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Proceeding of the 2018 Internasional Conference on Research and Learning of Physics (ICRLP 2018)

Theme
Innovative Research and Creative Learning of
Physics for Improving a Competitive and Dignified Nation



Padang, Indonesia
August 9-10, 2018

ORGANIZED BY

Department of Physics, Postgraduate of Physics Education, Postgraduate of Physics,
Faculty of Mathematics and Natural Science, Universitas Negeri Padang, Indonesia
in collaboration with Department of Physics, Faculty of Science and Mathematics,
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PREFACE

On behalf of the Committee, I would like to thank you for your participation in the 2018 International Conference on Research and Learning of Physics (ICRLP2018) which has been held at the Auditorium Universitas Negeri Padang, West Sumatra, Indonesia, August 9 - 10, 2018.

This ICRLP2018 is organized by the Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang. The main purpose of these conferences and seminar is the dissemination of the best research results from academics, researchers, professors, practitioners, observers, teachers, and students in both Physics Research and Physics Learning Research. This conference is expected to become a forum to discuss strategic issues in related fields. The two-day conference is expected to build cooperation between academics, researchers and institutions at both national and international levels. The scope of ICRLP 2018 covers various fields in Physics Research and Physics Learning Research.

I would like to express my sincere appreciation to all the participants, financial sponsors, exhibitors, supporting organizations and all the committee members who has made ICRLP2018 successful. With these strong support, we are sure ICRLP will be beneficial to all the participants, and you enjoy in Padang.

We are looking forward to meeting you in the next ICRLP.



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Land subsidence rate analysis of Jakarta Metropolitan Region based on D-InSAR processing of Sentinel data C-Band frequency

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Abstract. Land subsidence in Jakarta has been reported by many studies using various geodetic techniques. High exploitation of groundwater is the main factor of increasing land subsidence rate in Jakarta. The impact of land subsidence can be seen in several forms such as the damage on buildings and infrastructures and the change of surface water pattern flow. This paper presents the update status and analysis of land subsidence of Jakarta Metropolitan Region (Jabodetabek) based on Differential Interferometric Synthetic Aperture Radar (D-InSAR) technique. D-InSAR technique based on interferogram that developed from a coherence technology of active radar imaging. Two images acquired with the same nominal geometry is required to develop interferometry SAR by using phase as a fraction of the wave, and change to distance. The displacement map is the final result of interferometry SAR and external Digital Elevation Model (DEM) required to remove topographic phase. Displacement map using pair of Sentinel data that acquired on March 18, 2017 and March 13, 2018 was successfully developed. The highest rate of land subsidence with 6 cm/year occurred in eastern part and western part of north area of Jakarta, some part in West Jakarta, Central Jakarta, and South Jakarta. The similar rate also occurred in Bekasi City, Bekasi Regency, Depok City, and Tangerang Regency. The moderate rate of land subsidence occurred in Tangerang City and South Tangerang City with 2-3 cm/year. Jakarta Metropolitan Region is a susceptible area of flooding. In this study, land subsidence has a similar pattern with the emergence of flood inundation. Therefore, the increasing of areas with flood inundation is affected by land subsidence. Monitoring of land subsidence rate in Jakarta Metropolitan Region by using D-InSAR Sentinel data is highly required due to high temporal resolution and accurate data especially for flood management and other urban development management, and free access of the data.

1. Introduction

Many cities in the world have land subsidence problem because of environmental stressing due to urban development, including Jakarta Metropolitan Region. Land subsidence defined as the downward displacement of land surface to the relative of reference surface. Land subsidence usually caused by a natural condition like geologic structure movement and by human activities (anthropogenic), however



anthropogenic is the major cause of land subsidence of Jakarta. Urban development during last 50 years in Jakarta and surrounding areas are rapidly growing up to provide space for any kind of activities and settlement for population [1].

The population of Jakarta at present time more than 10 millions people, with population growth rate of 1.02% a year and density 15,366.97 people/km² [2]. Jakarta Metropolitan Region (Jabodetabek) is consist of Jakarta itself, and surrounding cities area including Bekasi City, Bekasi Regency, Tangerang City, Tangerang Regency, South Tangerang City, Depok City, Bogor City, and Bogor Regency. The population of Jakarta Metropolitan Region is amount 28 million, which is the highest agglomerations in the world. There are several Industrial Estate in Jakarta Metropolitan Region such as Jakarta 3 Industrial Estate, Tangerang 3 Industrial Estate, Bekasi 11 Industrial Estate, and Bogor 2 Industrial Estate with a total area around 12,962 hectares and 4,673 tenants [3].

