Plagiarism Checker X Originality Report

Similarity Found: 11%

1 Land subsidence analysis in Bandar Lampung City based on InSAR A Zaenudin1*, I G B Darmawan1, Armijon2, S Minardi3 and N Haerudin1 1Geophysical Engineering, University of Lampung, Bandar Lampung 35145, Indonesia 2 Geodesy Engineering, University of Lampung, Bandar Lampung 35145, Indonesia 3 Physics Department, University of Mataram, Indonesia *ahmad.zaenudin@eng.unila.ac.id Abstract.

Bandar Lampung is one of the cities in Indonesia, which has the potential to land subsidence due to human activities or natural phenomena. However, it is still lack of information and the study of land subsidence that was ever made. This research used 15 SARs data in the intervening years from 2006 to 2011 and was combined to produce the interferogram, and then, it was inverted by using SBAS algorithm. Based on data analysis, SBAS technique was reliable enough to determine the deformation symptoms quickly and accurately.

However, some locations had indications of subsidence more than 5 mm/year, even the highest reaches more than 30 mm/year which is identified in the Campang Raya, Camang, Kangkung, Sukaraja, Bakung, and Beringin Raya. Subsidence that occurred is suspected caused by tectonic and human activities and is more likely to occur in the new area suffered by land conversion.

Subsidence that occurred implies on damage to the building structure, the occurrence of tidal flooding in coastal areas, and landslides in hilly areas.

1. Introduction Land subsidence is the decline in land surface that is experienced by many cities in Indonesia and in the world. This phenomenon is the decrease of the soil surface due to several reasons: excessive groundwater exploitation, ground surface loading by construction and infrastructure, natural consolidation of alluvium, and tectonic activity [1]. In western

Indonesia, it was analysed for several cities experiencing an average subsidence above 22.5

cm/year. In Medan, Jakarta, Bandung and Semarang are caused by groundwater extraction for industry. In Arun, Lhoksumawe it is due to natural gas extraction and in Sidoarjo due to the discharge of the mud from the soil [2]. Land subsidence in urban areas is usually caused by a combination of excessive extraction of groundwater, the natural consolidation of alluvium soils, construction costs (i.e. high compressibility soil settlement), and sometimes tectonic activity.

The same phenomenon can occur in Bandar Lampung, due to the rapid changes of land use, the increasing exploitation of ground-water and the activity of the Panjang-Lampung Fault that crosses the city. To view the phenomenon, we examine it using DInSAR with the SBAS algorithm. 2 2. DInSAR-SBAS In the study of land subsidence in an area, the DInSAR - SBAS method can be selected to study the symptoms of ground subsidence because it has a wide range of spatially and temporally and has high accuracy.

InSAR is a very powerful technique for detecting deformations at a point in the LOS direction occurring between two SAR acquisitions that lead to a phase displacement (?? ?? ??). DInSAR technique has a deficiency that is still having the influence of the atmosphere and still having the influence of phase components due to topography and due to flattening imperfect [3].

To eliminate the influence of atmospheric propagation and topographic phase components, several algorithms have been developed, one of which is the Small Baseline Subset (SBAS) technique. 3. Data and Processing The research data used in the implementation of this research are: (a) ALOS-PALSAR dataset in horizontal aligned polarization (HH) in descending acquisition mode in Bandar Lampung City region obtained from ASF ALASKA (table 1).

Digital Elevation Model DEM) SRTM 1-Arc Second area of Bandar Lampung and surrounding areas obtained from Earth Explorer - USGS. Errors in the unwrapping process, the noise on the interferogram, as well as errors in data processing can lead to inconsistent deformation patterns. The quality index of the deformation data is also called the temporal coherence factor (Ctemp).

So by analyzing the value of Ctemp (figure 1(a)), it can be known that the pixel has reliable information, which is generally shown in the threshold value (generally > 0.7) [3]). Table 1. SAR dataset . No. Acquisition Date Acquisition Type No. Acquisition Date

Acquisition Type 1 21-12-2006 FBS 11 10 -02 -2009 FBS 2 23-06 -2007 FBD 12 01 -07 -2010 FBD 3 08 -08 -2007 FBD 13 16-08 -2010 FBD 4 23-09 -2007 FBD 14 01 -10 -2010 FBD 5 08 -02 -2008 FBS 15 16-02 -2011 FBS 6 10 -05 -2008 FBD 7 25-06 -2008 FBD 8 25-09 -2008 FBD 9 10 -11-2008 FBS 10 26-12-2008 FBS Based on figure 1(a), the C temp value is strongly influenced by the type of land cover in the study area, where in the dynamic areas (agricultural and forest) tend to have low Ctemp values, whereas in statutory population areas the Ctemp is high.

