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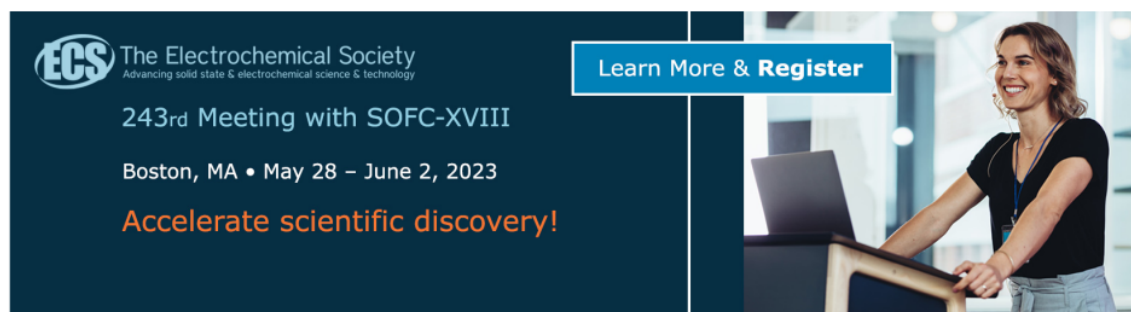
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# Mass movement disaster risk mitigation in Clapar district and surrounding area, Banjarnegara Regency, Central Java

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**Abstract**. The mass movement that affected by gravitation as it went down mainly occurred repeatedly during the rainy season in the same area. Until now, there was no clear method to anticipate it. Therefore, maximum management was unable to be implemented. Banjarnegara regency-Central Java, known as one of the high-risk regency. The movement typeset was not also avalanche, but also flow, collapse, creep, and complex movement. Mass movement research during 2017-2018 showed that land and rock in Clapar and its surrounding, was horizontally moved for 0.15-0.58 meter, and vertically moved for 0.01- 0.31 meter. Community-based disaster risk management can be utilized to mitigate mass movement through direct adaptation on land and building or cropping type and pattern.

## 1. Introduction

A natural disaster is a phenomenon that can be occurred anytime, every time, and anywhere, that may cause risk or harm for human life, both loss of assets or victims. Landslide is one of geological disaster that may cause great loss of material and victims. Land subsidence is a movement of the material that forms slope in the form of stones, soil, or mix materials that causing it down or outside the slope (SNI 13-7124-2005).

National Disaster Management Agency stated that from 1998 until the middle of 2014, there were 647 occurrences in Indonesia, in which 85% of those were flood and landslide. It can be seen that landslide is a very threatening disaster and important to be concerned, as the frequency of occurrence and total of victims were significant enough. Banjarnegara is a regency which has a mountainous area within the high-risk level of landslide occurrence. On Thursday (11 December 2014) and Friday (12 December 2014), there was at least landslide in 25 locations albeit their small scale (jogja.tribunnews.com). As Banjarnegara renowned as an area which has quite a high potential of the landslide, research of potential assessment of land subsidence is needed.

Clapar village is located in Madukara district, eastern of Banjarnegara and is bordered by Wonosobo regency. Clapar village geographically an approximately ±350 hectares hills area. According to Banjarnegara government, the village is a densely populated. There was a landslide disaster on 28 March 2016. The bridge that crossed along was suddenly bent. The road sunk by land mass.

The disaster must be assessed through sufficient assessment range to ease the assessment. In a wider sight, the village is located in a landslide-prone area in the western part of the village with high

Angle toward the village. Criteria of angle in the western part of the village started from the lowest, middle, and highest put the village in the disaster-prone area.

When subsidence started on 24 March 2016 at 19.00 WIT, continued on 25 March 2016 at 01.30 WIT and 6.00 WIT, the subsidence area was still about 5 hectares with a diameter for about 1.2 km. 9 houses were heavily damaged, 3 houses were partially damaged, and 29 houses were in danger. There aware 158 refugees there. One kind of mitigation is an early warning system to overcome natural disaster and reduce the risk, including data and information related to landslide-prone areas. Thus, comprehensive efforts are needed through mitigation to reduce the risk.

The objectives of this research are to describe mitigation effort and improve disaster mitigation related to landslide mitigation in Banjarnegara regency. Thus, monitoring in certain areas is needed. Through GPS geodetic for a year (2017-2018), it hopefully will be a good example to create an appropriate method and can be used to mitigate landslide disaster in the area.

