Evaluation of Settlement Relocation Due to the 2018 Palu Earthquake

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Abstract. The earthquake followed by the Tsunami and Liquefaction in Palu City, Donggala Regency and Sigi Regency, Central Sulawesi Province on Friday, September 28, 2018 with a magnitude of 7.4 on the Richter Scale has resulted in hundreds of people missing, more than two thousands of people injured and thousands of people dying. BNPB informed that there was quite a lot of physical damage to facilities and infrastructure, including several houses and public facilities in residential locations. The steps taken in response to the incident were the relocation of settlements in disaster-affected areas, one of which was in the Sidera Transmigration settlement area. This article aims to analyze and evaluate the relocation of settlements, especially in the Sidera Transmigration settlement area. The method used is thematic mapping of the factors that determine land suitability for settlements, and spatial analysis using map overlay techniques complemented by quantitative descriptive analysis. The results of the analysis and evaluation indicate that the transmigration area used as a residential relocation area for disaster victims is quite appropriate and meets the requirements for living, feasible for business, suitable for development, and environmental friendly.

1. Introduction

Geographically, Indonesia is situated in a disaster-prone area, so as various disasters occurrence is very potential [1], [2]. Hazard events can occur singly, such as volcanic eruptions, earthquakes, floods, tsunamis, and so on. However, it is occasionally occur multi-hazard in the same time in one place. For example, the occurrence of earthquake, tsunami and liquefaction disasters in Palu that happen in year 2018. Disaster events always have a negative impact on the people living in the disaster area [3], [4]. Disaster events can at least have economic, social and health impacts, and may even lose their homes [5], [6]. The multi-hazard disasters in Palu, Donggala, and Sigi that occurred in 2018 also caused a very significant impact on the community, inter alia more than two thousand people injured, more than a hundred people lost, and thousands people died. Furthermore, these disaster also impacted to some physical damage of infrastructure and public facilities, as well as hundreds housing was collapsed. Disasters are an incidents resulting from natural events people's actions, which cause physical or social changes, and result in loss of life or damage of property [7]. Natural disasters that hit an area can cause disturbing the human life [5]. In certain cases, natural disasters can destroy the community [6]. In every disaster event, there needs to be intervention, especially by the government, to help disaster victims [8], [9].

Based on BNPB Regulation No. 3 of 2013, refugees are people or groups of people who being forced to leave their place of residence for an indefinite period or time as a result catastrophic impact. Disaster victims who become refugees must be given treatment, including data and information management, protection and empowerment, relocation, compensation and restoration of refugee rights. Again, based on BNPB Regulation No. 3 of 2013, refugee relocation is a series of activities to move back refugees to their place of origin, placing refugees from temporary shelter locations to permanent housing in the same location or to a new place.
This paper aims to (1) identify the relocation of victims of the earthquake, tsunami, and liquefaction in Sigi, Central Sulawesi that occurred in 2018; and (2) evaluate the resettlements condition as a result of relocation by the government, particularly through the local transmigration process. Several stakeholders took the initiative to relocate the victims of earthquake, tsunami, and liquefaction disaster in Sigi, one of which was the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration. The transmigration pattern applied in the relocation of disaster victims is local transmigration [10].

As an introduction to the study site, the relocation of the earthquake, tsunami, and liquefaction victims in Sigi Regency was placed in Sidera Village, which is one of the transmigration reserve areas. Administratively, the Sidera Transmigration reserve area is located in Sidera Village, Sub-district of Sigi-Biromaru, Sigi Regency, Central Sulawesi Province. Geographically, Sidera is located at 119°05'60" - 119°05'80" east longitude and 00°00'58" - 01°00'00" south longitude. The location of research area can be seen in Figure 1.

![Location Map of Sidera Village](image1.png)

Economically, this village has the following distances from growth centers: 5 km to the capital city of Sigi-Biromaru sub-district is, and 13 km to the capital city of Central Sulawesi Province (Palu). Physically, Sidera is bordered by: North side with Pombewe Village and Paneki River, South side with Olobojo Village and Wuno River, East side with Mount Kafarantabo, and West side with Pombewe and Olobojo Village. Sidera can be easily reached from the city of Palu by using a vehicle via a 15 km asphalt road to the south of Palu, with a travel time of about 15–30 minutes. The administrative boundary or Sigi Biromaru Sub-District is shown in Figure 2.

