Mapping Land Collapse Hazard using SRTM Data and Geographic Information System in the Egyptian Terrain

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Abstract

Mapping geohazards is important factor to the decision making for strategic land use planning. This paper aims at setting a geographic information system (GIS) based methodology for identifying and mapping areas of land collapse hazard and its possible impacts on vulnerable areas. Shuttle Radar Topography Mission (SRTM) data was used to create terrain characteristics layers. These maps include elevation zones and slope. Geological map of Egypt was used to identify lithology (rock type) map and to delineate the lineament (fault) map of Egypt. The analysis of the various layers have been conducted which, included the creation of lineament density for the fault map. The other analysis procedures include reclassifying of the slope angle map, seismic intensity zone map, lithology (rock type) map, elevation zone and slope. Cartographic model has been conducted using ArcGis 9.2 software. The output of the model pointed out areas of high vulnerability to land collapse hazard that include landslides and rock falls. The resultant map is essential prior to locating development corridors, roads, highways and new settlements. It also provides indicators for the vulnerability of the existing infra structures in need for monitoring systems and environmental management.

Keywords
Vulnerability, lithology, geohazard, elevation zones, slopes, fault density, seismic intensity, GIS cartographic modeling, Egypt.

1. Introduction

Egypt is a republic in Northern Africa situated in Africa except for Sinai Peninsula east of the Suez Canal which is situated in Asia. Egypt covers an area of almost one million square kilometers in North Africa and Western Asia. The country shares land borders with Libya to the West, Sudan to the South, and Israel and the Ghaza Strip to the northeast. It has coasts on the north and east by the Mediterranean Sea and the Red Sea respectively. Egypt is the fifteenth most populous country in the world. The vast majority of its 78 million populations (2006 estimation) are mainly concentrated in the Nile Valley and the Delta as well as in the coastal zone along the Mediterranean Sea. Inhabited area resembles only 4% of the total territory. The Egyptian government has developed a strategy for future urban development and population redistribution outside the Nile Delta and Valley. The strategy is based on the development of axes based on the various resources of the Egyptian territory. As the national strategies necessitate the true understanding of the land's potentials and constraints, one of the development constraints is being studied in this research, namely the land collapse hazard. Land Collapse is a serious hazard that reflects a threat to the human environment. Specific zones are more vulnerable to this phenomenon than others according to their physical environment parameters. Land slides or rock falls are components of the land collapse hazard. Impacts are the damage of infra-structure, roads and buildings. Human activities changing the environment activate and accelerate the risk.

Land collapse has been studied by several scientists**. *Comegna L. et al 2007*** studied the undrained-drained deformation. Undrained conditions are established as a consequence of landslides mobilization or reactivation. ***Mitchell W.A. et al 2007*** *describes* the geomorphology of rock avalanche deposits that resulted from a major mountain slope failure at Keilong Serai on the north slope of the Indian high Himalaya. ***Fourniadis I.G. et al 2007 focused*** on the hazard impact of landslides in the three Gorges, and represents the progression of on regional land instability assessment in the area using imagery data from the ASTER data. They established a model that integrates land instability with several factors that can relate hazard to human life.

Objectives:

- To define some of the main parameters that contributes to the land collapse hazard.
- To develop a comprehensive methodology (model) using remotely sensed data and geographic information system for identifying zones vulnerable (hotspots) to the land collapse hazard.
- To map the relative risk index for land collapse areas in Egypt.

2.1. Materials and methods:

1. Shuttle Radar Topography Mission (SRTM) DEM data (Figure1) was used to create terrain characteristics layers including elevation zones grid (Figure 2),and slope angle grid (Figure 3).
2. The geological map of Egypt was used to delineate the lithology map (rock type) and fault distribution map.
2. Seismic maximum intensity zones map of Egypt was converted to a grid.