Accuracy of the result of deformation measurement in study area is obtained from several parameters such as coherence and wavelength which then calculated so that will get estimation of measurement accuracy (standard deviation), where the bigger value will be lower accuracy of measurement and vice versa. Estimation of measurement accuracy is calculated by the following equation [3]: ?? = v 1 - ?? 2 2 ?? 2 ?? 4 ?? (1) whsis he earemnt cccy,? ierfmc hence,a the elgus.

3 Based on the measurement accuracy estimat io(s e ueo figure 1(b)) tends to be inversely proportional to the Ctemp value (figure 1(a)),se he ue fsis lctedb n he value of Ctemp. Thmasue cuy) s u ig(2 -50 mm/year) in a dynamic area (high-vegetation are ncthvae fsis t fy abitermo easuremnto undsube in the millimetre order, no relevance that can be obtained in these areas. As ourbars oinatedbbingandhigwa e lue fsrangefm0to0 mm/year.

Accuracy is quite high considering the urban areas tend to be static (not experiencing significant changes) from time to time. Therefore, the result of SBAS measurement having high reliability is mostly obtained in urban area. (a) (b) Figure 1. (a) Temporal coherence map and (b) Precision velocity map.

In the inversion process to get the value that represents the deformation velocity model in the research area, linear regression is done by using Least Square method on time -series deformation data. To know the quality of the fitting of the inversion model used for the time -series data, the n a nonparametric comparative test using Chi Square method (kai square) is used. The low value of Chi Square shows good fitting to the regression line, and vice versa (figure 2(b)).

The result of calculation of Chi Square test on the result of this researc h is shown in chi squre map in figure 2. The value of Chi Square of the linear inversion model (figure 2(a)) is quite low in average value indicating that the fitting between the linear regression model chosen in the inversion process with the time-series data is quite good, although in some regions especially the high subsidence rate tends to have a high value of Chi Square because the trend of time -series data in the area tends to be non -linear

(parabola).

However, since the area with high Chi Square is not very dominant, the linear inversion model is still considered to be relevance enough to represent the deformation velocity in this study. 4. Analysis and Interpretation The result of SAR data processing using SBAS technique in this research produces information about deformation speed in Line of Sight (LOS) direction in Bandar Lampung City (figure 3) with data resolution of 20 × 20 meter.

The deformation velocity data in this study was limited to areas with an accuracy of <7 mm/year and temporal coherence> 0.7. The deformation speed in figure 3 refers to the direction of LOS (Line of Sight) and in the vertical direction (z-axis) referenced at a reference point which is a stable region (not deformed in 2006-2011).

Coherence Precision velocity (mm/year) 4 The deformation velocity in the LOS direction has a positive value (green colour scale) to represent the relative up end deformation and the negative LOS velocity (red colour scale) to represent relative deformation away from the satellite direction (subsidence). Indication of land subsidence in Bandar Lampung City spatially has two main patterns, namely patchy (<10 km2) in coastal area of Lampung Bay and Kemiling District, and local (10 - 100 km2) in Eastern part of Bandar Lampung City, that is in area East Tanjung Karang. (a) (b) Figure 2.

Chi Square map (a) Example of time -series data from two point adjacent to identical subsidence rate, but with very different Chi Square values. The black line is a time -series with a large Chi Square value (b). For the analysis process in this study, two approaches are used, the first to investigate the indication of land subsidence on a regional scale, by identifying areas that have high indication of land degradation based on the measurement of SBAS.

Further an alytics were conducted on a smaller scale (local) aimed at limiting the discussion to only certain areas to reduce the complexity of the subsurface geological conditions as well as the varied causes of ground subsidence. Therefore, in this study, only six observations were done to indicate land subsidence (mean > 5 mm/year in the area 200 × 200 met res) which is expected to represent the cause factors and the pattern of land subsidence according to Chaussard [2] as depicted in f igure 3.

The result of observa tion in the A area (f igure 3) shows the area indicated to land subsidence with an average speed of 9 mm/year, in Campang Raya Village. Graph of land subsidence is shown in f igure 4 (a) . The process of land subsidence in the A area correlates to land use in this area, where in this area it is an industrial area and densely

populated residential.

The pattern of soil surface decline velocity tends to be higher in the South, that is, around t he industrial estate. The development of industrial estate and settlements in this area caused additional load to the soil layer and also increased groundwater exploitation. The process of land subsidence in B area which is the area of Camang Mount (f igur e 4 (b)), which on average undergoes a decrease of 7.4 mm/year.

