Initiative evacuation routes for earthquake hazard in the active Opak fault (Sengon Village, Klaten, Central Java)

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Abstract. This research aimed to explain how the initiation process from the community reconstructs evacuation routes in high risk earthquake area. The study location took place in Sengon Village, Prambanan District, Klaten Regency. Sengon was located near Opak fault zone where experienced tremendous disaster in 2006. Since a decade, the mitigation infrastructure was very deficient. The community-based mitigation was not also available yet in this village. However, the community was highly potential to build disaster resilience since supports by the government. Route condition in Sengon was also greatly supportive to construct effective evacuation route. Based on identification and community planning, the evacuation route consisted of local road and tracking road. There were also found that eight places classified as secondary assembly shelters and two places classified as a primary evacuation shelter. The SWOT analysis was done for supporting the strategy to develop the evacuation infrastructure.

1. Introduction
A tremendous earthquake that ensued on May 27th, 2006 afflicted to entire DIY region. These phenomena happened due to a sinistral strike-slip fault in the Opak fault zone [1]. The earthquake had a formidable impact, especially in the afflicted region. The location of Sengon Village which was directly adjacent to the Opak fault zone in the north had implications for damages and casualties suffered during the 2006 earthquake. In addition, the area around the Opak fault became a dangerous area against earthquake [2]. Based on this, Sengon village could be commanded to a high risk of earthquake threats. Disaster did not only depend on threats, vulnerabilities, and exposures but also coping capacities and resilience of risk elements [3]. To overcome these problems, it was obligatory to transform the mindset and paradigm of human security. Transformation in the paradigm of disaster management should no longer see disaster management as an action during an emergency response situation but disaster management was prioritized in the pre-disaster phase which aimed to reduce disaster risk before the phenomenon. Since the biggest victims of disasters were people living in disaster-prone areas, attempts were needed to increase the awareness and capacity of the community in anticipating disasters. The community-based disaster management model expected as the best model that put forward the idea of community-based disaster management where communities were located in front line [4][5][6][7][8].

In line with this concept, one of the attempts that could be done was establishing disaster-resilient villages. The disaster-resilient village model was an effort to increase the community capacity in disaster mitigation. In disaster-resilient villages, communities were actively involved in assessing, analyzing, handling, monitoring, evaluating and reducing disaster risks in their areas, especially by utilizing local
resources to ensure sustainability. In addition, disaster-resilient villages also had a focus on training and increasing local community knowledge through local approaches that were expected to encourage communities to be more resilient in the face of disaster threats. This meant disaster-resilient villages were expected to be able to actively and sustainably support the reduction of community vulnerability in dealing with disasters.

The preliminary finding explained that the existing conditions of Sengon Village could be classified as Pratama disaster resilient village [9], which meant this village had already initial attempts to reduce the risk of disasters. A series of initial efforts showed that the community had already an awareness to deal with disasters. But community awareness was not adequate, it required more elements of resilience that were the capacity of the community. Therefore, the resilience of the community had to be represented in efforts to anticipate, protect themselves, and adapt to the environment that was prone to disasters and had to be followed by the resilience of the community in dealing with disasters. However, the results of a study showed that Sengon Village had no attempts to increase community capacity [9]. Meanwhile, the capacity of community groups was the basic asset in the formation of disaster-resilient villages [10]. Considering that no one else had a better understanding of the local situation than the local people themselves.

Furthermore, the preparedness in dealing with disasters could also reduce the risks arising from these disasters [11]. Meant that preparedness was observed from how far the community could respond to disasters. In addition, 3 aspects had to be possessed by resilient communities, namely preparedness, emergency response plans and disaster warning systems [12]. Basically, the 3 points referred back to the ability of the community in dealing with disasters. The results of the study also showed that Sengon Village had already a structured community communication forum but did not yet have an emergency response plan even for simple levels such as maps and evacuation routes [9]. Therefore, this article was intended to explain how the initiation process from the community was to identify evacuation routes and gathering points in Sengon Village.

