several factors, such as changes in land use. From these annual flood events, there will be a level of loss experienced by communities affected by floods. Floods that occur in the Upper Citarum watershed can be seen from the results of the visual model of the upstream Citarum watershed, so that the information can be obtained on the areas affected by flooding and large floods from each affected area. The purpose of this study is to determine losses due to flooding obtained from flood risk level data, which is the result of an overlay of the level of flood hazard and flood vulnerability. The level of flood hazard can be obtained from the processing of the digitized flood model and field survey. While the rate of flood returns is obtained from the processing of land use data which is the economic value of each land use. This research resulted in a level of flood risk which is dominated by a moderate level of flood risk of 44.15%, then the high-risk level is 42.25%, and the low flood risk level is 13.6%. The extent of the flood risk level is then converted to the economic value of each land use, to get the value of the loss rate. Determination the level of loss, in addition to taking into account the level of the parameters of flood risk, the extent of each region level of risk also influences the determination of the level of flood losses in the Upper Citarum Watershed. This research is carried out as an effort to develop disaster mitigation in the annual flood prone area to be used as a reference in the development planning process.

1. Introduction
Flooding is one of the most serious environmental disasters globally. Floods in most vulnerable regions of the world can cause damage including loss of human life, property damage, disruption to the transportation sector, and other damage arising from the disruption of economic activity [1]. The risk of flooding has become extreme in two parts of the world, both the northern hemisphere and the southern hemisphere, so the effectiveness of flood management is very important [2]. One factor in the occurrence of flooding is a change in land cover, which is influenced by high population growth [3]. Changes in land cover in watersheds increase the potential for flooding, for example, land cover changes from forests to settlements [4].

Indonesia is one of the countries that has been hit by floods. Rainfall in most parts of Indonesia in the range of December to February has caused flooding in many regions of Indonesia, especially in West Java Province [5]. Floods that hit West Java can reach more than one meter, causing damage to agricultural land and damage to community fisheries [6]. Floods that occur in West Java often occur in
Bandung Regency, such as in Baleendah and Bojongsoang sub-districts [7]. The flooding that occurred in West Java not only flooded villages but also urban areas, such as in the city of Bandung. Bandung City and Bandung Regency are part of the Upper Citarum Watershed which was affected by the floods. Floods that occur in the Upper Citarum watershed are caused by several factors, both natural and human factors [5]. Factors of natural flooding in the Upper Citarum watershed, such as high rainfall [6]. Whereas human factors cause flooding in the Upper Citarum watershed, such as changes in land cover [8]. The upstream Citarum watershed is one of the areas that always experience floods every year [9]. Floods that occur in the Upper Citarum watershed are caused by high critical land area, unplanned settlement area development, and agricultural cropping patterns that are not suitable for critical land. Floods that occur in the Upper Citarum watershed are also caused by physiographic form factors of the Citarum watershed [10]. One area in Upper Citarum that often experiences flooding is Cieunteung [11]. Every year hundreds of residents must leave their homes to flee to other places because their homes are flooded [6]. The flood has disrupted various activities of the population both for work, education, and other purposes. Areas affected by floods in Bandung result in loss, both materially (tangible) and non-material (intangible) [12]. As for this study, the analysis of the level of loss of the flood-affected areas used is tangible losses, so that only material losses are the topic of discussion in this study [12]. The material loss in question is loss based on physical parameters, namely land use in areas affected by flooding [13]. The parameters of the loss rate for each land use will be converted into economic calculations based on the area of each land use so that the level of flood losses can be displayed in units of rupiah [14]. This study focuses on flood areas in the Upper Citarum watershed. The final stage in this study was in the form of spatial analysis and descriptive analysis to assess the flood loss in a room. Spatial analysis is used to produce flood risk areas from the results of flood hazard maps and flood vulnerability maps. Then the resulting flood risk areas will be used for the assessment of flood losses descriptively. So that this research is very useful for policymakers and the public to minimize the level of losses due to areas affected by floods in the future.

