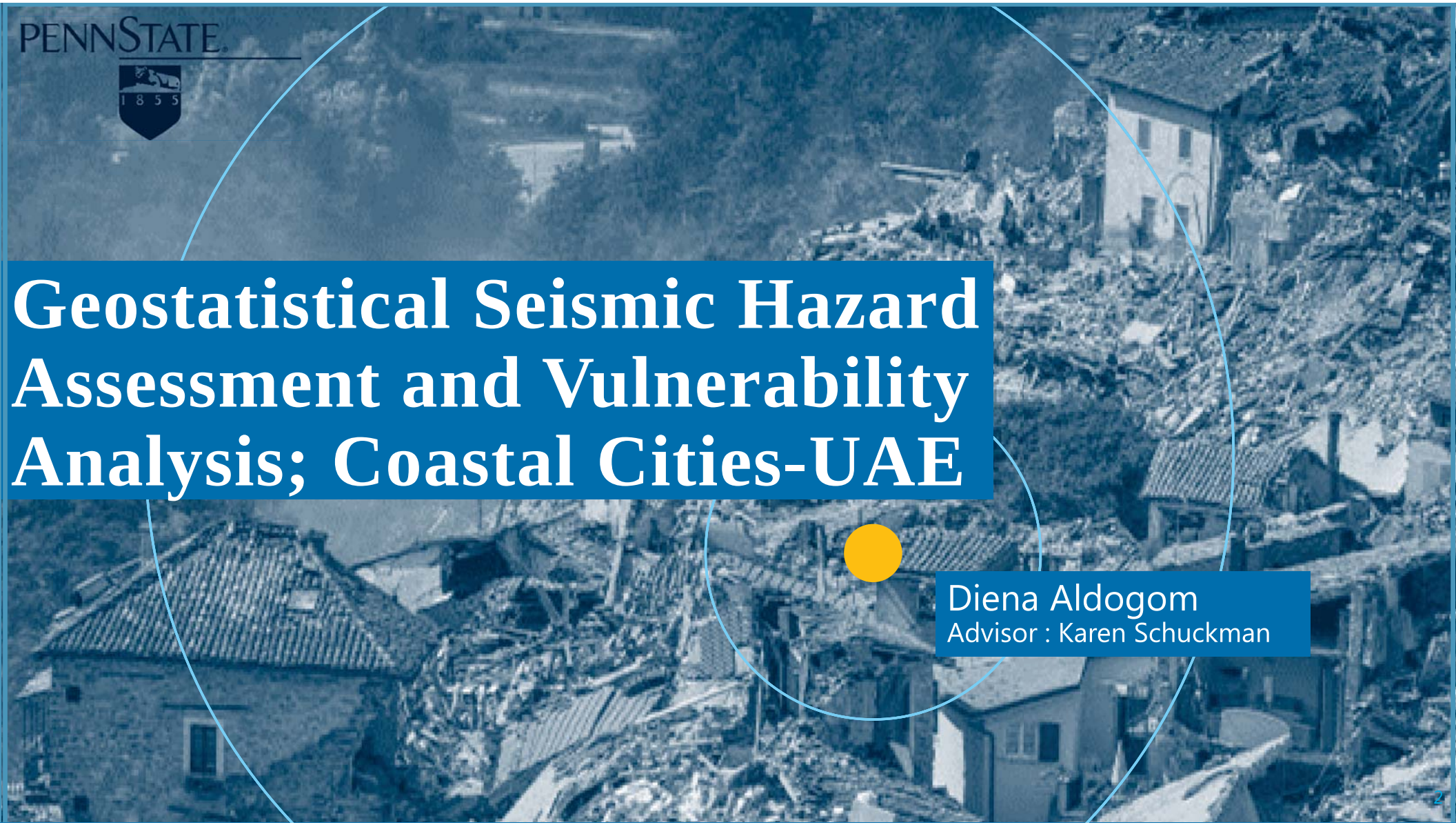


Geostatistical Seismic Hazard Assessment and Vulnerability Analysis; Coastal Cities-UAE

Diena Aldogom
Advisor : Karen Schuckman

- Introduction
- Literature Review
- Study Area
- Problem Statement and Objectives
- Data source
- Methodology
- Work Plan

Introduction

Earthquake:
is the shaking of the Earth surface, resulting from the sudden release of energy in the Earth's lithosphere that creates seismic waves

- Earthquakes have a substantial effect on human lives, infrastructures and economy. Even though it is considered as a short period disaster, its impact on the affected area could last for years
- Earthquakes are described by its magnitude, speed of onset, frequency, duration, and its geographic location (epicenter location)

Literature Review

Arab J Geosci
DOI 10.1007/s12517-013-0974-6

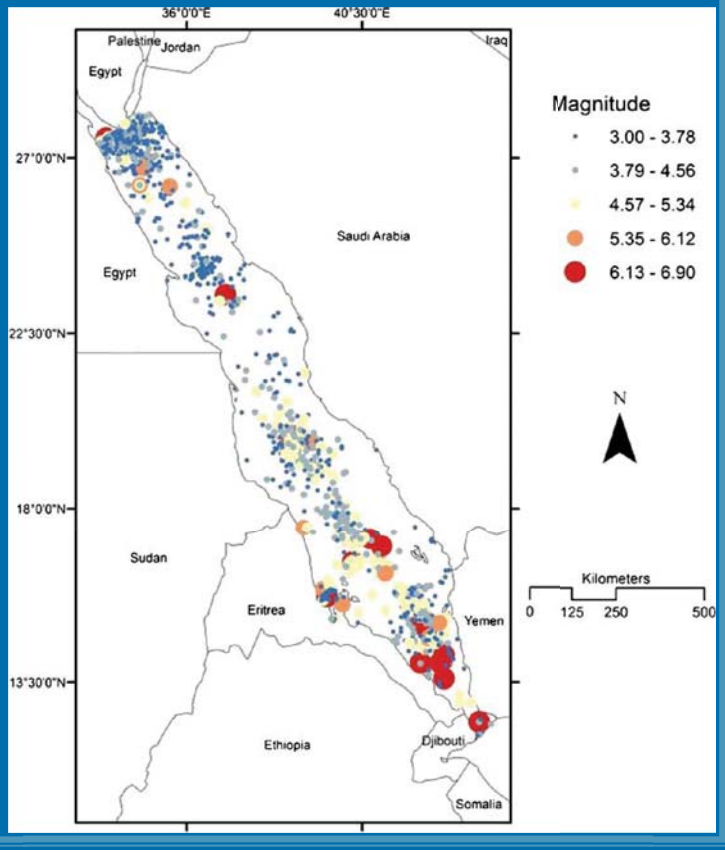
ORIGINAL PAPER

A spatial statistical analysis of the occurrence of earthquakes along the Red Sea floor spreading: clusters of seismicity

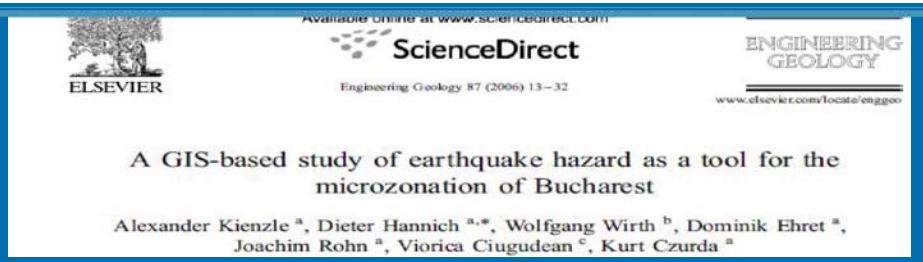
Khalid Al-Ahmadi · Abdullah Al-Amri · Linda See

(Al-Ahmadi et al., 2013)

- The aim of this study is to apply spatial pattern analysis techniques to a seismic data catalog of earthquakes beneath the Red Sea to try and detect clusters and explore global and local spatial patterns in the occurrence of earthquakes over the years from 1900 to 2009 using (GIS).
- The spatial pattern analysis include global Moran's I, Getis–Ord general G, Anselin Local Moran's I, Getis–Ord Gi*, kernel density.
- Earthquakes with higher magnitudes were notably concentrated in the central and southern parts of the Red Sea where seismic activities were most active.

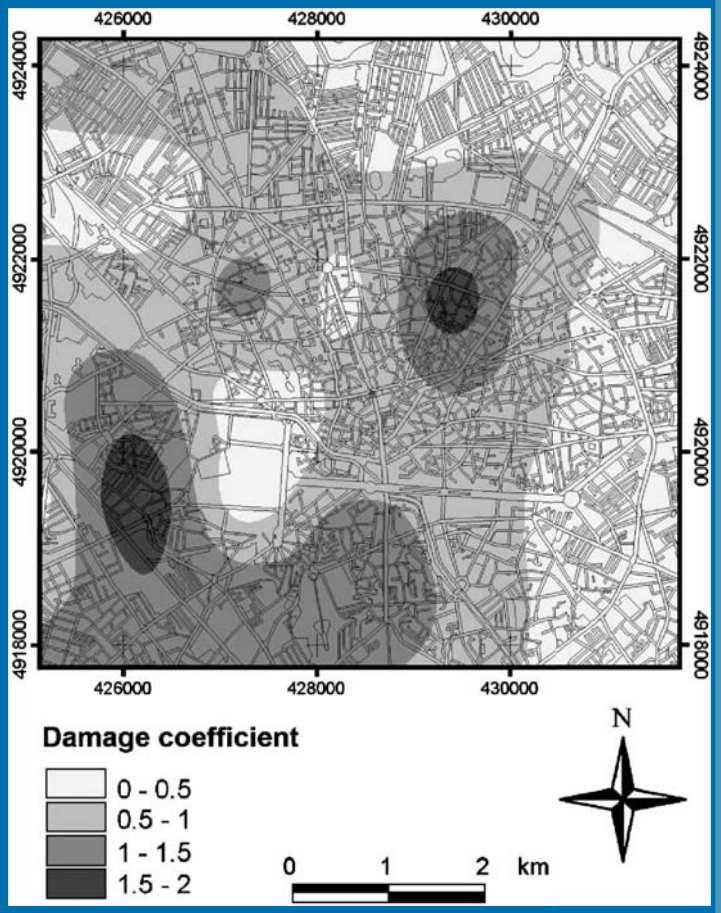


Literature Review



(Armaş, 2012)

- Generated a micro-zonation map of Bucharest-Romania Based on a precise Digital Geological Model (DGM).
- The Digital modelling of the subsurface conditions has been built throughout the integration of geological borehole data, analogue maps, geological cross-sections and tables with geotechnical data and soil profiles.
- The model has been verified using the 1977-earthquake
- It has been found that the GIS-based approach is a helpful tool for modelling local site effects in urban areas.



