Identification of ex-sand mining area using optical and SAR imagery

Novie Indriasari[1,2], Eko Kusratmoko [1], Tito Latif Indra[1] and Atriyon Julzarika[2]

[1] Geography Department, Faculty of Mathematics and Natural Sciences, Universitas Indonesia
[2] Indonesian National Institute of Aeronautics and Space (LAPAN)

E-mail: indriasari.novie8@gmail.com

Abstract. Open mining activities in Sumedang Regency has been operated since 1984 impacted to degradation of environment due to large area of ex-mining. Therefore, identification of ex-mining area which generally been used for sand mining is crucial and important to detect and monitor recent environmental degradation impacted from the ex-mining activities. In this research, identification ex-sand mining area using optical and SAR data in Sumedang Regency will be discussed. We use Landsat 5 TM acquisition date August 01, 2009 and Landsat 8 OLI acquired on June 24, 2016 to identify location of sand mining area, processed using Tasselled Cap Trasformation (TCT), while the landform deformation approached using ALOS PALSAR in 2009 and ALOS PALSAR 2 in 2016 processed using SAR interferometry (InSAR) method. The results show that TCT and InSAR method can can be used to identify the areas of ex-sand mining clearly. In 2016 the total area of ex-mining were 352.92 Ha. The land deformation show that during 7 years period since 2009 has impacted to the deformation at 7 meters.

1. Introduction

Traditional activities of open mining in Sumedang regency has been operated since 1984, while the estate mining companies with heavy machine equipment to excavate the sand came in 1993 [1]. According the local news, both the traditional and the estate mining companies were mostly operated in illegally.

Implementation of remote sensing data to detect the ex-mining area as a prominent method. This due to the accurate, effective and cost efficiency [2]. Optical remote sensing imagery as the main source in detecting the ex-mining area provides two-dimension analysis resulted from the completeness of wave length channels. But the optical imagery difficult to detect the depth of landform deformation [3]. Moreover, inaccurate interpretation was interferes and mixed due to the fast growing of grasses and shrubs [4]. Therefore, SAR imagery were deployed to detect the landform deformation that caused the degradation of environment and wide area of abandoned land.

This study aims to identify an appropriate method to detect the ex-mining area using combination of optical satellite imagery and SAR imagery. Selection of appropriate methods for data processing will affect the results obtained. Several research conducted on detecting ex-mining using NDVI [5,6] and VIDN [7] to identify abandoned area of mining using optical satellite imagery. This research used the implementation of Tasseled Cap Transformation (TCT) method for optical imagery analysis and Interferometry Synthetic Aperture Radar (InSAR) in detecting landform deformation based on SAR imagery.

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The successfully of landcover classification of TCT method due to the ability in detecting and differentiate the phenomenon of vegetation growth/phase [8,9]. The InSAR method were processed through combination of two/more of SAR imagery which known as a source to provide information of height or Digital Elevation Model (DEM) [10]. InSAR often to be utilised for research on landform deformation [2,11].

2. Materials and methods

2.1. Data

Optical remote sensing applied in this study were; Landsat 5 TM in August 01, 2009 and Landsat 8 OLI in June 24, 2016, while DEM derived from ALOS PALSAR in 2009 (level product 1.0) and ALOS PALSAR 2 in 2016 (level product 1.1). The ex-mining in Sumedang regency located at 6°46’21.27’S – 6°48’28.01”S, 107°55’59.17”E - 107°59’46.41”E (shown in figure 1).

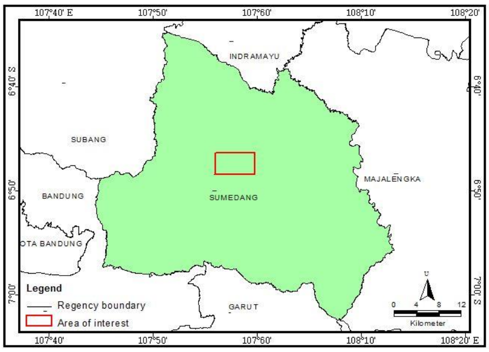


Figure 1. Study area.