2. Literature Study

2.1. Flood

Floods are higher than normal water levels in the river and usually flow overflowing beyond the river cliffs and the overflow of water flooding in an inundation area [15]. According to [16], flooding becomes a problem if it has disrupted the activities of life and human livelihood and even threatens his safety. According to [7] floods become a problem and develop into disasters when floods disrupt human activities, cause casualties, and eliminate property.

2.2. Flood Risk

According to the United Nations International Strategy for Disaster Reduction (UN-ISDR), risk can be defined as the possibility of estimated losses from the presence of a hazard (death, injury, loss of property, livelihoods, economic activities or environmental damage) resulting from the interaction between danger, both caused by nature and humans, to vulnerable conditions [17]. In simple terms, the relationship of these variables can be formulated in the following equation [18]:

\[
\text{Risk} = \text{Hazard} \times \text{Vulnerability}
\] (1)

2.3. Hazard

Hazard is a series of events that threaten and disrupt people's lives, either by natural factors or non-natural factors or human factors, resulting in casualties, environmental damage, property losses and psychological impacts ([18] No. 8 on Disaster Data Standardization). According to Republic of Indonesia's Law No. 24 of 2007 concerning disaster management, danger is a condition or characteristic of geological, biological, hydrological, climatological, geographical, social, cultural, economic, and technological in a region for a certain period of time that has the ability to prevent, reduce, achieve readiness, and reduce ability to respond to the adverse effects of certain hazards.
2.4. Vulnerability
According to the National Coordinating Agency for Disaster Management and Refugee Management (BAKORNAS) the level of vulnerability is an important thing to know as one of the factors affecting the occurrence of disasters. The level of vulnerability is important because new disasters will occur if hazards occur in vulnerable conditions. According to [19], vulnerability is a state of decline in resilience due to external influences that threaten conditions (life, livelihoods, natural resources, infrastructure, economic productivity, and welfare) which adversely affect disaster prevention and mitigation efforts. The relationship between danger and vulnerability produces a certain risk condition if the condition is not managed properly.

2.5. Loss Rate
A natural disaster causes not a few losses both in terms of material and moral. Losses due to natural disasters are divided into two: tangible and intangible. Tangible losses are losses that can be measured in monetary terms, for example, damage to valuables and public infrastructure. Meanwhile, intangible losses are losses that cannot be measured in monetary terms, for example, the number of lives lost due to a disaster [20].

According to [21] there are several parameters that can cause losses due to flooding, such as flood height, water speed, duration of floods, sediments, frequency of occurrence of floods, and the time of flooding (night or day). In addition, [22] argue the same thing, that the height of flooding and the duration of flooding are the factors that determine the small or the magnitude of the losses experienced by communities affected by the flood. Both of these factors were used as the main factors for flood losses. From each indicator of flood losses, it has a significant impact on the low or high level of losses experienced by communities affected by floods. In this study in determining the level of flood losses, only using high indicators of flood inundation as a result of flood hazards [23]. The resulting flood hazard will be overlayed with the flood vulnerability that has been generated previously from the economic value of land use, resulting in a flood risk which will subsequently produce a flood loss rate [24].

3. Materials and Methods
3.1. Flow chart of the study
The concept of research can be explained in Figure 1. The thought path that began in the flood event in the Citarum Hulu watershed, West Java. Flood events in the Upper Citarum watershed then produce flood-affected areas, which cover parts of Bandung City and Bandung Regency. Areas affected by flooding are generated by digitizing the map of the area affected by floods by [23]. The map of the flood-affected area is then carried out verification of field data in the form of observation and interviews.
In flood-affected areas, flood characteristics can be identified that determine the level of flood hazard in the Upper Citarum watershed. The flood hazard characteristics used in this study, namely the height of the flood. Flood hazard characteristics in the form of flood height were obtained through digitizing flood hazard maps by [23] and verification of field data, in the form of observations and interviews. In addition, flood-affected areas can be identified by flood-affected land uses, so that by combining flood-affected land use with the economic value of each land use affected by flooding, flood vulnerability will be obtained.

