Design principle of evacuation route for the pedestrian during a flood event in Borgo village

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Abstract. Flooding in the riverfront area is a danger for pedestrians without appropriate information and facility during the event. This research aims to analyze the principle design of the evacuation route for the pedestrian in Borgo Village. This village is located in Minahasa regency, North Sulawesi Indonesia. Many experiences of flooding followed by a landslide, Borgo Village has faced many destruction and victims during such an event. Therefore, creating a principle design can help improve access for evacuation for the pedestrian. The method of this research is field study with record area using photos and videos. Interview with the community in the area is conducted to support field data. Potential identification data is used to establish an area of evacuation and safety temporary location during evacuation. The result shows that several factors need to be implemented in the region. Such the factors are access from the river to the temporary evacuation building or area. The other one is the symbol and sign of evacuation that needs to be installed to the location, and the facility for the pedestrian pathway need to be constructed based on the standard design. Lastly, regulation for building setback in the riverfront area need to be applied to improve the city for water flow during flooding and flash flooding. There should be more attention to activity in the area as well as understanding land use for the riverfront and other waterfront areas for future research.

1. Introduction

Pedestrian is one of the active transport modes in which need easy access and safety, particularly during a natural disaster event. Borgo village in the Tombariri sub-district, Minahasa, North Sulawesi Indonesia, is one of the areas with activities of flooding and landslide that occur continually for many years. Land use and structure have changed during such a period. Most of the area and building in this area that has been washed by water are damage. Minahasa is the highest risk in terms of natural disasters with a score of 212.4 or high risk [1]. The evacuation route for disaster in this area has not planned well for the safety of the community. Principle design for evacuation routes is essential in preparing the region and its community to evacuate during flooding and landslide. This principle design is based on aspects of regional planning, the policy of pedestrian-friendly environment, pedestrian movement, and mapping area influenced by natural disasters. Free access and facility need to be supported with the adequate facility. This research explores the principle design for evacuation routes based on data survey, interview the community, and standard planning.
2. Literature review

The level Evacuation route is vital for the safety of the community who has the impact of a natural disaster. Any natural disaster could happen in the potential area such as near the river and beach. Pedestrian is the more comfortable to get impact due to flooding and landslide need facility and access to help during the disaster.

Research on the evacuation route has been done by researchers in many fields of study and natural disasters. Research on evacuation routes is widely such as tsunami [2], disaster management during flooding [3], feasibility study of evacuation route [4], evacuation route choice in the form of simulation [5] and evacuation route with GIS [6]. Planning standards on pedestrian support evacuation route planning, including the rule of pedestrian and their environment [7, 8, 9, 10, 11].

Pedestrian behavior is also needed to consider. Generally, pedestrian behavior influences the route choice and space use. Pedestrian behavior including behavior in taking the risk when a child in a hurry [12], route choice base on behavior [13], child pedestrian behavior and space capacity [14,15], pedestrian behavior influence by facility [16]. Also, the choice between GIS and GPS for the pedestrian trip route [17], route choice with GIS [18], and planning route due to a natural disaster [19].

The evacuation route based on community participation is made through Focus Group Discussion [20]. The community is involved in the decision of the evacuation route.

The evacuation route for natural disasters in Manado [21]. Guideline based on family disaster resistance [22]. The evacuation route should be accompanied by the symbol of evacuation consist of the symbol of Exit, evacuation road with arrow, meeting point, safety area, and natural disaster flooding area. The example of the symbol can be seen in the picture below.

3. Methodology

The research method used for this research is qualitative, with data recorded by photo and video during the site visit in the area of Borgo Village and its surrounding area. The interview is conducted
for the community that lives in the area. Data is analyzed use AutoCAD and google Maps for zoning the map and measurement, mapping the area with the impact of flooding based on the regulation of setback and land use, as well as an evacuation route. A list of principle design is established based on data and analysis. The map of Borgo Village and its surrounding area can be seen in the picture below.

4. Results and Discussions
Based Borgo village is area adjunction to river and beach. This area is vulnerable to natural disasters. An example of the event of flooding and landslide in this area can be seen in the table below.

**Table 1.** Borgo Village in flooding event and daily life.

| No | Natural Disaster | Daily |
|----|------------------|-------|
| 1  | Flooding Ranowangko river | ![Image](image1) |
|    | Flooding on the bridge | ![Image](image2) |
|    | Landslide near the hill | ![Image](image3) |

Some areas are changing after the flooding; some remain to stay. Below is the picture show the changing area and continue building.
Figure 3. The area that is changing after the previous flooding, new building (left) and green area (middle) The building that remains to stay, a church near major bridge Ranowangko (right).