2. Method
A tremendous earthquake that ensued on May 27th, 2006 afflicted to entire DIY region. These phenomena happened due to a sinistral strike-slip fault in the Opak fault zone [1]. The earthquake had a formidable impact, especially in the afflicted region. The location of Sengon Village which was directly adjacent to the Opak fault zone in the north had implications for damages and casualties suffered during the 2006 earthquake. In addition, the area around the Opak fault became a dangerous area against earthquake [2]. Based on this, Sengon village could be commanded to a high risk of earthquake threats. Disaster did not only depend on threats, vulnerabilities, and exposures but also coping capacities and resilience of risk elements [3]. To overcome these problems, it was obligatory to transform the mindset and paradigm of human security. Transformation in the paradigm of disaster management should no longer see disaster management as an action during an emergency response situation but disaster management was prioritized in the pre-disaster phase which aimed to reduce disaster risk before the phenomenon. Since the biggest victims of disasters were people living in disaster-prone areas, attempts were needed to increase the awareness and capacity of the community in anticipating disasters. The community-based disaster management model expected as the best model that put forward the idea of community-based disaster management where communities were located in front line [4][5][6][7][8].

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### Figure 1. Research Phase in order to initiative construction of evacuation route.

### 3. Result and Discussion

#### 3.1. The profile of Sengon Village

The profile of Sengon Village had been described in the Sengon Village Monograph Book. Sengon village had an area of approximately 233 Ha. Sengon Village had 16 sub-villages including: Cabakan, Summon, Jetis, Sengon, Pangkah, Belan Kulon, Garutan, Kutut Sari, Gedong, Sumberjo, Mangun Jayan, Gunung Pegat, Belan Wetan, Dukuh, Paten, and Tegalsari. The map of Sengon Village area was shown in Figure 2. Meanwhile, Sengon Village was administratively bounded by Cucukan Village in the north, Gantiwarno Village in the east, DIY Province in the south, and Kotesan Village in the west.
The total population of Sengon Village was 4,591 people, consisting of 2,250 male residents and 2,341 female residents. Comparison of the male and female population in the village of Sengon did not differ much even though the population of women was more remarkable. Meanwhile, for toddlers there were still 268 people or 5.8% of the total population and 780 elderly people or 16% of the total population. The education level of the population showed that around 48% or 2,216 people were educated below junior high school. Seeing these conditions, Sengon Village was still socially considered as vulnerable to social disasters. So that the creation of an evacuation route and the nearest evacuation site could support disaster mitigation and preparedness attempts in Sengon Village.

3.2. The road network and open land in Sengon Village

In each area, especially to the earthquake-prone area, had to hold an evacuation route and an evacuation site. These were intended to simplify the evacuation process as an emergency response effort when the disaster occurred. The earthquake became one of the disasters that needed an evacuation place by utilizing an open field during a disaster. To reach the evacuation site, the quickest and the easiest evacuation route was required to get hold of it. Therefore, an adequate road network was required both in terms of physical condition and its dimensions. The condition of the road network in Sengon Village currently had a width that varies between 1 to 3 meters, with the dominance of simple asphalt material. To facilitate the evacuation process at least the evacuation route had a width of 2 meters of road with adequate material and was easily traversed by local vehicles such as bicycles, motorcycles, and cars. The map of the distribution of road networks in Sengon Village showed on Figure 3.
Based on the map, the road network in Sengon Village was divided into 2, namely local roads and tracking roads. The local road in Sengon Village had a size of 2 to 3 meters with mostly asphalt material. Nevertheless, there were still local roads structured only by paving block/cement and sand material. There was also a local road which had a size of more than 3 meters, namely the main road of Prambanan Subdistrict in Sengon Village. Whilst the tracking roads had a size of 1 to 2 meters and were located in densely populated areas and around rice fields. Table 1 showed the network classification in Sengon Village.

Table 1. The road network classification in Sengon Village, inferred from aerial mapping and terrestrial survey

| Type of road | Class of road (dimensions) | Total length (meter) | Physical material                        |
|--------------|---------------------------|----------------------|------------------------------------------|
| Local road   | 2 meters                  | 7.764                | Pavement, cement, poor asphalt           |
| Local road   | 3 meters                  | 5.086                | Concrete, pavement, cement, poor asphalt |
| Local road   | More than 3 meters        | 3.273                | Asphalt and concrete                     |
| Tracking road| 1 meter                   | 4.613                | Gravelly soil                            |
| Tracking road| 2 meters                  | 3.363                | Pavement, gravelly soil                  |

The dominance of the road size in Sengon Village was a 2 meters local road. Local roads of this size had a total length of 7,764 meters. Meanwhile, the length of tracking roads in Sengon Village was currently shorter and the number was relatively less compared to local roads. This tended to give a positive impact since it would make easier to compose disaster evacuation routes in Sengon Village. The description of local roads and paths in the field could be seen in Figure 4. Through these images, it could
be noticed that there were differences in the physical material of the road. The larger the size, the material used was also more solid. Meanwhile, roads in dense settlements were dominated by paving block / cement and sand.

