Vulnerability assessment in the unrest volcano based on time-series land surface deformation and GIS approach (Case study at Mt. Bromo, Indonesia)

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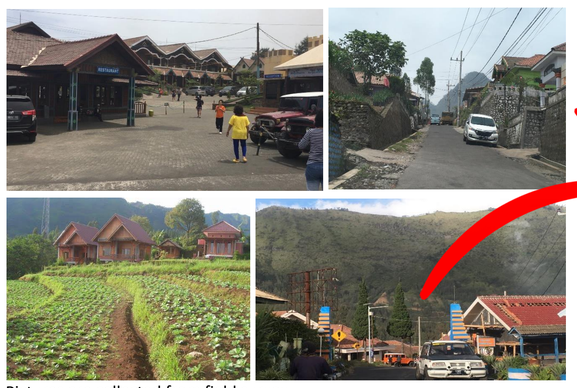
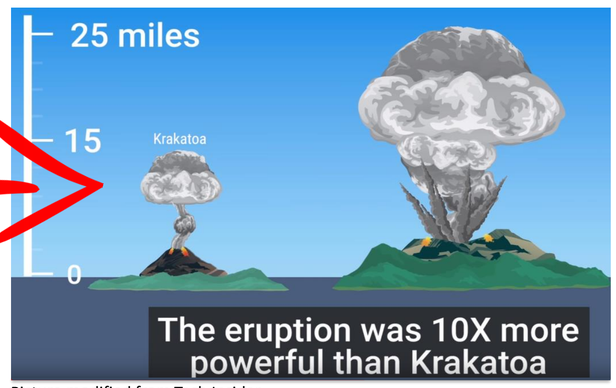
Abstract : Among the **130 active volcanoes** are located in Indonesia, Mt. Bromo is the most famous active volcano which located in East Java, type of Mt. Bromo is a strombolian. We applied remote sensing and GIS techniques for monitoring and creating the **disaster-prone area** of Mt. Bromo to deal with social vulnerability issues. SV assessment parameters to be obtained from the potential of land deformation, population density, and distance from the volcano dome. We used SAR data to observe time-series land surface deformation which derived from PALSAR sensor. The dataset is composed of 22 SAR images, collected from 24 May 2007 to 4 Nov 2011. In addition, Simple Additive Weight method is used in this study to determine level of the disaster-prone area of Mt. Bromo.

Background & Objective



Pictures are collected from field survey.



Picture modified from Tech Insider.

Mt. Bromo status is *siaga* (level 3 of 4) the last eruption occurred in the late of 2015. Volcanic processes which produce a variety of geological and hydrological hazards (Tilling, R.I., 1989) are difficult to predict and capable of triggering natural disasters on regional to global scales (Chowdhury *et al*., 2016).

Objective is to estimate the disaster prone-areas based on time-series deformation monitoring and volcanic materials, and number of population at Mt. Bromo.

Methodology

SAR Data

The dataset is composed of 22 SAR images, collected from 24 May 2007 to 4 November 2011 (Descending passes, HH polarization, Track 91, Frame 3780).

TimeFun D-InSAR

The TimeFun method is an implementation of the temporal inversion scheme established formerly for multiscale interferometric time-series techniques directly in the data domain. This method allows to explain each pixel's phase evolution using a dictionary of user defined functions (Agram *et al.,* 2013).

$$\Phi_{ij} = \sum_k \alpha_k \left(f^k(t_i) - f^k(t_j) \right) + eB^{ij}_{perp}$$

$f^k(t)$: *k*-th function ; α_k: Coefficient associated with the *k*-th function.

Social Vulnerability Assessment

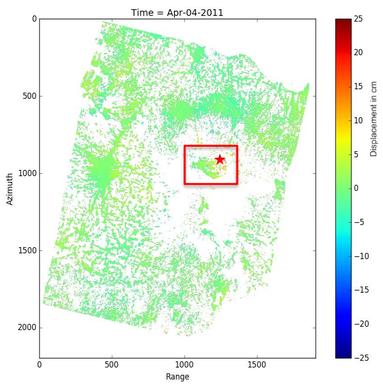
The method of formulating the vulnerability assessment is Simple Additive Weight Method with the following equation :

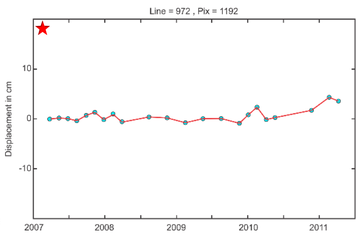
$$V = a(A) + b(B) + c(C) + d(D) + ...$$

Result

Deformation characteristics at Mt. Bromo

We have shown that the D-InSAR technique can be used to assess the deformation and volumetric changes when the eruption occurred in 2010 and 2015 [ACRS, 2016]. Picture below is time-series D-InSAR based on TimeFun algorithm.





At the Mt. Bromo most of pixels were processed with 110 interferoframs. The deformation occurred in the area of Mt. Bromo caldera with relative velocity about 10 cm/year.

Simple additive weight

A consistency index indicates the probability of have been assigned values in a randomly way. Values below 0.1 indicate good consistency.

