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# Residential Preferences of Post Great Disaster in Palu City, Indonesia

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**Abstract:** Indonesian Law No.1 of 2011 on Housing and Settlement Areas explains that housing and residential areas are organized based on safety, security, and order principles. This regulation indicates that the residential area should be safe from all hazards, including natural disasters. Residents in Palu City who experienced great disaster in 2018 are facing dilemmatic residential choices whether to 'avoid disaster' or 'survive'. Community's preference is a key to formulate resettlement or survival strategies. The disaster required the community to be more prepared and mindful in determining their residence location. This study aims to identify determine factors and indicators of the post-disaster residential preference in Palu City using multidimensional scaling (MDS) analysis with 21 attributes. The results showed the MDS analysis and its attributes were classified as good (the stress value: was 0.1). The community's residential preferences were grouped into preferences to move, hesitate to move, and do not move. Seven factors that influence preferences to move are community social activities, educational background, length of stay, prone to liquefaction, fracture disasters, ease of accessibility, and distance to the city center. Strangely, some are still reluctant to move, and some others even refuse to move. Six factors influencing the hesitation to move to other locations are the family structure, tsunami-prone, flood-prone, land prices, road conditions, and house building area. Factors affecting the preference not to move are income level, ownership of emergency funds, liquefaction-prone, community perceptions regarding environmental safety, and public facilities availability.

Keywords: residential preferences, multidimensional scaling (MDS), disaster.

## 1. Introduction

Preference is choice, trend, favorite<sup>1)</sup>. Preference is a person's tendency to choose the desired priority or is a trait in the form of a desire to choose<sup>2)</sup>. The preference for living consists of internal and external factors<sup>3)</sup>. Internal factors can be in the form of factors that exist in each individual or family that causes the desire for a location or place of residence. Meanwhile, external factors can be factors in a dwelling or the environment that causes a person or family to be interested in living in that environment. Internal factors are mainly social and economic factors, while externals are the environment and infrastructures (see table 2). A survey to identify residential preference is an effective tool before formulating strategies for resettling communities to a new location or developing survival strategies to remain in their settlement.<sup>4)</sup>

According to Bintarto<sup>5)</sup>, community's preference for resettlement is influenced by disseminating information

on disaster-prone areas so that residents move from their previous settlements to safer ones. The relocation of the population is also related to implementing the Minister of Home Affairs Number 33 of 2006 concerning General Guidelines for Disaster Management. The guidelines state that the dissemination of information carries out strategies for implementing disaster mitigation policies. The community's residential preference also indicates the level of resilience of the Palu community to absorb, anticipate, and adapt to change and pressure<sup>6)</sup>. The government uses this residential preference to prepare new settlements or improve the existing ones. Meanwhile, both the allocation of resettlement and rebuilding the existing ones must comply with the housing and residential act.

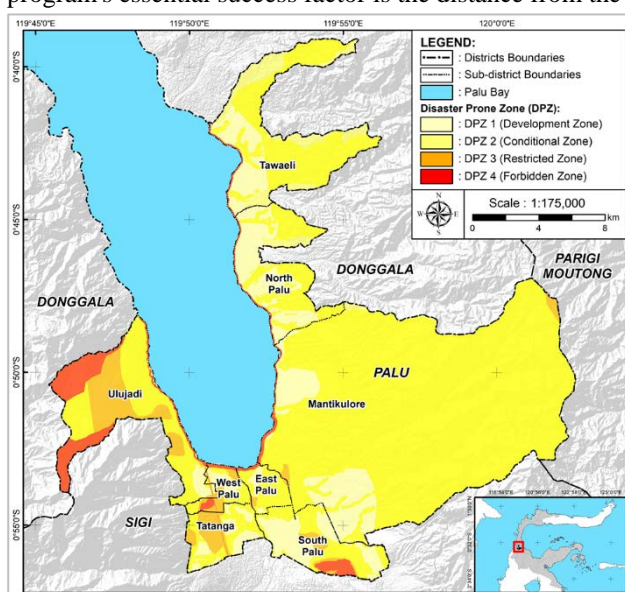
Indonesian Act on housing and residential areas<sup>7)</sup> explains that housing and residential areas are organized on the principles of welfare, justice and equity, nationality, efficiency & benefit, affordability & convenience, independence & togetherness, partnership, harmony &

balance, integration, health, and sustainability, as well as safety, security, and order. It shows that the residential area must be classified as safe from all hazards, including natural disasters. Natural disasters may cause trauma for survivors, while this traumatic experience influences adjustment over time<sup>8)</sup>. The adjustment may trigger the pressure to move or stay depending on their neighbourhood's vulnerability, safety, affordability, and other influential factors.

