Assessment Of Land Subsidence In Munroe Island Kollam, Kerala, India

Dr Sindhu G, Athira B

Abstract— Land subsidence is the displacement of the ground, sunk downwards by exogenous or endogenic activities. The rates of subsidence can commonly vary between 1 and 20 centimeters per year and even more in certain places. Subsidence produces impacts such as infrastructure damage, problems with drainage, more comprehensive expansion of floodwater, as well as tidal inundation flooding by seawater at coastal areas experiencing land subsidence. The subsidence of Munroe Island is attracting general publicity since the Tsunami occurred in 2004. Studies conducted in this area have revealed the factors influencing sinking are tidal effects, plate movement due to Tsunami, construction of the dam, and sand mining. The research focuses on the assessment of land subsidence. In this study subsidence zone analysis will be performed by creating a land subsidence susceptibility map (LSSM) and concluded that tide is the major factor for subsidence

Index Terms — AHP, LSSM, quaternary aquifer, groundwater, tide, thematic maps,

I. Introduction

Land subsidence is the movement of land, submerged downwards due to exogenic or endogenic activities. Land subsidence exhibits spatial and temporal variations, with the rates of about 1–15 cm/ year is being seen in the area. When level of coastal area becomes lower than the level of the sea after experiencing subsidence - leads to sea water flooding. Thus tide also become a victim for subsidence. Coastal aquifers are distinguished from other aquifers because of dynamic coastal boundary where tidal effects cause complicated groundwater flow and contaminant transport phenomena in regions adjacent to the coast. Saltwater intrusion occurs as a result of the landward movement of sea water into the coastal aquifer. This landward movement is caused by a change in the freshwater and saltwater pressure gradients.Pumping (over pumping, in particular) of the aquifer results in decreased freshwater hydraulic head. Sea level rise and tidal action also results in increased saltwater hydraulic head.Among the different impacts of climate change, sea level rises much concern mainly due to the direct physical impact of inundation and potential habitat loss. A comparative analysis on the impact of permanent inundation due to sea level rise on 84 countries of the world revealed that millions of people in the developing nations are likely to be displaced. In Kerala subsidence of Munroe Island, which consist of a quaternary aquifer – mixture of alluvial & terrace deposits of sand, silt, clay, and gravel, is getting overall attention after the occurrence of Tsunami in 2014. In this study, Land Subsidence Susceptibility Map (LSSM) of the study area is prepared by multi criteria analysis (MCA) and GIS.

II. Methodology

The methodology comprises of preparation of Land Subsidence Susceptibility Map (LSSM), Geophysical survey, Modelling and Optimization. LSSM preparation involves of making of Thematic maps. The weightage of each maps are computed by Multi Criteria Analysis (MCA) and from this thematic maps the LSSM is prepared. Thematic maps are validated by ground truth survey. Geophysical survey involves Field survey, preparation of pseudo cross section, and Identification of freshwater - saltwater interface. Final step deals with design of Groundwater flow model and Contaminant transport model and its optimization to find the optimum pumping using genetic algorithm. The flow chart of the methodology is shown in the Figure 1.

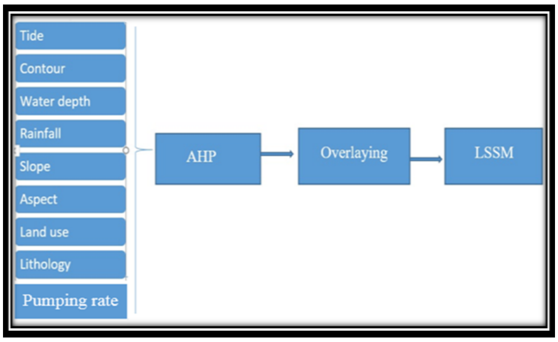


Figure 1. Flowchart of lssm

A. Thematic maps

Thematic maps are prepared by overlapping thematic layers namely Land cover, contour, DEM, Slope, Tidal map, Rainfall, Pumping rate, groundwater depth (bgl.) and are generated using Arc GIS software. They are reclassified in Arc GIS by assigning the appropriate ratings and were overlaid by multiplying their corresponding weightage obtained using AHP method and thus LSSM is prepared. The LSSM is classified into different classes of vulnerability. The figure 1 shows steps for preparation of LSSM map. Figure 2 to figure 11 shows different thematic maps

