Monitoring Land Subsidence by TerraSAR-X in Cengkareng, Jakarta City, Indonesia

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Abstract
Subsidence in urban area has the potential to cause severe damage in ecosystem. Therefore it is important to understand the subsidence phenomenon in urban area. The objective of this study is to investigate the land deformation in the metropolitan area of Jakarta, Indonesia using multiple satellite radar imagery. Differential synthetic aperture radar interferometry (DInSAR) is a technique useful for accurately detecting the ground displacement or land deformation in the antenna line-of-sight (slant-range) direction using synthetic aperture radar (SAR) data taken at two separate acquisition times. In this study the DInSAR technique was used to map the land subsidence in Jakarta region with X-band TerraSAR radar images. A total of 4 TerraSAR-X images acquired from 9 August 2010 to 1 March 2013 over Jakarta were used in this study. The results demonstrated that the land in the area of Cengkareng was deforming at different rates. Several subsidence bowls with peak displacement rates 10 – 17.5 cm/yr along the radar looking direction have been observed Cengkareng.
Keywords **:** Land Subsidence, Monitoring, TerraSAR-X

1. Introduction
Land subsidence in urban areas may result in adverse impacts and can lead to serious problems. Urban subsidence can lead to increased risk of flooding of coastal areas, severe damage to the buildings and infrastructures, destruction to local groundwater systems, and also tension cracks and reactivated faults [1]. Differential synthetic aperture radar interferometry (DInSAR) is a technique useful for accurately detecting the ground displacement or land deformation in the antenna line-of-sight (slant-range) direction using synthetic aperture radar (SAR) data taken at two separate acquisition times [2,3].

Cengkareng is located between $6^0$7’9’’S latitude and $106^0$43’10’’E longitude, in the western part of Jakarta city. The sub district consists of six regions, covering an area of about 27.93 km2. Fig.1A shows map of Cengkareng district area on Jakarta City Map. The area is relatively flat: topographical slopes range between 0^0 and 2^0. The elevation of the southernmost area is about 20 m above sea level, with the other areas being lower (Figure 1B). Cengkareng, located in the Jakarta basin, has the following five main landforms: alluvial, marine origin, beach ridge, swamp (including mangrove), and former channel.

2. Methods
TerraSAR-X is a German high resolution radar satellite program which will be the first commercially launched on the 15th of June 2007. Until now there is no C-Band and L-Band has an operational of advanced SAR-satellite system for scientific and commercial application for public. Because of that, we used X-Band data to make continuously land deformation monitoring in Cengkareng. TerraSAR-X data provides high spatial resolution of about 3 m and has high geometric accuracy imagery. The advantage of X-Band than L-Band and C-Band is The X-Band has short wavelength (about 3.1 cm) and confers a high sensitivity to land deformation. The TERRASAR-X data is the only data that has descending orbit in this study. In this study we would like to investigate land subsidence by applying DInSAR technique. We processed one pair of TERRASAR-X data between 2010 and 2013. This is the newest available data in this study. The pair, spatial baseline and temporal baseline of TerraSAR-X can be found in Table 1.

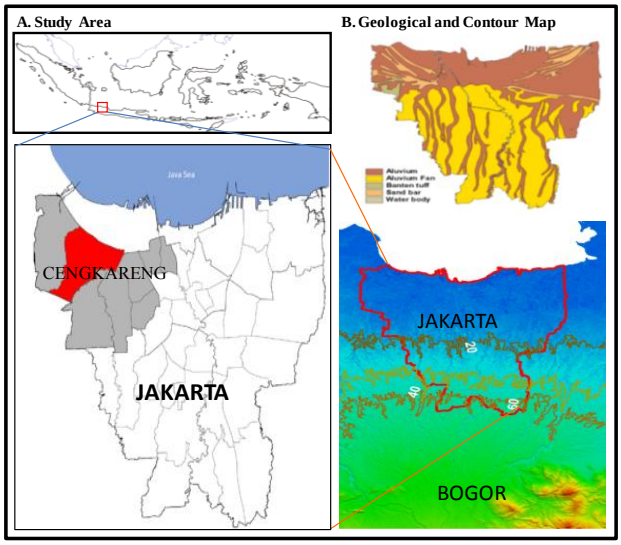

Fig. 1. (A) Map of Jakarta basin and (B) Geological map of Jakarta urban area.

