Analysis of economic and social vulnerability to disaster risk in Tawangmangu and Kejajar Districts

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Abstract. Climate change is a major concern. Climate change causes changes in the seasons and hydrological systems. Landslides are one of the most common hydrometeorological disasters in Indonesia. This study identifies indicators of economic and social vulnerability to the risk of landslides in the Tawangmangu and Kejajar sub-districts. The method used is scoring and weighting of each economic indicator namely the Gross Domestic Regional Product at Current Prices (PDRB ADHB) of the sub-district and the number of poor people, as well as social indicators used, including population growth rate, sex ratio, population density data, the number of children at risk, the number of elderly at risk which are analyzed using the SoVI index referring to the Regulation of the National Disaster Management Agency No. 2 Year 2012 and research conducted by Sulma, 2012 to determine the vulnerability of the two sub-districts to landslides. Tawangmangu and Kejajar sub-districts are classified as areas with moderate vulnerability, so the economic and social conditions of the Kejajar sub-district are more vulnerable to the risk of landslides. If a region has a high SoVI index due to landslides, it can affect agricultural productivity because landslides affect agricultural land. The government can use disaster studies as a basis for determining broader regional policies and accelerating regional economic recovery through the improvement of economic facilities and infrastructure in disaster-prone production sectors.

1 Introduction

Climate change is a phenomenon of primary concern. The IPCC states that the impacts of climate change in the Southeast Asian region, including Indonesia, are expected to increase threats to food security, human health, water availability, biodiversity, and sea-level rise. Climate change leads to seasonal shifts and alterations in the hydrological system, increasing flood intensity and rising sea temperatures [1]. Disasters will always impact all aspects of human life, including political, economic, social, and cultural aspects. Economic and social

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aspects are very vulnerable to the effects of a disaster because both aspects are closely related to people's lives. The community can directly feel the impact of changes in these two aspects. Both aspects must have a strong foundation because when an area is affected by a disaster, the likelihood of that area being in a high vulnerability level is very low. The vulnerability level of the economic and social aspects of the community affected by a disaster can be seen based on the amount of losses experienced by the community and the number of people affected by the disaster.

One of the hydro-meteorological disasters that frequently occurs in Indonesia, especially in Central Java Province, is landslides. The occurrences of landslides in Central Java from 2010 to 2019 reached 1,811 incidents [2]. This disaster has negative impacts, including decreased forest and land productivity due to environmental imbalances, leading to land degradation that can trigger landslides. Areas in Central Java prone to landslides include the Regency of Wonosobo and Karanganyar. Based on data from the Disaster Risk Assessment of Central Java from 2016 to 2020, the Wonosobo Regency has a high hazard index for landslides, evident from the potential hazard area of 44,149 ha, compared to the regency's total area of 98,468 ha. The Karanganyar Regency also has a high hazard index for landslides, with a potential hazard area of 17,827 ha, against the Regency's total area of 77,378.64 ha. Several areas in both Karanganyar and Wonosobo Regencies are also vulnerable to landslides, such as the Tawangmangu Sub-district in Karanganyar, as depicted in the following Figure 1:

![Landslide Vulnerability Map of Karanganyar Regency](image1.png)

Fig. 1. Landslide Vulnerability Map of Karanganyar Regency.

And also the Kejajar Sub-district in Wonosobo Regency, where the highland area of Dieng is located. The vulnerability of the area to landslide disasters in the Kejajar Sub-district can be seen in the following Figure 2:
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Fig. 1. Landslide Vulnerability Map of Karanganyar Regency.

And also the Kejajar Sub-district in Wonosobo Regency, where the highland area of Dieng is located. The vulnerability of the area to landslide disasters in the Kejajar Sub-district can be seen in the following Figure 2:

Fig. 2. Landslide Vulnerability Map of Kejajar Sub-district.

Research on the level ability to landslides in the Tawangmangu Sub-district and Kejajar Sub-district has been conducted frequently, but it has mostly focused on physical aspects. Mapping landslide-prone areas in the Kejajar Sub-district using Geographic Information System (GIS) technology with an overlay method was done to provide an overview of the landslide disaster threat in the Kejajar Sub-district [3, 4]. Physical aspect research on landslides in the Tawangmangu Sub-district has also been conducted [5]. This study is important to study the economic and social vulnerability levels in Tawangmangu and Kejajar Sub-districts to assess the community's ability to face landslide disasters.

