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Land Subsidence Studies of Seberang Perai Malaysia, By Integrating Remote Sensing Technique and Resistivity Survey Method

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Abstract: *This days land subsidence activities have been increasing rapidly in Malaysia. Land subsidence is now one of the serious threats to the country which is caused by excessive withdrawal of ground water and extraction of ground resources along with the rapid development of infrastructures of cities and urban areas. Ground subsidence is define as the differential sinking of the Earth's surface with respect to terrain that surrounded the surface area. It is due to the extraction of ground resources and presence of voids in the subsurface generated either naturally or by human activities. This study aims to detect and measure the ground movement in SeberangPerai using active remote sensing and geophysical approach. RADAR interferometry (InSAR) is a remote sensing technique which measures the minute changes in ground movement to millimetre scale. Persistent Scatter (PS) and Minimum Spanning Tree (MST) interferometry stacking techniques were applied to Sentinel-1A data to measure the changes in ground movement of Seberang Perai. Integration of both remote sensing and 2D resistivity method helped in identifying the possible subsidence areas and to also identify the subsurface anomalies of Seberang Perai in order to achieve that Dipole-Dipole array electrode configuration survey were conducted in Juru and Taman Bukit Minyak, subsidence was able to identified at different zone and relatively some uplift. Problems related to land subsidence has to be put in to consideration in order to save life and properties, hence a proper awareness is important in such affected areas.*

Keywords: *Interferometric synthetic aperture radar, Persistent Scatter Minimum Spanning Tree, Resistivity and subsidence*

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I. Introduction

Land subsidence has being increasing in an alarming rate in Malaysia. This is caused by excessive withdrawal of groundwater, extraction of ground resources, nature of the soil type and mining of mineral resources along with the rapid development of infrastructures of cities and urban areas[1].Ground subsidence is define as the differential sinking of the Earth's surface with respect to terrain that surrounds the surface area. It is as a result [2].Of extraction of ground resources and presence of void in the subsurface generated either naturally or by human activities

Interferometry synthetic aperture radar (InSAR) helps to detect deformation of subsidence and landslide. InSAR has become a very fast evolving remote sensing technique that measures directly the displacement in millimetre the phase changes between two phase measurements of the same ground pixel on the surface of the Earth [3] Interferometry technique easily permits mapping of the Earth's surface by using both spatial and temporal coherent characteristics that can be applied for classification of land cover by human activities, landslide, earthquake, flow of surface water, movement of oceanic water, snow accumulation, forest canopy changes, land subsidence due to high rate of withdrawing water from the ground, mining, permafrost melting and extraction of hydrocarbon, etc.[3].The shape of the Earth's surface and its structure can be changed by many natural process such as subsidence and landslide. Hazards are caused by the action of both subsidence and landslide. Similarly, the occurrence of land subsidence has an adverse impact to human life and safety Worldwide. Many urban infrastructures such as railways, buildings, highways, electrical instruments buried in the ground damages as a result of ongoing long term subsidence [4].In the world history, the major type of land use land cover change is due to urbanization. The increase in human population and utilization of land are the major factors necessary for Urbanization. The inability to maintain land use land cover changes associated with urban development can cause the changes in both climate and physical environment. The difference in

temperature between rural and urban area has a great impact to urbanization as the urban area have significant radiation and thermal conductivity compared to the rural area [5].It is good to keep researching on the subsidence in the Seberang Perai in order to know the course and be able to provide the awareness on the preventive measures against future occurrences. In this research main focus was on Minimum Spanning Tree (MST) and Persistent Scatter (PS) processing technique to be able to detect the subsidence in the study area. 2D resistivity surveys were also applied to map the subsurface feature.

II. Experimental

2.1 Study area

The Penang state is located on the north-west coast of the Malaysian peninsular. It is bounded to the north and east by the state of Kedah, to the south by the state of Perak, and to the west by the Straits of Malacca and by Sumatra (Indonesia) (Figure 1). Penang consists of the island of Penang and a coastal strip on the mainland known as Province Wellesley. The island covers an area of 285 km2 and is separated from the mainland by a channel. The rainfall is quite evenly distributed throughout the year with more rain occurring from September to November [6].Penang has a population of approximately one million people. The bedrock geology of the study area consists mainly clay, silt, sand, gravels andgranite [6].