Table 1. TerraSAR-X pair and baseline information

	Acquisition Date		Temporal Baseline	Spatial Baseline
Pair	Master	Slave	(week)	(meter)
1	20100809	20110613	44	110.5
2	20100809	20121214	122	149.3
3	20100809	20130301	133	138
4	20110613	20121214	78	39.1
5	20110613	20130301	89	248.1
6	20121214	20130301	11	286.3

Note: Date are given as year, month, and a day (e.g., 20100809 denotes 9 August 2010)

3. Results and Discussion

The DInSAR technique result of TerraSAR-X data shows the land deformation is getting larger in terms of area and depth associate to longer interval time observation. The largest deformation rate estimation reach 17.5 cm/year in some points based on DInSAR calculation during 44-week interval times.

Cengkareng, is a settlement area that covers more than 23 km2. Since 2005, flat housing has been widely developed in this region to relocate the slum dwellers. The international airport and industrial area were built nearby. The maximum subsidence rates found during the time span of the study are 17.5, 11.8, 11.7, 11.5, 10.5 and 10 cm/year (Table 2).

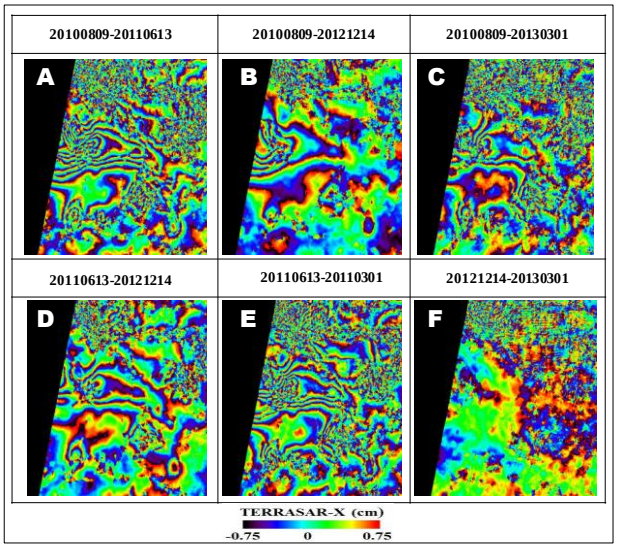

Fig. 2. Cengkareng DInSAR result of TERRASAR-X data pair all pairs mentioned in Table 1. (a) Data pair on 20100809-20110613, (b) Data pair on 20100809-20121214, (c) Data pair on 20100809-20130301, (d) Data pair on 20110613-20121214, (e) Data pair on 20110613-20130301, (f) Data pair on 20121214-20130301.

The study area is a newly developed residence area with more than 300 hundred households living over this area. The cause of subsidence was predicted as the result of ground water extraction, the building construction load and human activity over this area.

Table 3. Maximum subsidence and subsidence rate estimation in Cengkareng by using DInSAR.

Pair Number	Acquisition Date		Cengkareng Subsidence Rate (cm/year)
	Master	Slave	
1	20100809	20110613	17.5
2	20100809	20121214	11.5
3	20100809	20130301	11.7
4	20110613	20121214	10.0
5	20110613	20130301	10.5
6	20121214	20130301	11.8

4. Summary

This study shows that DInSAR methods able to detect the ground deformation in Cengkareng sub district area. The DInSAR analysis can be considered as potential tool to monitor the land subsidence on disaster with low cost, especially to detect ground deformation as an impact of flood hazard area in 2013. The observation continuation becomes important to monitor the ground deformation and to prevent further human severe. In the future, multiple aperture technique and GPS measurement will be applied to get a better result and analysis.

Acknowledgements

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