## 2. Reason and Objectives

The reasons and objectives are to reveal the phenomenon of landslide origin, the impact, and its mechanism analysis geometrically. By knowing the problem, effective and efficient mitigation can be done, and it can be a guideline to reduce the risk in another similar area.

## 3. Research Method

The landslide that occurred in Clapar village in Banjarnegara regency is still taking place until now. High precipitation and land condition contribute to the disaster. Two kinds of monitoring can be done there:

*3.1 Tool setting.*
Tool testing was used to test the tools' ability and smoothness, both GPS geodetic and the supporting software. Software that was used to process the GPS is Software Geogenius.

*3.2. Steps in data collection.*
Positioning through GPS was usually done by measuring the distance from several satellites that each of their locations were detected. Then, the monitoring position can be calculated. Monitoring through GPS technology created coordinates in the form of geodetic coordinate system ($\phi$, $\lambda$, h), three-dimensional Cartesians coordinate (X, Y, Z), and a time parameter. Calculation was implemented through reducing signal bringer phase from the satellites with the raised signal from the receiver.
Data that were utilized in the research were: GNSS data monitoring in November 2017 and April 2018 within eight control locations that were determined land subsidence for $\pm$ 8 hours for each location. Static differential with 15-second sampling rate was used to measure it. The control locations were P1, P2, P3, P4, P5, P6, P7, and P8.

*3.3. Data Steps in data analysis and processing.*
These were the steps to analyze and process the data in the studio and laboratory, followed by discussion and reference study related to the relevant topic:

*3.3.1. Data procession and analysis of GPS monitoring.* The next step was to download the data from the receiver to the laptop. Downloaded data were in the form of the raw data file and then converted into remix file data type. Two steps were done here: (1) average baseline calculation, (2) network adjustment calculation.

During average baseline calculation, a simple method was implemented, which was through taking an average of coordinate points within the same location, by giving them same value proportionally. Monitoring value was taken from the standard deviation of the average of statistical calculation for relevance points.

Based on final adjustment through an averaging method for the whole baseline, analysis value for each standard deviation for each coordinate can be known. These coordinate values or results that were processed by using Geogenius software were coordinate within in geographical system and UTM projection coordinate system.

*3.3.2. Land subsidence analysis.* Based on historical events within the research area, basic indicators can be determined as the base of land subsidence. Through geodetic monitoring and measurement, the degree of land subsidence during certain of time can be known to determine an estimated event in the future. Land subsidence analysis can be done through a statistic test. It was through the parameter significance differential test. It was used to know that the subsidence was proven statistically. Organizing community.

Capacity building process and awareness building on disaster risk management in the community started with local trainers at the village level. Facilitators of DRR actors are selected to encourage public awareness and mitigation action.

*3.4. Disseminating programmed.*
Community believes that good disaster risk reduction is the responsibility of all parties and is carried out all the time before disaster occurs, during a disaster and after a disaster, and in disaster risk reduction activities should be community based, as the community as the beneficiary directly, as weak as the community still has the ability to conduct DRR activities, the community is better understood its territory. Early Warning System. Information is fast and from the right source is very helpful in the preparedness of people who are in disaster-prone areas. To mitigate mass movement, community action through direct adaptation on land and building or cropping type and pattern.

*3.5. Maintain Sustainability.*
Eliminating dependency can only occur if the institutional sustainability in the community and disaster risk management activities is carried out continuously. For that done to share trigger activities in the form of Disaster Preparedness Team, Joint open event to rehabilitation.

## 4. Result and Discussion

*4.1. Results of Software Geogenius Analysis.*
Estimation results of X, Y, Z coordinated and the measurement in the geographical coordinate system during 2017-2018 can be seen in Table 1 and 3. Table 2 and 4 are also shown an estimation of X, Y, Z components within their UTM coordinate system in 2017 and 2018. The estimation results are obtained through *GPS Geodetic - software Geogenius*.