There are four different types of land subsidence which probably occurred in Jakarta and Jakarta Metropolitan Region: subsidence due to groundwater extraction, subsidence induced by the load of construction, subsidences caused by the natural consolidation of alluvium soil, and tectonic subsidence. Considering the spatial variations of land subsidence rate, types of land subsidence also distribute in spatial variations. Subsidence due to tectonic seem to be least possibility and subsidence due to groundwater extraction is the dominant type of subsidence [4].

Several methods can be applied to detect land subsidence in an urban area such as leveling survey, gravity method [5], and Differential Interferometric Synthetic Aperture Radar (D-InSAR) technique. The latest method is the novel technology and most effective to detect land displacement and subsidence based on interferogram that developed from a coherence technology of active radar imaging besides PS-InSAR [6].

Land subsidence in Jakarta already reported by several studies based on D-InSAR technique by using Terra SAR X-Satellite data Band frequency [7] and ALOS Satellite data L-Band frequency [8] and successfully to analysis the land subsidence condition. In other studies, land subsidence also reported based on D-InSAR technique by using ALOS satellite data in several cities such as Lhokseumawe, Medan, Jakarta, Bandung, Blanakan, Pekalongan, Semarang, Bungbulang, and Sidoarjo regency respectively with rate subsidence between 8.3 - 22.5 cm a year [9].

This research focus to detect the rate of land subsidence in Jakarta Metropolitan Region at the present time during March 2017 - March 2018. Sentinel satellite data C-Band frequency was used in this research due to high temporal resolution, high accuracy, and free access to the data.

2. Background of Research Area

The research areas are Jakarta city and surrounding cities areas namely Jakarta Metropolitan Region, consist of Jakarta, Bogor, Tangerang, and Bekasi (Jabodetabek). About 22% of Jabodetabek is located on elevation 10 m below sea level, while 73% is 200 m below sea level. In the southern area, most elevation is 1,000 m below sea level, and the average slope is about 7% [2].

3. Methodology

This research used Differential Interferometric Synthetic Aperture Radar (D-InSAR) approach based on interferogram that developed from a coherence technology of active radar imaging. in 1974, Graham carried out experience about D-InSAR for the first time. Recently, D-InSAR was grown up and very useful to identify the phenomenon in the earth like land subsidence and land movement.

The Sentinel data acquired on March 18, 2017 and March 13, 2018 was used as input of the D-InSAR processing. Sentinel data was used has specification Single Look Complex (SLC) format, Ascending orbit, Vertical-Vertical (VV) and Vertical-Horizontal (VH) Polarization, Path 98, Raw 1159, Absolute Orbit 20995, and frequency C-Band. The footprint of the data shows in Fig.1(a).

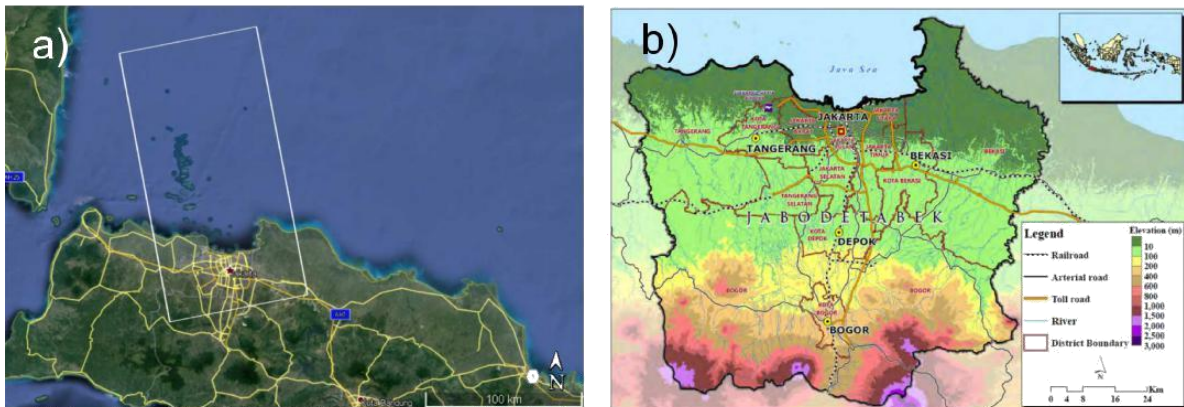


Figure 1. (a) Footprint of Sentinel data C-Band frequency used in this research, and (b). Research Area of Jakarta Metropolitan Region (source (b): [3])