Flood risk in flood-affected areas can be identified by combining flood hazards and flood vulnerability that has been produced previously. The results of combining flood hazards and flood vulnerability will illustrate the risk of flooding that occurs in the upstream Citarum watershed. The risk of flooding can be classified into three, namely low risk, moderate risk, and high risk. Flood risk is lower if the flood hazard is low and flood vulnerability is low. On the contrary, flood risk is higher, if the flood hazard is high and the flood vulnerability is high. By knowing the risk of flooding that occurs in flood-affected areas, then the level of losses that occur through the process of assessing the level of flood losses will be known.

The assessment of the level of flood loss uses physical parameters in the form of land use damage, such as damage to regular settlements, irregular settlements, agriculture, business areas, ponds, open land, and roads. Each of these physical parameters is then converted to the other economic value, based on the economic value of land use. The process of converting the value of land use into economic value,
carried out by providing certain economic values on a land-use per hectare [14]. The results of the conversion of the value of land use into economic value are presented in units of rupiah. From the results of the assessment of flood losses, a descriptive analysis approach can then be carried out. Descriptive analysis was conducted to describe the distribution of the rate of flood losses that occurred in the Upper Citarum watershed.

3.2. Data processing

3.2.1. Flood Hazards. The flood hazard map was obtained from the digitization process of the map of the flood-affected area based on the return period of the 25-year flood event, which provided information on flood inundation as an indicator of flood characteristics. The resulting flood hazard map is verified by field data in the form of observations to the research area. Based on the resulting flood hazard map, the flood hazard level classification can be carried out into three classes, which can be seen in the table.

| No | Flood Depth | Class | Value |
|----|-------------|-------|-------|
| 1. | > 1,5 m     | High  | 3     |
| 2. | 0,76 – 1,5 m| Medium | 2     |
| 3. | < 0,76 m    | Low   | 1     |

[Source: [18] No. 2 the year 2012]

3.2.2. Flood Vulnerability. The flood vulnerability map in this study uses physical parameters of land use that have been converted into economic values of land use, to describe the level of flood vulnerability in the study area. The higher the economic value of land use, the higher the value of its vulnerability. Conversely, the lower the economic value of land use, the lower the value of its vulnerability. Based on the resulting flood vulnerability map, we can determine the vulnerability level of each physical land use parameter which is classified as follows:

| No. | Landuse           | Class | Value |
|-----|-------------------|-------|-------|
| 1.  | Commercial / Industrial | High  | 3     |
| 2.  | Settlement        | High  | 3     |
| 3.  | Rice fields       | Medium| 2     |
| 4.  | Plantation        | Medium| 2     |
| 5.  | Ponds             | Medium| 2     |
| 6.  | Waterbody         | Low   | 1     |
| 7.  | Moor              | Low   | 1     |
| 8.  | Vacant land       | Low   | 1     |

[Source: [12] modification, 2019]

3.2.3. Flood Risk. Flood risk maps are generated from the process of overlaying flood hazard maps and flood vulnerability maps. The higher the value of flood hazards and flood vulnerability, the higher the risk of flooding. Conversely, if the lower the danger of flooding and flood vulnerability, the risk of floods will be lower. The relationship between the variables of flood hazard and flood vulnerability in producing flood risk areas can be explained in the following table.
### Table 3.5.3 Hazard and Vulnerability Matrix

| Vulnerability       | Low Hazard  | Medium Hazard | High Hazard |
|---------------------|-------------|---------------|-------------|
| Low Vulnerability   | Low Risk    | Low Risk      | Medium Risk |
| Medium Vulnerability| Low Risk    | Medium Risk   | High Risk   |
| High Vulnerability  | Medium Risk | High Risk     | High Risk   |

Source: [24]

#### 3.2.4. Flood Loss Rate. The analysis of flood losses is based on an assessment of the level of loss from the flood risk map produced. The flood risk map resulting from an overlay of flood hazard maps with flood vulnerability maps can then be used to determine the level of flood losses in the study area. As for knowing the level of flood loss, the physical parameters that are the reference in this study must be converted into economic parameters in rupiah units. The conversion of physical parameters in the form of land use into economic parameters in rupiah units can be seen in the following table.