![Administrative Boundary of Sigi Biromaru](image2.png)

2. **Research Method**
The research method used in this study is a survey method with quantitative and qualitative descriptive analysis techniques. The study begins with the interpretation of aerial photography images produced
from an UAV. The interpretation of this image is intended to produce a thematic map of the physical condition of land in the study area and land use/cover as well. The technical specifications of the UAV equipment used in this study is the UAV Fix Wing SB80 K Long range. Fix Wing SB80 K is equipped with an 18.2 MP Sony camera that can record an area with a wide range of up to 70 Km, while the recording area is up to 750 Ha. And the resulting ground spacial distance is up to 7 cm/pixel. A complete specifications can be seen in Table 1.

Table 1. Specification of UAV Fix Wing SB80 K Long range

| Specification          | Description                  |
|------------------------|------------------------------|
| Weight                 | +/- 3kg                      |
| Wingspan               | 1880mm                       |
| Length                 | 1100mm                       |
| Material               | EPO Foam + Carbon            |
| Propulsion             | Brushless Electric Motor     |
| Battery                | Lithium Ion Polymer          |
| Camera                 | Sony 18.2                    |
| Telemetry Radio Frequency | 433 MHz                |
| Telemetry Range        | up to 30 km                  |
| Flight Time            | up to 90 minutes             |
| Flight Mode            | Manual, FBWA, Auto, RTL      |
| Take Off               | Hand Launch                  |
| Speed                  | Belly Landing                |
| Travel Distance        | up to 70km                   |
| Coverage area max      | 750 Haa per flight           |
| Ground Spacial Distance| up to 7cm/pixel              |

Based on the identification of the physical condition of the land and the use of land in the study location, an analysis of the suitability of the relocation of residential settlements for permanent housing is carried out. Secondary data is used to support information regarding the population relocation process. Furthermore, based on the suitability analysis, an evaluation of the relocation of disaster victims in Sigi was carried out.

Some variables are employed due to analyze the settlement relocation outcome. This variables are: land physical condition, socio-economic characteristic of refugees, economic potency of settlement site, accessibility, and disaster vulnerability [8], [9]. All variables are analyzed descriptively in order to evaluate settlement relocation process in study area.

3. Results and Discussions

The results of this study cover several aspects including: the physical land condition and its landuse, the socio-economic characteristics of the population, economic opportunities, accessibility, and the disasters vulnerability. The physical land condition and its landuse resulted from the interpretation of aerial photo images produced from UAV and supported by field observations. The socio-economic characteristics of the population were obtained from interviews and secondary data analysis, while economic opportunities are assessed by analyzing secondary data. Accessibility and disaster vulnerability were analyzed using thematic maps generated from aerial photo interpretation.

Before Sidera restlement area was decided as a relocation site for Palu earthquake refugees, it was conducted a technical planning for preparation of new settlement zone, so called RTSP. Based on the RTSP study, Sidera is suitable for settlement site as well as agricultural land. Carrying capacity of Sidera area for settlement and agricultural land is for 50 household.
3.1. Physical Land Condition of Sidera Resettlement Area

The topography of Sidera resettlement area is dominated by undulating and mountainous land. Mountainous land can be found at northern to eastern part, while flat to undulating land can be found at center to south part. Spatial distribution of topography class in Sidera is shown in Figure 3.

![Fig 3. Slope Map (A) and Contour Map (B) of Sidera Resettlement Area](image)

The distribution of total area of topographic condition at Sidera is presented in the Table 2. At least 400 hectare of land in Sidera is flat and undulating and it is suitable for settlement zone and seasonal agricultural land as well.

| Topography   | Slope (%) | Total Area | %  |
|--------------|-----------|------------|----|
| Plain        | 0 – 3     | 45.50      | 3.70|
| Undulating   | 4 – 8     | 34.90      | 27.80|
| Wavy         | 8 – 15    | 95.30      | 7.70|
| Slightly Hilly| 15 – 25  | 122.40     | 10.00|
| Hilly        | 25 – 40   | 170.30     | 13.80|
| Mountainous  | > 40      | 454.60     | 37.00|
| **Total**    |           | 1,230.00   | 100.00|

There are two types of soil in Sidera, namely: (1) Eutric Regusol which is formed from alluvium parent material and covers an area of 775.7 Ha, spreads from flat (0-3%) to hilly (26-40%), and (2) Eutric Regusol which is formed from alluvium parent material and is generally formed in mountainous areas (> 40%). The area for this type of land is 454.6 Ha.