Many authors promote factors of settlement preferences (see Table 2). Manatunge and Abesinghe (2017) stated that factors affecting post-disaster resettlement satisfaction in the city are site selection, the dwelling unit's design, material well-being and provision of services and infrastructure, aspects related to social factors, and perceptions regarding the resettlement process, neighbourhood and social interactions<sup>9)</sup>. Regarding the resettlement of natural disaster survivors, the settlement program's essential success factor is the distance from the

following names exemplify the warning that the tribe had identified: 1) The *Kaombona* area was believed to be unsafe. Until recently, that area was used as an urban forest in order not to be inhabited. 2) *Petobo* Village was a restricted area that should not be populated by more than 60 persons due to the mitigation of the forecasted disaster. 3) *Ngia* River was a name of a river that had dried up and unfortunately was inhabited into a residential. When the liquefaction hit Palu in 2018, the settlement on the formerly *Ngia* River has destroyed. 4) *Balaroa* means many disasters. However, due to people's ignorance, this area had been settled by many people since the 1980s.

Across the 20<sup>th</sup> century, Palu City has a history of disasters from the earthquake (1923) and tsunamis (1930 and 1938). For the rest of the 20<sup>th</sup> century, the city looks 'safe' until the great disaster in 2018 shocked the city with earthquakes, tsunami, and liquefaction. Palu is a water front city, therefore the impact of the disaster which included tsunami was devastated (Figure 2). Based on the



**Fig. 1:** Disaster Prone Zones in Palu. Source: Government of Indonesia<sup>11)</sup>

disaster areas<sup>10)</sup>. Both Manatunge and Abesinghe<sup>9)</sup> and Seneviratne et al.<sup>10)</sup> underlined the significance of spatial arrangement that brings together development trends based on economic considerations with land vulnerability of potential hazards. Unfortunately, the existing settlement pattern in Palu City is a grid form that linearly follows rivers and beaches. This settlement form is very vulnerable to tsunami and flood disasters. Another evidence shows that Palu City has a disaster-prone zone of 37,939.5 ha or more than 90% of the total area<sup>11)</sup> (Fig.1).

Associated with the disaster risk, the finding of the archaeologists was interesting. The majority of the residents of Palu City are Kaili tribes. Archaeologists' research found that the tribe had specific local wisdom to mitigate the disaster. They revealed that the tribe had named the area based on the disaster risks. It was intended as a sign that the location should not be inhabited<sup>10)</sup>. The



**Fig. 2:** Palu City's area that was swept by 2018 tsunami

Public Work and Housing Ministry report (2018), data from the National Disaster Management Agency shows that natural disasters in Palu City caused 2,256 residents to die, 4,612 people were seriously injured, 223,751 people were displaced, and as many as 1,309 people disappeared. Meanwhile, the damaged buildings resulting from the disaster were 68,451 houses, 265 schools, 327 worship buildings, and 45 health facilities<sup>13)</sup>. Figure 2 shows the impact of tsunami in 2018.

This condition certainly changes the image and the feasibility of the City of Palu as a safe place to live. Currently, the community is recovering from a downturn in economic, social, physical, and psychological due to the disaster. This study has two objectives: 1) to investigate how people's perceptions towards their settlement after experiencing a disaster; 2) to explore the essential factors and indicators that influence community's residential preference.

## 2. Method

### 2.1 Analysis

Residential preference was analyzed using multidimensional scaling (MDS) analysis, a multiple variables technique to determine another object's position

based on its similarity assessment<sup>14)</sup>. MDS analysis serves to determine the relationship or the dependence between variable data. MDS has several types of algorithms so that it can be classified into several categories. MDS aims to form customer considerations or assessments regarding similarity or preference to the distance represented in a multidimensional space<sup>15)</sup>. MDS is applicable for research in physics, psychology, physiology, linguistics, political science, and market research<sup>16)</sup>. The study used non-metric MDS measurement. Non-metric MDS's objective is to establish a non-monotonic relationship between the distances between points with observed similarities.

The advantage of non-metric MDS is that it does not require assumptions about the underlying transformation function. The only assumption required is that the processed data is ranking (or ordinal) data.

According to Jaworska & Anastasova<sup>17)</sup>, several things can explain MDS analysis as follows:

1. MDS analysis is widely used in perceptual studies.
2. MDS analysis is an exploratory data analysis technique that can test a particular dimension or structure hypothesis in a data set.
3. MDS analysis is a flexible technique that can model non-linear relationships and is not bound by the many assumptions associated with general linear modelling or factor analysis. Nonetheless, interpreting the outputs of the MDS analysis can be challenging and highly subjective.

