

The 3rd International Geography Symposium - GEOMED2013**Settlement suitability analysis of local ground characteristics in
Iskenderun: A case study****Mehmet Değerliyurt****Mustafa Kemal University, Hatay, Turkey*

Abstract

Current study aimed to determine the settlement suitability of local ground characteristics in the city of Iskenderun. In this context, classes such as lithology, distance from fault lines, shear velocity (Vs), ground water, distance to sea and slope suitability were generated by utilizing geology maps, landslide velocity (Vs), and digital contour line data scaled 1:25.000 obtained from Mineral Research and Exploration Institute, Iskenderun Municipality and General Command of Mapping respectively. Multi criteria decision-making analysis was used to assess these suitability classes. Results show that 3 % of study area has 1st degree of suitability while 7 % and 21 % have 2nd and 3rd degree of suitability, respectively. Moreover, 69 % of study area was found to display ground characteristics not suitable for settlement.

It is observed that the degree of damage caused by an earthquake in this study area would be more than expected, as settlements were often made in the areas with no suitability or 3rd degree of suitability. Therefore, damage reduction measures should be immediately taken.

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Keywords: Iskenderun; Geographical Information Systems (GIS); Local Ground Characteristics; Settlement Suitability Analysis; Earthquake.

1. Introduction

Today, cities became centres of attraction due to better socioeconomic conditions. Construction processes for new buildings have accelerated in order to meet accommodation needs in settlements with rapid population growth

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and the demand for land has increased. Increased demand on land has resulted in increased land prices and ended up with the invasion of each free space in the cities in one way or another by buildings. In time, sloped hills, valley floors, areas around fault lines, agriculture and forest areas and wetlands were exposed to settlement pressure due to shortage of land for human settlement (Smith & Petley, 2008, Martins et al, 2012). Agricultural land acquired by drying out alluvial grounds and swamplands especially became settlement areas by time. The fact that settlement areas have been moved to the areas that are not suitable for settlement and can cause significant damage in a possible earthquake is worrisome for the future. Studies state that local ground characteristics may be effective in causing bigger damages even in areas that are far from the epicentre of earthquakes and therefore it is important to take this issue into consideration during construction of buildings (Tezcan & Durgunoğlu, 2000; Uyar, 2006; Uyanık, 2006; Ansal et al., 2011; Zarif et al., 2005; Smith & Petley, 2008).