Based on the Oldeman climate classification, Sidera, which is located in Sigi-Biromaru sub-District, classified into type E4 where there is no wet month, and the dry month occurs between 6 – 12 months. The average annual rainfall is around 971.2 mm with a distribution the largest rainfall occurred in July of 109.7 mm and the smallest rainfall occurred in March of about 37.5 mm. Water resources of Sidera come from Wuno river and piped about 9 km away, is flowed by gravity to the people's house and yards for irrigation and domestic use. The application technique of piped irrigation water by most residents uses a sprinkler so that the use of water becomes more efficient and really supports the cultivation of horticultural crops (mainly vegetables).

Based on the data from the water quality test, it shows that physically and chemically, the quality of surface water that is channeled through pipes to people's homes has met the criteria for the quality standards of clean water and drinking water. In addition, in Sidera previously also had deep wells as a source of ground water with an equifer depth of between 198 – 225 meters with moderate discharge. However, the use of deep wells is ineffective and inefficient compared to surface water due to the high
operational costs. Thus, the two units of deep wells at Sidera will no longer be operated except in emergency conditions. Previously, land use in Sidera was dominated by secondary forest and mixed garden. Some forest plantation was covered in the hilly to mountainous topography, while some annual crops coverage was found in plain to wavy topography. Figure 4 show the distribution of landcover or landuse in Sidera resettlement area before relocation project is done.

![Fig 4. Land Cover/Land Use Map of Sidera Resettlement Area](image)

Comparing to previous study, a research conducted by Oliver-Smith (2015), it is an identical result between two studies. Oliver-Smith stated that due to successful disaster resettlement, it is need some consideration so as good site selection for relocation, comprehensive land and water condition study, and Relocation plan flexibility. In Sidera resettlement, all of that requirements was conducted comprehensively. It is also coincident with other previous study as Vijekumara (2015), Sherbinin et al (2011), and Badri et al. (2006) as well.

3.2. Socio-economic Characteristic of Sidera Residents

Administratively, Sidera resettlement area belongs to Sidera Village, Sigi Biromaru sub-Districts. The population of Sigi Biromaru District in 2020 was 46,754 with a total of 10,901 households, so that the average household has 4 household members. The total male population is 23,805 people and the female population is 22,949 people. The village with the highest population is Kalukubula Village, which is 10,321 people, while the least populated is Sidono II Village, which is 840 people. When viewed from the population density, the average population density in Sigi Biromaru District is 161 people/km2. The most densely populated village is Sidondo I Village, which is 736 people/km2. While the most sparsely populated is Sidondo IV only 33 people/km2.

Meanwhile, the total population in Sidera Village is 2,469 people, or 5% of Sigi Biromaru total population. In between this total population, 1,231 are male (49.8%) and the rest are female. The distribution of total population, population density, number of household, sex ratio, and birth and death number in Sidera Village, is presented in Table 3 and Table 4.

| Nr | Village | Area ($Km^2$) | Population (person) | Population Density ($Km^2$) | Number of Household (KK) |
|----|---------|----------------|---------------------|-----------------------------|--------------------------|
| 1. | Sidera  | 7.52           | 2,469               | 328                         | 576                      |
Based on transmigrants data at UPT Sidera, it is known that the total previous transmigrant is 912 people (230 households). The origin of transmigrants are Central Java, NTT, NTB, and others. The addition of total household and population after first transmigrant placement came from spontaneous transmigrants as many as 34 families from communities affected by the Poso conflict. Recently, 50 household come from Palu Earthquake refugees as local transmigration program.