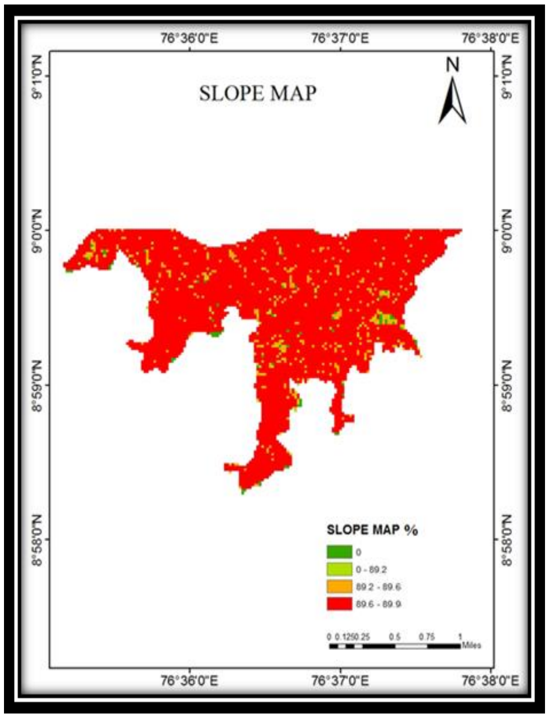
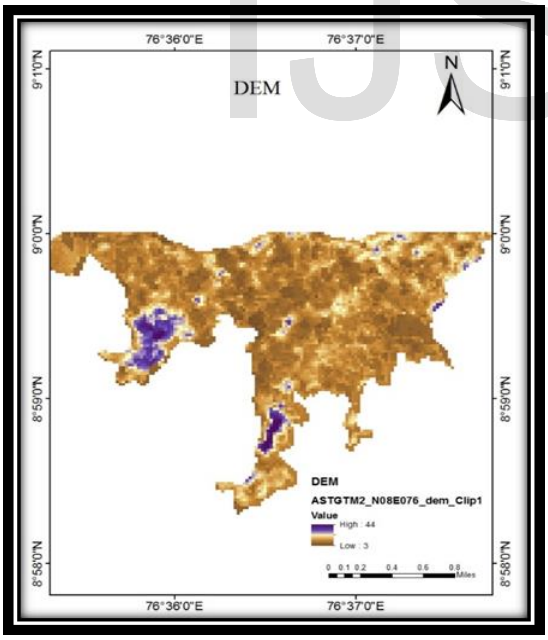