Shuttle Radar Topogrphy Mission (SRTM) was used to derive the elevation zones grid for the Egyptian terrain. Using ArcGIS 9.2 software, the slope angle was derived. The lithology (rock type) and the faults distribution were derived from the geological map of Egypt. The seismic maximum intensity donation map was converted to a grid. Effective parameter for land slides studied in this paper are lighology, elevation zones, slope angles, geolobic structure (faults). These layers were used as input table(1) for the landslide cartographic model as illustrated in figure (1).

A multi-criteria evaluation model was used that standardizes the various layers into a standard measuring scale. These layers were reclassified according to the contribution of every factor and its impact on the land collapse phenomenon to a measuring scale. The elevation zone map figure (3-A) was reclassified to depict the effect of elevation on the land collapse vulnerability, high elevation areas are more subjected to land collapse due to gravity effect. The slope grid was produced as shown in figure (3-B). The continuous slope grid was reclassified into a risk index grid according to the condition figure (3-C)s. Steep slopes are vulnerable to land collapse more than gentle slope areas. Various rock types have different vulnerability for land collapse due to their physical characteristics including hardness. The lithology map figure (3-D)was reclassified according to their vulnerability to land slide figure (4-A). Fault distribution map figure (4-B)has been reclassified to a fault density map figure (4-C), high fault density areas are more subjected to land collapse figure (4-D). Seismic intensity zones map figure (5-A) was reclassified into a vulnerability scale figure (5-B), Zones with higher intensity scores are more vulnerable to land collapse. The above mentioned five layers (variables) were input into a cartographic model in ArcGIS 9.2 software using the weighted overlay module. For the weighted overlay module all input grids must be integers. A floating-point raster must first be converted to an integer raster before it can be used in Weighted Overlay. Using the reclassified above mentioned parameter grids, different scenarios were applied to produce different output. Equal weights (Unity weight) were given to the input grids. The five variables produced the vulnerability map for land collapse. Changing the map assignment evaluation scale value or the percentage influences can change the results of the weighted overlay analysis. The second scenarios maximized the weights of the slope and fault density grids. The output risk map is shown in figure (5-C,D).

Table 1: Rules and contribution of the studied parameters for deriving the rock collapse risk map

Parameter (variable grid)	**Parameter contribution to rock collapse**
Elevation zone	Higher elevation zones are more vulnerable to land collapse.
Slope	Steeper slope angles are more risky.
Rock type	Different rock type have different response to land collapse
Fault density	Higher fault density is more vulnerable to land collapse
Seismic maxim um intensity zones	Higher seismic magnitudes are more vulnerable to land collapse