There are 2 religious adherents at Sidera, dominated by Islam and the rest are Christians. The main capital for community economic business activities at Sidera is agriculture land ownership. The total area of agriculture land that has been distributed to refugees is 200 ha, consisting of 100 ha for settlement and yard and 100 ha for agriculture land.

Sidera has established an economic institution in the form of a Village Unit Cooperative (KUD) with a total members as many as 150 people. To carry out its activities, KUD has received capital assistance from the Manpower and Transmigration Office of Central Sulawesi province in the amount of 48,000,000.00, and members' principal savings of 754,000.00, so that the total working capital of this KUD has reached 49,540,000.00. In the next stage of development, the activities of this KUD must be maximize in assisting its members, especially in supporting various economic business activities including production, processing and marketing activities for farming and other business results.

Health facilities and services that have been built in Sidera are 1 sub-center health facility equipped with 1 health worker's house. In carrying out health services, the officer is assisted by 2 traditional nurses. Doctors serving residents are incidental or only in under certain conditions. In terms of improving public health services, health workers, medicines and adequate equipment are needed. Table 5 is describe about health facilities and health workers in Sidera.

### Table 4. Number of Male, Female, Sex Ratio, and Birth dan Death Rate of Sidera

| Nr | Village | Male | Female | Sex Ratio | Birth | Death |
|----|---------|------|--------|-----------|-------|-------|
| 1  | Sidera  | 1,231| 1,238  | 99        | 16    | 7     |

The types of diseases that attack and the number of people affected by these diseases in the past year, such as malaria 11 people, vomiting 36 people, digestive tract infections 40 people, acute respiratory infections (ARI) 125 people, skin diseases 39 people and wounds 6 people. It is known that there are quite a lot of types of diseases at Sidera. This is related to the use of toxic chemicals in every farming activity that causes diseases such as digestive tract infections, ARI, and other skin diseases.

In an effort to control population growth at Sidera, there are 2 family planning posts were built which were served by 1 officer (PLKB). As for the use of contraceptives such as pills, 60 people, 5 spirals/IUDs, 1 kodom, 53 injections and 20 implants. This shows that the level of awareness in controlling birth is quite good.

In some previous study, it is stated that resettlement is a very complex process that goes beyond the mere rehousing of the survivors. It implies the social reconstruction of homes, social and political ties, and livelihoods at large [15]. These ties are rooted in long cultural, social, economic, and political histories and are often constrained by structural forces [15]. In this study at Sidera resettlement area, all of that statement by scholars as is mentioned are proved.
3.3. Economic Opportunity in Sidera Resettlements Area

Onion or Shallots are one of vegetable varieties to be a leading commodities that have important meaning for the community, both in terms of high economic value and nutritional content. Almost every dish uses onion as a complementary seasoning. This commodity is also a source of income and employment opportunities that contribute quite high to the economic development of a region. Although the interest of farmers in cultivating shallots is quite strong, the process of exploitation is still facing various obstacles, both technical and economic constraints.

In 2014 onion production in Central Sulawesi reached 2.85 ton/ha, with productivity at least 5.24 ton/ha and harvested area of 543 ha (BPS, 2015). The low production of onion is caused by the lack of farmers’ absorption of new technology, such as the use of quality seeds, inappropriate use of fertilizers and less attention to pest and disease control (Sutapradja, 1996). Due to increase the production of shallots, it can be taken by optimizing the biological fertility usage instead of using chemical fertilizers. The soil will get an increasing availability of nutrients, mainly unicellular and microscopic one. Increasing crop production can be done by paying attention to production facilities which are supporting factors in the cultivation business.

Beside onion, types of plants that are mostly cultivated at Sidera are types of vegetables such as corn, tomatoes, and chilies. The average area of vegetable cultivation for each household is 0.1 Ha. Total crop area for onion is 12.5 Ha and gained productivity on average is 8-10 tons/ha. Planted area for chili at least 8.25 ha The, while the productivity of chilies is around 10-12 tons/ha.

Annual crops that cultivated by residents at Sidera are very limited, i.e 120 trees of cocoa, 10 coconuts and 85 cashew trees. In other hand, horticultural commodities such as fruit plants, mostly cultivated in this location. i.e 500 mango trees, 300 oranges, 150 jackfruit trees, as well as bananas, pineapples and avocados. The fruit plants are generally productive, and the results are not only for household consumption but also many of them are sold to increase family income. The types of livestock available are 18 cows, 67 goats, 230 chickens and 60 ducks.