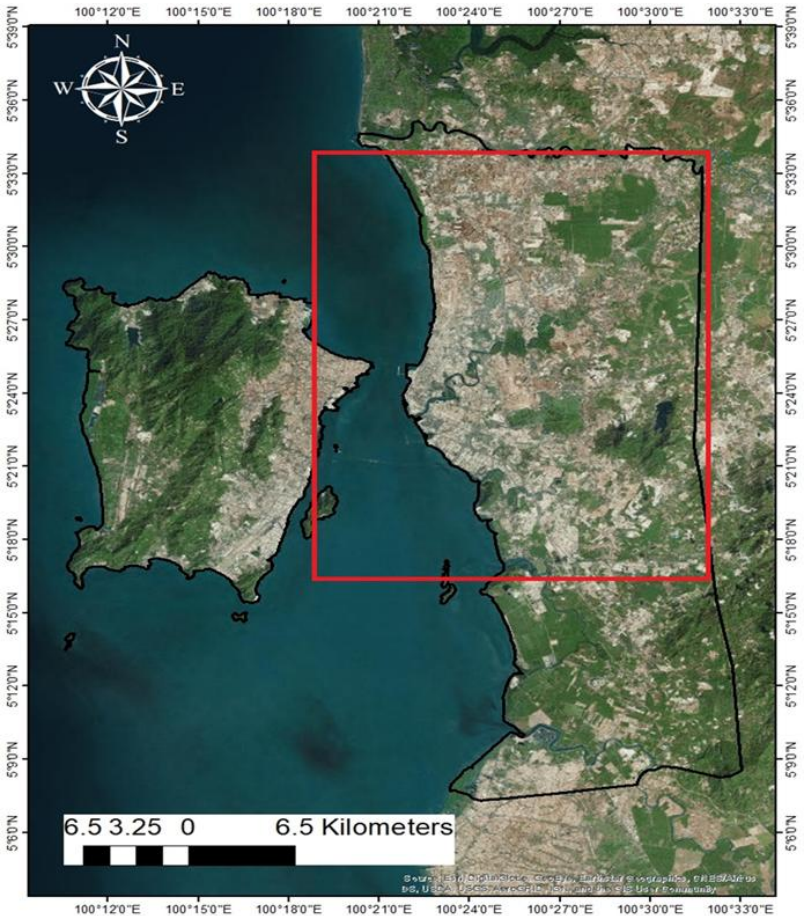

Figure 1. Geology map of the study area

2.2 Data Acquisition and Analysis

The Sentinel-1A data used for this research was downloaded from European Space Agency (ESA) (http://scihub.copernicus.eu/)This data covered the period from 3rd July 2018 to 12th February 2019 with a total of 20 descending images with 12-revisit day's interval by the satellite. The data set of Sentinel-1A images acquired in descending orbits are in Single Look Complex (SLC) format and the SAR images are in VV Polarization. The images were processed using SARPROZ software. The SARPROZ tool was the prominent software for processing INSAR data, programmed in MATLAB. Originally, the code was achieved to find the solutions to certain problems of fixing coherently data with various carrier frequencies generally ERS (European Remote Sensing) and Envisat(Environmental Satellite) [7].Hence, the SARPROZ tool was designed with a module for recognition and characterization of the target, able to process and extract information from

amplitude of radar data [7].Nowadays, series number of choice was provided by SARPROZ by combining long series of data and the processor and select the set of interferogram to process through certain techniques. In this research PS techniques were chosen to process the data. SARPROZ used in this research is a research tool and is continually under development. As it is written in MATLAB, it provides the ability to process the data very easily and to make its own modifications.

III. Results and discussions

Investigation of land subsidence in this research is based on the integration of Interferometry SAR techniques (MST and PS) and resistivity geophysical approach(Figure 2, 3,4a and 4b).The data processed in this study were obtained from ESA (European Space Agency) and resistivity survey. Sentinel 1A satellite data used are of descending orbit and the acquired images are from 03/07/2018 to 16/02/2019. For PS technique, master image was selected on 07/10/2018. For preliminary geocoding and removing the topographic phase component, Shuttle Radar Topography Mission (SRTM) Digital Elevation Model was used. In the analysis of this work, 20 images from Sentinel-1A were processed using SARPROZ with the image footprint of about 1510 pixel in range and 6000 pixel in azimuth of SAR coordinate. Both the MST and PS results show the subsiding and uplift of some zones in the study area.