Literature Review

Soil Dynamics and Earthquake Engineering
Volume 66, November 2014, Pages 263-280

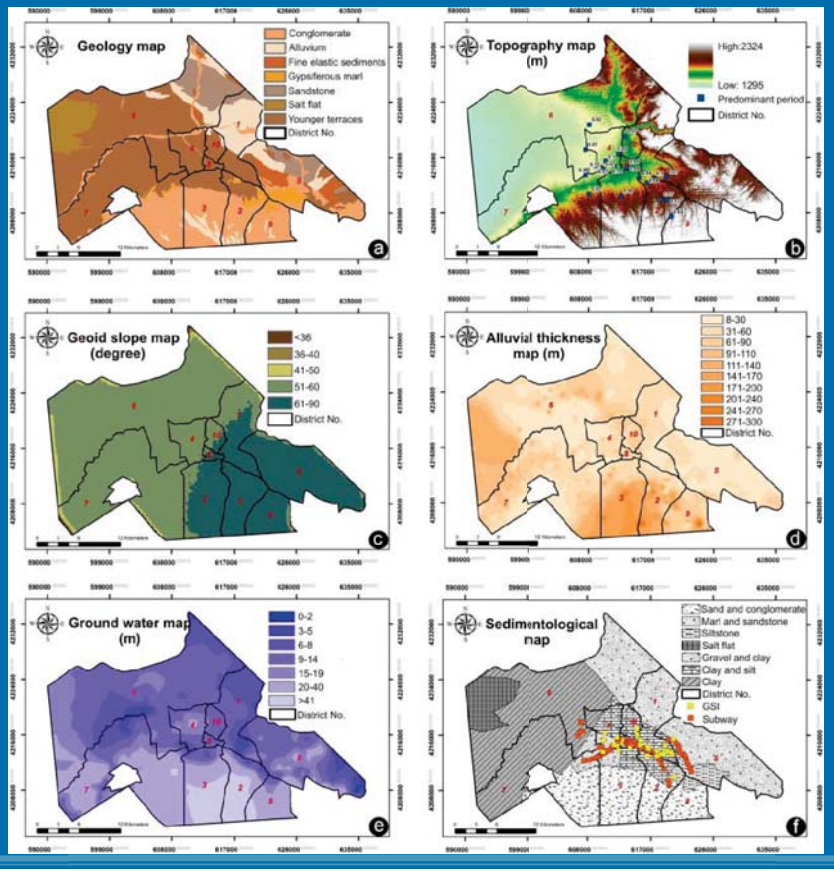
Review

A GIS-based seismic hazard, building vulnerability and human loss assessment for the earthquake scenario in Tabriz

Sadra Karimzadeh [a], Masakatsu Miyajima [a], Reza Hassanzadeh [b], Reza Amiraslanzadeh [a], Batoul Kamel [c]

(Karimzadeh et al., 2014)

- conducted GIS-based seismic hazard study and estimate building vulnerability and human loss for earthquake scenario in Tabriz.
- Detailed geological, geodetically, geotechnical and geophysical Parameters for Metropolitan Tabriz-Iran are combined using AHP.
- Vulnerability analysis done using building and population layers. An actual earthquake was used to validate the presented model.



Literature Review

(Yagoub, 2015)

Yagoub *Geoenvironmental Disasters* (2015) 2:13
DOI 10.1186/s40677-015-0020-y

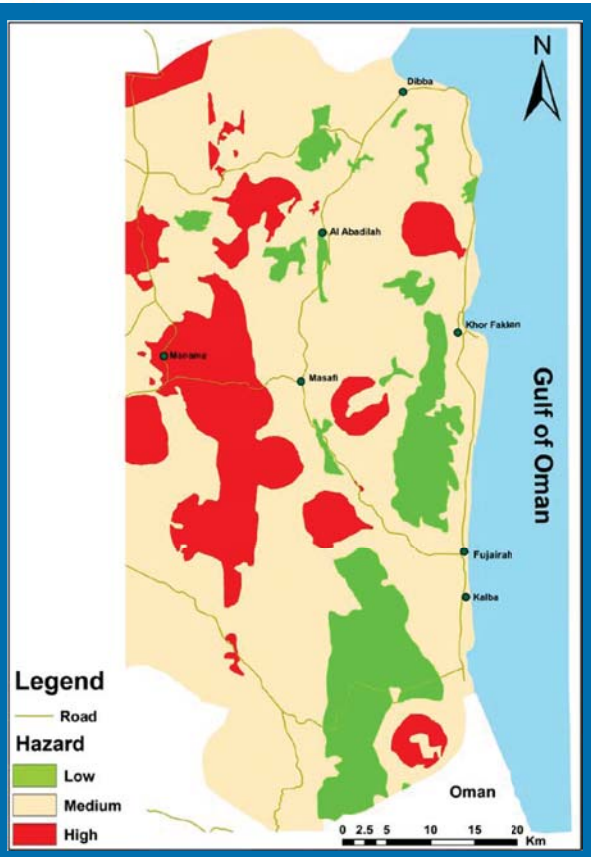
Geoenvironmental Disasters
a SpringerOpen Journal

RESEARCH ARTICLE Open Access

Spatio-temporal and hazard mapping of Earthquake in UAE (1984–2012): Remote sensing and GIS application

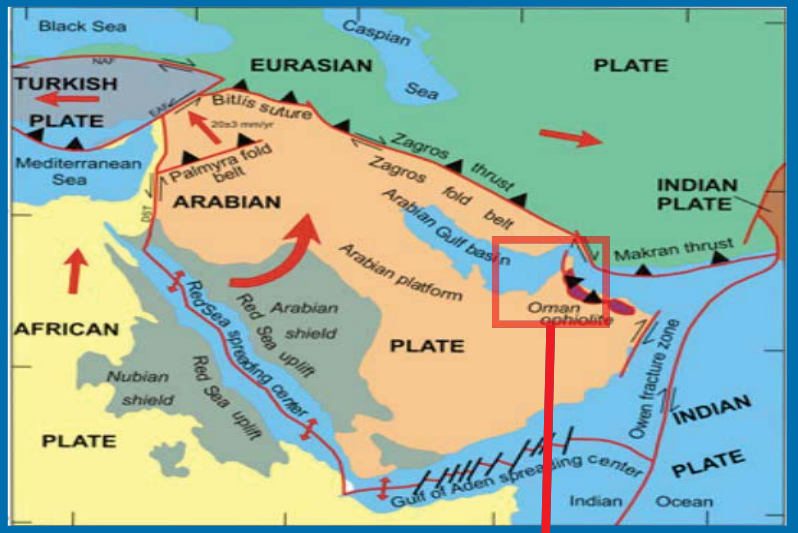
Mohamed Mohamed Yagoub

- His study investigates the spatial-temporal distribution of earthquake events taking place in UAE and its effect on the population
- Seven parameters are used for generation of a hazard map, this includes geology, soil, slope, land use, historical earthquake events, fault line, and roads. GIS weighted overlay analysis is used to demarcate the earthquake risk zones
- Hazard map for the Eastern part of UAE has been produced to will help in systematic and proper development of land use for community planning and mitigation policy.

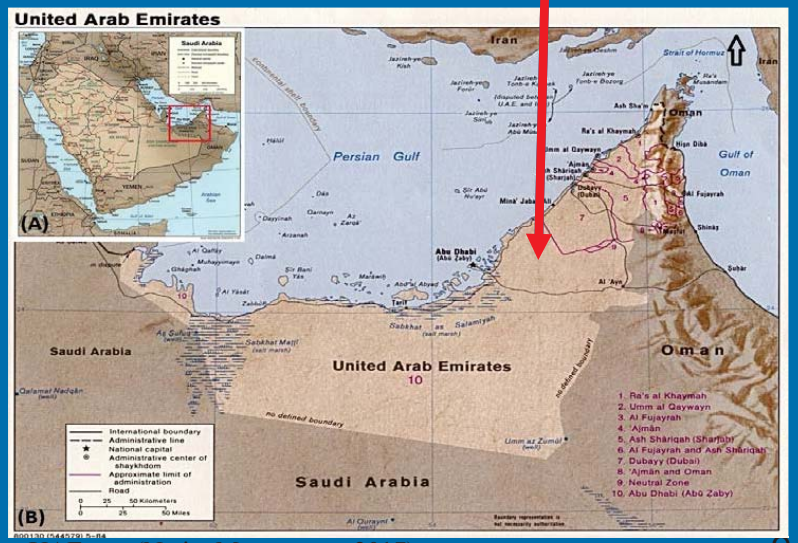


Study Area

- The Arabian Plate located at the northern and eastern hemispheres. It is a minor tectonic plate bordered by three different plates
- UAE located at the Arabian plate, western Asia, lies between 22°30' and 26°10' north latitude and between 51° and 56°25′ east longitude
- UAE area is 32,300 sq mi. In 2017, the UAE's population is 9,400,000



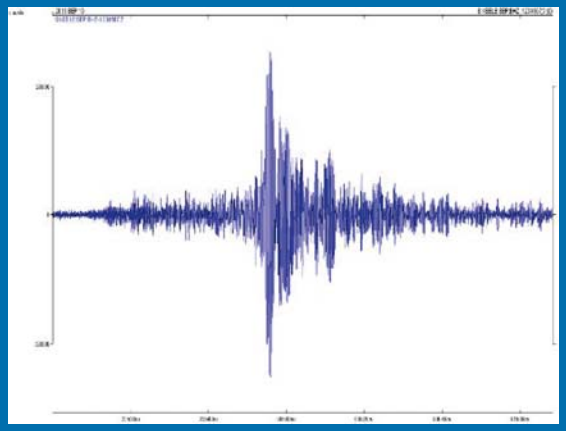
The Arabian plate location (Aldama-Bustos et al., 2009).