Local people of Sidera Village are traditionally reliable farmers or cultivators. This is supported by the availability of sufficient land. On that basis, the main business pattern for improving the economy of the refugees is through farming, especially the dry land food crop pattern. Based on the analysis of land suitability, climate suitability and topography, it is recommended that the yards for the cultivation of shallots and corn be the main commodities in Sidera.

In some previous study, it is stated that resettlement process will be succesful whenever some requirements are to lade, such as increase in the levels of home ownership, the relocation process has been participatory, adequate size and quality of housing, reestablishing such a community-place relationship in a new environment requires a long period of time that is contrary to the collective wish of disaster survivors to settle back as quickly as possible [15]. For these reasons, resettlement often fails to foster post-disaster resilience [16]. Again, in this study, all of the statement was proved.

3.4. Accessibility

The location of Sidera can be easily reached from the city of Palu by using a vehicle through a 15 km asphalt road. The accessibility level of Sidera is quite good, between the city of Palu (capitol city of Central Sulawesi Province) to Sidera location connected by good infrastructure. Moreover, on holidays this location can be a choice of recreation for Palu city residents as well as to buy vegetables for family needs. Figure 5 shows the accessibility condition of Sidera.
Fig 5. Accessibility Map of Sidera Resettlement Area

To support the economic flow, it is necessary to provide transportation facilities between the regions and the village itself, so that the traffic, both motorized and non-motorized vehicles, can operate properly. The dominant means of transportation in Sigi Biromaru sub-district are motorbikes (two wheels) and cars (four wheels). The transportation situation from Sidera to the market center (city) is presented in the Table 6.

In order to streamlined agriculture commodities and other economic businesses, it is very necessary to provide infrastructure and transportation facilities. Transportation facilities also can make social facilities such as health centers, clinics, schools, places of worship, markets, recreation areas, playgrounds, sports venues, multipurpose rooms, tombs, and so on much more accessible.

Table 6. Transportation Condition in Sidera

| Nr | Items                              | Market (City) |
|----|------------------------------------|---------------|
|    |                                    | Sub-District  | Regency  | Province  |
| 1. | Distance from settlement area (Km) | 5             | 40       | 15        |
| 2. | Transportation modes               | 4 wheel       | 4 wheel  | 4 wheel   |
| 3. | Frequency                          | 3 times a week| Daily    | Daily     |
| 4. | Travel time                        | 20 minute     | 1 hour   | 1 hour    |

Regarding the importance of accessibility of disaster resettlement location, some precious study mentioned that well-planned disaster recovery and development processes have the potential to improve the long-term stability of the communities, for instance relocation site accessibility [17]. Post disaster development policies have major positive and negative consequences for communities, in both the short and long term [18]. Unfortunately, all of the requirements that stated by previous study was conducted in Sidera resettlement process.

3.5 Disaster Vulnerability of Sidera Area

Geologically, Sidera is situated in unvulnerable zone, especially fault zone. The altitude of Sidera also quite high, so it is not vulnerable with tsunami as well. The decision to choose Sidera as resettlement area for refugees is very smart. Figure 6 illustrated how Sidera location is an ideal for settlement, not only in term of disaster vulnerability consideration, but also good accessibilities for people.
Fig 6. Aerial Photo (A) and Settlement Site Design (B) of Sidera Resettlement Area

It is very important to guarantee that resettlement site are save and unvulnerable for disaster. Some scholars stated in previous study such as Davis, Quarantelli, and Oliver-Smith, that resettlement through geographical relocation is usually considered as the worst alternative to spur people’s resilience [15]. So, the process of resettlement site selection in Sidera was a good choice, considering this location are safely.