The requirements for using MDS are as follows<sup>18)</sup>:

1. The model is correctly specified.
2. The model uses the correct measurement level. For example, for metrics, MDS uses ratio or interval scales.
3. The number of objects is at least as many dimensions. If the number of objects is less than the number of dimensions, then MDS is unstable. If the number of objects is slightly more than the number of dimensions, then  $R^2$  is inflated. The number of objects is at least four times the number of dimensions plus 1.
4. The scale used is equivalent, and if it is not equal, then the size used should be a standardized value. The data that can be used are ordinal, interval, and ratio.
5. Comparability: the objects being compared have certain similarities which are significant enough to be comparable.

MDS analysis was carried out using SPSS software with the following steps<sup>19)</sup>:

1. Determination of attributes
2. Assessment and ordinal scoring on each attribute
3. Perform MDS ordinance on the leverage factor of the attributes based on the Root Mean Square (RMS) on the x-axis
4. Assessment of the analysis accuracy. The accuracy uses the goodness of fit based on the stress value calculated from the S and R2 values. When the R2

value is close to 1, the iteration process can be stopped. A low-stress value indicates adequate goodness of fit, and a high-stress value indicates the opposite. The voltage shows the difference between the estimated input and output distances on an n-dimensional map.

The value of the stress function is between zero and one. The smaller the voltage function, the better the model represents the input data. Although there are no strict rules regarding how much stress can be tolerated, the rule of thumb is that a value of  $\leq 0.1$  is very good, and anything that is  $\geq 0.15$  cannot be tolerated<sup>17)</sup>.

## 2.2 Sampling

The population in this study is the population of Palu City. The study focuses on the samples taken from the affected areas. The questionnaires distributed to the samples using 'survey123.argis.com tool'. This tool was chosen because it can locate the geographic position of the respondents. The selected samples aim to interpret the population in Palu based on specific procedures that are considered capable of representing the population in particular disaster zones. Isaac Michael's formula was used to estimate the number of samples.

$$S = \frac{\lambda^2 \cdot N \cdot P \cdot Q}{d^2 \cdot (N-1) + \lambda^2 \cdot P \cdot Q} \quad (1)$$

Where:

s = number of samples

N = number of population

$\lambda^2$  = chi-square, the value depends on the degree of freedom (dk) and the error rate, with dk = 1, the error level is 1%, then the chi-squared = 6.634, the error rate is 5%, then the chi-squared = 3.841, and the error level is 10%, then the chi-squared = 2.706

d = degree of accuracy expressed as a proportion (0.05)

P (probability of true) = Q (probability of false) = proportion of the population = 0.5

The population of Palu City was 371.365 persons. Thus, using a 5% error rate, the sample was 136 respondents. Due to Covid 19 circumstances, an online platform was employed to collect data from residents across all sub-districts in Palu City from April to June 2020.

## 2.3 Factors and Indicators

Four factors used in this study are social, economic, environmental, and infrastructure. Based on the literature review, the authors used 21 indicators (Table 1). Each indicator is classified using the Likert scale. Most of the approach is classified in 5 scales<sup>20)</sup>: 1: Strongly bad; 2: Bad; 3: Neutral; 4: Good; 5: Very well

## 3. Result

The community's survey results in Palu City showed that 47.41% of the community's residential preference was to move away from the existing location. This preference

may be caused by: 1) the proximity of the location of their neighbourhoods to the tsunami and liquefaction prone zone; 2) due to their traumatic experience; 3) the successfulness of the dissemination of the disaster-prone zone (DPZ) by the Government which increased the awareness of this community, and 4) the Government of Indonesia has developed resettlement locations and improved zoning regulations based on disaster mitigation. Meanwhile, 17.78% of respondents preferred to stay, and 34.81% were hesitant to move (Fig. 3 and Fig. 4). They, who wanted to stay and were hesitant to move, had several reasons: 1) the shelters were inadequate, and location around the shelters had minimal facilities (medical equipment and materials, sanitation, and clean water facilities); 2) the majority of victims (82% of samples/respondents) do not have an emergency fund. Their occupation is closely related to the agricultural land in their neighbourhood, so they do not have fixed income (56% of respondents); 3) their economy or income significantly limited the community's choice to move. The choice to move needs high costs that they cannot afford<sup>6)</sup>; 4) the data collection process for home replacement recipients was flawed<sup>20)</sup>; 5) their existing neighbourhoods (49.25% of respondents) are located in DPZ 1 and DPZ 2 (see Table 1. and Fig. 4).