UAE map(NationMaster.com, 2017).

PROBLEM

UAE can be considered as low seismic activity area



Major faults and active seismic sources region

Rapid urban development activities and growing population

PROBLEM

On March 11th, 2002, an earthquake of moderate magnitude hits UAE northeastern part (Fujairah city), where a small damage around Masafi area was reported (Al Shamsi, 2013)

Reported damage around Masafi area (Al Shamsi, 2013)

Objectives

1. Locate the earthquake events hotspots and cold spots areas in the Arabian plate.
2. Prepare an earthquake hazard zonation map of UAE, using multi-criteria factors which draw the study area geomorphological and the seismological characterizations.
3. Estimate the vulnerability of UAE coastal cities, and human losses based on the population, building intensity, schools, and hospital locations and interactive analyses.
4. Provide better land use and urban development planning the takes in to consideration the area seismicity and the rapid increasing number of population, high rise buildings, and infrastructures.

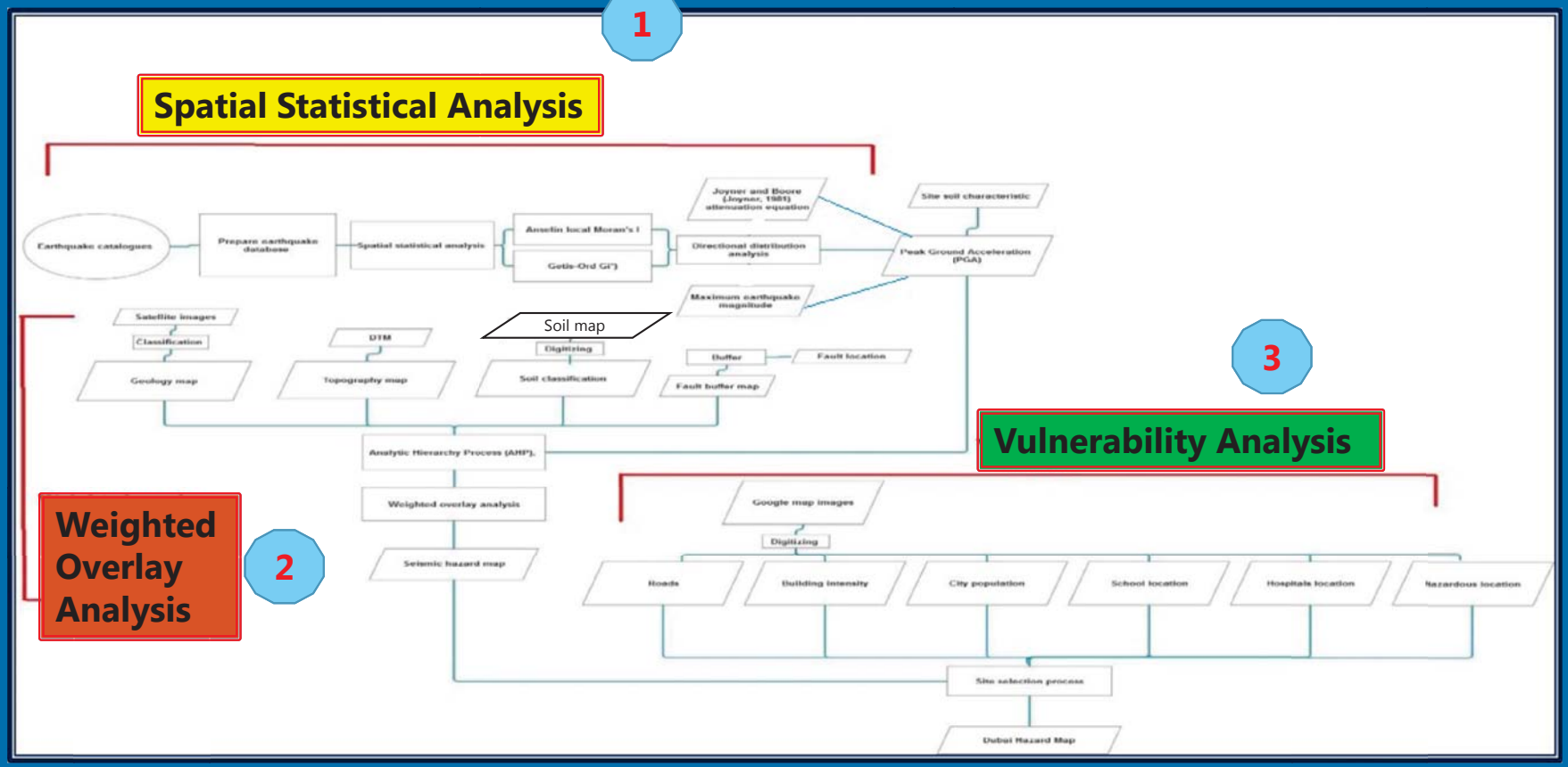
Data Source

- ASTER Global DEM.
- The Sentinel-2.
- Soil map.
- Geology map.
- Fault lines location.
- Earthquake historical events.
- Population.
- Road layer.
- Schools and hospital locations.