2 Method

This research is conducted using a quantitative approach. The quantitative data in this study includes information related to regional disaster data, Gross Regional Domestic Product at Current Prices (GRDP CP) of sub-districts, population growth rate, gender ratio, population density, the number of vulnerable children, the number of vulnerable elderly population, and the number of impoverished population. This study uses secondary data, a data source that indirectly provides data to the data collector [6]. The secondary data required for this research comes from various government agencies or Local Government Work Units (SKPD) in the Karanganyar and Wonosobo Regencies. The research analysis method employs scoring and weighting methods for each indicator using a quantitative descriptive approach. The scoring and weighting methods are modified using the Social Vulnerability Index (SoVI), based on Regulation of the National Disaster Management Agency No. 2 Year 2012 and research conducted by Sulma, 2012, to determine the vulnerability of the two sub-districts to landslides. The related research aims to determine the sensitivity level of the Tawangmangu and Kejajar sub-districts to landslide disaster risks.

3 Result and discussion

3.1 Indicators of Economic and Social Vulnerability in Tawangmangu and Kejajar Sub-districts

Economic and Social Vulnerability Indicators in Tawangmangu and Kejajar Sub-districts. In this study, the economic vulnerability indicators used are the Sub-district's Gross Regional Domestic Product (GRDP) and the number of people living in poverty, while the social vulnerability indicators used include population density, population growth rate, gender ratio, and vulnerable groups such as children and the elderly [7]. Based on data analysis, it is known that the GRDP of Tawangmangu Sub-district in 2019 reached IDR 1,903,764.11 million, approximately 5.4% of the total GRDP of Karanganyar Regency, while the GRDP of Kejajar...
Sub-district in the same year reached IDR 1,034,353.14 million, around 5.49% of the total GRDP of Wonosobo Regency. Based on data obtained from the Integrated Social Welfare Data (DTKS) of the Central Java Social Service, the number of people living in poverty in Tawangmangu Sub-district in 2019 was 3,617 individuals, accounting for 7.9% of the total population in Tawangmangu Sub-district. In Kejajar Sub-district, the number of people living in poverty reached 5,987 individuals, representing 13.9% of the total population.

The social vulnerability indicators related to population density in Tawangmangu Sub-district increased from 2017 to 2018, while in 2019 the population density in Tawangmangu Sub-district experienced a decrease. In 2019, the population density was 651.11 individuals per square kilometer. Meanwhile, in Kejajar Sub-district, the population density increased from 2017 to 2019. In 2019, the population density was 753 individuals per square kilometer. Regarding the social vulnerability indicator of population growth rate until 2019, the population of Tawangmangu Sub-district reached 45,598 individuals with a population growth rate of 0.53%. In contrast, the population of Kejajar District in 2019 was 43,368 individuals with a population growth rate of 0.53%. Another social vulnerability indicator is the gender ratio. The gender ratio in Tawangmangu Sub-district is 98.43%, while in Kejajar Sub-district, it is 104.73%.

Social vulnerability indicators for vulnerable groups consist of the population of children and the elderly. In Tawangmangu Sub-district in 2019, there were a total of 17,586 individuals in the children age group and 7,964 individuals in the elderly age group who fall into the vulnerable category. In contrast, in the Kejajar Sub-district, there were 16,382 individuals in the children age group and 4,533 individuals in the elderly age group who were considered vulnerable.

### 3.2 Level of Economic and Social Vulnerability in Tawangmangu and Kejajar Sub-districts

Classification of Economic and Social Vulnerability Levels is determined based on the scoring results assigned to each indicator. The placement of each indicator refers to the predetermined classifications of low, moderate, and high vulnerability, as shown in the following Table 1:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Score</th>
<th>Low (1)</th>
<th>Medium (2)</th>
<th>High (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standardized Values</strong></td>
<td></td>
<td></td>
<td>&lt; 0.33</td>
<td>0.33 – 0.66</td>
<td>&gt; 0.67</td>
</tr>
<tr>
<td><strong>Economic Aspect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-District Gross Regional Domestic Product</td>
<td>Percent</td>
<td>&lt; 3</td>
<td>3 – 6</td>
<td>&gt; 6</td>
<td></td>
</tr>
<tr>
<td>Population Below the Poverty Line</td>
<td>Individuals</td>
<td>&lt; 2.600</td>
<td>2.600 – 4.910</td>
<td>&gt; 4.910</td>
<td></td>
</tr>
<tr>
<td><strong>Social Aspect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population Density</td>
<td>Individuals /Km²</td>
<td>&lt; 420</td>
<td>420 – 2.234</td>
<td>&gt; 2.234</td>
<td></td>
</tr>
<tr>
<td>Population Growth Rate</td>
<td>Percent</td>
<td>&lt; 0.5</td>
<td>0.5 - 1</td>
<td>&gt; 1</td>
<td></td>
</tr>
<tr>
<td>Gender Ratio</td>
<td>Percent</td>
<td>&gt; 99.86</td>
<td>99.86 – 104.06</td>
<td>&lt; 104.06</td>
<td></td>
</tr>
<tr>
<td>Elderly Population</td>
<td>Individuals</td>
<td>&lt; 2.200</td>
<td>2.200 – 5.711,2</td>
<td>&gt; 5.711,2</td>
<td></td>
</tr>
</tbody>
</table>