**Table 1.** 3D Component value (X, Y, Z) and their measurement within the geographical coordinate system in 2018.

| Point | Latitude (LS) | Longitude | High (m) | Accuracy (mm) | | |
|-------|---------------|-----------|----------|---------------|---|---|
| | | | | Latitude | Longitude | High |
| P1 | 7° 21' 08.82598" | 109° 45' 52.34976" | 769,016 | 12,9 | 20,4 | 53,7 |
| P2 | 7° 21' 12.72396" | 109° 45' 52.09993" | 758,206 | 39,5 | 42,3 | 73,1 |
| P3 | 7° 21' 08.23575" | 109° 45' 59.51515" | 762,141 | 26,5 | 24,1 | 61 |
| P4 | 7° 19' 55.62834" | 109° 46' 19.56972" | 865,406 | 17,5 | 31,2 | 54,7 |
| P5 | 7° 19' 46.77739" | 109° 46' 14.50891" | 837,616 | 33 | 54,9 | 88,4 |
| P6 | 7° 18' 40.74416" | 109° 44' 25.95218" | 762,659 | 15,8 | 22,3 | 58,7 |
| P7 | 7° 18' 40.00674" | 109° 44' 27.04483" | 767,118 | 27,5 | 21,8 | 58 |
| P8 | 7° 18' 41.79185" | 109° 44' 28.60675" | 748,67 | 19,1 | 32,2 | 58,9 |

**Table 2.** Component value (X, Y, Z) and their measurement within the UTM coordinate system in 2018.

| Point | X (m) | Y (m) | Z (m) | Accuracy (mm) | | |
|-------|-------|-------|-------|---------------|---|---|
| | | | | X | Y | Z |
| P1 | 363637 | 9187100 | 769,017 | 27,1 | 50,1 | 14,9 |
| P2 | 363630 | 9186981 | 758,212 | 60,5 | 62,8 | 33 |
| P3 | 363857 | 9187119 | 762,141 | 27,9 | 58,1 | 29,3 |
| P4 | 364466 | 9189351 | 865,394 | 28,7 | 54,3 | 22,1 |
| P5 | 364309 | 9189622 | 837,556 | 48 | 92,6 | 32,4 |
| P6 | 360975 | 9191641 | 762,671 | 28,4 | 54,9 | 19 |
| P7 | 361008 | 9191664 | 767,118 | 26,7 | 53,9 | 31,4 |
| P8 | 361056 | 9191609 | 748,652 | 32,5 | 58,2 | 20,9 |

**Table 3.** Component value (X, Y, Z) and their measurement
within the geographical coordinate system in 2017

| Point | Latitude (LS) | Longitude | High (m) | Accuracy (mm) | | |
|---|---|---|---|---|---|---|
| | | | | Latitude | Longitude | High |
| P1 | 7° 21' 08.82578" | 109° 45' 52.34987" | 769,02 | 5 | 5,3 | 12,9 |
| P2 | 7° 21' 12.72466" | 109° 45' 52.09840" | 758,27 | 6,1 | 6,4 | 19,3 |
| P3 | 7° 21' 08.23721" | 109° 45' 59.51445" | 762,199 | 6,2 | 7,6 | 18,6 |
| P4 | 7° 19' 55.60890" | 109° 46' 19.57531" | 865,74 | 7,9 | 10,7 | 23,8 |
| P5 | 7° 19' 46.77745" | 109° 46' 14.50869" | 837,678 | 6,4 | 9,2 | 22,5 |
| P6 | 7° 18' 40.74369" | 109° 44' 25.95198" | 762,581 | 5,7 | 5,9 | 17,4 |
| P7 | 7° 18' 40.00632" | 109° 44' 27.04370" | 767,104 | 5,4 | 5,8 | 14,7 |
| P8 | 7° 18' 41.78840" | 109° 44' 28.60692" | 748,494 | 5,7 | 7,1 | 18,1 |

**Table 4.** Component value (X, Y, Z) and their measurement
within the UTM coordinate system in 2017.

| Point | X (m) | Y (m) | Z (m) | Accuracy (mm) | | |
|---|---|---|---|---|---|---|
| | | | | X | Y | Z |
| P1 | 363637,0128 | 9187100,364 | 769,017 | 12,9 | 20,4 | 53,7 |
| P2 | 363629,687 | 9186980,621 | 758,212 | 39,5 | 42,3 | 73,1 |
| P3 | 363856,6818 | 9187119,098 | 762,141 | 26,5 | 24,1 | 61 |
| P4 | 364465,5179 | 9189350,904 | 865,394 | 17,5 | 31,2 | 54,7 |
| P5 | 364309,4685 | 9189622,294 | 837,556 | 33 | 54,9 | 88,4 |
| P6 | 360974,9291 | 9191641,317 | 762,671 | 15,8 | 22,3 | 58,7 |
| P7 | 361008,3722 | 9191664,062 | 767,118 | 27,5 | 21,8 | 58 |
| P8 | 361056,3907 | 9191609,36 | 748,652 | 19,1 | 32,2 | 58,9 |

*4.2. The accuracy of X, Y, Z components.*

Through GPS – Geogenius Sofware data processing, the standard deviation value of XYZ in 2017 and 2018 can be known. It is used to see the accuracy of XYZ coordinates every year. Figure 1 depicts comparison of XYZ coordinates for 1 year (2017-2018). Based on figure 1, the highest average accuracy is a P1 point for 2017 and 2018. The lowest average accuracy is P5 for 2017 and 2018. If these are being put for 2017 and 2018, it will be P1, P6, P4, P7, P8, P3, P2, and P5.