Methodology

1

Spatial Statistical Analysis



Weighted Overlay Analysis

2

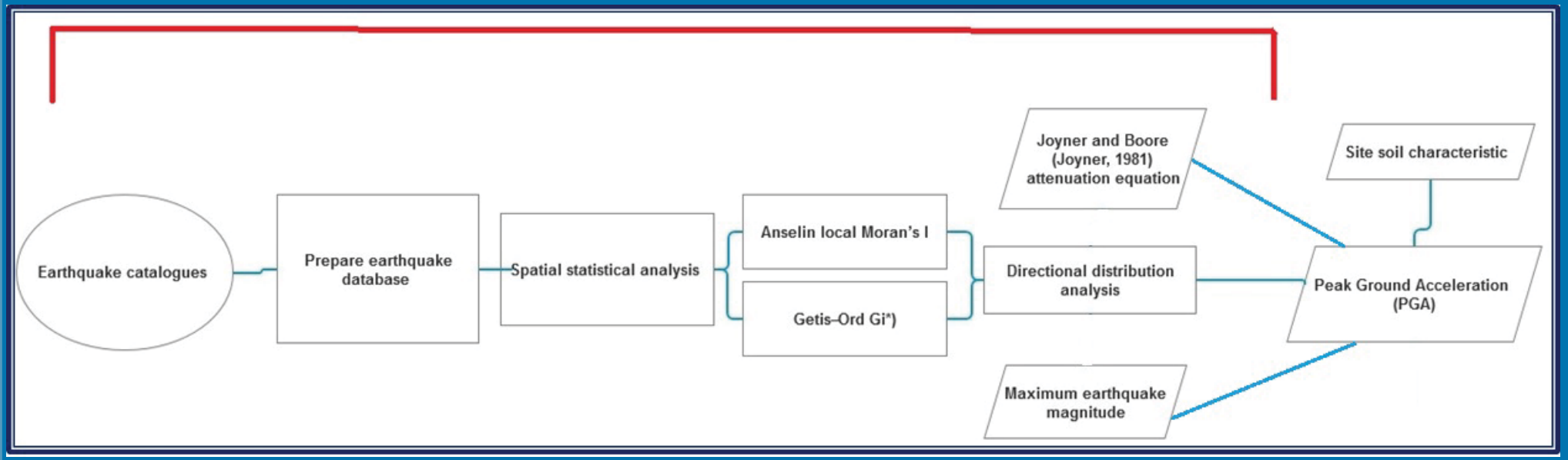
3

Vulnerability Analysis

Methodology

1

Spatial Statistical Analysis



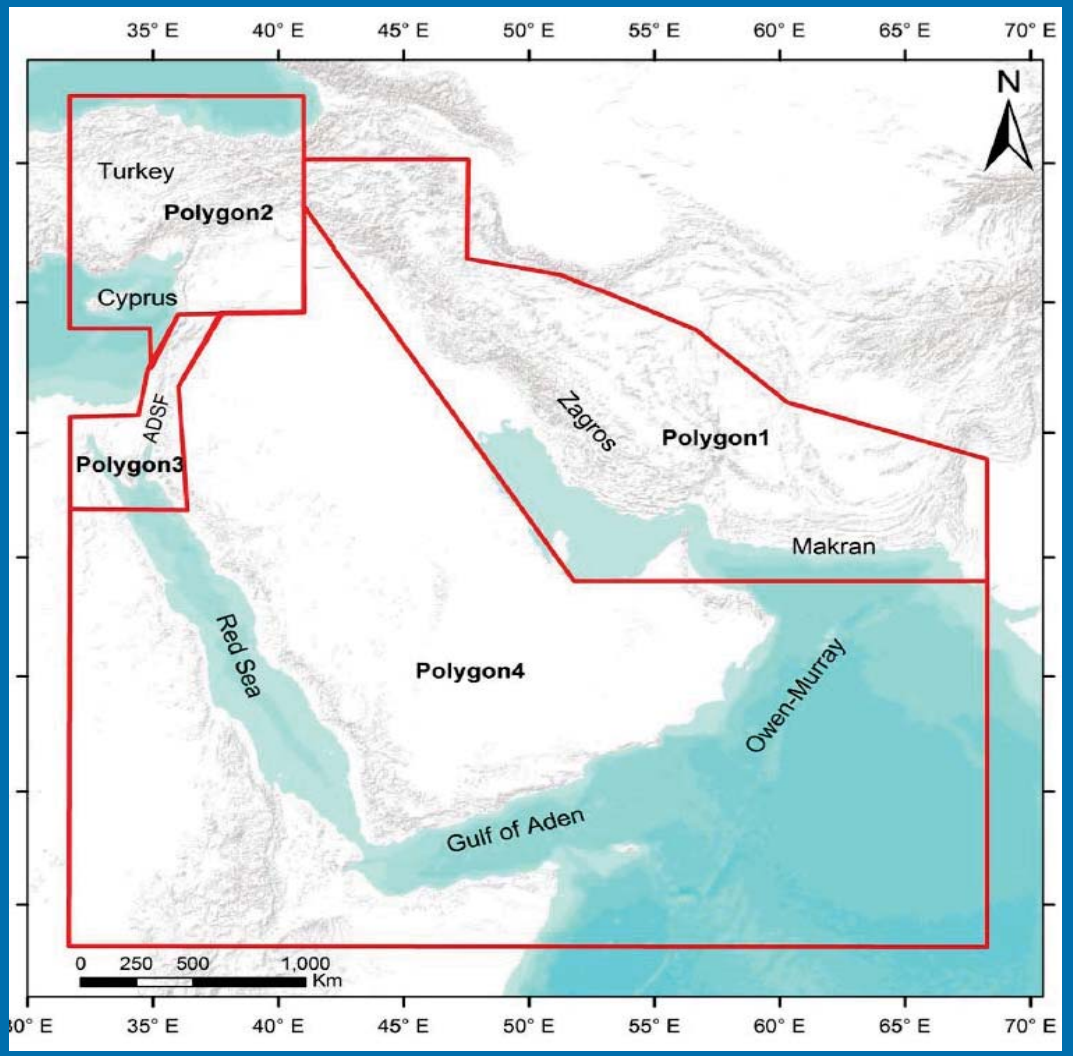
Methodology

1

Spatial Statistical Analysis

Earthquake Database Preparation

- The Arabian plate area will be subdivided into four polygons (Deif, et al., 2017),
- Earthquake events (1964-2017) will be combined from different catalogues,
- Temporally or spatially duplicated earthquake events, will be removed manually,
- Conversion of different magnitude scales into Mw will be achieved.



The Arabian Plate Subdivided Into Four Polygons (Deif, et al., 2017)

Methodology

1

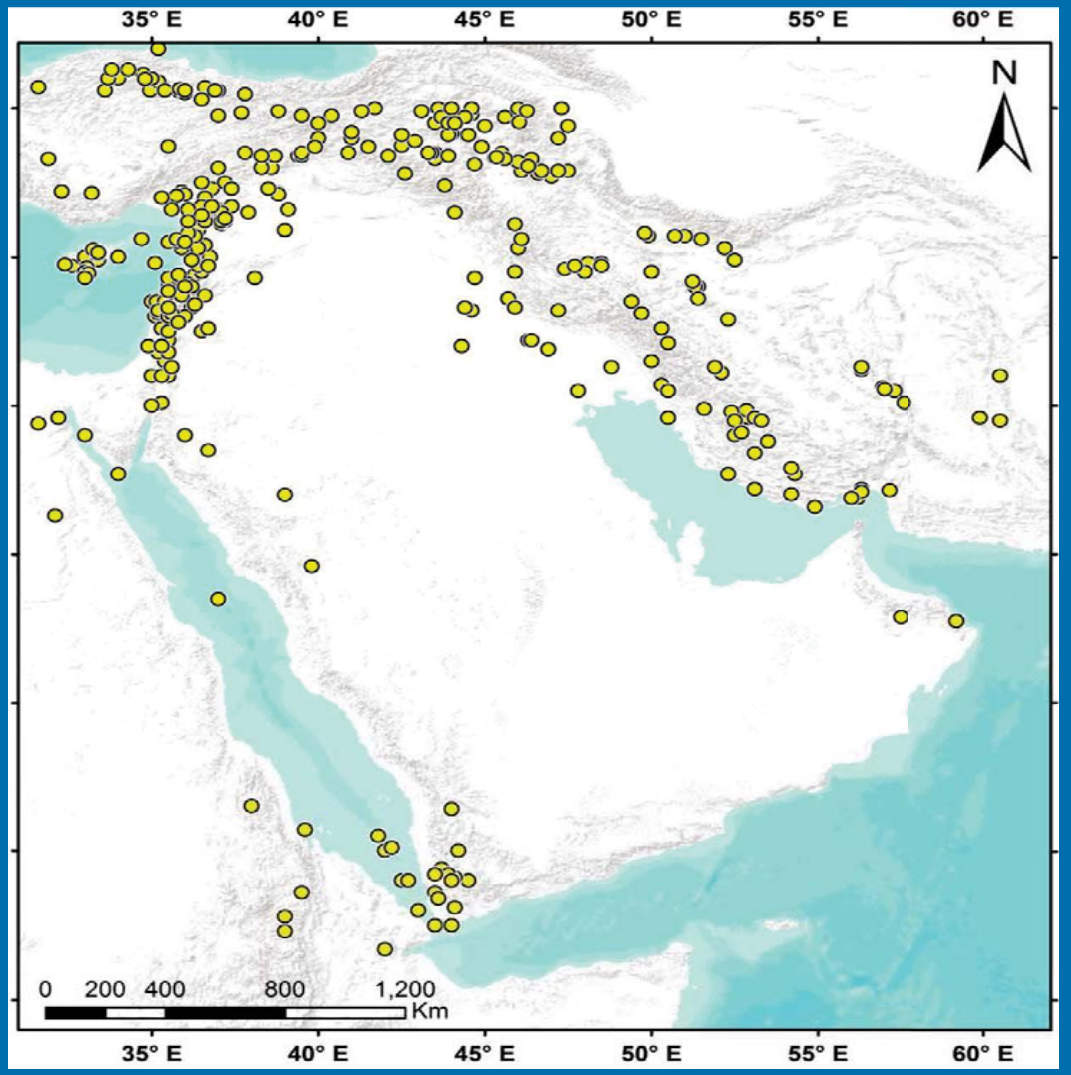
Spatial Statistical Analysis

Hotspot analysis

- Local statistics will be used to detect the spatial relationships difference between variables, the presence of clusters or hot spots, and for determining the distance beyond which spatial effects between variables cease

- local statistics: (1) Anselin local Moran's I,

$$I_i = \frac{x_i - \overline{X}}{S_i^2} \sum_{j=1, j \neq i}^{n} \omega_{i,j} \left(x_j - \overline{X} \right)$$



Earthquake Events (1900-2015), (Deif, et al., 2017)

Methodology

1

Spatial Statistical Analysis

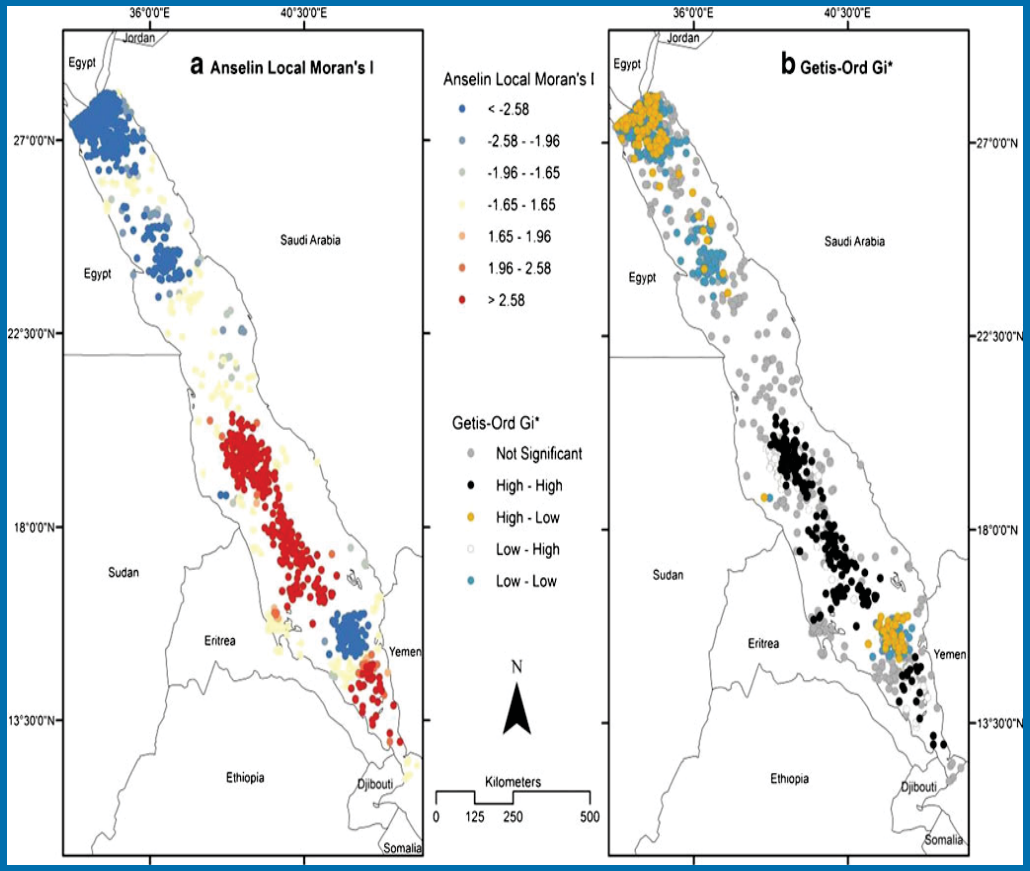
Hotspot analysis

- **local statistics: (2) Getis–Ord Gi*,**

$$G_i^* = \frac{\sum_{j=1}^{n} \omega_{i,j} x_j - \bar{X} \sum_{j=1}^{n} \omega_{i,j}}{s \sqrt{\frac{\left[n \sum_{j=1}^{n} \omega_{i,j}^2 - \left(\sum_{j=1}^{n} \omega_{i,j} \right)^2 \right]}{n-1}}}$$