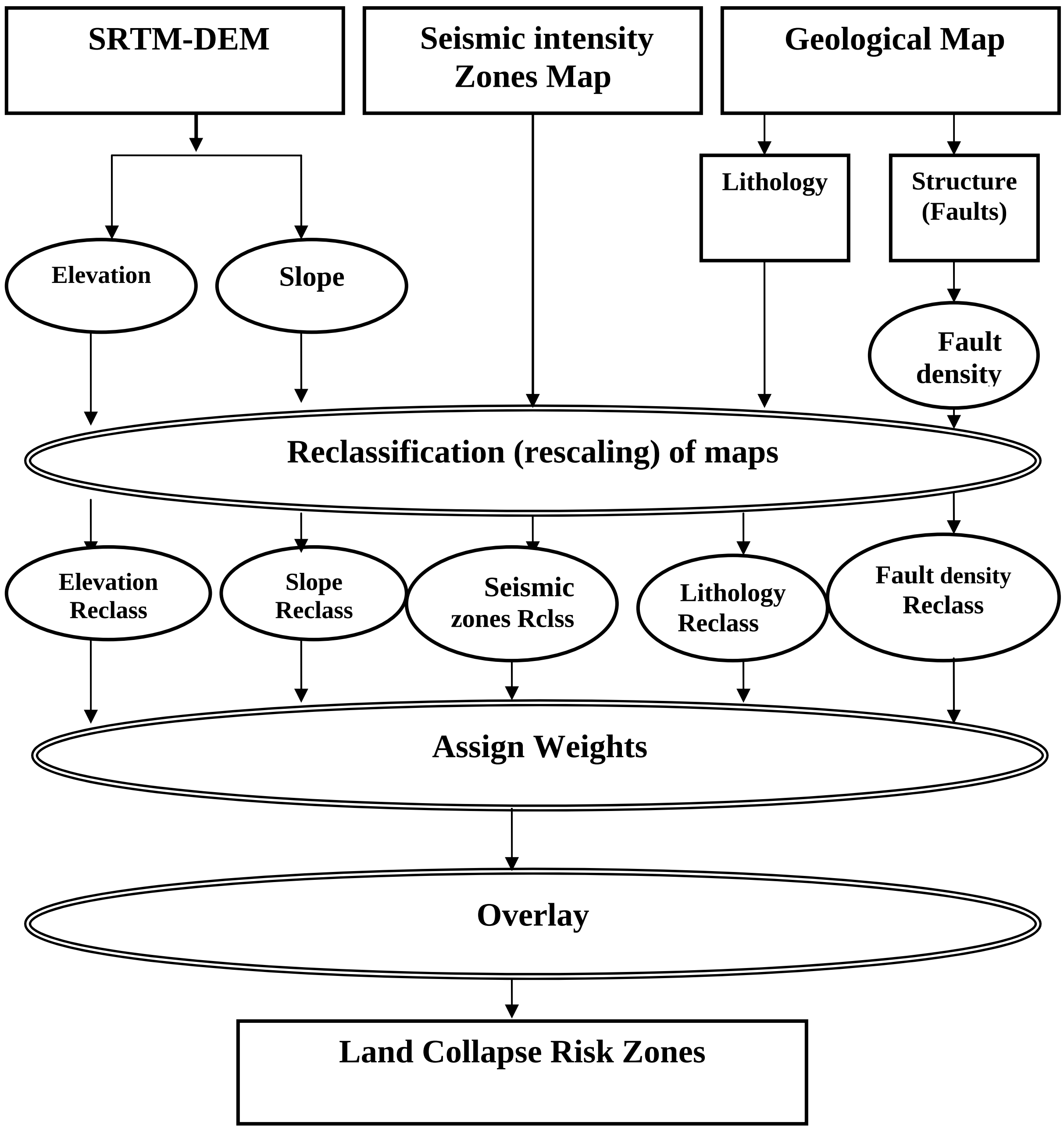

Figure (1): Land collapse Risk map flow chart

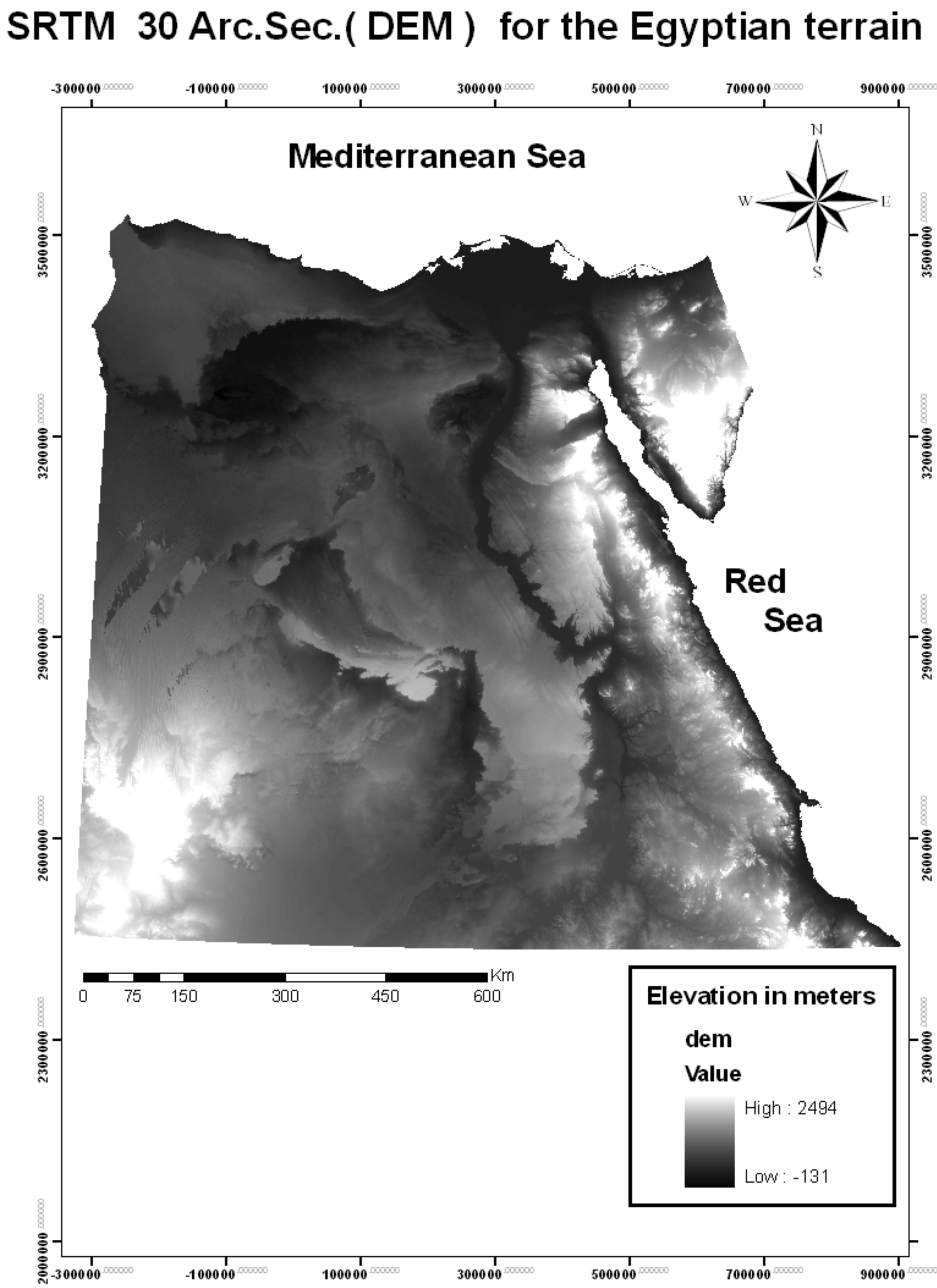