4. Conclusions and Recommendation

Sidera resettlement site has the feasibility to be developed into a residential unit. This is based on the results of studies from various aspects, i.e spatial planning, soil, topography, land use, socio-economics, and disaster vulnerability. The feasibility of the prospective location is assessed on the basis of four criteria, namely (1) Liveable (disaster invulnerable, endemic disease free, clean water availability, accessible, and physiographically suitable), (2) Marketable (agro-production, agro-industrial, and agro-business availability), (3) Expandable (networking opportunities, commodity excellency, and acceptable), and (4) Environmental Friendly (environmental harmful-free, environmentally preservation, and socio-cultural sustainabilities).

Some recommendation of post resettlement are: (1) it is need to conduct agricultural business development with commodities and cropping patterns in accordance with agro-climatic conditions in the study location, as well as developing household-based processing industries and marketing, and (2) it is also need to activate role of the government in order to counseling and training of refugees on methods, technology, and management of farming and rural sector businesses in a broad sense.

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References

[1] Hermon, D. (2014). *Geografi Bencana Alam*. Jakarta: Radja Grafindo Persada Press
[2] Kusumasari, B. (2014). *Manajemen bencana dan kapabilitas pemerintah lokal*. Yogyakarta: Penerbit Gama Media
[3] Lestari, P., Prabowo, A., Wibawa, A. (2012). Manajemen Komunikasi Bencana Merapi 2010 pada saat tanggap darurat. *Jurnal Ilmu Komunikasi*. Vol. 10, No. 2, [173-197]
[4] Nurhadi., Suparmini., Ashari, A. (2018). Strategi penghidupan masyarakat pasca erupsi 2010 kaitannya dengan kesiapsiagaan menghadapi bencana berikutnya. *Majalah Geografi Indonesia*. Vol. 32, No. 1, [59-67]
[5] Sudibyakto, H. A. (2011). *Manajemen bencana di Indonesia ke mana?*. Yogyakarta, UGM Press.
[6] Srihariani. (2010). Membangun masyarakat sadar bencana. *Jurnal Dakwah*, Vol. XI, No. 2, [157-
171
[7] Anonimous, (2007). Undang-undang Republik Indonesia Nomor 24 Tahun 2007, tentang Penanggulangan Bencana
[8] Wulansari, M.A.D., and Wihardayanto, D. (2017). Metodologi penilaian kualitas hunian paska bencana sebagai evaluasi strategi rekonstruksi; analisis faktaual dan perceptual. Langkau Betang. Vol. 4, No. 2. [89-94]
[9] Klein, Naomi. (2007). Shock Doctrine: The Rise of Disaster Capitalism. Random House of Canada. Canada
[10] Chambers, R. (1983). Pembangunan Desa Mulai Dari Belakang. Jakarta: LP3ES
Dirjen Pembinaan Pengembangan Masyarakat dan Kawasan Transmigrasi. (2006). Kota Terpadu Mandiri, Jakarta
[11] Oliver-Smith, A. (2015) Post-Disaster Resettlement: The Transition to the New Community in Gramalote, Colombia, Natural Hazards Center: University of Colorado Boulder
[12] Vijekumara, P A. (2015) A Study on the Resettlement Planning Process Applied in Post-Landslide Disaster Resettlement Projects in Sri Lanka, NBRO Symposium: Innovations for Resilient Environment
[13] Badri, S.A., Asgary, A., Eftekhari, A.R., & Levy, J. (2006). Post-disaster resettlement, development and change: a case study of the 1990 Manjil earthquake in Iran. Disasters, pp 451−468.
[14] Sherbinin, A. D., Castro, M., Gemenne, F., Cernea, M. M., Adamo, S., Fearnside, … Shi, G. (2011). Preparing for Resettlement Associated with Climate Change. SCIENCE, VOL 334, 456-457.
[15] Gaillard J.C. (2015) Post-Disaster Resettlement. In: People’s Response to Disasters in the Philippines. Disaster Studies. Palgrave Macmillan, New York
[16] Oliver-Smith, Anthony. 1991. “Success and Failures in Post Disaster Resettlement.” Disasters, 15: 12 24.
[17] Hall, A. (1994) Grassroots Action for Resttlement Planning: Brazxil and Beyong. World Development 22(12) pp 1793-1809
[18] Afolayan, A A., (1987) The Sosa Resttlement Project: A Study in Problems of Relocation., Habitat International, 11(2) pp. 43-57