In addition to this, there is also intensive land conversion at the peak of Camang Mount into a luxury residential. Decreased ground level is possible although in fact Camang Mount is composed of tuff-tuffit, because the decrease of land surface due to mining activities and land conversion can intensively affect all kinds of rocks [2]. ChiSqr 5 Figure 3.

The location on the indicated area has subsidence more than 5 mm/year in Bandar Lampung City. Figure 4. The land subsidence in (a) Campang Raya Village (industrial area) and (b) B area (Camang Mount and surrounding area). In C area, the land subsidence is detected in densely populated areas in Pasar Kangkung, South of Teluk Betung (figure 5(a)), with a characterized spatial pattern of less than 10 km2 (patchy). This area indicates a decrease in ground level with an average speed of 14.7 mm/yr.

The D area is one of the beach reclamation projects on Sukaraja, South of Teluk Betung. In the west, the reclaimed area is currently used as a coal deposit site, but the East is still an untapped land. The land of reclaimed land is still largely unconsolidated and well-compacted, so that the physical properties and mechanics of the embankment material may potentially subsided, and based on the results of SBAS measurements, the land subsidence in this area averaged 30.5 mm/yr, as shown in figure 5(b).

Indication of land subsidence in the southwest of Bandar Lampung City shows an interesting pattern of land subsidence in a residential area in Bakung Village, West Teluk Betung District. In this area, it was found anomalous land subsidence that is very contrast with the surrounding area that tends to be stable. This area has decreased ground level with an average speed of 15.23 mm/year (figure 6(a)).

Based on observations in the field, this area has morphology of syncline (valley) which is located between three hills and the northern part is a swamp, while in the south stands a residential area. This then leads to the occurrence of underground layer compaction in the form of organic materials that can experience decomposition and also compression due to building loads on it. Displacement (mm/year) (a) (b) 6 Figure 5.

The land subsidence in (a) C area (Pasar Kangkung, South of Teluk Betung) and (b) D area (Sukaraja reclamation area). Decreased ground level is indicated in Kelurahan Beringin Raya, Kemiling Sub-district (F area), which is dominated by clay-rich layer. The average decrease in this area based on the SBAS measurement is 16.04 mm/yr which is shown in figure 6(b).

Due to the area dominated by the clay- rich layer, so the mechanics of the soil is what is suspected as the cause of the decrease of ground level in this area. Land that is cohesive (clay-rich soil) is very likely to decrease the face of the soil, because this layer is very sensitive to changes in water content (soil moisture). This makes it expanding when moist/wet, and then shrinking when dries (volumetric change). Figure 6.

The land subsidence in (a) E area (Bakung area) and (b) F area (Beringin Raya, Kemiling). Table 2. Compilation of the observations made in the six locations experiencing subsidence. Location Average vert. rate (mm/year) Spatial pattern Surface geology Correl. with surface geology Land use Correl.

with land use Interpreted cause of rapid subsidence Campang Raya (A) 9 local Surficial deposits × Industrial and residential Industrial water extraction and loading structure Camang Mount (B) 7,4 patchy Surficial deposits (tuff tuffit) × Residential and mining Water extraction and mining Pasar Gudang Lelang (C) 14,6 patchy Surficial deposits (sandstone) Residential and trade and services Water extraction by residence and industry Reclamation Area, Sukaraja (D) 30,5 patchy Surficial deposits (alluvial) Industrial and stockpiling of coal consolidation of embankment material Bakung (E) 15,5 patchy Surficial deposits and peat Residential and swamp decomposition of organic matter and loading structure Beringin Raya (F) 16 patchy Surficial deposits (clay) Residential and vacant land × volume shrinkage in the clay layer (b) (a) (a) (b) 7 The results of the analytics for the six regions of indicated land subsidence are summarized in this section which are then represented in table 2.

The observed area is correlated to the characteristics and factors of lands subsidence in table 2, so as to obtain a provisional estimate of the factors causing land subsidence in Bandar Lampung City based on spatial patterns, land use, and geological conditions. Land subsidence is likely to occur in areas of alteration or land conversion that occurred less than 20 years earlier.

This is why the Central Tanjung Karang and Kedaton areas with high population densities are not indicated to decrease the land surface. Based on the previous statement and if we look at the pattern in figure 5 then it is suspected that the Central of Tanjung Karang area and Kedaton may have already experienced consolidation as it

were developed earlier than other regions, and in the past 10 years has tended to be stagnant in terms of development and conversion of land, this is certainly similar to the statement Sestini (1996) in [1], which states that land subsidence due to reclamation, construction and agricultural activities is limited to the first twenty years or directly after land conversion. 5. Conclusion 1.