Figure 2: SRTM Digital Elevation Model of Egypt

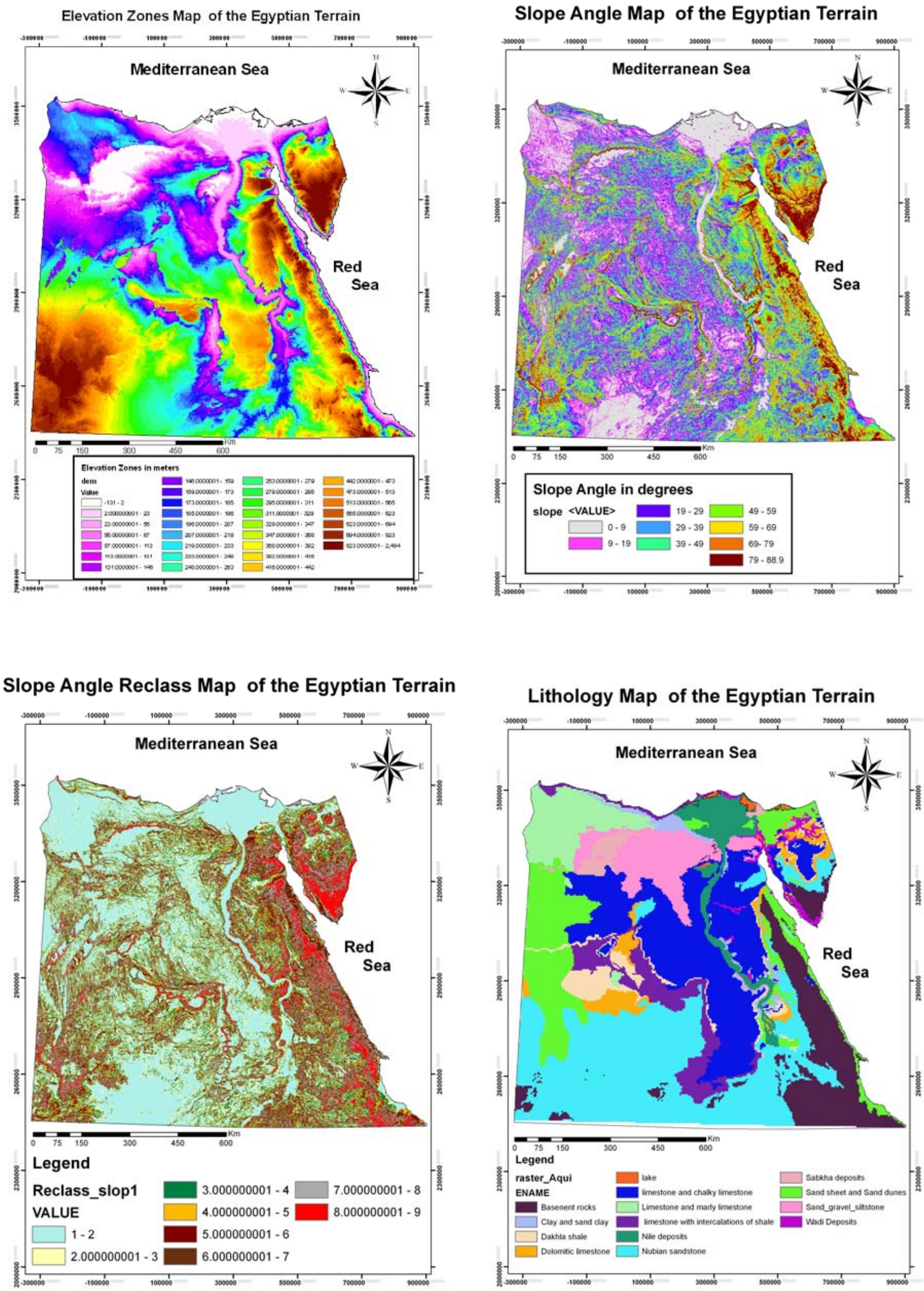

Figure (3)-A: *upper left:* Elevation zones. B-*Upper right:* Slope angles in degrees. *C-Lower right*: slope reclass map. D- *Lower right* :Lithology map