Figure 3. SLOPE MAP



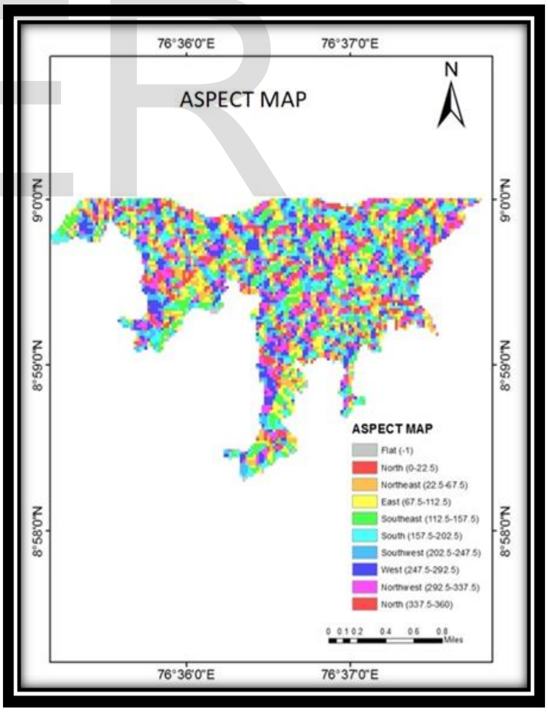


Figure 4. ASPECT MAP

Figure 2. DEM

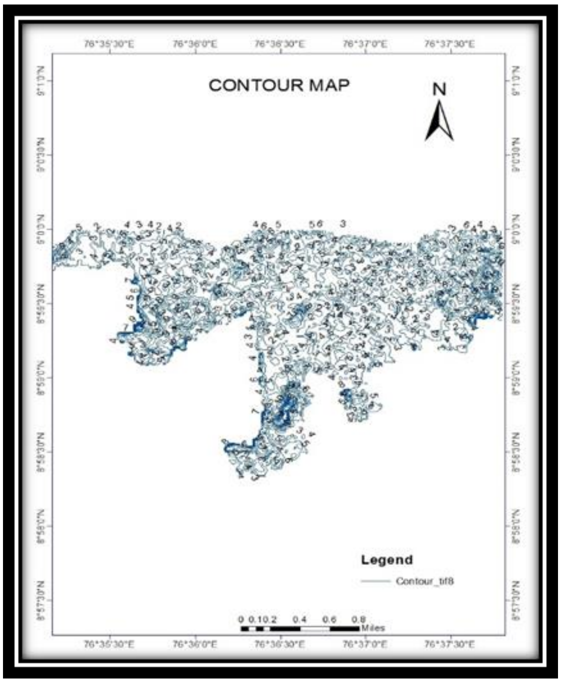


Figure 5. CONTOUR MAP

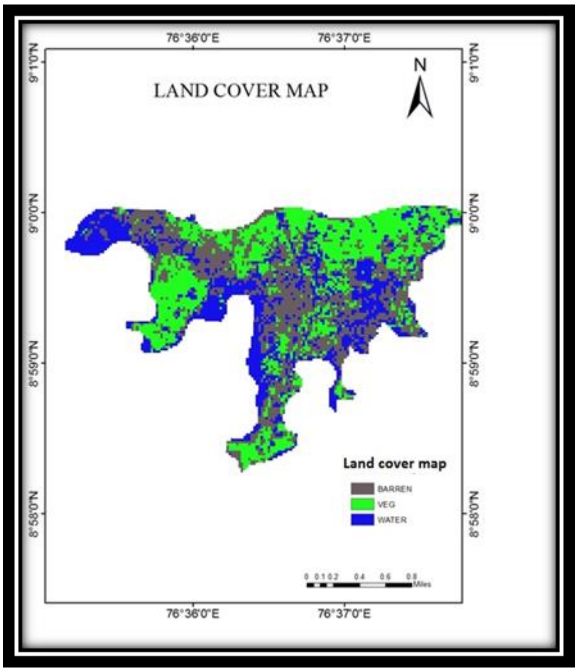


Figure 7. LAND COVER MAP

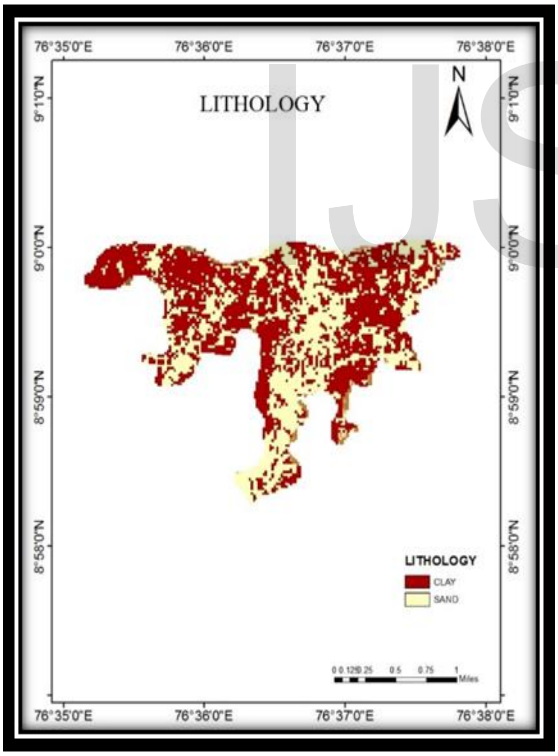


Figure 6. LITHOLOGY

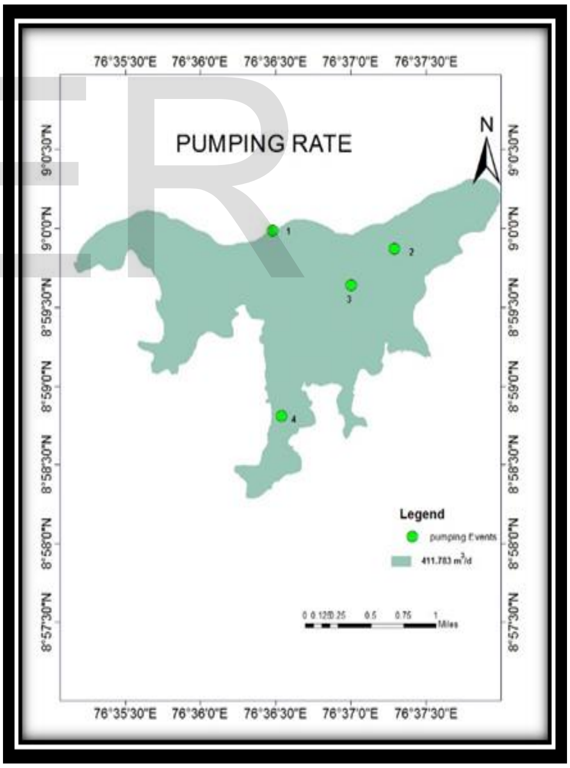


Figure 8. PUMPING RATE

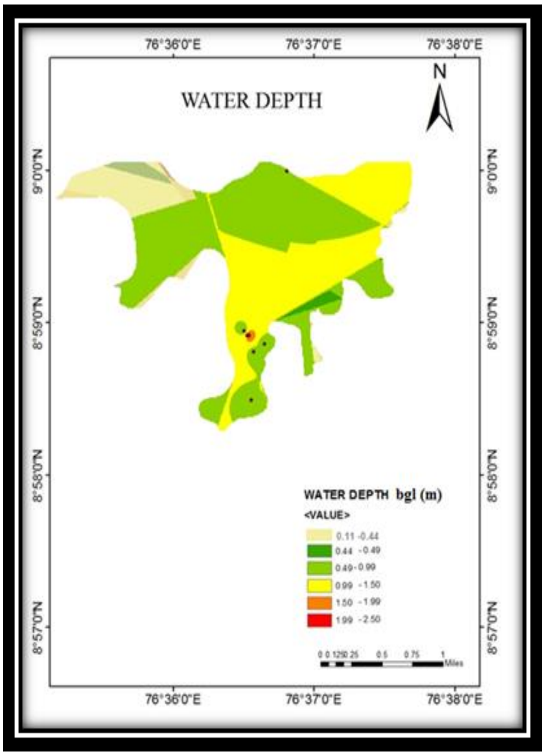


Figure 9. WATER DEPTH

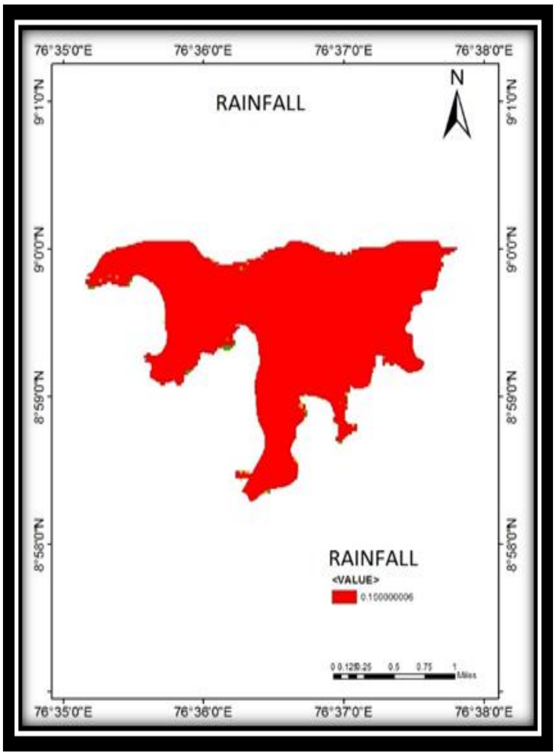


Figure 11. RAINFALL

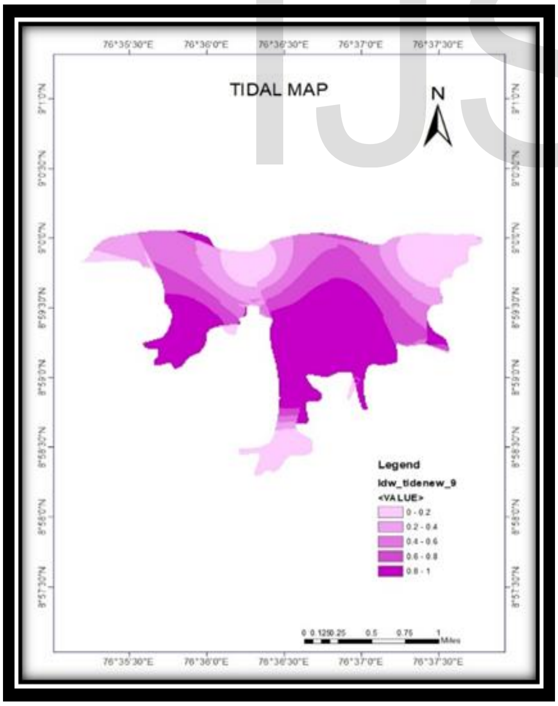


Figure 12. TIDAL MAP

The decision making tool used in this study Analytical Hierarchy Process (AHP). The analytical hierarchy process was developed by Saaty (1980) - an analytical tool which is a General theory of measurement. It used to derive ratio scales from both discrete and continuous paired comparisons.These comparisons may be taken from actual measurements or from a fundamental scale which reflects the relative strength of preferences and feelings. Finally ratings are multiplied by a weighing