The type of land use greatly affects the reliability of the data, the more dynamic the area, the measured deformation speed information by InSAR-SBAS method becomes less precise for the measurement of deformation symptoms in millimetres. SBAS technique is reliable enough to know the symptoms of deformation in Bandar Lampung City quickly and accurately. 2.

Indication of land subsidence is not evenly distributed in all places, but on average Bandar Lampung city decreased the average of 0.06 mm/year with trend which tends to linear. In some areas in Campang Raya, Camang, Kangkung, Sukaraja, Bakung, and Beringin Raya have subsidence more than 5 mm/year, where the highest one is in Sukaraja (> 30 mm/year). 3.

Subsidence with a speed of more than 5 mm/year spatially has two patterns, namely patchy (<10 km2) on the coastal area of Lampung Bay and Kemiling District, and local (10 - 100 km2) in the East Bandar Lampung, that is in East Tanjung Karang area. 4. Land subsidence in Bandar Lampung City occurred due to tectonic activity and also due to human activities (industry, loading, mining, ground water extraction, and land conversion). The above factors affect the speed of land subsidence individually or simultaneously. 5.

Subsidence is not highly correlated to population density and rock lithology, but tends to occur in areas where land conversion is less than 20 years ago. Acknowledgments Acknowledgements were delivered to DRPM Ristekdikti who has funded this research through the grant PPT 2017 and those who have contributed to the success of this research.

References [1] Teatini P, Tosi L and Strozzi T 2011 Journal of Geophysical Research 116 B08407 [2] Chaussard E, Amelung F, Abidin H and Sang-Hong 2013 Elsevier Remote Sensing of Environment 128 150 [3] Casu F 2009 The Small Baseline Subset Technique: Performance Assessment and New Development for Surface Deformation Analysis of Very Extended Areas (Cagliari: University of Cagliari).

INTERNET SOURCES:

<1% -
https://id.123dok.com/document/1y914kwq-proceeding-of-the-1-international-conference-on-science-st-technology-and-interdisciplinary-research-2015.html

1% - https://www.researchgate.net/profile/Ahmad_Zaenudin

<1% - http://hydrologie.org/redbooks/a121/iahs_121_0365.pdf

3% -
https://www.researchgate.net/publication/42429327_La_transmission_des_patrimoines_paysans_cle_de_voute_de_la_reproduction_sociale_et_faux_probleme_L'exemple_du_canton_de_Plelan-le-Grand_au_milieu_du_xixe_siecle

2% - http://repository.lppm.unila.ac.id/9804/

<1% - https://mssanz.org.au/modsim2017/H4/dalio.pdf

<1% - https://www.sciencedirect.com/science/article/pii/S0034425712003975

<1% -
https://www.fig.net/resources/proceedings/fig_proceedings/fig2015/ppt/TS04I/TS04I_abidin_andreas_et_al_7568_ppt.pdf

<1% -
https://www.researchgate.net/publication/322394211_GIS-Based_Study_of_Land_Subsidence_in_the_City_of_Bologna

<1% -
https://www.researchgate.net/publication/332975885_Ground_Deformation_Analysis_of_Bolvadin_W_Turkey_by_Means_of_Multi-Temporal_InSAR_Techniques_and_Sentinel-1_Data

<1% - https://www.nature.com/articles/s41598-017-00620-y

<1% - https://www.sciencedirect.com/science/article/pii/S0926985109000251

<1% -
https://www.researchgate.net/profile/Robert_Zomer/publication/232679129_Land_Cover_Change_Along_Tropical_and_Subtropical_Riparian_Corridors_Within_the_Makalu_Barun_National_Park_and_Conservation_Area_Nepal/links/0a85e53c4fa6e2e401000000.pdf?disableCoverPage=true

<1% - http://www.real-statistics.com/regression/regression-analysis/

<1% -
https://www.researchgate.net/publication/317277180_Factors_determining_subsidence_in_urbanized_floodplains_Evidence_from_MT-InSAR_in_Seville_southern_Spain

<1% - https://link.springer.com/article/10.1007%2Fs00190-013-0685-5

<1% -
https://www.researchgate.net/publication/329533633_Spatiotemporal_Evolution_of_Postseismic_Deformation_Following_the_2001_Mw78_Kokoxili_China_Earthquake_from_7_Years_of_Insar_Observations