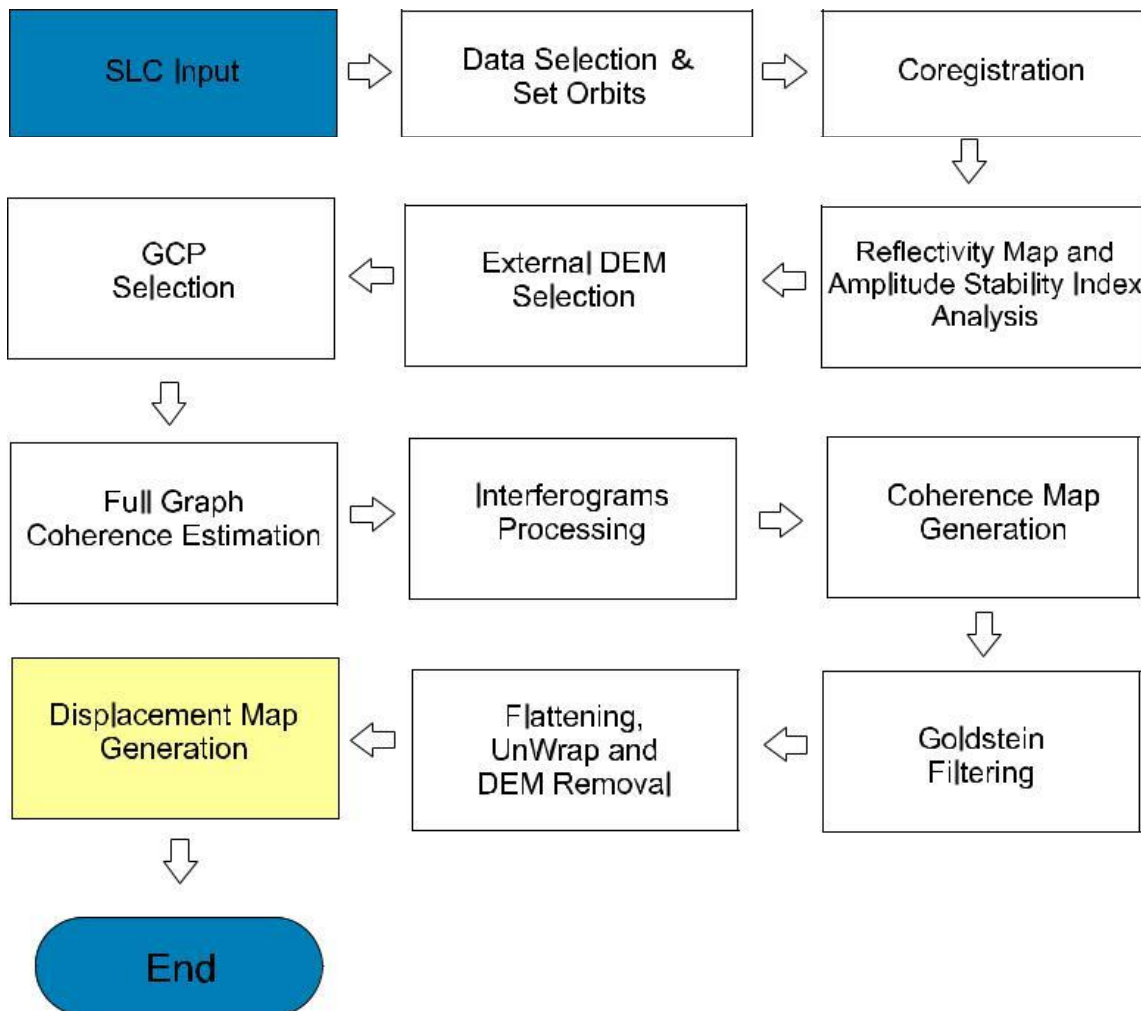


Figure 2. Working steps of D-InSAR processing in this research

Working steps of D-InSAR processing in this research (Fig. 2) was started from Single Look Complex (SLC) data input. After SLC input, data selection and orbit setup were conducted using sub