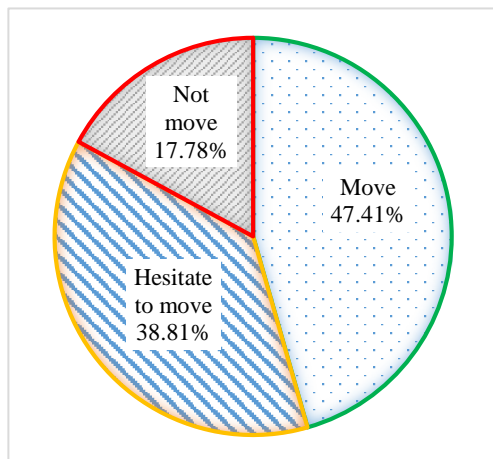


Fig. 3 Community's Residential Preference

Superimposing Fig. 1 to Fig. 4 figures out that 37.48% of the respondents are living in disaster-prone zone (DPZ) 1; 55.15% in DPZ 2; 6.63% in DPZ 3; and there are still 0.74% living in DPZ 4. The preferences of the residents in each zone are as follows (table 1):

Table 1. Residential preferences of the respondents

Preferences	DPZ 1	DPZ 2	DPZ 3	DPZ 4	Total
move	14.70	28.68	3.68	0	47.06
hesitate to move	17.64	14.71	2.21	0	34.56
not to move	5.14	11.76	0.74	0.74	18.38
Total	37.48	55.15	6.63	0.74	100.00

One thing to be noted from table 1. that there are 1.48% of the respondents living in the forbidden zone (DPZ 4) do not want to move, and 2.21% of respondents living in the restricted zone (DPZ 3) hesitate to move. It is necessary to find factors that influence these preferences. The distribution of respondents who preferred to move (yellow dots), hesitate to move (blue dots), and not to move (black dots) is described in Fig.4.

Factors beyond their preference are analyzed using 21 (twenty-one) indicators selected from 16 (sixteen) authors

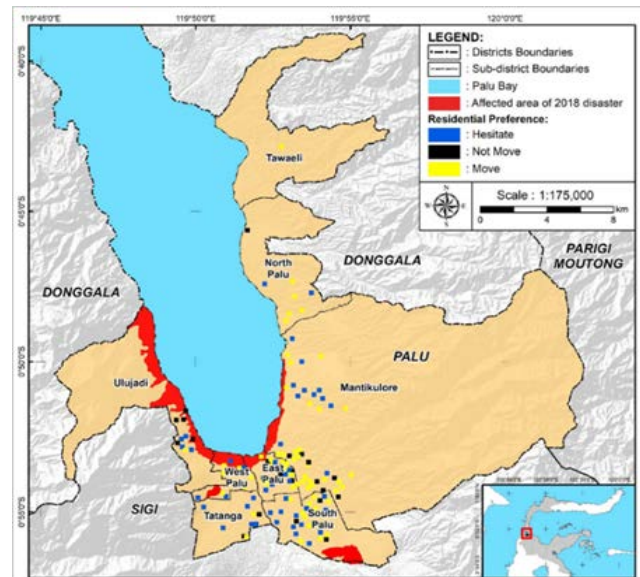


Fig. 4: Post disaster residential preferences in Palu City

in the following table (Table 2). This table's compilation shows that the social factor has 4 indicators; the economy has 3 indicators; environment has 7 indicators; infrastructure has 7 indicators.

Table 2. Factors and indicators

Factors	Indicators	Authors
Social	Community Social Activities (X1)	Hempe & Tucker <sup>22)</sup> ;
	Family Structure (X2)	Farasa &
	Educational background (X3)	Kusuma <sup>23)</sup> ;
	Length of stay (X4)	Johnston et al. <sup>24)</sup> ; Longstaff et al. <sup>25)</sup>
Economy	Income level (X5)	Bastaminia et al. <sup>26)</sup>
	Ownership of an emergency fund (X6)	Watanabe & Maruyama <sup>27)</sup>
	Type of livelihood (X7)	Moschen et al. <sup>28)</sup>
Environment	Ground Movement Prone (X8)	ISO:37120 <sup>29)</sup>
	Liquefaction prone (X9)	
	Tsunami-prone (X10)	
	Fault Prone (X11)	
	Flood prone (X12)	



Factors	Indicators	Authors
Infrastructure	Public perception of environmental safety (X13)	Azizah et al. <sup>30)</sup> , Ridzuan et al. <sup>31)</sup>
	Land prices (X14)	Chirisa <sup>32)</sup>
	Accessibility (X15)	Twumasi-Boakye et al. <sup>33)</sup>
	Distance to the city center (X16)	Awotona <sup>34)</sup>
	Road conditions (X17)	Hutapea <sup>35)</sup>
	Post-disaster house condition (X18)	Armela et al. <sup>36)</sup>
	House size (X19)	Nurhadi <sup>3)</sup>
	Availability of public facilities (X20)	Azizah et al. <sup>30)</sup>
	House ownership status (X21)	

The data used for the MDS analysis of each attribute is the average scoring data of 136 respondents. The assessment and ordinal scoring on each attribute was determined based on statistics and a primary survey. Table 3 is the example to determine the data for MDS running. The result of standardized data that is used for running is in Table 4.