![Figure 4. The road network condition in Sengon Village](image)

Nowadays, facilities and infrastructures in Sengon Village related to evacuation route boards and evacuation sites were still deficient by reason of not evenly distribution so there were still communities that were too far-off to reach the evacuation site. The results of the initiation obtained 2 types of evacuation sites in the Village Sengon which are temporary evacuation places and final evacuation places. Temporary evacuation sites were on open land in the middle of settlements such as the village office yard, badminton court, posyandu yard, and so on. Meanwhile, the final evacuation site was in an open area that had more commodious area. One of the final evacuation sites in Sengon Village was in the Dukuh Hamlet field which was also on the edge of a local road that connected villages in Prambanan Subdistrict. Figure 5 was the Dukuh Hamlet field which was utilized as one of the final evacuation sites in Sengon Village.

![Figure 5. Aerial photograph results and field conditions of final evacuation shelter in Dukuh Hamlet, Sengon Village](image)
3.3. **Mechanism of tentative evacuation**

Evacuation routes in Sengon Village were generally divided into two northern and southern sites. In the north, the population was directed to the final evacuation at Sengon Village Hall, while the south was directed towards the Dukuh Field. Built evacuation routes only utilized existing roads by paying attention to road conditions. The main evacuation route engaged local road classes and asphalt road types, while secondary evacuation routes engaged local road classes and footpaths that were constructed using paving block / cement. This evacuation route network directed residents towards two places, namely temporary evacuation points and final evacuation. Figure 6 showed the design of the evacuation route in Sengon Village. Evacuation mechanisms needed to be built to complement the design of the created lane. Sketchily, each hamlet was equipped with a secondary evacuation shelter. This location was applied for gathering during a disaster. If there was an evacuation order, then the mass was mobilized to move to the final assembly shelter.

![Evacuation Route Map](image)

**Figure 6.** Initiation results of evacuation routes and evacuation sites in Sengon Village.

To support the planning of evacuation path infrastructure in Sengon Village, a SWOT analysis was required. Table 2 showed a SWOT analysis in Sengon Village. The strength of Sengon Village was highly supportive, as was the awareness of the community. In addition, support from the BPBD also greatly supported the opportunity for Sengon Village to develop an evacuation route. However, weaknesses were also existed, namely the need for institutions to facilitate the construction of evacuation routes. In addition, the earthquake that could not be predicted was also a big threat to Sengon Village.
Table 2. SWOT analysis results

| SWOT Analysis | Strengths | Weaknesses |
|---------------|-----------|------------|
|               | 1. People awareness of disaster |
|               | 2. Plain village topography and quantity of open land |
|               | 3. Lindu Gede monument |
|               | 1. There were no communities and institutions in terms of disaster management |
|               | 2. There were no facilities for disaster management |

|                | Opportunities | Threats |
|----------------|---------------|---------|
| 1. BPBD governmet promoted the village | 1. Tend to be an earthquake-prone area |
| 2. Concern of the neighboring village towards disaster |

The results of the SWOT analysis showed W-O awareness where organizations were poor. Strategic recommendations were to alter the strategy since it was feared that the old strategy could not capture opportunities while improving organizational performance. Through the results of aerial photograph processing and SWOT analysis, the evacuation route design of temporary evacuation sites and final evacuation routes was obtained. The temporary evacuation site was at the meeting of each hamlet in Sengon Village. The current scenario when an emergency response occurred was gathering residents from each hamlet at the temporary evacuation site. If there was a bad case (worse case) happened, it was resolved to proceed headed for the final evacuation site. The final evacuation sites were in two places, namely Sengon Village Hall and Dukuh Field, and there were 8 temporary evacuation sites scattered in each village of Sengon Village.

![Quadrant Graph of SWOT Analysis](image)

**Figure 7. Quadrant result in SWOT analysis.**

4. Conclusion

Basically, the existing infrastructure in Sengon Village had been very supportive to construct evacuation routes and evacuation shelters. Supports from the government, especially BPBD could develop Sengon Village as a disaster resilient village where turned out into a valuable asset for the village itself. Community inventory regarding evacuation infrastructure indicated that Sengon had a proper evacuation route and shelter. The evacuation routes in Sengon Village was designed in a participatory, considering the distribution of hamlets, and community-based mechanisms. However, since Sengon Village had W-O characteristics, some effort must be done together with the construction of evacuation roads and shelter. These efforts include the legalization of the disaster risk reduction community including its SOP.
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