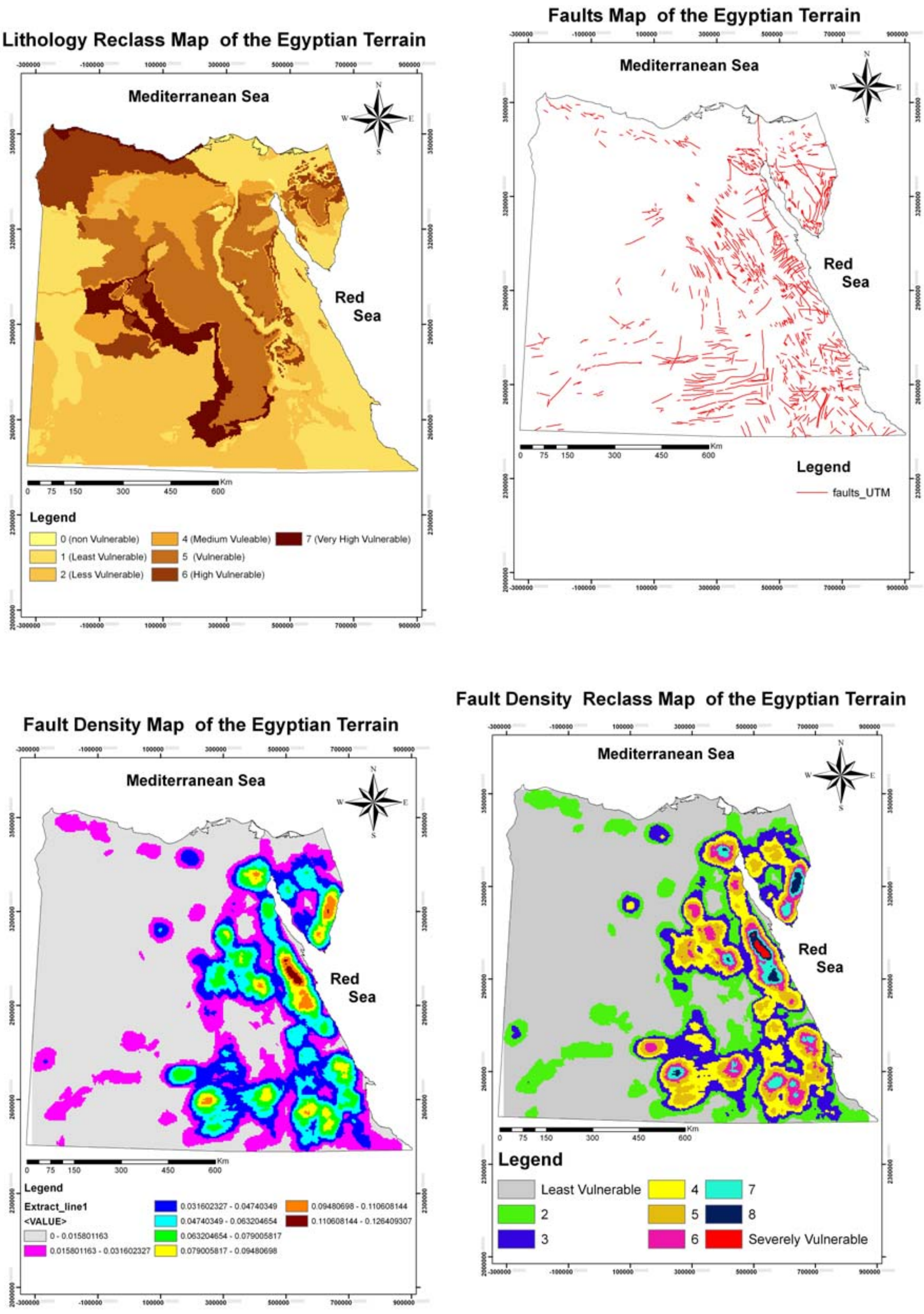

Figure (4): A-*Upper left:* Lithology reclass. B-*Upper right:* Faults map.C- *Lower Leftt*: fault density *D- Lower right*: fault density reclass map