### Table 3.5.4. Land Use Value Conversion

| Land Use          | Land Use Value (USD/Hektar) | Rupiah       |
|-------------------|-----------------------------|--------------|
| Settlement        | 246,200                     | Rp 3,562,021,600.00 |
| Commercial / Industrial | 517,900               | Rp 7,492,977,200.00 |
| Plantation        | 2350                        | Rp 33,999,800.00   |
| Rice Fields       | 2350                        | Rp 33,999,800.00   |
| Ponds             | 3800                        | Rp 54,978,400.00   |
| Moor              | 1600                        | Rp 23,148,800.00   |
| Vacant land       | 1600                        | Rp 23,148,800.00   |
| Water Body        | 3800                        | Rp 54,978,400.00   |

Source: [25] modification by [12]

#### 4. Result and Discussion

**4.1. Flood Risk Levels**

The level of flood risk results from the process of overlaying flood hazard maps and flood vulnerability maps. The higher the value of flood hazards and flood vulnerability, the higher the risk of flooding. Conversely, if the lower the danger of flooding and flood vulnerability, the risk of floods will be lower. The low level of flood risk has an area of 2,959 hectares. Medium level of flood risk has an area of 2,245 hectares. Then the level of high flood risk has an area of 2,198 hectares.
4.2. Rate of Flood Loss

The level of flood loss in the Upper Citarum watershed based on physical parameters of land use can be seen from the value of the loss of each economic value of land use. The value of the level of flood loss in the Upper Citarum watershed can be seen in Table 5.5 below.

| Land Use    | Total Area (Ha) | USD | Rp       | Loss (Rupiah) |
|------------|----------------|-----|----------|---------------|
| Vacant land| 77             | 1600| 23,148,800.00 | 1,600,457,600.00 |
| Moor       | 167            | 1600| 23,148,800.00 | 3,865,849,600.00 |
| Water body | 103            | 3800| 54,978,400.00 | 5,662,775,200.00 |
Table 5.5 Losses Due to Floods in the Upper Citarum Watershed

| Land Use       | Total Area (Ha) | USD   | Rupiah             | Loss (Rupiah) |
|----------------|-----------------|-------|-------------------|---------------|
| Ponds          | 312             | 3800  | Rp 54,978,400.00   | Rp 17,153,260,800.00 |
| Plantation     | 55              | 2350  | Rp 33,999,800.00   | Rp 1,869,989,000.00   |
| Rice fields    | 2000            | 2350  | Rp 33,999,800.00   | Rp 67,999,600,000.00 |
| Settlement     | 388             | 246200| Rp 3,562,021,600.00| Rp 1,382,064,380,800.00 |
| Commercial/Industrial | 24   | 517900| Rp 7,492,977,200.00| Rp 179,831,452,800.00 |

| Total          | 3126            | Rp    | Rp 1,660,229,765,800.00 |

[Source: Survey and Field Data Processing, 2019]

The estimated rate of flood loss in the upstream Citarum watershed is strongly influenced by the type of land use and the economic value of each type of land use. In addition, the area of land use factors also influences in calculating the rate of flood losses in the Upper Citarum watershed. It can be seen that the biggest loss is in residential land use, which is equal to Rp. 1,382,064,380,800. While the smallest loss is found in the use of vacant land, which is equal to Rp. 1,782,457,600.

5. Conclusion

Based on the results of overlaying the flood hazard map and the level of flood vulnerability that produces a flood risk level map, there are three categories of flood risk levels, namely low flood risk levels, moderate flood risk, and high flood risk. The level of flood risk in the study area was dominated by the moderate flood risk level of 44.15%, then the high level of flood risk was 42.25%, and the low level of flood risk was 13.6%.

The extent of the flood risk levels area that has been generated can be the level of loss is obtained in each risk level region. A high level of flood risk has the highest level of loss. While the level of risk of moderate flood has the lowest level of loss. Determination of the level of loss, in addition to taking into account the parameters of the level of flood risk, the extent of each area of risk level also influences the determination of the level of loss flooding in the Upper Citarum Watershed.

6. References

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