- **Directional distribution (standard deviational ellipse) will be used to measure the geographic distribution of earthquakes**

- **The created standard deviational ellipses will show the spatial characteristics of earthquake events such as: directional trends, central tendency, and dispersion.**



Spatial statistical analysis of the occurrence of earthquakes(1900-2009) along the Red Sea floor spreading (Al-Ahmadi et al., 2013)

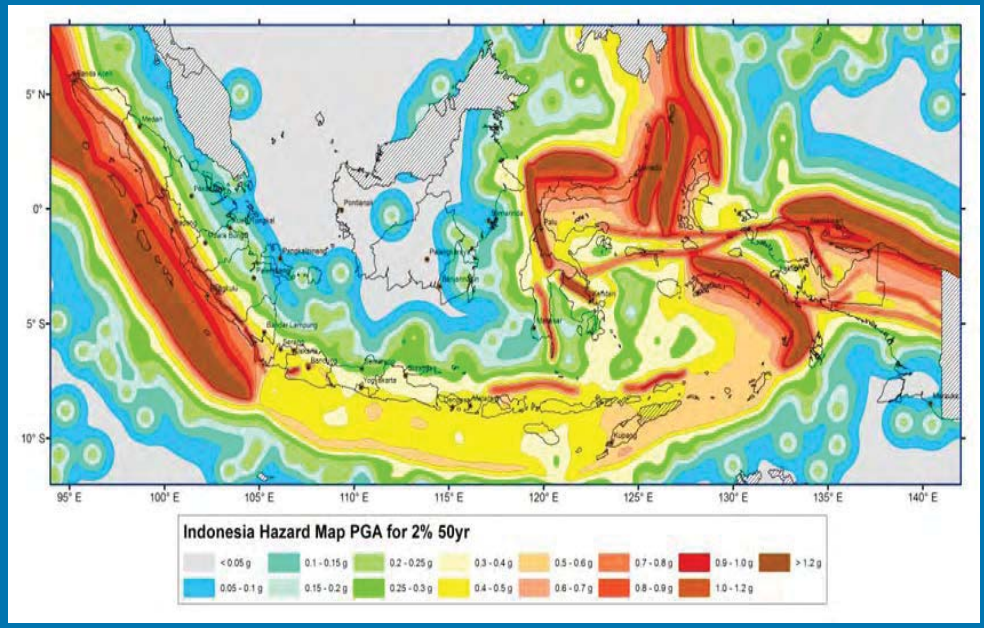
Methodology

1

Spatial Statistical Analysis

Peak Ground Acceleration (PGA)

- Earthquake hazard zonation depends on the seismological characterization of the site such as PGA.
- The attenuation relationship or Ground Motion Prediction Equations (GMPEs), describes the decrease in PGA
- PGA is equal to the maximum ground acceleration that occurred during earthquake shaking at a location



Map of Peak Ground Acceleration (PGA) of Indonesia (Irsyam et al., 2011)

Methodology

1

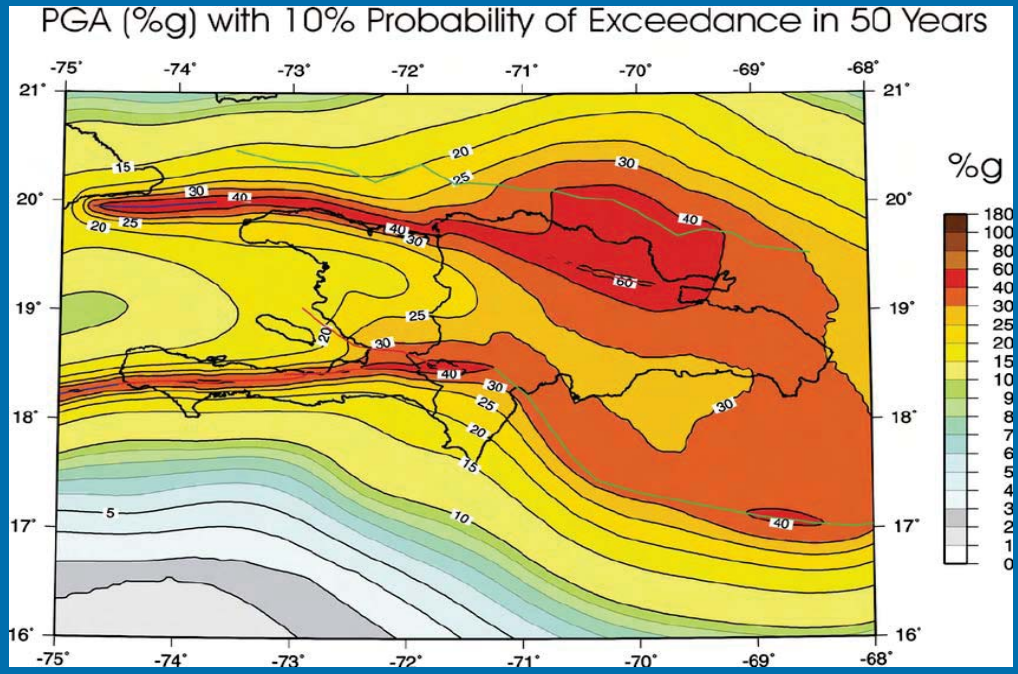
Spatial Statistical Analysis

Peak Ground Acceleration (PGA)

- Since there were no seismograph networks in UAE until 2010, Ground Motion Prediction Equations (GMPEs), specific to UAE, are not available,

- Joyner and Boore (Joyner, 1981) attenuation equation will be used to estimate PGA for UAE.

$$\log A = C_1 M_w + C_2 R - C_3 \log R + c_i S_i + (\sigma) P\,, \quad i = 1, 2, 3, 4\,,$$

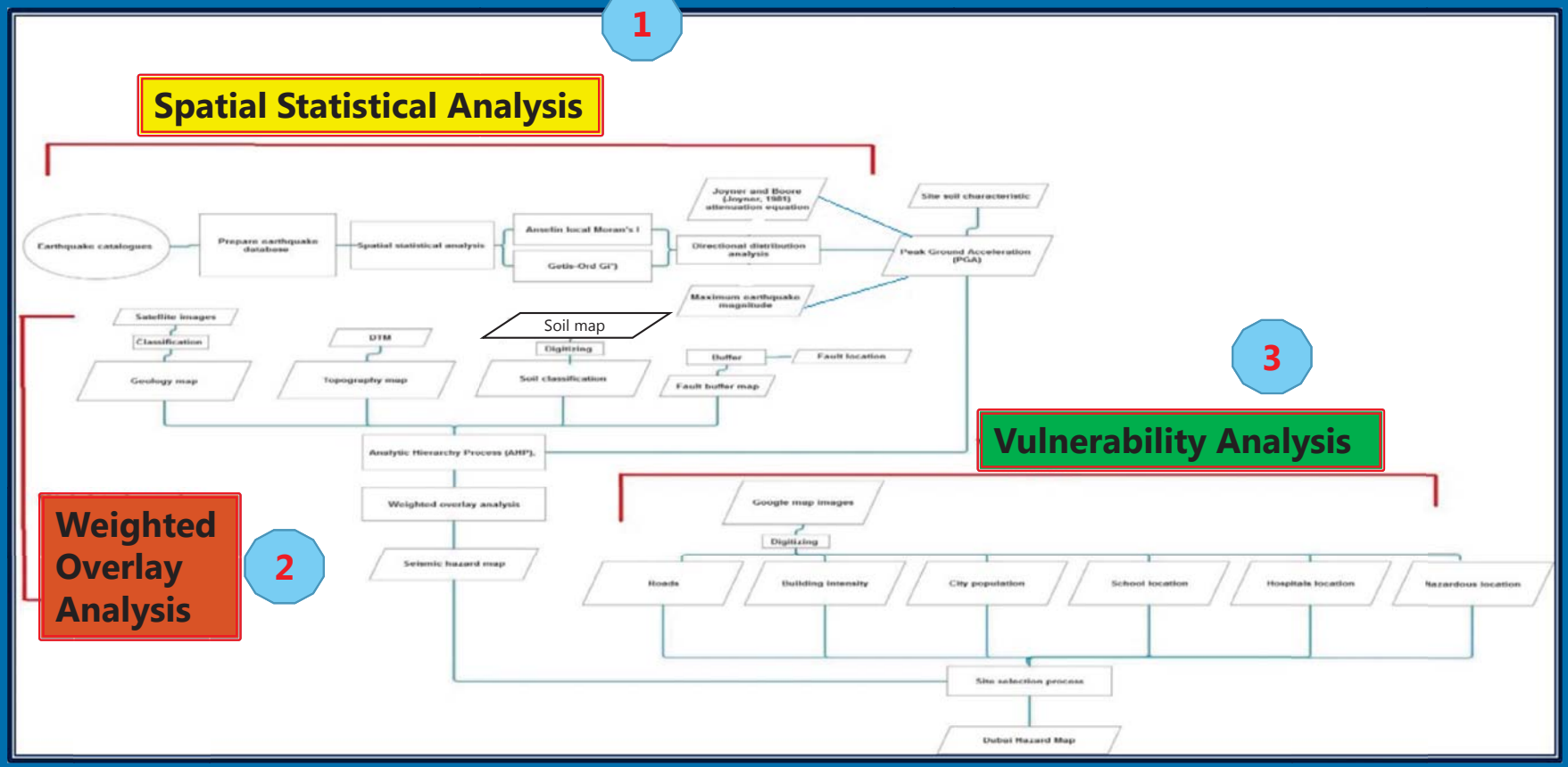


Seismic hazard map of South Africa representing the expected peak ground acceleration (g) (Source: Esterhuyse et al. 2014)