Table 3. An example to count the data for MDS

Parameter	Number of respondents	Score	Result
Rent	18	1	18
Own	29	2	58
Total A	47	Total B	76
Standardize = Total B/Total A			1.62

Table 4. Data analysis based on residential preferences

Indicators	Settlement Preference Data		
	Hesitate	Not Move	Move
X1	2,79	3,04	2,55
X2	2,55	2,83	2,56
X3	2,57	2,58	2,53
X4	2,74	3,08	2,20
X5	1,77	1,58	2,05
X6	1,19	1,04	1,22
X7	1,13	1,13	1,17
X8	1,98	1,58	1,66
X9	3,02	2,83	2,81
X10	1,91	2,17	2,14
X11	1,60	1,63	1,36
X12	2,26	2,29	2,36
X13	1,89	1,83	2,09
X14	2,09	2,29	2,16
X15	2,74	2,71	2,70
X16	1,09	1,08	1,06
X17	2,21	2,29	2,52
X18	2,47	2,75	2,47
X19	1,09	1,17	1,11
X20	2,49	2,42	2,72
X21	1,62	1,75	1,55

The MDS analysis results (Table 5) show that the generated stress value is 0.10 in the 0<sup>th</sup> iteration and 0.00 in the 15<sup>th</sup> iteration. This stress value confirms that the results of the MDS analysis are classified as very good.

Table 5. Stress Value

Iteration	Penalized Stress	Difference	Stress	Penalty
0	.3193376		.1012782	1.0068946
15	.0000842a	.0000509	.0000000	1.0053479

a. Current penalized stress value less than the minimum stress criterion.

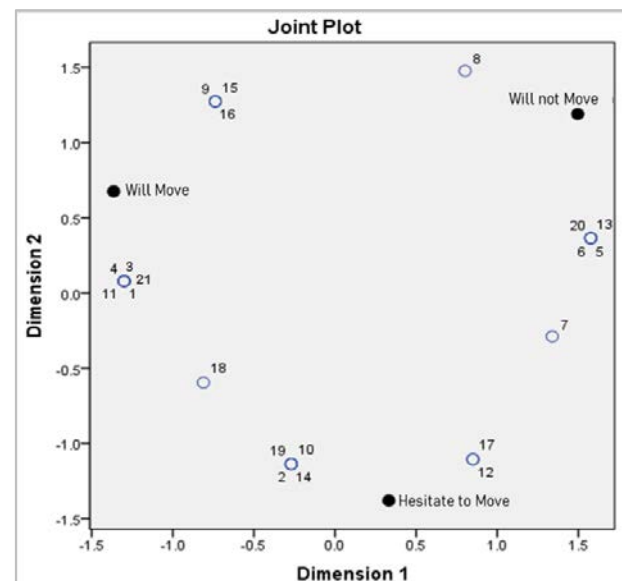


Fig. 5: MDS analysis of the three preferences

Figure 5 (the result of the MDS analysis) shows a graph of influencing factors based on three categories of community's residential preferences. Numbers around the dots represent indicators the residential preferences. Their positions show the 'distance' with the preferences. The distance between points is related to the homogeneity of their profiles or the respondent's response pattern.

The joint plot (Fig.5) shows the dimension that is determined by the coordinates of each point, such as: Hesitate to Move (0,332; -1,379), Will not move (1,496; 1,189), and will move (-1,364; 0,675). The coordinates of 21 indicators are listed in Table 6.

Table 6. Coordinates of Indicators

Indicator	Dimension	
	X	Y
X1	-1.301	0.079
X2	-0.27	-1.136
X3	-1.301	0.079
X4	-1.301	0.079
X5	1.576	0.365
X6	1.576	0.365
X7	1.339	-0.288
X8	0.802	1.476

Indicator	Dimension	
	X	Y
X9	-0.738	1.273
X10	-0.27	-1.136
X11	-1.301	0.079
X12	0.85	-1.105
X13	1.576	0.365
X14	-0.27	-1.136
X15	-0.738	1.273
X16	-0.738	1.273
X17	0.85	-1.105
X18	-0.811	-0.595
X19	-0.27	-1.136
X20	1.576	0.365
X21	-1.301	0.079

The description of the results of the clustering of factors (indicators) that affect residence preferences are as follows:

1. Factors on 'will move' preference: Eight factors have close distance to 'will move' (Fig.4.). They are divided into two clusters. Five factors (X1, X3, X4, X11, X21) are in a cluster below the coordinate of 'will move'. The other cluster belongs to X9, X15, and X16.

a. Community social activities (X1).

