The Correlation of Settlement Preferences and Community Resilience Post-Disaster in Palu City

D K Wardhani†, Surjono† and A Yudono†

† Department of Urban and Regional Planning, Faculty of Engineering, Brawijaya University, Malang, 65145, Indonesia. ORCID ID 0000-0002-3024-5397

† dharakusuma@student.ub.ac.id, †surjono@ub.ac.id, †adipandang@ub.ac.id

Abstract. In 2018, Palu City was affected by massive disasters (earthquakes, tsunamis, and liquefaction) which paralyzed various activities and resulted in losses of around Rp. 7.6 trillion. The government compiled a disaster-prone zone map (ZRB) that showed 96.03% of Palu City was classified as disaster-prone. It does not only impact the community's perception of disaster risk, but also on settlement preferences (moving, hesitant to move, and not moving). This condition will affect the community resilience level against disasters. This study aims to determine the correlation between settlement preferences and community resilience, and determine the level of post-disaster community resilience in each sub-district of Palu City. This study’s analysis was done by using SEM-PLS. The variables used are social, economic, environmental, infrastructure, culture, government, and settlement preferences. The results show that all variables have significant impacts. The highest correlation came from the settlement preferences. High community resilience is found in Mantikulore and East Palu sub-districts, moderate community resilience is found in South Palu and West Palu sub-districts, while low community resilience is found in Tawaeli, North Palu, Ulujadi, and Tatanga sub-districts. The results of this study can be used as recommendation for the government to increase community resilience in Palu City.

1. Introduction

In 2018, Central Sulawesi Province experienced a major disaster, namely an earthquake (7.4 RS) which caused a tsunami and liquefaction [1]. The biggest disaster impact occurred in Palu City with the total area affected by the disaster being 1,392.98 ha [2]. After the disaster occurred, the President facilitated the strengthening of post-disaster mitigation, rehabilitation, and reconstruction aspects. Regarding the settlement plan, the fact is that some disaster-affected communities did not agree to move and chose to stay in the disaster area until the end of 2019 [3].

The decision to stay or move could be due to the influence of community relations in the place of residence [4]. The relationship with residence caused people to live in disaster-prone locations even though it has been known that there are potentials for upcoming hazards [4]. The higher the sense of belonging of the place they live in, the lower the preference for moving. Preferences are also strongly influenced by people's perceptions of the threat of disaster. The perception of disaster risk is an important factor in understanding the community's response to disasters [5].

The community response has a wider impact, which affects disaster management in the form of the level of preparedness, emergency response, and ability to recover so that it affects community resilience [6]. Resilience communities have the opportunity, capacity and ability to identify and reduce hazards.
and risks, absorb the effects of disruptive events, adapt or transform in anticipating or responding to disruptive events and returning to a functioning state [7]. Community resilience to disasters in Palu City is important because 96.03% of Palu City is included in the ZRB area.

Previous research also showed that the preference of resettlement in disaster events was also relatively low. In the 2017 study, it was found that the research was a pilot project of relocation willingness in areas threatened by geological disasters [4]. Besides, community resilience to disasters in Indonesia is still considered very low so it requires a lot of development [8]. This research is a continuation of the research in 2020. The previous research focused on community resilience post-disaster in Palu City [9]. The difference with this paper is the previous research did not correlate it with settlement preferences. This research combined both topics, the settlement preferences and community resilience in order to identify the correlation of both topics after natural disasters. In addition, this research want to know the level of community resilience in each sub-district in Palu City. It is hoped that this research would be able to provide knowledge and awareness to other research related to settlement preferences and community resilience, especially against disasters. Therefore, the government could receive more inputs regarding increasing community resilience against disasters.

2. Method

2.1. Data collection and analysis

Due to the Covid-19 outbreak, the technique of data collection made use of an online survey from www.survey123.arcgis.com by accessing bit.ly/ketahanankotapalu. The results of the primary survey obtained were 150 respondents. The online survey was conducted for 3 weeks, starting from April 16, 2020 until May 6, 2020. It did not limit the results of the research analysis because the data obtained was spread across all sub-districts in Palu City so that it would represent the condition of the population.