Methodology

1

Spatial Statistical Analysis



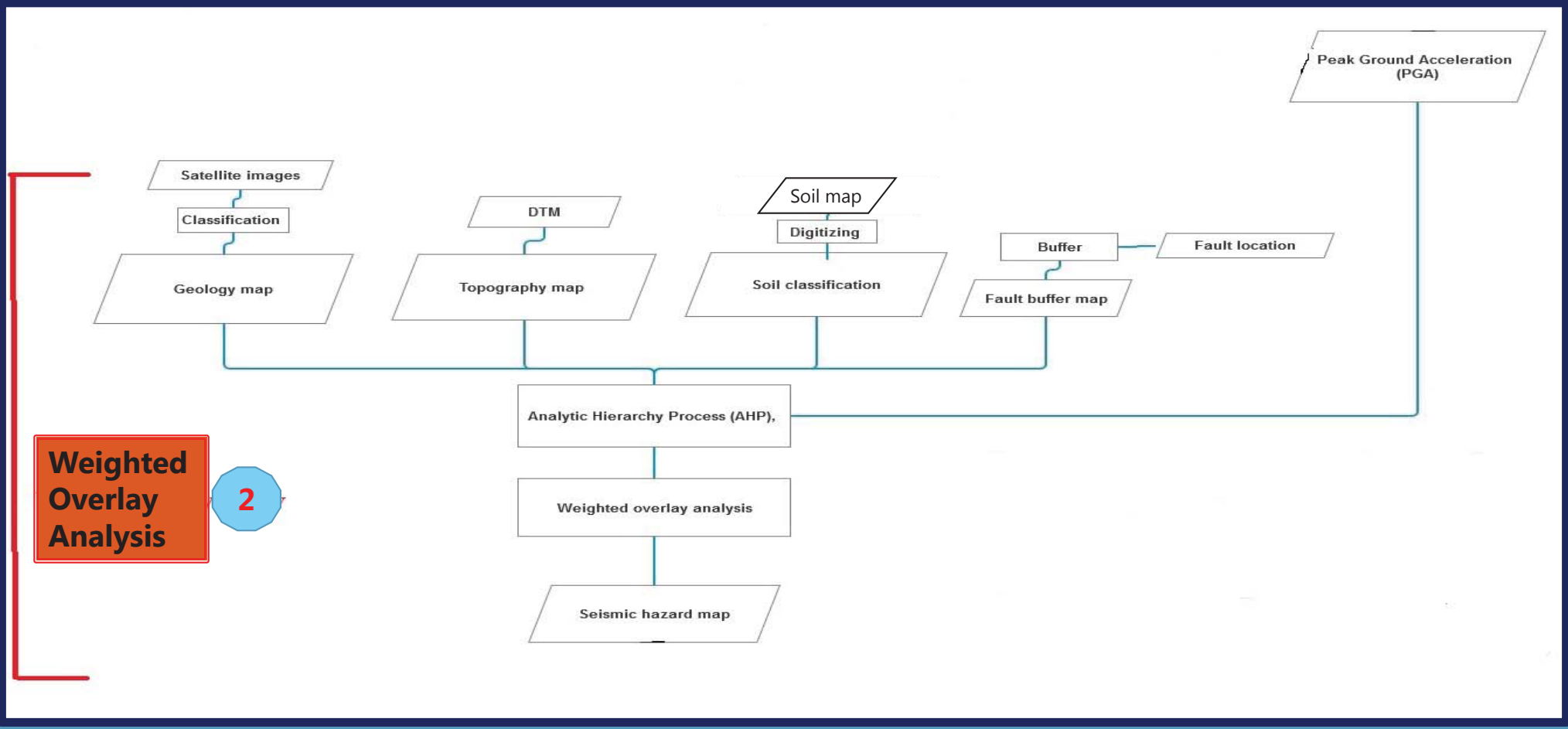
Weighted Overlay Analysis

2

3

Vulnerability Analysis

Methodology

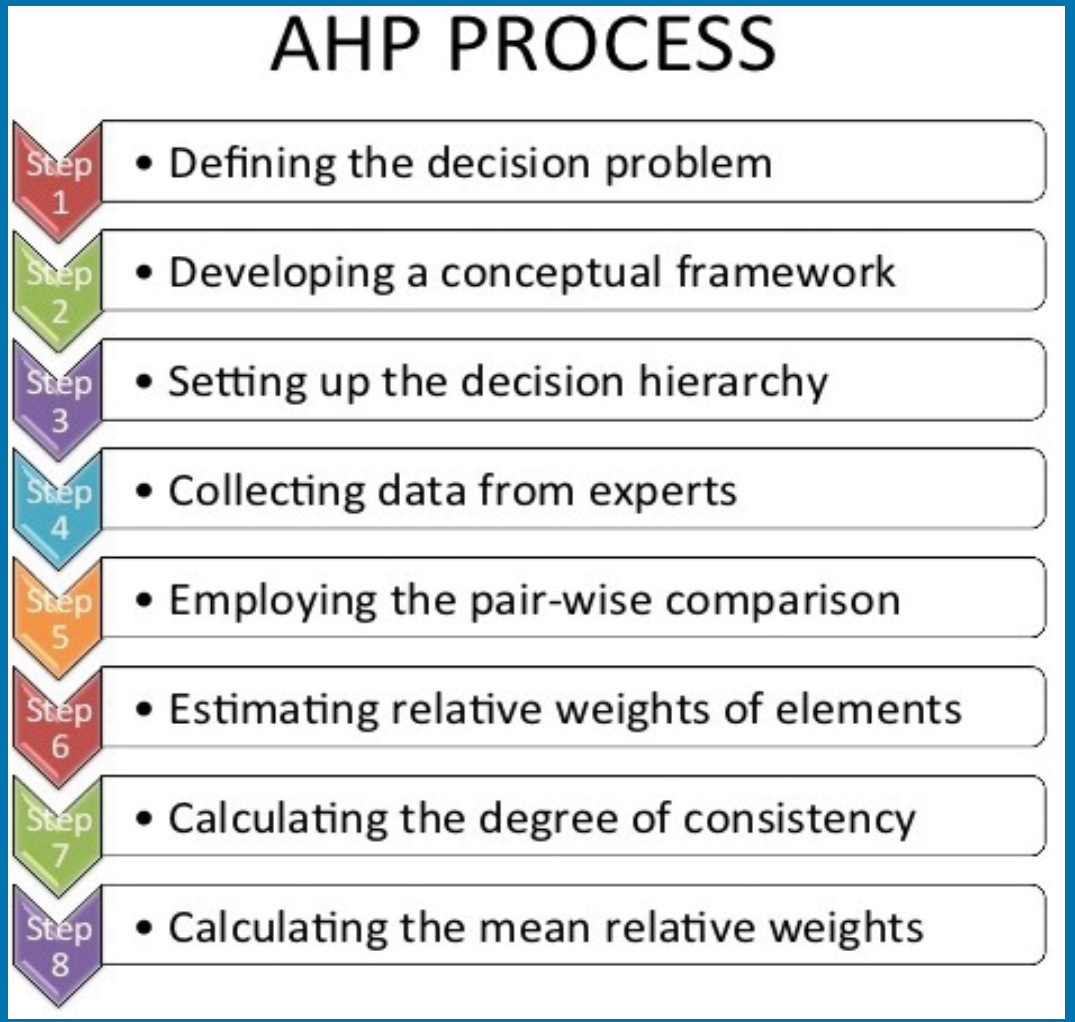


Methodology

Weighted Overlay Analysis 2

Analytic Hierarchy Process (AHP)

- One of the most usually used multi-criteria decision making (MCDM) tools.
- Method that allows the consideration of both objective and subjective factors in ranking alternatives



Apply AHP in decision making (Farid Awang, 2012)

Methodology

Weighted Overlay Analysis 2

AHP procedures:

1. Developing a comparison matrix at each level of the hierarchy, starting from second level to the last level.
2. Computing the relative weights for each element of the hierarchy,
3. Estimating the consistency ratio to check the consistency of the judgments (Saaty, 1980)