The population's social activity who were reasonably active are about 37%, while 17% were rarely active, and 25% are even inactive. Logically, the more active the population in social activities in the community, the higher the potential to be informed with valid information. It may be one of the causes that not all populations understood about the category of risks of post-disaster areas in Palu. Many of the community members do not have significant roles in social activities in their community or neighbourhood.

b. Educational background (X3)

Educational background is an influencing factor for 'willingness to move' preference. The higher the level of education, the higher the community's preference to move for resettlement in the post-2018 disaster. The pattern is that education level corresponds to the ability of the respondents to absorb valid information and locate disaster-prone zones (DPZs).

c. Length of stay (X4)

Fifty-three per cent of respondents who prefer to move were in the 'short' category of the average length of stay (ALOS= 0-5 years), which means that they are newcomers (non-native-born residents) and do not have emotional place attachment. So they do not find it hard to leave their former settlement. Thus, the shorter the residents' length of stay, the higher the potential to move to other residential places.

Most people who prefer to move were formerly from zones prone to liquefaction hazards at all levels. Significant liquefaction in 2018 showed the danger of the hazards. Willingness to move corresponds to the level of perceived risks.

d. Fault prone (X11)

Eighty-six per cent of the community preferred to move to the surrounding areas that are not classified as prone to fault zones. 21.28% of residents lived in zones with medium to high prone potential to fault disaster. These areas are also classified as DPZ 3 and 4, which are prone to liquefaction and tsunami. Lessons learned from the strike-slip fault that hit the Palu coast has increased their preparedness. The largest number of people moved to higher place areas.

e. House ownership status (X21)

The status of ownership consists of 54.69% individual title certificates and 45.31% rental houses. Based on Presidential Instruction No.10 of 2018, the Government provides stimulant funds for minor and moderate housing's damages. Meanwhile, the Government provides permanent shelter in the resettlement areas for residents who have lost their houses or are severely damaged or located on DPZ 4 (forbidden zone).

f. Liquefaction prone (X9)

About 39.06% of respondents lived in liquefaction prone areas. The 2018 disaster cost lives, destroyed and buried Balaroa and Petobo villages, and therefore totally changed the landscape of these two villages. Since people lost their properties, most survivors preferred to move. However, the village community still claimed the 'forbidden zone' as their village community's land and prohibited others to utilize the land.

g. Accessibility (X15)

As many as 70% of the population, who preferred resettlement choice, argued that accessibility to public facilities is crucial. Unfortunately however, current areas/districts with adequate access to public facilities, that they chose to move, were not in the safe category. For example, they move to districts in East Palu and West Palu where have adequate access, however, these areas are in the restricted zone (disaster-prone zone/ DPZ 3), which are still very risky.

h. Distance to city center (X16)

Ninety-five per cent of people who choose to move have a close distance from the city center (0-13.33 km). This shows their perception city center area is not safe anymore. The central district in Palu City is classified as a high disaster-prone zone, while districts far from the city center, such as Tawaeli and Mantikulore Districts, have a lower risk.

2. Factors of 'hesitate to move.' There are also two clusters. Four indicators (X2, X10, X14, and X19) on the left and two indicators (X12 and X17) on the right of the 'hesitate to move' coordinate (Fig.4).

a. Family structure (X2)

There were about 60% of people who were hesitant to move have many families in the same district (Palu City's area). Basically, people with many families in the same district are native-born community. Since they have less families in other districts, they were hesitant to move. Their willingness to move was strongly affected by big family's

collective actions.

b. Tsunami prone (X10)

There is about 40% of the previously residential area that is not classified as a tsunami-high prone area. The residents who lived in this area perceived that their area was safe, but their area is not safe if a great tsunami, such as the 2018 tsunami, occurs.

c. Land price (X14)

The average land price of the current settlement was within a range of Rp. 279,000 - Rp. 400,000 per m<sup>2</sup>. The condition influenced the hesitation to move that the price of their property would drop significantly if they sold because the location is in a disaster prone zone. On the other hand, improving the road network and transportation system has a positive impact on the property value<sup>37)</sup>. It increases the land price of the safer location. The money from selling their property may not be enough to buy houses with good public service access and safe. Without any other saving or capital, the choice may only lead to a safer place but no public service access or a place with adequate public service access but not very safe.

d. House size (X19)