2.2. Method

Location of ex-mining area were detected from Landsat imagery. The steps to detect the ex-mining area were firstly, the image pre-processing the TOA correction of Landsat imagery which normalized the digital number into reflectance and to avoid the illumination geometry [12], the next steps is the TCT process which resulted in a specific landcover classes physically. The scatterplot of TCT as a based to determine the suitable training sample were using the composite of Brightness and Greenness bands of TCT. Based on the result from the field surveying for verification the mapping result, it can be seen that only few of ex-mining area were processed reclamation and others were mostly abandoned and covered by grass and bush. Therefore in this study, the ex-mining area identified in 2009 will be added to the ex-mining area in 2016.

DEM creation were firstly processed by focusing method that synchronize between raw and metadata as to fulfil the requirement in interferometry processing. The result of focusing step was the Single Look Complex (SLC) that provide information of intensity value and result phase from acquisition. The second-step was the interferogram to obtained the fringe (contrast between dark and bright) from the different phase of master and slave imagery. The third-step was the flat earth correction method for the interferogram imagery that based on the earth surface measurement in Indonesia, and followed by filtering process order to enhanced the coherence of interferogram imagery. The final process in InSAR production was the phase unwrapping which corrected the cyclic phase of 2π to absolute phase (unwrap) before converted to DEM.

Landform deformation resulted from ex-mining area was measured using the subtraction of DEM in 2016 with the DEM in 2009. Research flow diagram can be seen in figure 2.

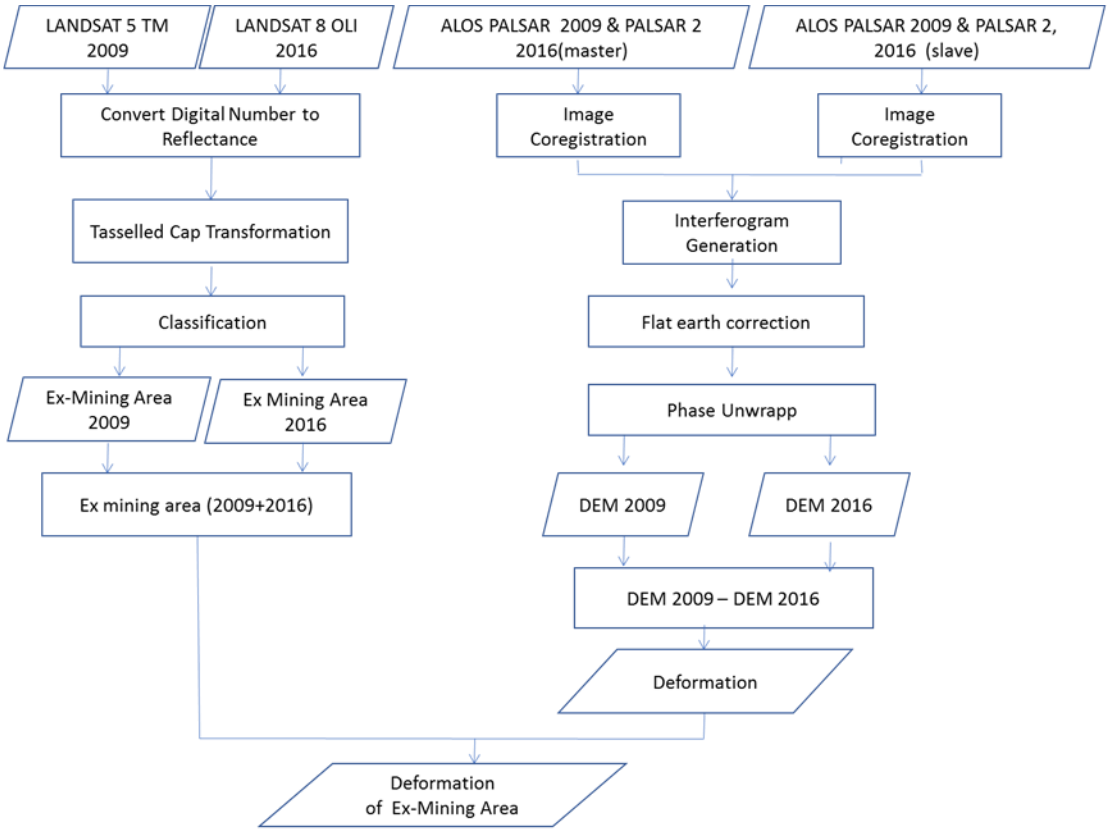
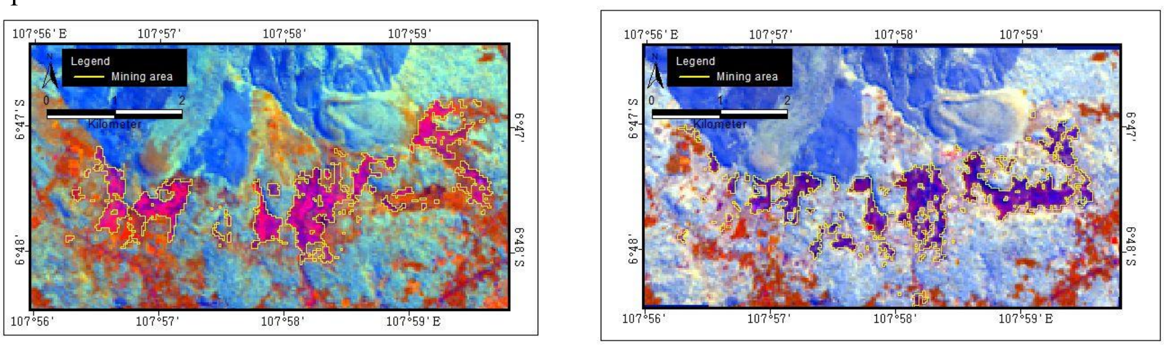