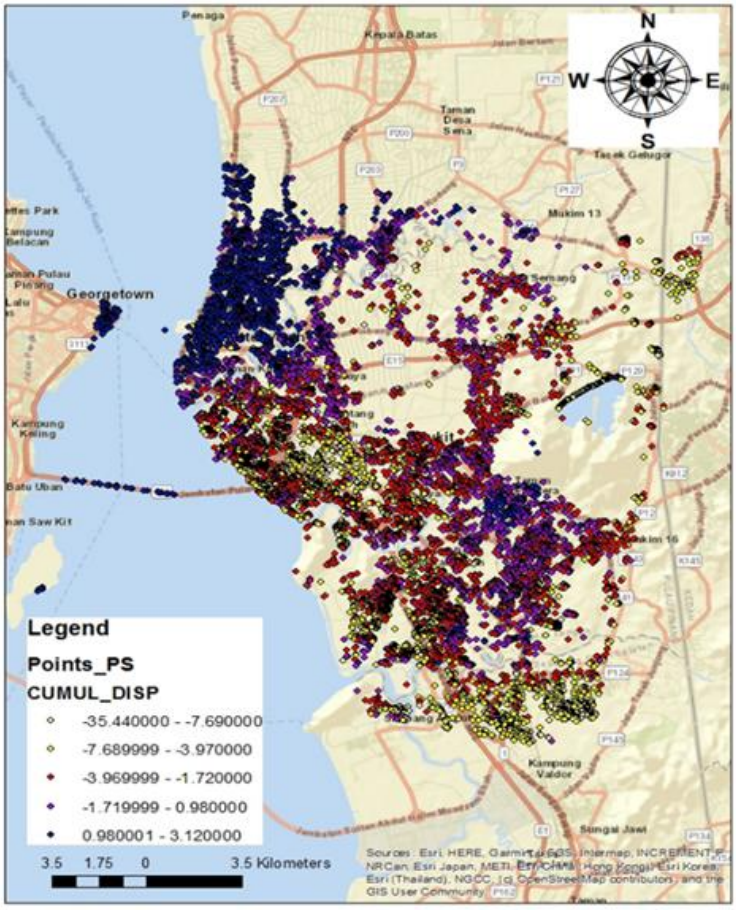

Figure 2. : PS point processed from ArcGIS 10.5

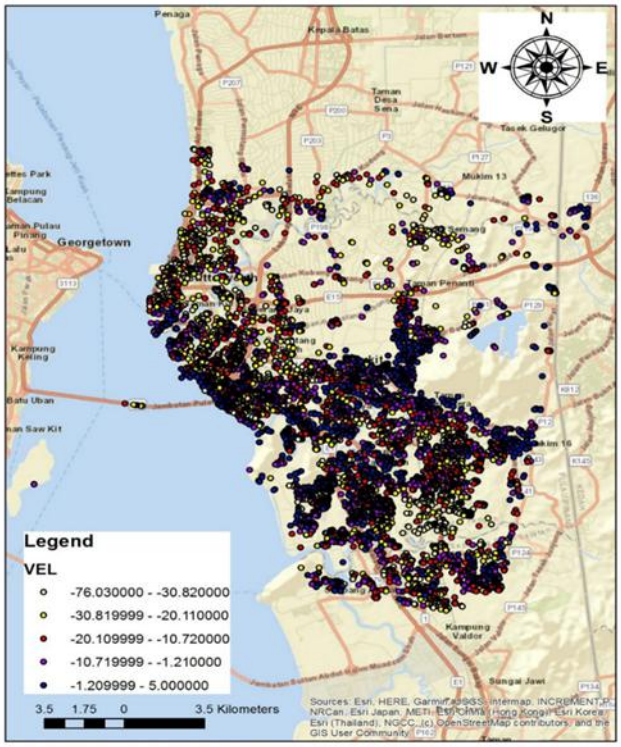

Figure 3. : MST point processed from ArcGIS 10.5

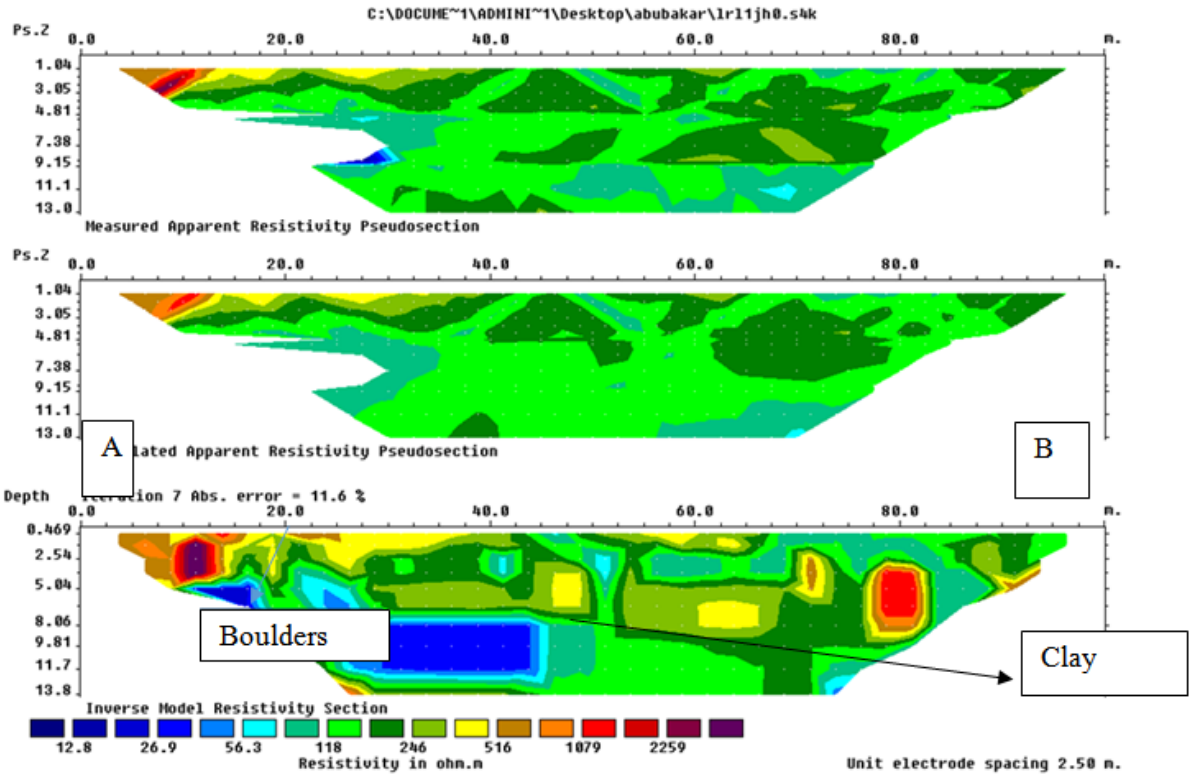

Figure 4a: Resistivity section for Juru Height area

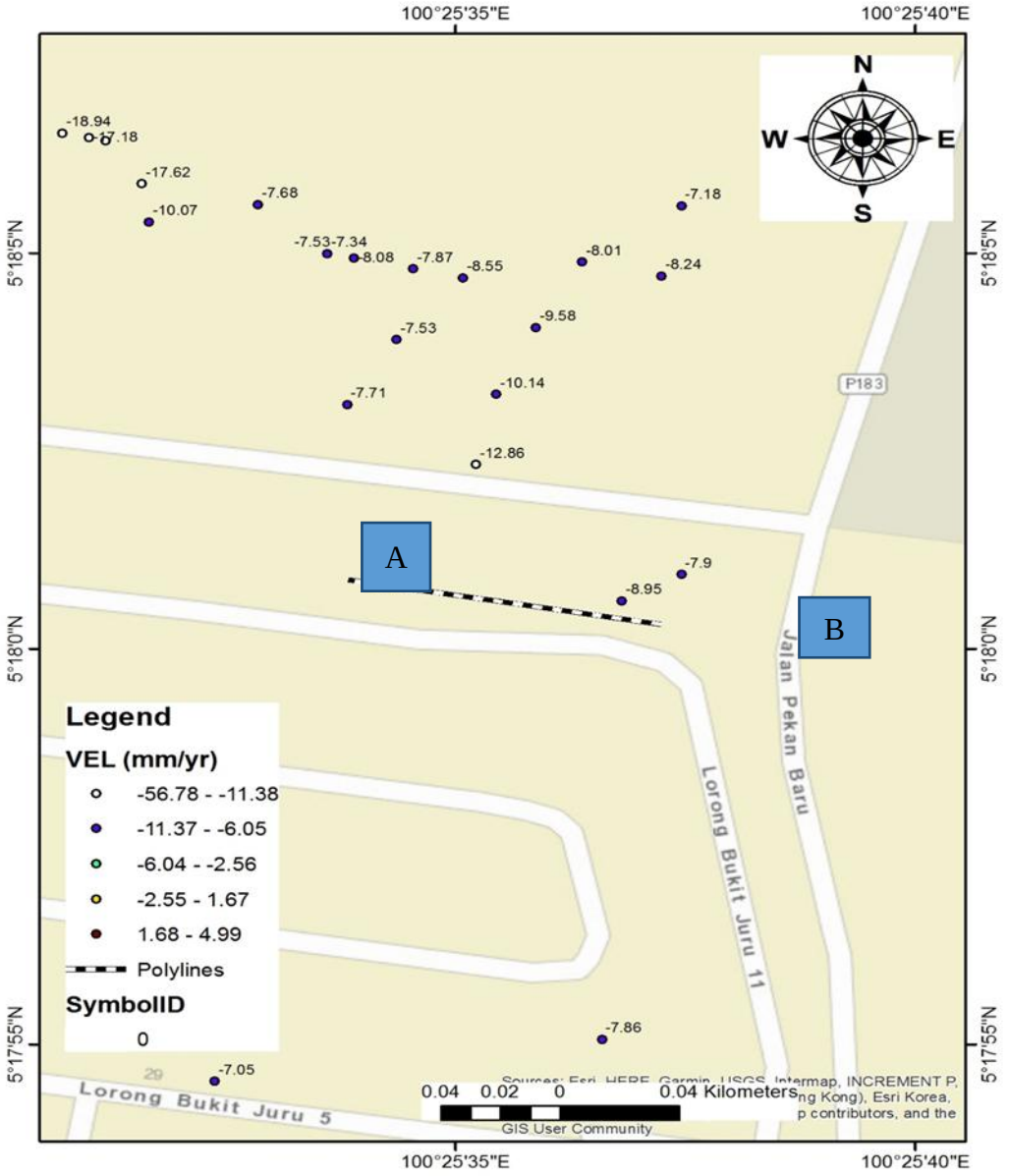

Figure 4b: Resistivity line for Juru Height area

Both the InSAR and resistivity result are in agreement as the two result are used to be able to identify the subsiding zone in the study area, the processed InSAR result help in identifying the subsiding area and uplift as shown in the zonal statistics map and bar chart (figure 5 and 6) in which the five selected zone are characterized by subsiding and uplift. The result suggests that there is an uplift in the Butterworth of an average mean of about 4mm/year. And also suggest the subsidence at Prai, Bukit Mertajam and Juru of about -5mm/year,-2mm/year and -7mm/year respectively. Hence no data detected in Kubang Semang as reason stated earlier. This part shows the real application of remote sensing by identifying the surface deformation feature. The subsurface anomalies was also suggested by the resistivity sections as well as the causes of subsidence as the area is mainly composed of clay saturated with water as identified by the survey conducted at Juru and Taman Bukit Minyak (figure 4a).