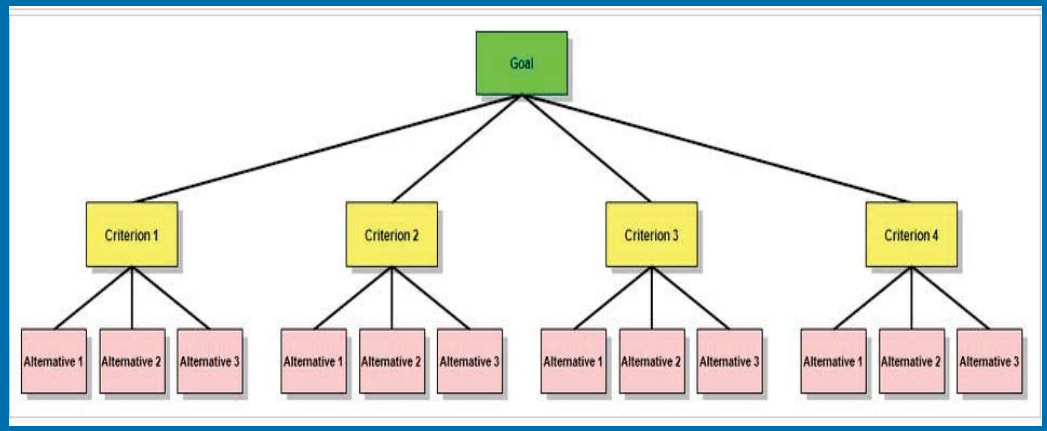


Figure. A simple AHP (Wikipedia, 2016)

Methodology

Weighted Overlay Analysis 2

AHP procedures:

❖ **Consistency ratio:**

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

❖ **By calculating the consistency ratio, the value is used as a reference index. (CR) of the estimated vector. Using Eq. (4), the CR can be calculated by as follow**

$$CR = \frac{CI}{RI}.$$

Table 1. Arithmetic Means of Respondents with respect to their disciplines. . (Erden, T. and Karaman, H., 2012)

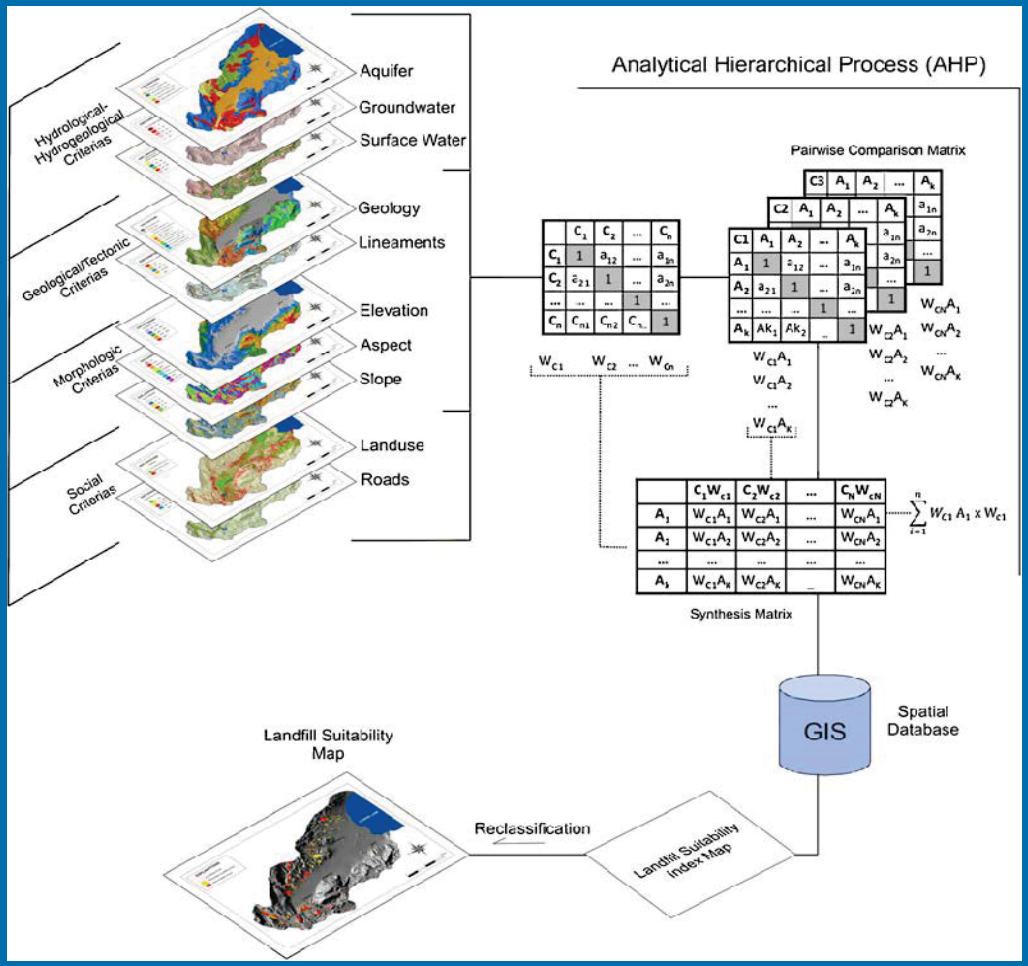
Criteria	Aritmetic means of the weights/priorities			
	Civil Engineers	Geomatics Engineers	Geophysics Engineers	Geology Engineers
FT (field topography)	0.07 (%7)	0.05 (%5)	0.05 (%5)	0.05 (%5)
DS (source to site distance)	0.27 (%27)	0.46 (%46)	0.35 (%35)	0.24 (%24)
SC (soil classification)	0.25 (%25)	0.17 (%17)	0.33 (%33)	0.25 (%25)
LP (liquefaction potential)	0.36 (%36)	0.17 (%17)	0.18 (%18)	0.22 (%22)
FM (fault/focal mechanism)	0.05 (%5)	0.15 (%15)	0.09 (%9)	0.24 (%24)
Consistency Ratio's	0.090	0.056	0.043	0.090

Methodology

Weighted Overlay Analysis 2

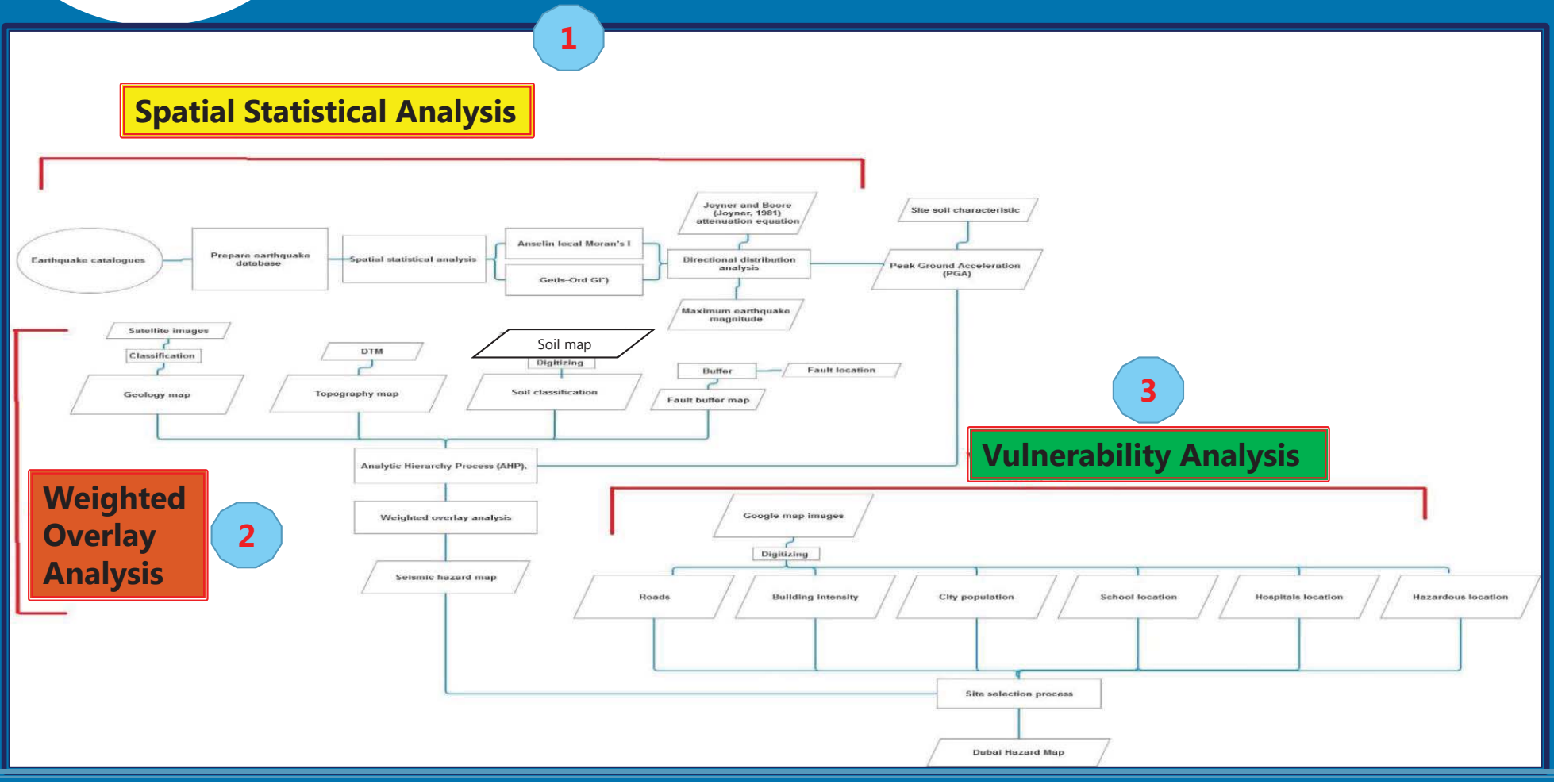
AHP procedures:

- More literature review and experts meeting will be conducted to choose the most appropriate weight and rank for the previously mentioned maps.
- Using ArcGIS; resulted PGA map, topography map, soil classification, slope map, geology map, and fault to site distance buffer map will be created, weighted, and ranked using AHP and overlaid.