coefficient in the range 0.1 to 0.9, obtained by AHP method. Table 1 to 3 shows the calculatons of weitage parameter using AHP. Pairwise comparison matrix and Normalized matrix developed is shown below.

ISSN 2229-5518

Table 1. Pairwise Comparison Matrix

	Tide	Contour	Pumping rate	Water depth	Rainfall	Slope	Aspect	Landuse	Lithology
Tide	1	1	3	3	5	1	1	3	5
Contour	1	1	1	5	5	1	1	5	3
Pumping rate	1/3	1	1	3	5	1	1	3	5
Water depth	1/3	1/5	1/3	1	1	1	1	5	5
Rainfall	1/5	1/5	1/5	1	1	5	5	1	1
Slope	1	1	1	1	1/5	1/5	1	3	5
Aspect	1	1	1	1	1/5	1/5	1	1	1
Landuse	1/3	1/5	1/3	1/5	1	1/3	1	1	5
Lithology	1/5	1/3	1/5	1/5	1	1/5	1	1/5	1

Table 2. Normalized Matrix

	Tide	Contour	Pumping rate	Water depth	Rainfall	Slope	Aspect	Landuse	Lithology
Tide	0.8158	0.105	0.3248	0.223	0.2307	0.230	0.183	0.325	0.155
Contour	0.2445	0.2105	0.5403	0.743	0.769	0.769	0.061	0.195	0
Pumping Rate	0.4076	0.2105	0.0403	0.115	0.769	0.769	0.061	0.325	0.093
Water depth	0.8158	0.042	0.1088	0.223	0.769	0.769	0.061	0.325	0.155
Rainfall	0.8158	0.2140	0.108	0.0743	0.769	0.3845	0.061	0.065	0.031
Slope	0.8158	0.214	0.216	0.0743	0.3845	0.3845	0.305	0.195	0.155
Aspect	0.8158	0.04209	0.216	0.044	0.769	0.176	0.061	0.065	0.031
Landuse	0.8158	0.0707	0.108	0.044	0.3845	0.176	0.061	0.065	0.155
Lithology	0.163	0.0707	0.108	0.0743	0.769	0.176	0.061	0.013	0.031

From the above matrices weightage of the parameters are calculated.

Table 3. Weightage Assigned to Each Parameter

PARAMETER	WEIGHTAGE VALUE
Tide	0.82
Contour	0.2
Pumping rate	0.13
Water depth	0.39
Rainfall	0.108
Slope	0.0769
Aspect	0.061
Land use	0.065
Lithology	0.031

Using the weightage obtained from AHP method, LSSM is developed with the help of ARC GIS software. From the map it is found that Kidappuram and North Pattom Thuruth seen to have high subsidence range and Peringalam shows medium range of subsidence. These areas are nearer to Ashtamudi lake and are highly affected by tide. Sand mining was very often in the lakes near to the above areas which may contribute to the subsidence. Increased subsidence rate may be the major effect of tidal fluctuations in the area.