The analysis method used the Structural Equation Modelling with Partial Least Square (SEM-PLS) to explore the relationship between criteria and indicators of settlement preferences and community resilience [10]. SEM-PLS analysis was chosen because it is able to accommodate both large and small amounts of data, can be done with one data series, and can explore the relationship between variables and indicators using model structure. SEM-PLS is consisted of formative and reflective models. The model is Formative if the arrow moves away from the indicator towards the construct, which shows a causal (predictive) relationship from the indicator to the construct and Reflective Model if the arrow moves away from the construct towards the indicator, which indicates the assumption that the construct causes the measurement of the indicator. The systematic evaluation of the results of the SEM-PLS analysis begins with the evaluation of the outer reflective model, the outer formative model, and then the inner model.

2.2. Variables

The variables consist of seven items with a total of 47 indicators. Whereas in the previous research [9], it consisted of six variables (minus settlement preferences), 16 sub-variables, and 41 indicators. The assessment was carried out using the Sturges’ formula [11]. Sturges’ formula can also be used in ArcGIS software to generate spatial classifications that named class breaks [12]. The variables used in this research are:

1. Social ([8], [13], [14]): teacher:student ratio (S1), total population of university graduates (S2), community knowledge related to disaster areas (S3), experience in dealing with disasters (S4)
2. Economic ([15], [13], [16]): expenditure (E1), social welfare (E2), ratio of entrepreneurs to total population (E3), insurance holdings (E4)
3. Infrastructure ([13], [14]): availability of basic materials (F1), internet availability (F2), clean water service (F3), health services (F4), and disaster infrastructure (F5)
4. Environment ([13], [14]): green area (L1), percentage of ZRB 1 area (L2), percentage of ZRB 2 area (L3), percentage of ZRB 3 area (L4), percentage of ZRB 4 area (L5), and availability of natural resources (L6)
5. Culture ([16], [17]): availability of customs (B1), identity kinship level (B2), availability of cultural preservation (B3), and tolerance of diversity (B4)
6. Government ([8], [13], [14]): mentoring (P1), government preparedness (P2), provision of emergency needs (P3), number of victims of natural disasters (P4), and women in government & council (P5)
7. Settlement Preferences - Moving ([9]): community social activities (BP1), educational background (BP2), length of stay (BP3), prone to liquefaction (BP4), flood prone (BP5), ease of accessibility (BP6), distance to city center (BP7), and building ownership status (BP8)
8. Settlement Preferences – Hesitant to move ([9]): family structure (RB1), tsunami prone (RB2), fault prone (RB3), land price (RB4), road condition (RB5), and house building area (RB6)
9. Settlement Preferences – Not Moving ([17]): income level (TB1), emergency fund holdings (TB2), prone to ground movement (TB3), environmental safety (TB4), and availability of public facilities (TB5)

3. Results and discussion

3.1. Community Resilience Analysis
Based on SEM-PLS analysis (Figure 1), it is known that the variables that mostly influence the community resilience in Palu City based on the path coefficient value are settlement preferences (0.330), environment (0.239), social (0.191), economy (0.187), government (0.168), culture (0.055), and infrastructure (0.041). Whereas, the most influential community resilience variables in previous research were only four variables, such as: environment (0.582), social (0.210), culture (0.173), and infrastructure (0.115). Meanwhile, other variables were not significant to explain the community resilience because they had p values >0.05, such as: economic and government.

![Figure 1. The result of community resilience analysis using SEM-PLS.](image-url)
Interpretation of the correlation between settlement preferences and community resilience of this research will be explained based on the most influential variables below:

1. Settlement preferences: the higher the settlement preferences, the better the community resilience will be. It means the higher the settlement preference level, the easier the people can move to new residences. Residents who have a high preference and want to move are 38.67%. This can be due to their economic capability, ownership of other houses, or other reasons.

2. Environment: the wider the ZRB 2 and the narrower the area of the ZRB 4, the better the community resilience in Palu City. This is because ZRB 2 is a relatively safe area for the community to inhabit while ZRB 4 has life-threatening hazards and massive damage potentials, for example in tsunami and liquefaction disasters.

3. Social: the more people who graduate from universities and the better the experience of dealing with disasters, the better the community's resilience will be since the experience in dealing with disasters has correlation with understanding of the disasters and emergency response actions.

4. Economy: the higher the entrepreneurship number to the population ratio and social welfare, the better the resilience of the community will be. The lower number of poor people is good because the ability to cope with the economy in emergency and post-disaster responses will be higher.

5. Governance: the better the role of women in government and the the lower the number of disaster victims, the more resilience of the community in Palu City will increase.