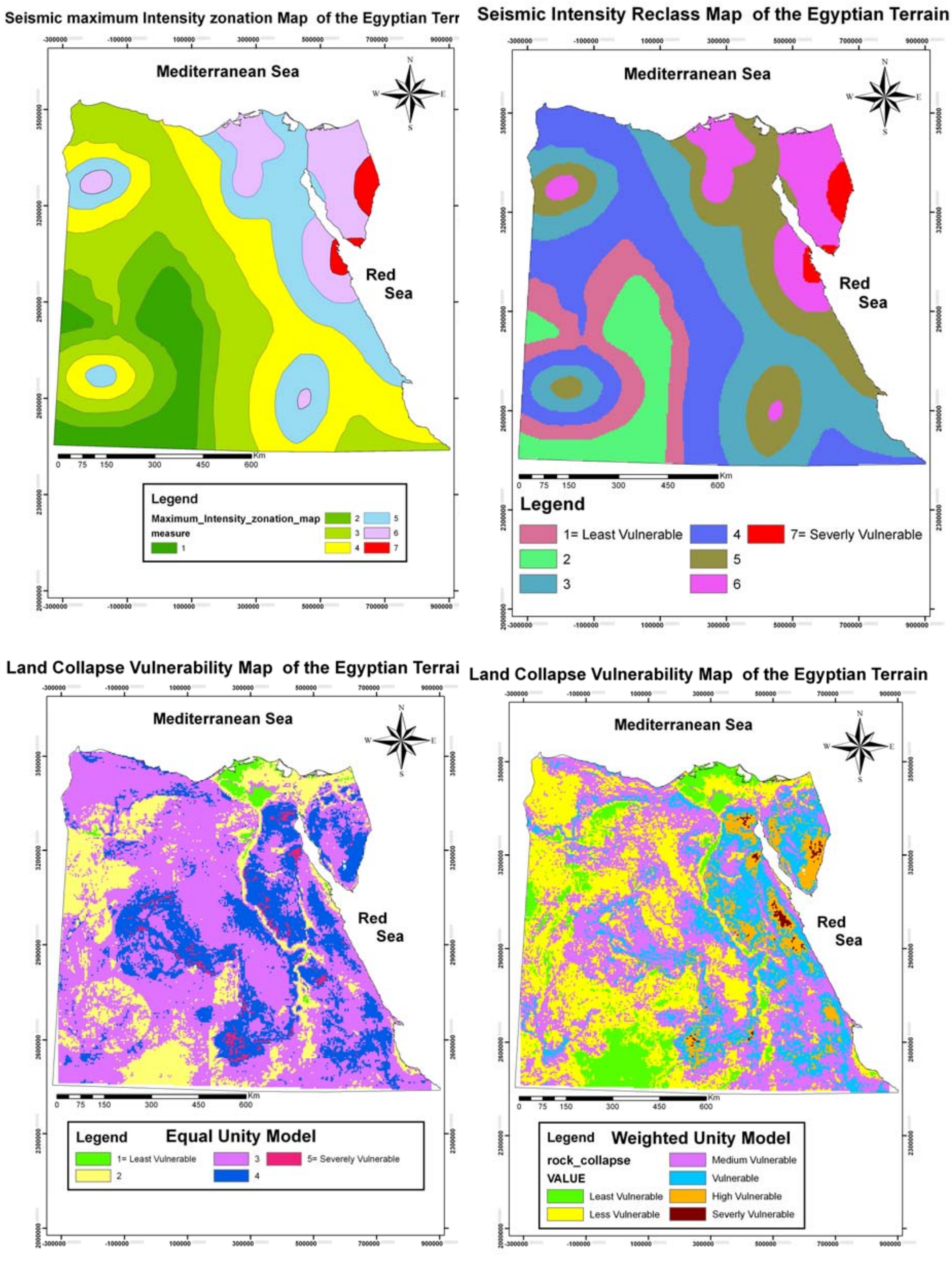

Figure (5) A-: *Upper Left:* Seismic intensity zones. *Upper right:* B-Seismic intensity reclass. C- *Lower Leftt*: Land collapse vulnerability map (equal weights).D- *Lower right*: Land collapse vulnerability map (weighted overlay).