**Figure 1.** Comparison graphic of XYZ coordinates for 2017 and 2018.

*4.3. Horizontal and Vertical Subsidence Value.*

Table 5 shows the difference in XYZ coordinates within 1 year. Table 6 shows horizontal and vertical subsidence value within 1 year from 2017 until 2018. Then, image 7 depicts the quality and direction of land subsidence in Clapar within 1 year (2017-2018). Vertical subsidence is in a negative value, which can be concluded that decreased subsidence is proved there. Meanwhile, a positive value means that increased subsidence is proved.

**Table 5.** Differential value of XYZ coordinates from 2017 until 2018

| Point | $X_i$ (m) | $Y_i$ (m) | $Z_i$ (m) | $X_i$ (mm) | $Y_i$ (mm) | $Z_i$ (mm) |
|-------|-----------|-----------|-----------|-----------|-----------|-----------|
| P1 | -0,01041 | -0,00555 | -0,069 | -10,41 | -5,55 | -69 |
| P2 | 0,04869 | 0,02256 | -0,014 | 48,69 | 22,56 | -14 |
| P3 | 0,02288 | 0,04367 | -0,1 | 22,88 | 43,67 | -100 |
| P4 | -0,16957 | -0,56346 | -0,311 | -169,57 | -563,46 | -311 |
| P5 | -0,14401 | -0,04493 | -0,103 | -144,01 | -44,93 | -103 |
| P6 | -0,00699 | -0,02428 | 0,108 | -6,99 | -24,28 | 108 |
| P7 | 0,03262 | -0,04229 | 0,092 | 32,62 | -42,29 | 92 |
| P8 | -0,0902 | -0,09332 | 0,069 | -90,2 | -93,32 | 69 |

**Table 6.** Value and direction of horizontal and vertical subsidence from 2017 until 2018

| Point | HORIZONTAL (m) | VERTICAL (m) | HORIZONTAL (mm) | VERTICAL (mm) | ARAH (RADIAN) |
|-------|----------------|--------------|-----------------|---------------|---------------|
| P1 | 0,011797058 | -0,069 | 11,79705845 | -69 | 1,080989 |
| P2 | 0,053662554 | -0,014 | 53,66255418 | -14 | 1,136905 |
| P3 | 0,049300742 | -0,1 | 49,3007422 | -100 | 0,482607 |
| P4 | 0,588422602 | -0,311 | 588,4226019 | -311 | 0,292323 |
| P5 | 0,150856173 | -0,103 | 150,8561732 | -103 | 1,268374 |
| P6 | 0,025266154 | 0,108 | 25,2661537 | 108 | 0,280311 |
| P7 | 0,053408881 | 0,092 | 53,40888055 | 92 | -0,65702 |
| P8 | 0,129786988 | 0,069 | 129,7869879 | 69 | 0,768399 |

*4.4. Analysis Results on Horizontal and Vertical Subsidence.*
Horizontal and vertical subsidence value that is achieved during 2017-2018 is analyzed through statistic test, which is the parameter significance differential test. It is used to reveal the real score of horizontal and vertical, which can be caused by subsidence or only random error on control points. Image 7 shows the parameter significance differential test results.

**Table 7.** Parameter significance differential test results

| Joint | Test to difference X | Test result | Test to difference Y | Test result | Test to difference Z | Test result |
|-------|---------------------|-------------|----------------------|-------------|----------------------|-------------|
| P1 | -0,78986 | not significant | -0,27063 | not significant | -123,353 | **significant** |
| P2 | 1,223657 | not significant | 0,530471 | not significant | -87,7944 | **significant** |
| P3 | 0,857916 | not significant | 1,799926 | not significant | -31,472 | **significant** |
| P4 | -8,96093 | **significant** | -17,8321 | **significant** | -367,992 | **significant** |
| P5 | -4,29355 | **significant** | -4,81612 | **significant** | -192,471 | **significant** |
| P6 | -0,43608 | not significant | -1,07706 | not significant | 48,95214 | **significant** |
| P7 | 1,180916 | not significant | -1,9301 | not significant | 33,47787 | **significant** |
| P8 | -4,57438 | **significant** | -2,87919 | not significant | 9,099917 | **significant** |

Based on table 7, the test is significant for vertical subsidence within all control points. Meanwhile, significant results for horizontal subsidence can be seen on point p4 and point p5.