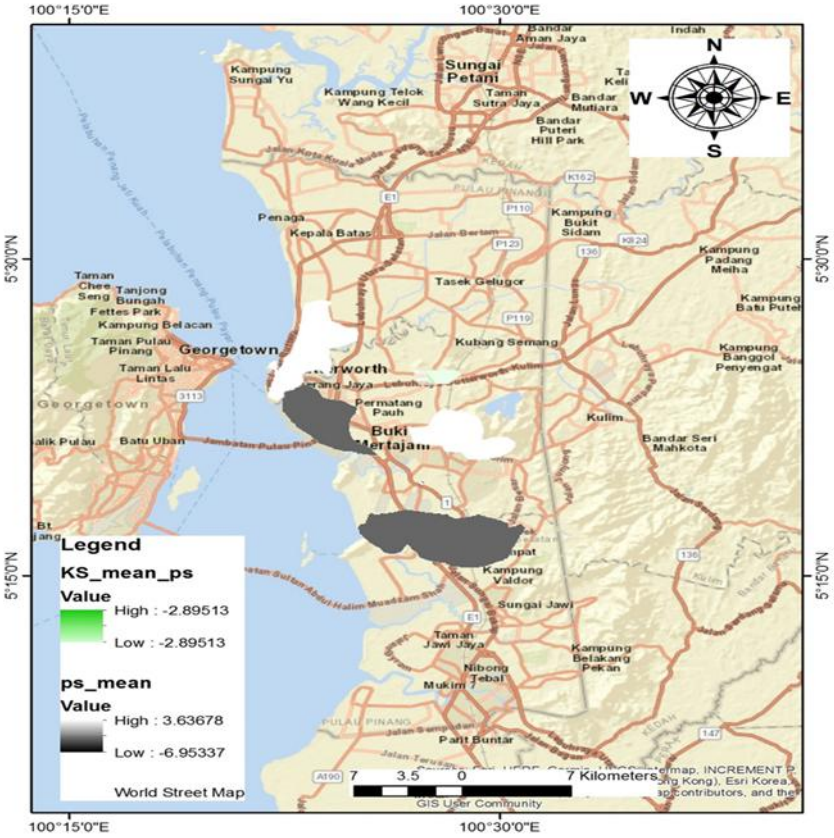

Figure 5. Potential zonal statistics map for subsidence and uplift mm/year

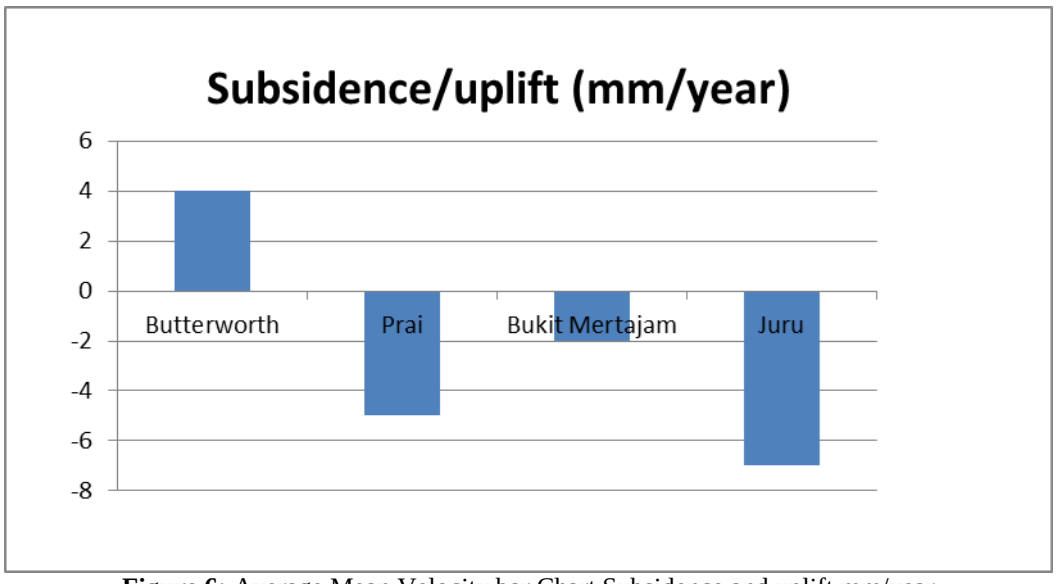

Figure 6: Average Mean Velocity bar Chart Subsidence and uplift mm/year

IV. Conclusions

The Result of this research suggest that there is an uplift in the Butterworth of an average mean of about 4mm/year. And also suggest the subsidence at Pari, Bukit Mertajam and Juru of about -5mm/year, -2mm/year and -7mm/year respectively. This approach serve as efficient and cheap technique for acquiring information of ground movement covering large area of land.

This study has shown that mainland Penang is susceptible to land subsidence due to the presence of clay saturated with water, fracture as well as the processed InSAR result from Persistent Scatter (PS) and

Minimum Spanning Tree (MST). The Penang government have to provide proper awareness to the residence of this affected area for the safety of entire people.

Acknowledgement

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