3. Results and conclusion

The output of the Model pointed out areas of high vulnerability to land collapse geohazard. These include landslides and rock falls. The resultant map is essential prior to locating development corridors, roads, highways and new settlements. The resultant map also provides indicators for the vulnerability of the existing infra structures in need for environmental management

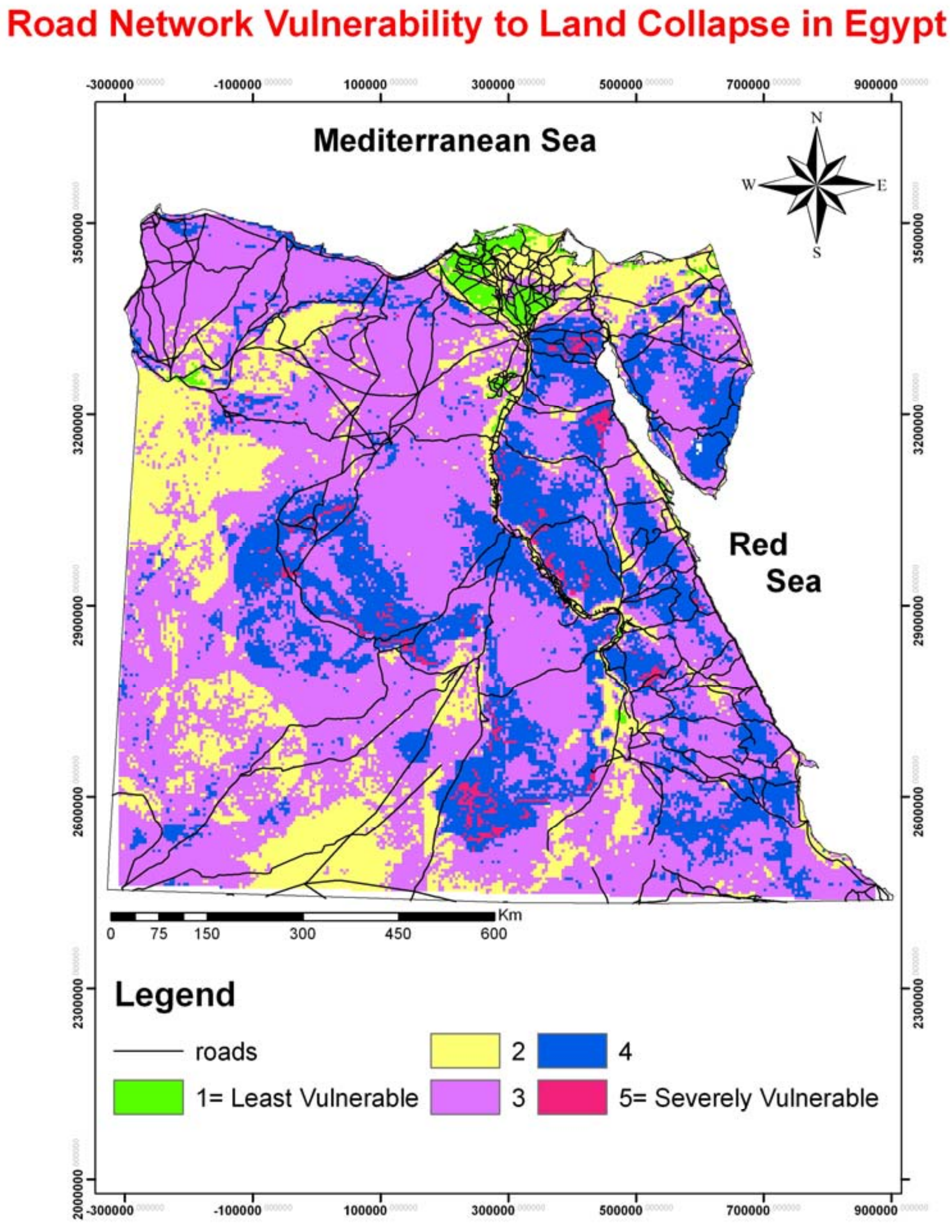

Figure 6: Road network vulnerability to land collapse

4. Recommendations

It is recommended to conduct hazard assessment at national scale in order to point out hot spots (zones most vulnerable to land collapse risk).These studies have to be followed by regional and local quantitative studies using high resolution satellite data and field verifications. The results of such studies can provide guidelines for needed mitigation measures and costs.

5. References

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