An integrated GIS and Geophysical-based approach for geohazards risk assessment in coastal region: a Case study in Suez city, Egypt

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In coastal regions, more precaution for urban expansion should be considered regarding hidden geological hazard from the existence of expansive clay soil and shallow groundwater level. These conditions cause huge damage to engineering constructions that leads to losses of human lives and financial property. However, very little studies were focused on hazard assessment of swelling clay potentiality using GIS approach, because its natures as occur slowly by time. The purpose of the present work is the analysis of geological–geotechnical factors to present a geo-hazard risk assessment model for the identification of high risk-prone regions in the coastal zone using an integrated GIS statistical system and Electrical Resistivity Tomography (ERT) mapping. Suez city (the case study area) is located in the northwest of the Gulf of Suez that has a vital and attractive global location for trading and investment. The geo-hazard model was created in a GIS environment by integrating thematic maps of possible controlling factors from ALOS-DEM image and available geological and geotechnical boreholes. These factors showed a varied ranges: slope (0-35˚), elevation (0-50 m), superficial soil (Conglomerate to silty clay), clay thickness (0-25 m), depth to groundwater (0-20 m), TDS (1000-35000 ppm), Cl-1 (500-17000 ppm), So4 (250-9000 ppm) and pH (6.8-8.7) and in conjunction with swelling potentiality (Liquid Limit (LL) (35-88 %), Plastic Index (PI) (12-62 %) and free Swelling (Sf) (35-150 %)). Assessment these factors causes kind of uncertainty during the evaluation procedure, thus all thematic maps were scored and weighted according to specified criteria to produce severity distributions maps. The crucial relationships between surface and subsurface factors were identified by employing geospatial qualitative and Pearson' correlation analysis. In the considered case, the clay soil is an inorganic cohesive type of high to a very high swelling degree. Among tested factors, the existence of clay soil and its thickness seem to play an important role to increase groundwater level that approach surface in several sites of Suez city, hence rising the risks of Total Dissolved Salts (TDS), Chloride (Cl-1), and augmenting swelling potential. Accordingly, the designed suitable relative weights were determined and all thematic maps were combined to produce a geo-hazard map using Simple Weighting Overlay (SWO) method. This approach illustrates the significant factors and the arithmetic weights assigned to each level of severity, and therefore they should be considered in similar studies. Geo-hazard map was produced with four degrees of severity for urban development: low, marginal, severe and very severe comprising 36.38, 40.28, 22.13 and 1.2 %, respectively, of the study area. The very severe area was observed mainly around El Kapanon district. An extensive field survey was performed, noted significantly high saline groundwater move into the sewage system. Seven 2D- ERT profiles were executed in this region using Dipole-Dipole (DD) array that integrated with available boreholes to establish a clear image for subsurface layers. The topsoil identified as gravelly sand (> 30 Ωm) extending down to - 3 m (a.s.l). A low resistivity layer (< 4 Ωm) attribute to thick silty clay observed underlined this topsoil, the clay behaviour in this area characterized by high swelling potentiality as indicated from near boreholes SZ-3 to SZ-7. The inverted sections were

used to create a 3D visualization by fitting all DD profiles. The result displays the existence of a buried channel of gravelly sand extending from the shoreline to city and underlined by thick clay soil more than 10 m that reduced the vertical infiltration rate. This suggested a lateral invasion of seawater usually occurred from a coastal part to the residential area during high tidal events in winter seasons. This continuous wetting caused the high salinity values and clay swelling measurements in this site. Therefore, government and urban planning should seriously consider treating proper action for current problematic conditions, before they become worse and affect the future development plan in this area. Overall, the results obtained in this study suggest that the GIS-based hazard model combined with localized ERT survey can be a vigorous tool for planning and management, by identifying the appropriate sites for environmental interventions and/or engineering risks.

Keywords: Geographic Information System, Geo-engineering , Electric Resistivity Tomography , Swelling , Geo-hazard map , Seawater