swath 1. Coregistration was applied with images acquired on 18 March 2017 chooses as master image and the other as slave image. After coregistration, reflectivity map and temporal standard deviation were generated by performing a preliminary analysis of Reflectivity Index and Amplitude Stability Index. Followed by that, preliminary geocoding was applied using external Digital Elevation Model in order to correct the initial orbit offset [3]. After full graph coherence estimated, Interferogram generated from master and slave image. To handle the noise interferogram, Goldstein Werner filtering approach used in this step and coherence map generated. The past unwrapping was carried out to derive the subsidence depth from the interferogram. Finally, the resulting sample-line (s,l) subsidence depth was converted to vertical subsidence rate in millimeters.

4. Result and Discussion

Analysis of land subsidence in Jakarta Metropolitan Region can be done by using Sentinel data C-Band frequency D-InSAR processing. In addition, the result of coherence map is around 0.8-1 (Fig.3a). It means that two images area is coherence. The result of phase interferogram maps is between -3 until 3 (Fig.3b). Land subsidence in Jakarta Metropolitan Region detected between 2 - 6 cm/year (Fig.3c).

Land subsidences rate of each city in Jakarta Metropolitan Region tabulated and shown in Table 1. Based on this table, the maximum land subsidence rate in Jakarta is 6 cm/year. This is similar to land subsidence rate in Bekasi City and Bekasi Regency. In Tangerang City, land subsidence rate is around 4 cm/year, whereas in Tangerang Regency and South Tangerang City is around 6 cm/year and 3 cm/year, respectively. This research is not cover all Bogor areas but still can represent the land subsidence condition in some part area of Bogor.

In Jakarta itself, the pattern of land subsidence rate is nearly similar to several previous studies. However, the value is different because this is base on recent condition. The widest areas that have high land subsidence rate is in the eastern part area of Jakarta, including East Jakarta and North Jakarta. All of Kelapa Gading areas, the luxury resident, in North Jakarta, has high rate of land subsidence 6 cm/year. This is one of the reasons for the increasing frequency of flood inundation in Kelapa Gading areas, and the other place is Sunter, Plumpang, and Cilincing, Warakas, and Swasembada Barat.