Example of using GIS and AHP for landfill site selection (Şener, et al., 2010)

Methodology

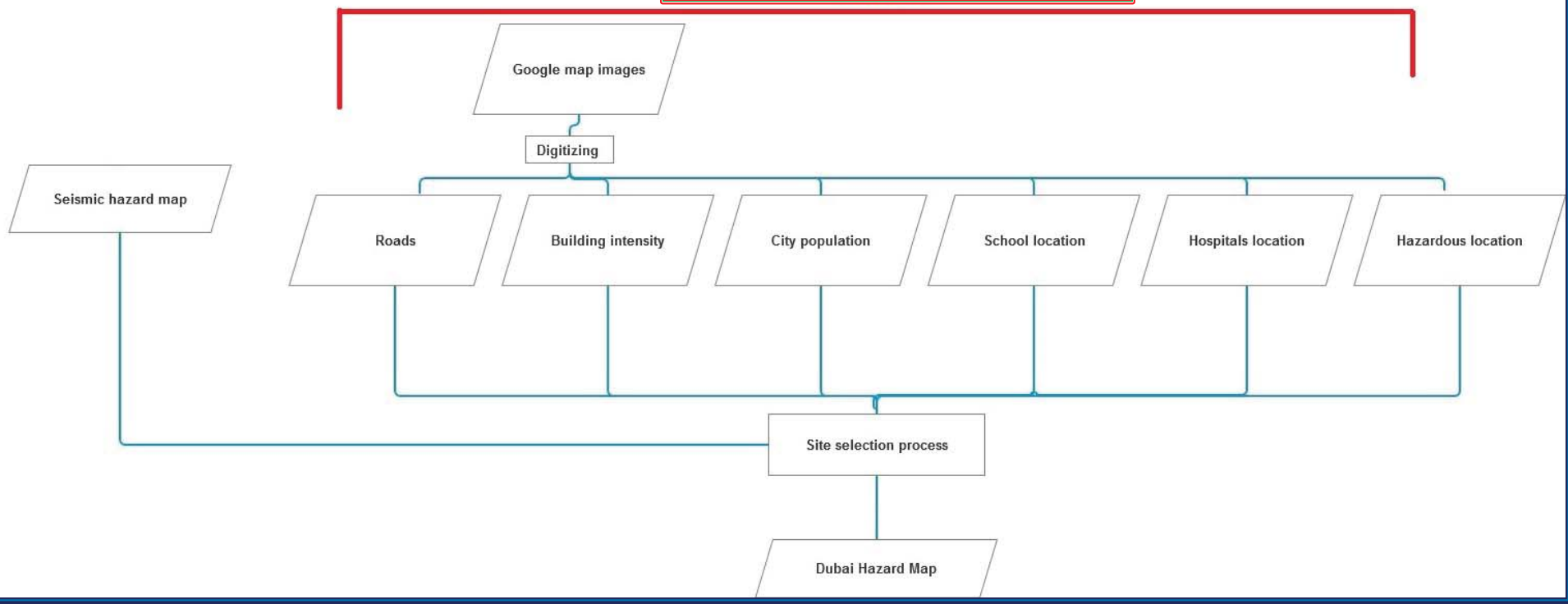


Methodology

Vulnerability can be defined as the weakened ability of a person, people or a country to anticipate, deal with, struggle and recover from the impact and effect of a natural or man-made hazard such as earthquake.

3

Vulnerability Analysis



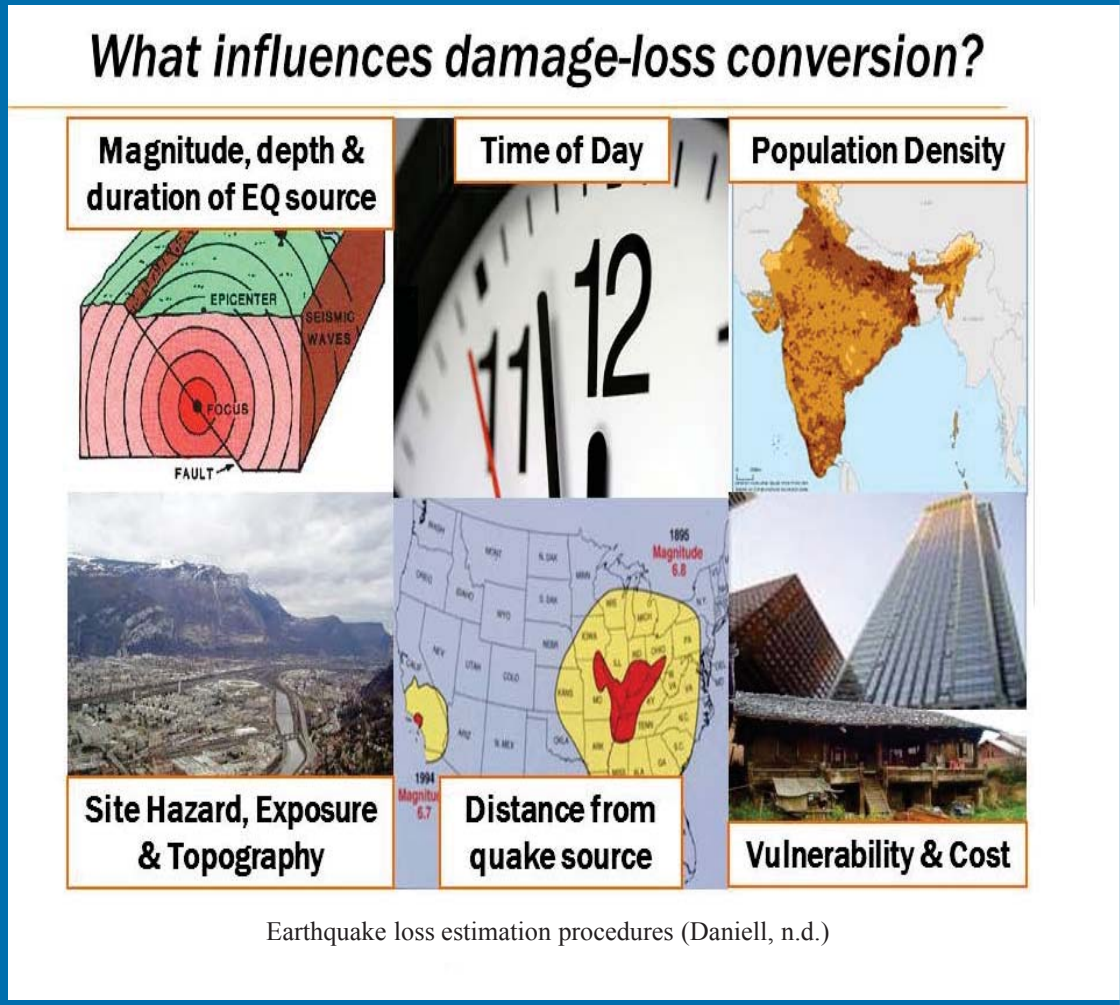
Methodology

3

Vulnerability Analysis

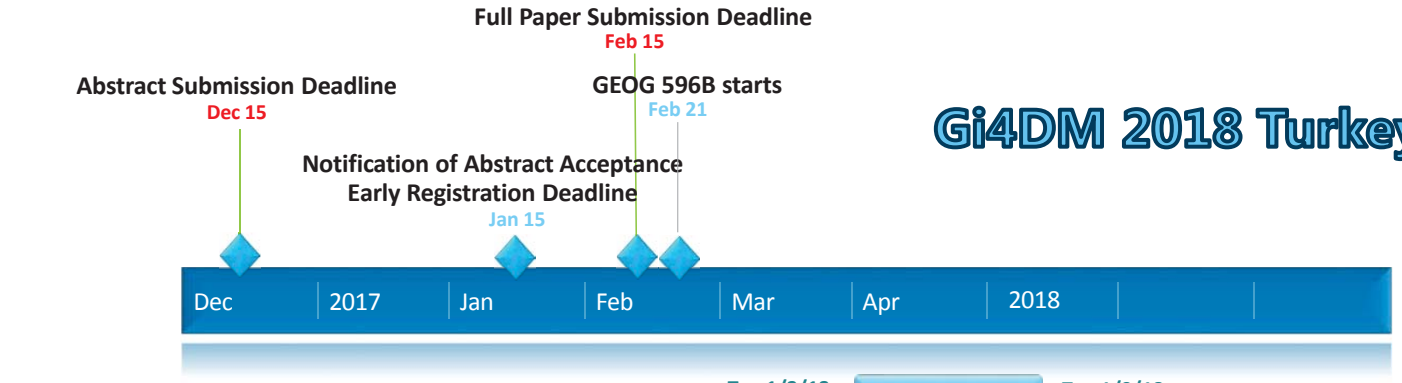
In this study the vulnerability of Dubai city, UAE will be investigated in terms of:

- City population
- Building intensity
- Distance from the roads
- Schools location
- Hospitals locations
- Hazardous location



Earthquake loss estimation procedures (Daniell, n.d.)

Capstone Work plan



Gi4DM 2018 Turkey

Earthquake Database Building	Tue 1/2/18	Tue 1/9/18
Documentation	Wed 1/10/18	Sun 1/14/18
Spatial Statistical Analysis	Mon 1/15/18	Mon 1/22/18
Documentation	Tue 1/23/18	Sat 1/27/18
Weighted Overlay Analysis	Sun 1/28/18	Sun 2/4/18
Full Paper Documentation	Mon 2/5/18	Thru 2/15/18
Vulnerability Analysis	Sun 2/18/18	Sun 2/25/18
Documentation	Mon 2/26/18	Thru 3/1/18
Full Paper Documentation	Sun 3/4/18	Thru 3/15/18
Preparing GEOG 596B Presentation	Sun 3/25/18	Sun 4/1/18

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Questions?