Based on standards for management disaster and planning, as well as the law, design principles can be assessed. The policy of design for the evacuation route can be seen in the table below:

| No | Principle                     | Reference                                                                 |
|----|-------------------------------|---------------------------------------------------------------------------|
| 1  | Access                        | Access from the center of the disaster area to evacuation area             |
| 2  | Route choice                  | The shortest trip from all access available Pedestrian behavior           |
| 3  | Sign and symbol               | Complete symbol and information                                           |
| 4  | Land use                      | Buildings setback on river area 100 meters                                |
| 5  | Evacuation area               | Area highest than the affected area                                       |
| 6  | Facility                      | Width of access appropriate size for pedestrian Temporary evacuation building and area |
| 7  | A potentially large number of pedestrians | Public facility available and number of users based on BPS data |
| 8  | Time of evacuation            | Shortest access and pedestrian pathway facility                           |

From the table above map based on the principle design of the evacuation route is explored. Mapping the access is accompanied by an evacuation route using available street and potential street. The evacuation route below shows the alternative access from the center of the disaster, the river, to the safest place in the neighborhood, the highest spots area above 100 meters.

Figure 4. Access, Green Area and Bridges in Borgo Village.
Figure 5. Principle of evacuation during flooding and Map of 100 meters setback area affected of flooding.

Figure 6. Map of evacuation route

Based on the evacuation route proposed above, the distance and walking time for each way can be seen in the table below. Walking time is based on walking speed 1.5m/s.

| No | Access Route                                                                 | Distance (M) | Walking Time (Min) |
|----|------------------------------------------------------------------------------|--------------|--------------------|
| 1  | A significant street, pedestrian pathway                                    | 308.9        | 3.4                |
| 2  | A considerable road, pedestrian pathway                                     | 369.7        | 4.1                |
| 3  | Riverbank, lane, neighborhood street, major street, pedestrian pathway      | 500.4        | 5.6                |
| 4  | Riverbank, lane, neighborhood street, major street, pedestrian pathway      | 449.2        | 5                  |
| 5  | Riverbank, road, neighborhood street, major street, pedestrian pathway      | 510.2        | 5.7                |
| 6  | Riverbank, neighborhood street, major street, pedestrian pathway            | 474.3        | 5.3                |
The level of land near the main river is varied due to the natural hill in the surrounding area of the Borgo Village and Ranowangko area. The flooding may not directly impact the area near the river as in sections C and D but contribute more to the area on the lower part of the river. In this area, the village settlement is located. It should be considered to rearrange build environment in this area. The greener space can protect the settlement from the destruction of flooding, as shown in the picture of river setback. River section and river setback can be seen in the image below:

Access of the area to and from Manado is Tanawangko bridge in national road connected to other provinces in Sulawesi island. The area of riverfront has changed from settlement to green space after the flooding. The proposed design element can be seen in the table below.
Table 4. Proposed facility for an evacuation route.

| No | Existing | Proposed |
|----|----------|----------|
| 1  | Symbol of evacuation | Symbol of evacuation clear and easy to see |
| 2  | Access to the highest area | Access easily and clear for pedestrian |
| 3  | Evacuation area and building in the highest place | Example of evacuation area and building |
| 4  | Pedestrian access near the river | Clear access and sign |
| 5  | Building for area vulnerable of flooding | Relocated in a high place or high building |

![Image of symbol of evacuation](image1.jpg)
![Image of access to the highest area](image2.jpg)
![Image of evacuation area and building](image3.jpg)
![Image of pedestrian access near the river](image4.jpg)
![Image of building for area vulnerable of flooding](image5.jpg)
5. Conclusions

Mapping evacuation routes is essential for the community in disaster areas such as Borgo village. Open access and proposed access to the highest safe place can help the community to evacuate quickly and faster. The proposed evacuation route is based on direct access from the riverbank, bridge, or street near the river as the center of the disaster. In considering the access to the higher place could take time, clear symbol, sign, and access can reduce time spent on walking to the evacuation area. Around 5 minutes, it is available for the pedestrian to walk from the riverbank to a safe place in the evacuation area. A large number of pedestrians can slower walking speed. Therefore, the alternative route is prepared. Moreover, the area that is affected by flooding should be clear from building and function as a green buffer zone area for the settlement nearby. It will need further investigation and study on land use and its impact on community daily life and in a disaster event.

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