The social vulnerability indicators related to population density in Tawangmangu Sub-district is determined based on the sub-district in the same year reached IDR 1,034,353.14 million, around 5.49% of the total population in Tawangmangu Sub-district. In Kejajar Sub-district, the number of people living in poverty reached 5,987 individuals, representing 13.9% of the total population. The gender ratio in Tawangmangu Sub-district is 98.43%, while in Kejajar Sub-district it is 104.73%.

Table 2. The score of the Economic Vulnerability Indicator in Tawangmangu Sub-district.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Tawangmangu Sub-district</th>
<th>Kejajar Sub-district</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-District Gross Regional Domestic Product</td>
<td>Percent</td>
<td>Low (1)</td>
<td>Low (1)</td>
<td>40 %</td>
</tr>
<tr>
<td>Population Below the Poverty Line</td>
<td>Individuals</td>
<td>Low (1)</td>
<td>Medium (2)</td>
<td>60 %</td>
</tr>
</tbody>
</table>

Based on the calculation of the economic vulnerability index using the SoVI equation, it can be determined that the economic vulnerability index in Tawangmangu Sub-district is 0.33. Thus, the level of economic vulnerability in the Tawangmangu Sub-district falls into the category of moderate economic vulnerability. Meanwhile, the economic vulnerability index in Kejajar Sub-district is also calculated using the SoVI equation, resulting in a value of 0.53. Therefore, the level of economic vulnerability in the Kejajar Sub-district is classified as moderate economic vulnerability.

Table 3. Scores of Social Vulnerability Indicators in Tawangmangu and Kejajar Sub-districts.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Tawangmangu Sub-district</th>
<th>Kejajar Sub-district</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Density</td>
<td>Individuals/Km²</td>
<td>Low (1)</td>
<td>Low (1)</td>
<td>30 %</td>
</tr>
<tr>
<td>Population Growth Rate</td>
<td>Percent</td>
<td>Medium (2)</td>
<td>Medium (2)</td>
<td>25 %</td>
</tr>
<tr>
<td>Gender Ratio</td>
<td>Percent</td>
<td>Low (1)</td>
<td>High (3)</td>
<td>15 %</td>
</tr>
<tr>
<td>Child Population</td>
<td>Individuals</td>
<td>Low (1)</td>
<td>Low (1)</td>
<td>15 %</td>
</tr>
<tr>
<td>Elderly Population</td>
<td>Individuals</td>
<td>Medium (2)</td>
<td>Low (1)</td>
<td>15 %</td>
</tr>
</tbody>
</table>

Based on the calculation of the Social Vulnerability Index (SoVI), it is found that the social vulnerability index in Tawangmangu Sub-district is 0.47. Therefore, the level of social vulnerability in Tawangmangu falls into the category of moderate social vulnerability.
Based on the analysis conducted using the SoVI method, the results show that Tawangmangu Landslides pose significant environmental risks, threatening human and livestock lives, as regional government policies prioritize disaster risk assessments as the basis for resilience of the local population. Mitigation efforts to address these issues may include farmland affected by landslides. Additionally, such disasters can result in challenges to vulnerability due to landslides, it can lead to a decrease in the productivity of farmers because of 0.40, falling into the low category and the medium category for one of the social vulnerability indicators, namely the gender ratio. For the Kejajar Sub-district, the economic-social vulnerability index is 0.52, classifying it into the medium category. Therefore, it can be concluded that the economic and social conditions in the Kejajar Sub-district exhibit a higher level of vulnerability to the occurrence of landslide disasters. This is also consistent with previous research findings that the Tawangmangu Sub-district is an area with a moderate to high potential for landslide disasters in residential areas, especially during the rainy season. The vulnerability level of the Tawangmangu Sub-district falls into the category of sub-district/area with a moderate level of vulnerability to potential landslide disasters that may occur throughout the Karanganyar Regency. Research related to vulnerability to landslide disasters in the Kejajar Sub-district has also been conducted by the Regional Disaster Management Agency (BPBD) of Wonosobo Regency. The results indicate that the Kejajar Sub-district has a moderate to high potential threat of landslides. In conclusion, both of these Sub-districts exhibit a medium level of vulnerability to landslide disasters.