6. Culture: the higher the availability and preservation of customs, the better the community’s resilience in Palu City. The Kaili tribe in Palu City believes in inhabiting several locations which are known to have frequent disasters.

7. Infrastructure: Clean water services and disaster infrastructure can increase the resilience of the community in Palu City. The better the disaster infrastructure service, for instance, the implementation of early warning systems, the more the community's resilience will be increased by direct media from the government to inform the latest disaster conditions.

3.2. Community Resilience After Natural Disasters in Palu City
The calculation of community resilience in Palu City is based on the value of the SEM-PLS latent variables of community resilience per respondent and averaged by sub-district. They were classified in the ArcGIS software as follows: high community resilience (0.211 - 1.283), moderate (-1.186 - -0.212), and low community resilience (-1.416 - -1.187). Next, these results were used to map community resilience in Palu City by sub-district (Figure 2).
The explanations related to community resilience after disasters per sub-district in Palu City are:

1. Mantikulore Sub-district (High Community Resilience - score: 1.283)
   All variables in Mantikulore Sub-district classified in high classification. Furthermore, it has 90.49% of ZRB 2 area and 0.56% of ZRB 4 which mean that the area is a more developed area for residents.

2. East Palu Sub-district (High Community Resilience - score: 0.542)
   East Palu Sub-district is classified in high community resilience because it has four variables which are positioned in high classification, namely settlement preference, environment, economic, and infrastructure. As many as 63.16% of the community of East Palu sub-district chose to move in order to avoid any massive disasters. East Palu also has 76.39% ZRB 2 and only 4.421% of ZRB 4 so it is safer for the community to live there.

3. South Palu Sub-district (Moderate Community Resilience - score: -0.212)
   There are five out of seven variables that were classified in moderate classification. Government variable in South Palu is classified in high classification because the government of Palu City and Central Sulawesi Province are centered there. It provided an easy access and significant government attention. Also, the environmental variable has a significant impact because it is comprised of ZRB 2 of around 40.66% and the ZRB 4 is rather extensive (8.01%). The greater the percentage of ZRB 4 area, the greater the potential for property losses and loss of life.

4. West Palu District (Moderate Community Resilience - score: -0.709)
   It has each 3 variables in moderate classification. Cultural variable has the highest score due to the existence of preserved customs, which do not allow the community to inhabit Part of Balaroa Village (villages that frequently have many disasters). As many as 86.6% of the people of West Palu District have the experience in dealing with disasters of some frequency, which is about 6-10 times from 2011-2018.

5. Tawaeli Sub-district (Low Community Resilience - score: -1.187)
   There are five out of seven variables classified in low classification. But the environmental variable is high because the percentage of ZRB 2 area is higher than ZRB 4 area, which is 74.27% compared
to 2.09%. Tawaeli District is located at the northern end of Palu City and ZRB 4 is only found around the coast.

6. North Palu (Low Community Resilience - score: -1.209)
There are four variables in moderate classification and three variables in low classification. For environmental variables, as many as 46.19% of the area belongs to ZRB 1 and 50.65% belongs to ZRB 2, there is no ZRB 3, and only 3.17% belongs to ZRB 4.

7. Ulujadi District (Low Community Resilience - score: -1.273)
It has five variables in moderate classification and the others are in low classification. As many as 86.84% of the community has the knowledge of disasters and has very frequent experiences with disasters, such as: 11-15 times during the 2011-2018 period. The better the experience of the community in dealing with disasters, the better the community resilience is in Palu City.

8. Tatanga District (Low Community Resilience - score: -1.416)
It has five variables in moderate classification and two variables in low classification. Tatanga sub-district is a traversed by the Palu-Koro Fault so that the area became an unpredictable fault-prone zone.

4. Conclusion
Based on the results, it is known that all variables have a significant correlation to community resilience after the disaster in Palu City. The influential variables based on the highest value are Settlement Preferences (0.330), Environment (0.239), Social (0.191), Economics (0.187), Government (0.168), Culture (0.055), and Infrastructure (0.041). Based on the classification results, it is known that communities with high resilience are situated in the Mantikulore and East Palu Sub-district, moderately resilient communities inhabits South Palu and West Palu Sub-district, and low community resilience can be found in the Tawaeli, North Palu, Ulujadi, and Tatanga Sub-districts. The result of this research can be used as an input for the government in formulating policies related to disasters (especially settlement plans and efforts to increase community resilience against disasters).

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