Figure 2. Flow diagram of research.

3. Results and discussion

The TCT method implemented for Landsat 5 TM and Landsat 8 OLI in Sumedang Regency resulted in a clear and detail differentiation for several land cover types where detected from Brightness channel for Red and Greenness channel for Green and Wetness channel for Blue (figure 3). For TCT Landsat 5 TM (figure 3a), it can be seen from the red to purple objects identified as soil surface that has vegetation patches and for bare land, cyan to dark blue use to detect vegetation, and building area depicted as an orange. Slight difference when viewing TCT Landsat 8 OLI (figure 3b) that the bare land look in dark purple.



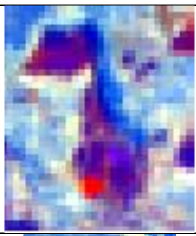
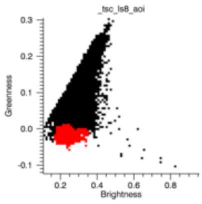
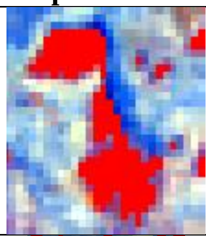
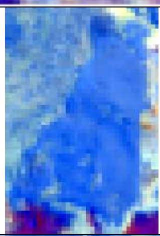
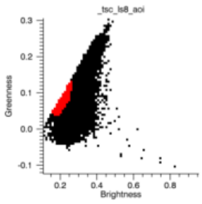
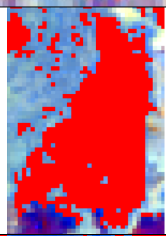
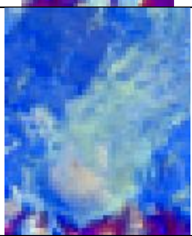
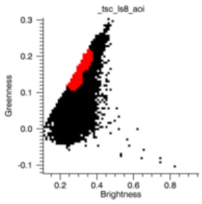
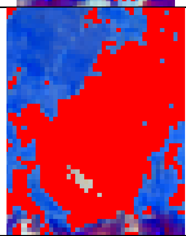
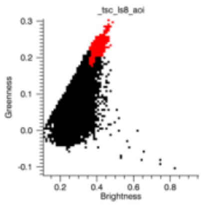
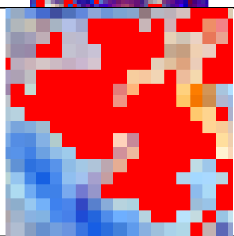
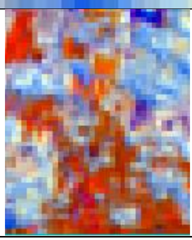
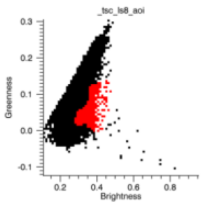
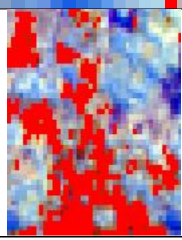
(a) (b)

Figure 3. TCT of (a) Landsat 5 TM and (b) Landsat 8 OLI.