### 3.3 Comparison of Economic and Social Vulnerability Levels in Tawangmangu Sub-district and Kejajar Sub-district

Based on the calculations using the SoVI method, it is evident that the economic-social vulnerability index in Tawangmangu Sub-district is 0.40, falling into the low category and the medium category for one of the social vulnerability indicators, namely the gender ratio. For the Kejajar Sub-district, the economic-social vulnerability index is 0.52, classifying it into the medium category. Therefore, it can be concluded that the economic and social conditions in the Kejajar Sub-district exhibit a higher level of vulnerability to the occurrence of landslide disasters. This is also consistent with previous research findings that the Tawangmangu Sub-district is an area with a moderate to high potential for landslide disasters in residential areas, especially during the rainy season. The vulnerability level of the Tawangmangu Sub-district falls into the category of sub-district/area with a moderate level of vulnerability to potential landslide disasters that may occur throughout the Karanganyar Regency. Research related to vulnerability to landslide disasters in the Kejajar Sub-district has also been conducted by the Regional Disaster Management Agency (BPBD) of Wonosobo Regency. The results indicate that the Kejajar Sub-district has a moderate to high potential threat of landslides. In conclusion, both of these Sub-districts exhibit a medium level of vulnerability to landslide disasters.

### 3.4 The Impact of Landslide Disasters on Food Vulnerability

Landslides pose significant environmental risks, threatening human and livestock lives, as well as destroying land use systems and agricultural production. These impacts have severe repercussions on the livelihoods of those affected, their economic conditions, and food security. Landslide disasters occurring in various countries have resulted in serious damage across multiple aspects of human life. The consequences of landslide disasters include land degradation for farmers, as agricultural land becomes unusable for years, crops and seeds are destroyed, and losses occur in terms of livestock and food stocks. Research conducted by Mertens et al. found evidence of income losses among Ugandans working in the agricultural sector due to landslides. As a result, they are unable to meet their basic needs, leading to hunger and the necessity to seek alternative income sources. Adaptive and diversified land use planning and rural livelihood improvement can reduce the vulnerability of mountain communities to climate change and food insecurity. Efforts that can be made to prevent landslides and maintain food security in landslide-prone areas by utilizing sloping land by planting forestry and agricultural species can provide benefits in terms of soil and water conservation and economic aspects.

### 4 Conclusion

Based on the analysis conducted using the SoVI method, the results show that Tawangmangu Sub-district has lower economic and social vulnerability levels to landslide risks compared to Kejajar Sub-district, with a percentage of 0.40, while Kejajar Sub-district has a percentage of 0.52. It can be concluded that the economic and social conditions in Kejajar Sub-district are more vulnerable to the risk of landslide disasters. When an area has a high socio-economic vulnerability due to landslides, it can lead to a decrease in the productivity of farmers because farmland is affected by landslides. Additionally, such disasters can result in challenges to the resilience of the local population. Mitigation efforts to address these issues may include regional government policies prioritizing disaster risk assessments as the basis for development and investment decisions. Furthermore, focusing on improving economic
Based on the analysis conducted using the SoVI method, the results show that Tawangmangu regional government policies prioritizing disaster risk assessments as the basis for resilience of the local population. Mitigation efforts to address these issues may include farmland is affected by landslides. Additionally, such disasters can result in challenges to the vulnerability due to landslides, it can lead to a decrease in the productivity of farmers because of 0.52. It can be concluded that the economic and social conditions in Kejajar Sub-district to Kejajar Sub-district, with a percentage of 0.40, while Kejajar Sub-district has a percentage Sub-district has lower economic and social vulnerability levels to landslide risks compared.

4 Conclusion

moderate social vulnerability. Meanwhile, the social vulnerability index in Kejajar is categorized as established classification, the level of social vulnerability in Kejajar is categorized as. The results indicate that the Kejajar Sub-district has a moderate to high potential for landslide disasters. This is also consistent with previous research findings that the level of vulnerability to landslide disasters.

infrastructure in sectors vulnerable to disasters can help the regional economy recover more quickly. The results of this research can be used as considerations for the government in formulating policies that are in line with the local conditions and needs when disasters occur, ensuring that the well-being of the community does not decline.

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