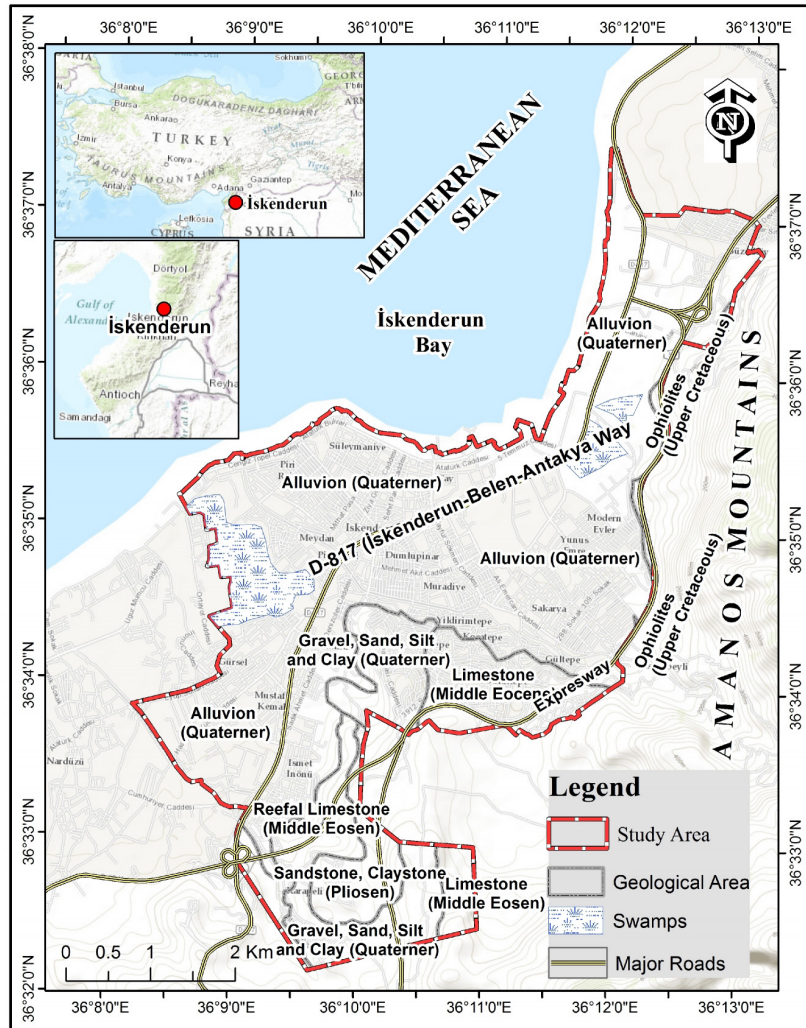


Fig. 1. Location Map of the Study Area

Cities founded on weak ground are under risk in earthquakes in terms of population, building and infrastructure system characteristics since any problems in any of these characteristics will create a domino effect on the others. Unfortunately, many of the cities in the world today were established in such areas with weak ground and high risk

(Montoya & Masser, 2005). Since it is not possible to relocate these settlements to other areas, it is necessary to establish a strong planning process and maps should be generated with detailed local ground characteristics to be used both in the selection of site and identification of structural characteristics of residences, public buildings and industrial facilities.

Main purpose of the current study was to identify the regions with weak ground characteristics by using parameters for local ground characteristics of Iskenderun city centre and therefore to present the areas that suitable and unsuitable for settlement against earthquake risk. Since it is a strong decision making tool, Geographical Information Systems (GIS) was used in the process. Many of the prior studies also state the use of Geographical Information Systems as an important decision making tool (Zerger, 2001; Dash, 1997; Yan-xi, 2009; Alexander, 2008; Alparslan et al., 2008; Kienzle et al., 2006; Lazzari, et al., 2009; Guk Sun, 2009; Papadimitriou et al., 2008; Altan et al., 2001).

2. General Geographical Properties of the Study Area

The study area is located Iskenderun district center of Hatay province in the east coast of Mediterranean in the south of Turkey. It is situated between 36° 08' 26" - 36° 32' 06" North latitudes and 36° 08' 26" -36° 12' 09" East longitudes according to geographic coordinate system (Fig. 1).

Altitude values in the study area which carries all the characteristic features of Mediterranean climate starts at 0 on sea level and rises up to 340 meters towards the Amanos Mountains. City was founded on an alluvial prairie that lays parallel to Amanos Mountains from the coast. Swamplands were created due to groundwater emerging from both north and south of the study area on which steep slopes meet with alluvial flatlands (Okur, 2000; Ulus, 2000; Doygun, 2003). Akçay Swamp on the north around the Organized Industrial Area and Fernak Swamp on the south prevents the development of the city (Okur, 2000). Swamplands in this study area have an approximate surface area of 1 km². Due to seasonal streams coming from Amanos Mountains and rainfalls that increase during some periods, drainage problems are experienced in swamplands that were dried out in order to acquire new areas for settlement and to prevent health problems (Doygun, 2003).

D-817 highway passes inside the study area which has an important position in transportation between Adana-Hatay and freeway also passes in close vicinity. This road provides transportation en route Adana-İskenderun-Belen-Antakya.

The population of the study area with a surface area of 27.5 km² and with 28 different neighborhoods was 201.183 in 2012 according to Address Based Population Registration System (ADNKS) (TUIK, 2013).

3. Seismic Activity History of the Study Area

There are fault lines with potential to generate intense earthquakes around the study area. The most important fault line in the study area is Iskenderun-Güvenç fault line located nearby Dead Sea Fault Zone (DSFZ) and Eastern Anatolian Fault Zone (EAFZ). This is a left-lateral fault line dividing the South of the Amanos Mountains into two and its north block was uplifted. The other fault line in this area is Iskenderun-Dört Yol fault line whose eastern block was uplifted (Günay, 1984). Although these fault lines caused earthquakes by becoming active many times in the past, there were no serious earthquakes around Iskenderun in the last century (Demirtaş & Erkmen, 2000).

The most violent earthquake that caused a significant loss of life and property in the past occurred in 1882 which resulted in 20.000 death (<http://www.koeri.boun.edu.tr/sismo/>). Furthermore, 2 earthquakes in the years of 1951 and 1997 were recorded on the early instrumental period. 6 people lost their lives in the earthquake of 1951.