The TCT Brightness obtained from the sum of six bands. The TCT Brightness beneficial for detecting soil character. This due to the transformation of the total soil reflectance. The transformation in Brighteness channel occurred when the dense canopy vegetation increase causes the increasing reflectance in NIR band and lower in the visible bands.

The Greenness shows the high absorbtion of visible band due to the vegetation pigment, such as chlorophyll and leaves structures (high reflectance in NIR band). The combination of Brightness and Greenness based on the Tasseled Cap developed by Kauth and Thomas applied in the Landsat MSS, shows that the method can provide and identified all of the landcover for Landsat 5 and Landsat 8. The accurate method to identify the bare land of ex-mining from TCT can be conducted by delineating the scatterplot as a part stage in the cap analysis (table 1).

Table 1. Land cover scatterplot.

Land Cover	Image	Scatterplot	Result of Scatterplot Delineation
Bare land			
Forest			
Bush			
Grass			
Building area			

The process in identifiying the object using delineating the scatterplot can be use as the training sample for further classifiction steps. While the classification was conducted using SVM method where the area of ex-open mining sand ca. 230.220 Ha in 2009 and increased into 353.92 Ha in 2016, as shown in figure 4.

The DEM created from interferometry of ALOS PALSAR and ALOS PALSAR 2 provide information with vertical accuracy at 70-80 cm and 65-70 cm. The DEM produced by ALOS PALSAR has a prominent of accurate geometric accuration and precision. This because the ALOS PALSAR compose by L band. The L band has better penetration compare to the X and C bands [2,13].

The DEM created using the InSAR method shows detail topographic of the research study, where located at 450 – 1300 meters above sea level. Analysis on overlying the DEM with the information classification of Landsat imagery shows that the mining area in 2009 located at 622.5 - 802.5 meters above sea level and the mining activities continue growth in 2016 to the area that located in higher topographic area, at 825 meters above sea level.