*4.5. Subsidence adaptation for mitigation.*
Community-based disaster risk management can be utilized to mitigate mass movement through direct adaptation on land and building or cropping type and pattern.

**5. Conclusion and Suggestion**

*5.1. Conclusion.*
Several judgments can be concluded. Based on the statistic test during 2017-2018, horizontal and vertical subsidence are occurred within point p4 and point p5. For point p1 until p8, subsidence is limited vertically. Thus, there is no horizontal subsidence within point P1, P2, P3, P6, P7, and P8.

The results are right spot on with the condition during the measurement within a year, which rainy season was quite long at that time. Thus, both horizontal and vertical subsidence occurred within the control points. Table 8 shows the value of horizontal and vertical subsidence during 2017-2018

**Table 8.** The values of occurred horizontal and vertical subsidence

| Point | HORIZONTAL (m) | VERTICAL (m) | HORIZONTAL (mm) | VERTICAL (mm) |
|---|---|---|---|---|
| P1 | minus sign on | -0,069 | minus sign on | -69 |
| P2 | horizontal | -0,014 | horizontal | -14 |
| P3 | subsidence | -0,1 | subsidence | -100 |
| P4 | 0,588422602 | -0,311 | 588,4226019 | -311 |
| P5 | 0,150856173 | -0,103 | 150,8561732 | -103 |
| P6 | minus sign on | 0,108 | minus sign on | 108 |
| P7 | horizontal | 0,092 | horizontal | 92 |
| P8 | subsidence | 0,069 | subsidence | 69 |

Table 8 shows that control point p4 undergone horizontal subsidence, with 0.58-meter subsidence and p5 undergone horizontal subsidence, with 0.15-meter subsidence. Furthermore, control point p4 undergone vertical subsidence, with 0.31-meter subsidence. For control point p2, it undergone the least vertical subsidence, with 0.01-meter subsidence. The minus sign on vertical subsidence shows its decreased subsidence.

*5.2. Suggestion.*
Several suggestions can be taken. The measurement was done in a relatively similar meteorological condition between 2017 and 2018, as the results are heavily affected by meteorological condition during the measurement. Information from another field such as physical status, material character, voltage, and load connectivity is needed to make the results more accurate.

**References**
[1]     Abidin H Z, Andreas H, Gamal M, Sadarviana V, Darmawan D, Surono, Hendrasto M and Suganda O K 2007 Studying landslide displacements in the ciloto area (Indonesia) using gps surveys *J. Spat. Sci.* **52.**
[2]     Apriyanti D 2014 *Analisis Pergerakan Horizontal Waduk Sermo Tahun 2012-2013 Berdasarkan Hasil Hitung Perataan Parameter Berbobot* (Yogyakarta: Universitas Gadjah Mada).
[3]     Caspary W F 1987 *Concept of Network and Deformation Analysis* Edition School of Surveying (Kensington : The University of New South Wales).
[4]     Gikas V and Sakellariou M 2008 FIG *Symp. on Deformation Measurement and Analysis* (Lisbon: lnec).
[5]     Howard A D 1967 Drainage analysis in geologic interpretation: A summation *Am. Assoc. Pet. Geol. Bull.* **51** 2246-2259.
[6]     NASA 2015 *The IGS Tracking Network* (Pasadena : International GNSS Service).
[7]     Postuma J A 1971 *Manual of Planktonic Foraminifera* (Netherlands: Royal Dutch/Shell Group)
[8]     Rickard M J 1972 Fault classification: discussion *Geol. Soc. Am. Bull.* **83** 2545-2546.
[9]     Rizos C 1997 Principles and Practice of GPS Surveying (Sydney: The School of Geomatic Engineering, The University of New South Wales).
[10]    Streckeisen A 1967 Classification and nomenclature of igneous rocks *Nues Jarb. fur Mineral. Abhandlungen* **107** 144-240.
[11]    Verstappen 1985 *Geomorphological Surveys for Eviromental Development* (Amsterdam: Elsevier Science Publishing Company Inc).

[12]   Widjajanti N 2010 Deformation *Analysis of Offshore Platform using GPS Technique and its Application in Structural Integrity Assessment* (Malaysia: Universiti Teknologi PETRONAS).

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