Ninety-four per cent of the people perceive that their current houses have fulfilled their needs and desires, although the location is not safe. Moving to a safer location with a permanent building still needs high housing prices and adjusting family's needs. Moving to a temporary residential building is cheaper, but the condition is far from the family's expectation.

e. Flood prone (X12)

The residential areas of the respondents were in the category of low risk of flood-prone (64% respondents). This position causes people to hesitate to move because they can adapt if a flood occurs in their neighborhood. Meanwhile, 15% of people were living in high risk of flood prone zone but were still hesitant to move.

f. Road condition (X17)

Good road condition influences residential preference for 47% to hesitate to move in the post-disaster in Palu.. Difficulties caused the hesitation to move to find safer areas with good road access. The existing urban areas accessible by road network are classified as disaster-prone zones 2 to 4 (conditional to forbidden categories).

3. Factors of 'will not move' preference. There are two clusters of indicators as factors influencing this preference. Indicators of X5, X6, X13, and X20 are in the first cluster and X8 in the other side. The first four indicators are associated with human-modified factors while X8 is nature affected factor.

a. Income level (X5)

The majority of respondents (71%) had low income level (category  $\leq$  IDR 2,000,000). This category is only sufficient for basic needs. The survey indicates that the resistance of people to move is mostly caused by insufficiency of income. Moving costs lots of money that many of them cannot afford.

b. Ownership of saving or emergency fund (X6)

Most people (82%) in the affected areas did not have emergency funds to deal with disasters. Moving to a new environment means finding new occupations, particularly those working in informal sectors.

c. Public perception of environmental safety (X13)

As many as 75% of the community perceived that their residential place was safe enough so that they did not want to move and felt they could adapt and cope with the current and upcoming disaster. In addition, this could also be caused by a lack of knowledge dissemination and socialization regarding disaster-prone zones in Palu City so that people are not aware of the risk level and types of hazards that do not have cycles such as liquefaction or earthquakes, which may also generate a tsunami.

d. Public facilities (X20)

The Local Government of Palu City has provided public facilities in health, education, and worship facilities for about 71% of respondents. This condition shows that some districts in Palu lack public facility services, while public services are crucial factors that influence settlement preference.

e. Ground movement-prone (X8)

As much as 99.95% of the area in Palu City is in a disaster-prone zone for ground movement. So, people prefer to stay and adapt because most Palu City locations are prone to land movements.

4. Factors affecting more than one preference:

a. Type of livelihood (X7) affects the 'hesitate to move' and 'will not move'.

People's livelihood and occupation attached to the current location tend to cause people to hesitate or even reject moving—only a few residents worked in different districts. For most of them, moving to other districts also means finding other jobs or occupations.

b. Post-disaster house condition (X18) affects the 'hesitation to move' and 'will move'.

House condition in the post-2018 disaster was an important factor influencing people's preference to move and find a new place or hesitate to move. When their properties (houses) were severely damaged or vanished, they accepted the resettlement program. Meanwhile, if their houses were only slightly damaged, they think that moving was not too necessary.

## 4. Discussion

Crucial aspects that the Government of Indonesia and the Local Government of Palu City must pay attention to in this recovery period are: a) paying attention to factors and indicators affecting the community's residential preference. The focus should be given to those who do not want to move, or at least those who are hesitant to move, who live in DPZ 3 and DPZ 4; b) restructuring the spatial management of Palu City comprehensively, particularly in developing countries residential zones. Spatial management is crucial since the area of Palu City is now segregated into four DPZs that need particular spatial development strategies for each zone; c) focusing



attention on the most vulnerable people who remain living in disaster-prone locations, and d) developing social capital of the community to improve awareness and preparedness.

#### 4.1. Factors (indicators) affected the preference

The most influential factors affected residential are grouped into three preferences: 'will move', 'will not move', and 'hesitate to move'. The most influential indicators are those that are spatially the nearest to preferences (see fig. 5). There are 5 (five) indicators affected preference to move: community social activities, educational background, length of stay (social factors), fault-prone (environmental factor), and homeownership status (infrastructure). For those who preferred 'hesitate to move', the most influential factors are the environment (flood-prone) and infrastructures (road condition. The environment (ground movement prone) was the most influential factor that affected people 'not to move' was the environment (ground movement prone).

#### 4.2. Spatial management

Since the former urban area is mainly located in disaster-prone zones, new strategic spatial planning for both general and detailed plans should be imposed for the Central Sulawesi Province and Palu City. Reviews of the general spatial plans prepared in a post-disaster emergency in 2018 should be periodically performed. To provide direction for changes in the spatial structure and pattern of urban spaces concerning residential centers, new road networks (X15 and X17 indicators) and public facilities (X20) must be placed in safer and higher locations (DPZ 1 and DPZ 2 with high control mechanism). It is hoped to create the growth of new residential areas as well as new city center which are safe from the hazards ground movement (X8), liquefaction (X9), tsunami (X10), and flood (X12).