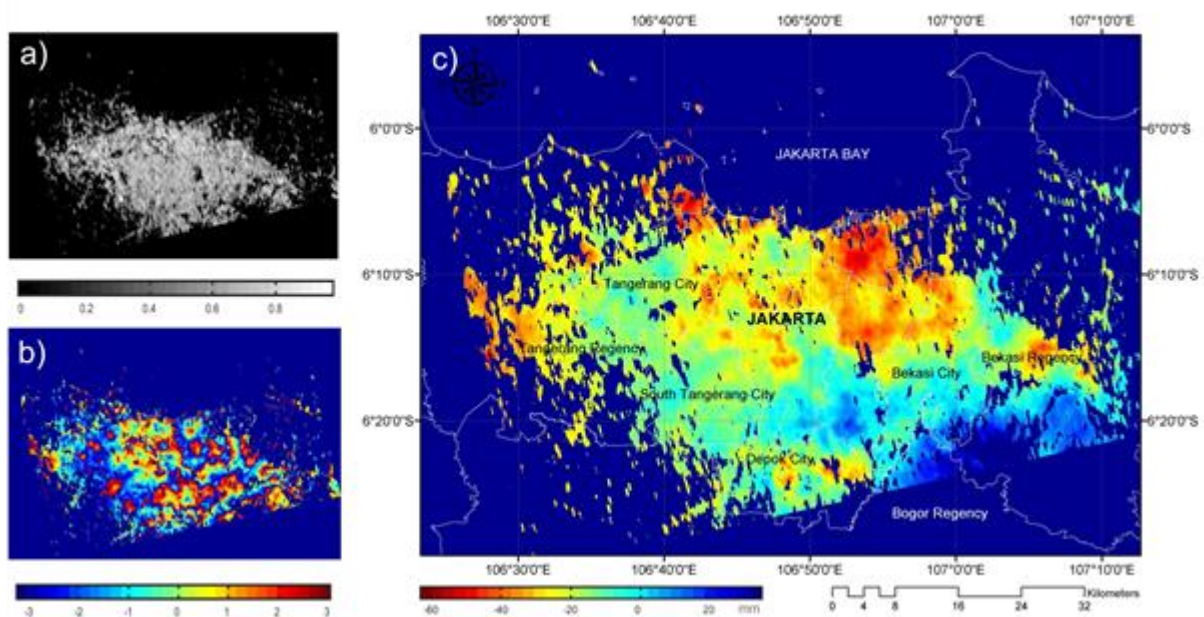


Figure 3. (a) Coherence Map, (b) Phase Interferograms and (c) Displacement Map of Jakarta Metropolitan Region based on D-InSAR Processing of Sentinel data C-Band frequency

Bekasi areas is divided by two administration places: Bekasi City and Bekasi Regency. In Bekasi City, areas that have significant subsidence rate of 6 cm/year is around Shopping Mall Summarecon Mal Bekasi, Hermina Hospital Bekasi, Shopping Mall Revo Town, Kranji, Harapan Indah, Tambun, Pondok Ungu, and Cakung. High land subsidence rate in that area is strongly correlated with Industry, Business, and Settlement Areas. In Bekasi Regency, the highest subsidence occurred in northern part of Teuku Umar street and Imam Bonjol street, around H. Bosih Street. There are many Industries activities in this area and settlement areas. Around Cikarang Train Stasiun and surrounding areas, land subsidence rate also high and related with high density of settlement areas.

Table 1. Land Subsidence Rate in Jakarta Metropolitan Region

City	Land Subsidence Rate (cm)
Jakarta	6
Bogor Regency	2
Depok City	6
Tangerang City	4
Tangerang Regency	6
South Tangerang City	3
Bekasi City	6
Bekasi Regency	6

Tangerang is separate to 3 administrative areas i.e. Tangerang Regency, Tangerang City, and South Tangerang City. Almost all of the areas have high population density, and many industries operated in these areas. In Tangerang Regency, land subsidence rate of 6 cm/year occurred in Kutabumi, around Cadan Daon street and Sepatan Raya street. There are many industries activity in this area. Other places in Balaraja, around Raya Serang street, Raya Pantura street, Area Jaya Sentika street, and Jl. Pemda Tigaraksa street. All areas are related to industrial areas. However, there is settlement area that has land subsidence rate more than 6 cm/year in Perumahan Sudirman Indah Tigaraksa, and Perumahan Puri Permai Tigaraksa. Soil consolidation and groundwater extraction probably the dominant factor that causes this condition.

In Tangerang City, high land subsidence rate occurred in Palem Ganda Asri and Parung Koret street. This area is detected as settlement area that developed in paddy field area. Land subsidence rate probably caused by consolidation of soil and also groundwater extraction. The same condition also occurred in Graha Raya Residence, Pinang, around Kebayoran Utama street and KH. Mas Mansyur street. The flood inundation in this area is increasing at present time. The rate subsidence around 2-3 cm/year also occurred in Jatiuwung, around Prabu Siliwangi street, Gatot Subroto, and Kian Santang street. In South Tangerang City, land subsidence rate 3 cm/year occurred in some part area such as around highway area of Pondok Ranji, Taman Puri Bintaro Residence, areas around Jombang Raya Street and Arya Putra Street. Buaran, Victor, Muncul, Ciater, Lengkong, Bumi Serpong Damai Residence Areas, and Bintaro Residence. There are industrial areas in South Tangerang City like Taman Techno BSD and industrial area around Raya Serpong street but the rate of land subsidence in these areas are not significant.

In Depok City, land subsidence rate of 6 cm/year occurred in East Depok and Sawangan, around Tanah Baru street, Nusantara Raya Street, Dewi Sartika Street, Kampung Bojong street, and Proklamasi street.

There is strong correlation between land subsidence rate and flood inundation. As shown in Fig.4, the pattern of land subsidence rate was associated with the pattern of flood inundation in Jakarta areas. In each Jakarta Metropolitan Region areas, flood inundation occurred in urban development areas, and mostly in industrial areas and the other in dense settlement areas. Flood inundation also has correlation with flood-damaged areas and money loss. From another study, money lost cause by flood inundation is between 10.000 - 100.000 US\$ per hectare [11] and mostly in the area that has land subsidence rate of 6 cm/year.