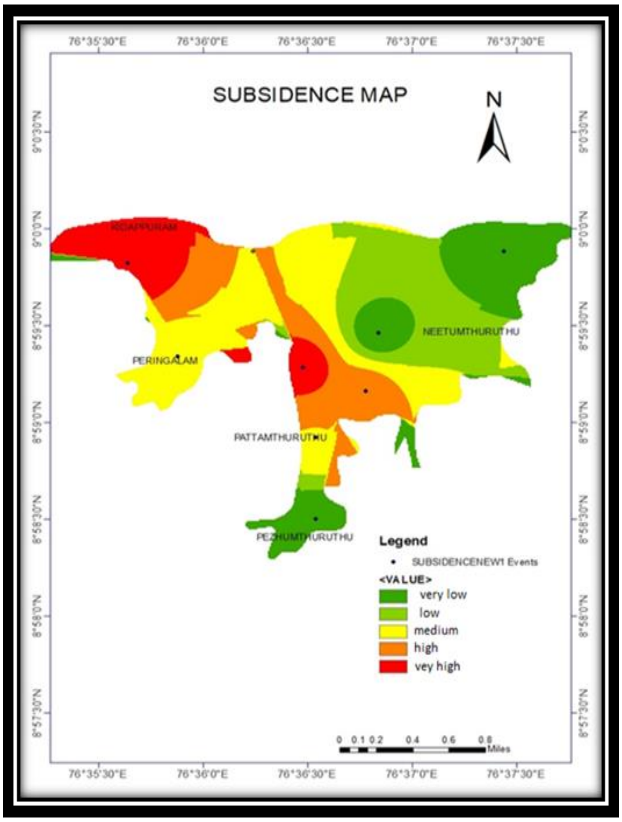


Figure 13. LSSM

III. CONCLUSION

Using the weightage obttained from AHP method , develop LSSM with the help of ARC GIS software. Figure 4.12 shows the LSSM . From the map it is found that Kidappuram and North Pattom Thuruth seen to have high subsidence range.Peringalam shows medium range of subsidence. The above areas are nearer to Ashtamudi lake and are highly affected by tide.Sand mining was very often in the lakes near to the above areas which may contributed to the subsidence. Increased subsidence rate may be the major effect of tidal fluctuations in the area.

REFERENCE

[1]Ismaila B.Obikova, Jim D. Bennell (2012). "Geophysical Investigation of the Fresh-Saline Water Interface in the Coastal Area of Abergwyngregyn", Journal Of Environmental Protection,Vol.3.

[2]Ko-Fei Liu .,(1996) "joural oTide-induced ground-water flow in deep confined aquifer" journal of hydraulics engineering

[3]M A El Fakharany , Nehad Mansour (2013). "Using Modflow And MT3D Groundwater Flow And Transport Models As A Management Tool For The Quaternary Aquifer, East Nile Delta, Egypt", International Journal Of Science Commerce And Humanities,Vol.1.

[4]Michelle Sneed, Marti E Ikehara , Sylvia V Stork, Falk Amelung, and Devin L Galloway (2003). "Detection and measurements of land subsidence using global positioning system and interferometric synthetic aperture radar, Coachella valley, California", U.S. Geological Survey Water Resource Investigations Report 03-4015.

[5]Padmalal D., Maya K. and Mohan V. (2013) "Late Quaternary climate, sea level changes and coastal evolution – A case study from SW India", Monograph, Centre for Earth Science Studies, Thiruvananthapuram, ISBN 81-901842-1-0Pieter Neilson (1990), "Tidal dynamics of water table in beach", Water Resour. Res., vol 26 pp.546-548, 2001

[6]Richa Bhattarai (2017). "Land Subsidence Mapping and Risk Assessment in Kathmandu Valley, Nepal, using DInSAR and GIS Techniques" , Department of Earth Sciences

[7]Saranya U (2019). "Identifying the Factors and Effects of Sinking in the Munroe Island of Kollam District, Kerala", International Journal of Science and Research, Vol.8.

[8]Omid Ghorbanzadeh, Bakhtiar Feizizadeh, and Thomas Blaschke (2018), "An interval matrix method used to optimize the decision matrix in AHP technique for land subsidence susceptibility mapping" Environmental Earth Sciences , pp 77:584

[9]Omid Ghorbanzadeh, Thomas Blaschke, Jagannath Aryal & Khalil Gholaminia (2018), "A new GIS-based technique using an adaptive neuro-fuzzy inference system for land subsidence susceptibility mapping" Journal of Spatial Science, DOI:10.1080/14498596.2018.1505564

[10]P. Tzampoglou and C. Loupasakis (2017)., "Mining geohazards susceptibility and risk mapping: The case of the Amyntaio open-pit coal mine, West Macedonia, Greece" Environ Earth Sci, pp 76:542