#### 4.3. The most vulnerable community

Main attention must be given to the most vulnerable community, i.e., those who live in the DPZ 3 and DPZ 4 and cannot or do not want to move to a safer zone. The Government at all levels must facilitate and provide wide range of choices for housing and settlement. It is important to understand that 71% of population have low income level. Some of them, who remain in the vulnerable location, do not always mean that they do not want to move, but they may be unable to move because they have no choice. Former areas of liquefaction and tsunami will become urban residual spaces. Without clear regulations, the existence of these residual spaces becomes an alternative to public<sup>38</sup>, that the poor may likely reclaim as their settlement.

For those who are actually capable to move, but still hesitate, increasing awareness of environmental safety

(X13) is important. Because the city is potential for environmental hazards, environmental safety should become the spirit of the society in developing an environmentally friendly society<sup>39</sup>, which incorporates the Government, the communities, academic institutions, private sectors, and media (the penta-helix).

#### 4.4 Human and social capital development

Human and social capital context-related this research includes two factors (social and economic). Indicators social and economic factors that influence people's residential preferences are community social activities (X1), educational background (X5), family structure (X2), income level (X5), ownership of an emergency fund (X6), and public perception of environmental safety (X13). Based on the interview result, X1 is closely related to X13. The first two indicators (X1 and X5) influence people's preference on the willingness to move. Family structure (X2) influences people's hesitation to move, while the last three indicators (X5, X6, and X13) influence the decision 'not to move'.

In this region, human and social capital management is significantly developing what Shahriari et al. called green human resource management. The term green human resource management can be defined as the human capital and its management, which are instrumental to fulfilling green objectives<sup>40,41</sup>. The green objective of the disaster-prone in Palu City is definitely a disaster-resilient and sustainable society, i.e., a society that links lessons learned from the past to current development and future benefits.

### 5. Conclusion

Lessons learnt from the 2018 disaster in Palu prove that ignorance of local wisdom and natural hazards was fatal. Indigenous tribes in Palu somehow was aware of the potential risks of their land. They had even named their land as signs or warnings. After the 2018 disaster, the Government delineated Palu City into four zones that indicate levels of vulnerability. Unfortunately, most of the current administrative area of Palu City is considered not safe, and normatively, people be relocated into a safer settlement. However, the affected residents in Palu have different perceptions regarding the relocation. People's residential preferences in the post-disaster in Palu city can be categorized into three: willingness to move (resettlement), hesitation to move, unwillingness to move. Factors affecting the preferences are as follows:

a. Factors affecting 'will move' preference are social (3 indicators), infrastructures (3 indicators), and environment (2 indicators). The economic factor does not influence people's intention to move. The indicators of the three factors are:

- 1) Community social activities (X1)
- 2) Educational background (X3)
- 3) Length of stay (X4)
- 4) Tsunami prone (X11)

- 5) House ownership status (X21)
- 6) Liquefaction prone (X9)
- 7) Accessibility (X15)
- 8) Distance to the city center (X16)

The first five indicators are the most influential for community's preference to move.

b. Factors influencing 'hesitation to move' are environment (3 indicators), infrastructure (2 indicators), and social (one indicator). Again, economic factor does not influence hesitation to move.

- 1) Flood prone (X12)
- 2) Road conditions (X17)
- 3) Family structure (X2)
- 4) Tsunami prone (X10)
- 5) Land price (X14)
- 6) House size (X19)

The first two indicators are the most influential (environment and infrastructure factor).

c. Factors affecting 'will not move' preference are environment (2 indicators), economic (2 indicators), and infrastructure (one indicator). Social factor does not influence community's objection to move.

- 1) Ground movement prone (X8)
- 2) Income level (X5)
- 3) Ownership of an emergency fund (X6)
- 4) Public perception of environmental safety (X13)
- 5) Availability of public facilities (X20)

Among five indicators, ground movement prone (environment) is the most influential factor.

It is hoped that the government considers these factors in preparing programs and constructing post-disaster resettlement in Palu so that the relocation of housing is based on both technical analyses of disaster mitigation and people's perceptions.

A more comprehensive risk based-urban and regional planning is crucial to prevent fatal impacts in the future. Shifting urban and dense residential areas to safer places is important. This obviously changed the city's urban structure and pattern of future Palu. Infrastructures should be focused on DPZ 1. Adaptation to this disaster also changes the administrative boundaries of the local governments in Palu and surrounding areas.

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