Matrix pairwise	Population	Land Deformation	Distance From Lava	Criterion Weight
Population	1.0	0.333	0.25	0.124
Land Deformation	3.0	1.0	0.667	0.358
Disatance From Lava	4.0	1.5	1.0	0.517

$$CI = \frac{\lambda\, maksimum - n}{n-1} \quad ; \quad CR = \frac{CI}{RI}$$

CI = 0.000770972

CR = 0.132%

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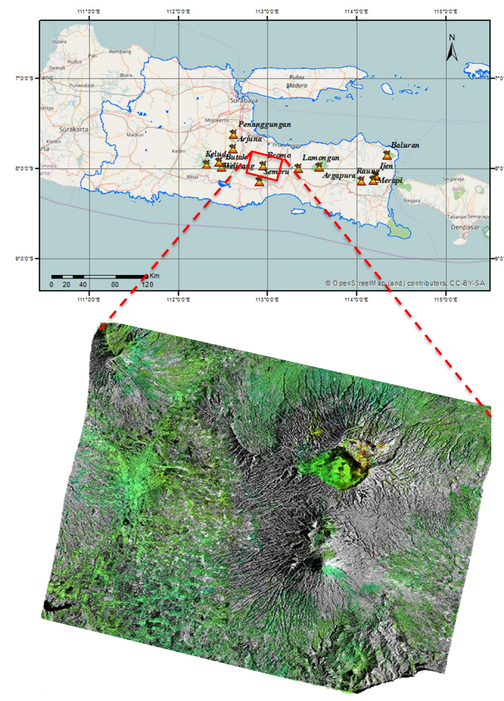
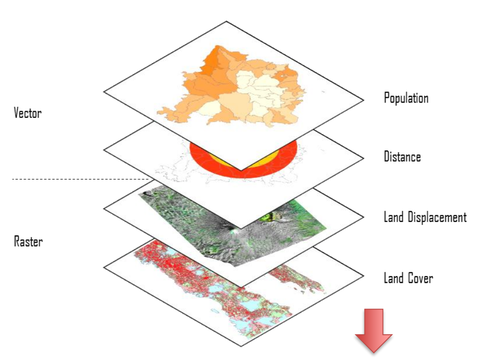
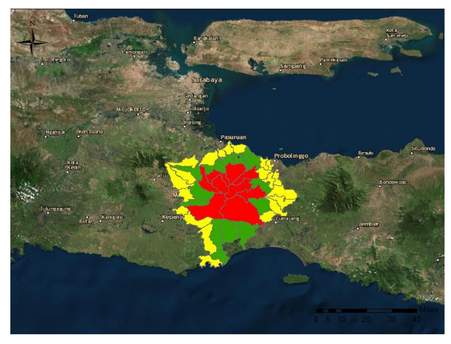
Random Index table :

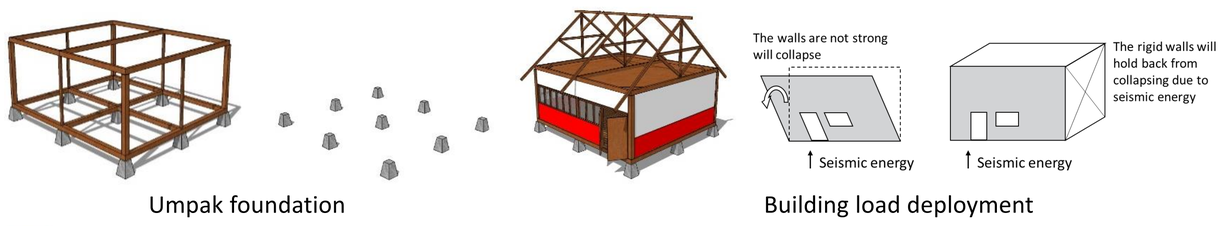
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59







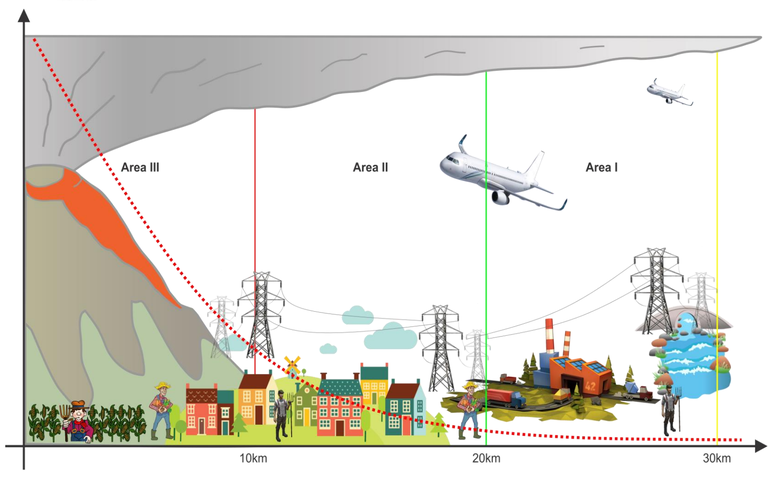
We have discussed comparison studies among SBI (SBAS and TimeFun) algorithm [ISRSE, 2017], SBAS is suitable for the urban area [IIS Forum, 2017]. **Our goal** is to support the authority for **assessing 5 years cycle** of Mt. Bromo and creating **education relationship** [ICOIRS, 2016] with local people who are staying close to the volcano. Finally, we suggested the various architecture construction [AsiaGIS, 2017] in the area of disaster-prone for supporting **SDGs program** in sustainable cities and communities.



Umpak foundation

Building load deployment

Remark



By this study, a larger percentage of vulnerable area based on the model is **Sukapura, Ngadisari**, **Sumber** and **Tosari.** Spatial technology makes good use of the enormous capacity in a single work environment for making the decision in various information layers.

References

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- [.....] is Arliandy P. Arbad *et al* publications within Master Student at The University of Tokyo

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