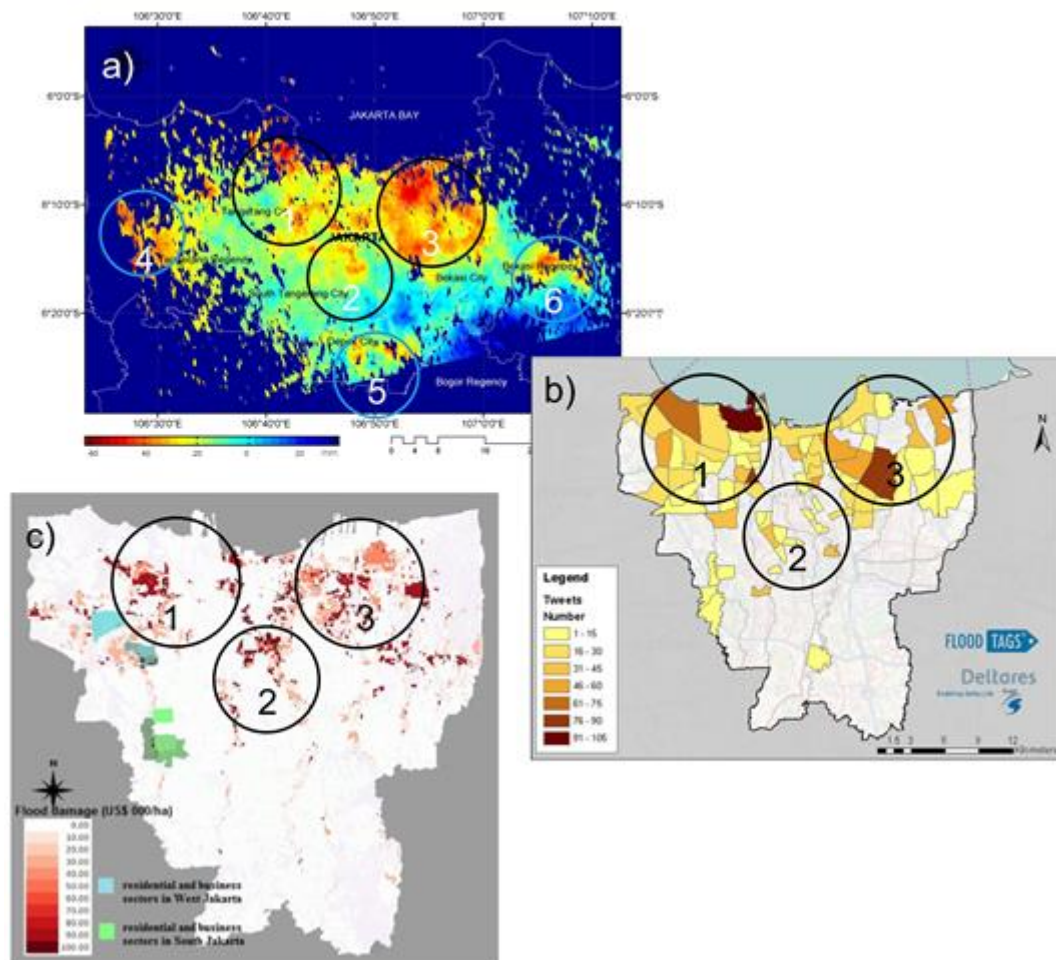


Figure 4. Relationship between (a) Land subsidence rate, (b) Flood inundation [10], and (c) Flood damage in Jakarta Metropolitan Region [11]

5. Conclusion

Based on land subsidence rate analysis by using Sentinel Data C-Band frequency, there is some part of Jakarta Metropolitan Region that has high land subsidence rate around 6 cm/year. The land subsidence occurred in Jakarta, Bekasi City, Bekasi Regency, Tangerang City, Tangerang Regency, South Tangerang City, Depok City, and some part in Bogor. Land subsidence rate mostly associated with urban development activities like settlement and industry area. Land subsidence rate also has correlation with flood inundation phenomenon and money loss cause of that.

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