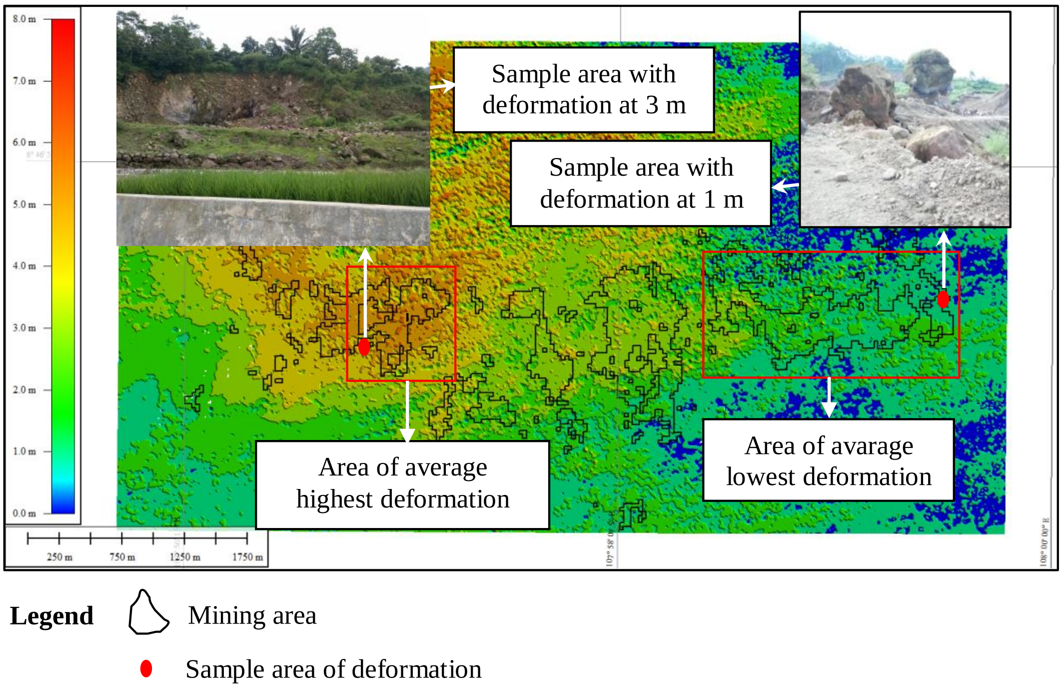
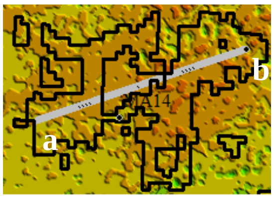
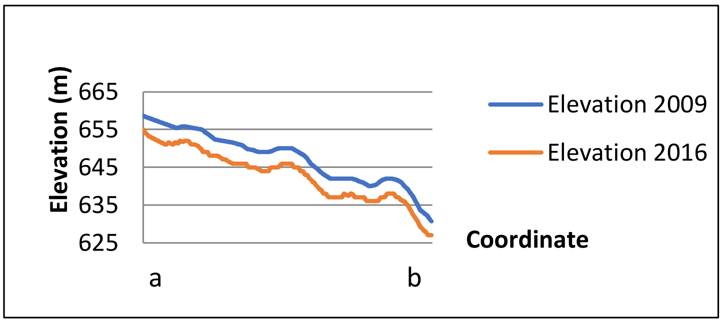
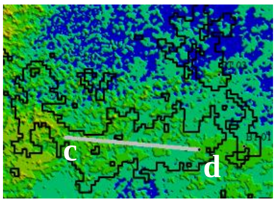
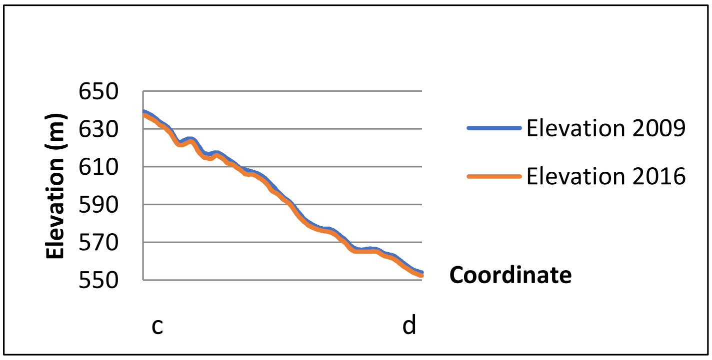


Figure 4. Deformation at mining area.

The DEM from the InSAR method was successfully measured the land deformation in the sand meaning which had decrease 1 – 7 meters within 7 years in the period. This can be seen in the figure 4, where the highest deformation occurred in the western part of ex-mining, while the lowest land deformation occurred in the eastern part of ex-mining area. For more detail, the highest and the lowest land deformation of mining area can be seen in table. 2.

Table 2. The highest and lowest land deformation.

Mining area	Change of elevation
 Average change of elevation 5 m	 Coordinate a (825826.537; 9248042.659) Coordinate b (826750.905; 9248357.853)
(a)	
 Average change of elevation 1.6 m	 Coordinate c (829331.392; 9248218.101) Coordinate d (830378.574; 9248122.903)
(b)	

The various number of land deformation, where in the eastern part was lower compare to the intesive mining at the western part, which can also be identified in the TCT image of Landsat 5 imagery in 2009 that none of the area was detected and classified as a mining area (figure 3a).

4. Conclusion

TCT method shows an accurate and robust method to detect an accurate location of ex-mining area because its prominent method in differentiating between vegetation and soil. The ex-mining were reached 230.220 Ha in 2009 and reached 353.92 Ha in 2016. The deformation detected from ALOS PALSAR using the InSAR method provide an accurate result. The deformation between 2009-2016 reached 7 meters, while the direction trend for new mining approaching to the higher topography area.
Improvement for future research can be done by measuring the actual deformation in field for detail accuracy. This because the current research solely focused on measuring deformation based on satellite imagery and analysis of the landcover changes.

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