4. Material and Method

Multi criteria decision-making analysis based on Geographical Information Systems (GIS) was used to determine the suitable places for settlement in the study area. In this analysis, it is required to specify a sequence of criteria in order to evaluate the geographically defined basic units as map layers. These criteria are classified according to their degree of suitability and each of them is assigned a weight value. Then, maps are consolidated after weights based

on preferences made by decision makers are assigned. For this reason, weights have great impact on obtaining result from multi criteria decision-making analysis (Chen et al., 2009). The obtained results will make it possible to compare different alternatives in case of having more than one criterion. Listing alternative solutions will provide the optimum solution that gives better results with all objectives that fit the aim (Caterino et al., 2008).

Information regarding the fault lines was obtained by using Atlas of East Anatolian Fault (EAF) compiled by Günay (1984) and Herece (2008) and the lithology map was generated by utilizing the geology map which is an appendix of Atlas of East Anatolian Fault (EAF). In order to identify ground endurance properties, Ates et.al. (2004) and Korkmaz (2006) were referenced. Measurement values for shear velocity (V_s) and underground water were obtained from Municipality of Iskenderun. Slope map was generated by means of ArcGIS 10 Spatial Analysis by using digital contour line datasets with a scale of 1:25.000 obtained from General Command of Mapping (HGK).

Each criterion was ranked from the most suitable to unsuitable while identifying the areas suitable for settlements. Digital Raster Maps were then created by assigning susceptibility values after the classification of the data.

5. Generating the Settlement Suitability Map

In order to generate the settlement suitability map of study area; many factors including lithology, distance from fault lines, shear velocity (V_s), underground water depth and slope were assessed and suitability classes were generated.

5.1. Lithological Suitability Classes

Rocks characteristics that compose the ground in the study area were used to determine the basic rock classes based on “Schmidt Hammer Rebound value” and “Rock Classification Scheme according to Discontinuity Surface Roughness Measurement Technique” and then, lithological suitability classes were generated as below:

Harzburgite, dunite, serpentine and gabbro lithologies that belong to Upper Cretaceous period were all identified as adamant and used as areas with 1st degree of suitability. As limestone is a strong and relatively strong rock that belongs to Middle Eocene period, it is mostly utilized as lands with 1st degree of suitability. Units formed by reefal limestones that belong to Middle Miocene period were identified as strong and relatively strong rocks. Hence, they were utilized as lands with 1st degree of suitability. As sandstone and claystone that belong to Pliocene period were identified as rigid soil, they were identified as lands with 3rd degree of suitability. Debris cone sediments made up of gravel, sand, silt and clay and alluvions formed by sediment accumulation in rivers that belong to Quaternary period are all classified as unsuitable lands for settlement, because they are not solidified and contain loose structures.

5.2. Classes of Suitability for Distance from Fault lines

Many authors (Verstappen, 1983; Erinc, 2002; Demirtaş, 2003; Bolt, 2008; Erguvanli, 1995) stated that seismic intensity would normally increase around the fault lines and decrease away from them. In this context, it is accepted that its destructive effect and thereby sensitivity normally decreases when moved away from fault lines in the study area. When determining suitability classes in terms of distance from fault lines, intervals were ranked as 0-1000, 2000, 3000, 4000 metres and above to generate sensitivity zones.

5.3. Velocity Shear (V_s) Factor

Several methods are used to determine ground characteristics such as ; measurements based on microtremor method carried out to zoom in by using sensitive seismometers and calculations of enlargement factor based on one dimensional numerical analysis of sediments and shear (s) velocity shear (V_s) (Ulusay, 2010).

Datasets used to determine velocity shear (V_s) suitability classes were gathered from Municipality of Iskenderun. The obtained Data points were transformed into Spatial Data via Kriging Method which is used to predict the basic spatial distributions of strong earthquake movement parameters (Shabestari, et al, 2004). Geostatistical analysis tool

ArcGIS 10 was used in the process. Furthermore, a legislation titled “Guidelines for Constructing New Buildings in Seismic Zones” was utilized (<http://www.koeri.boun.edu.tr/depremmuh/eski/DBYBHY-2007-KOERI.pdf>). According to this, study area consists of B, C and D class lands.

5.4. Underground Water Suitability Classes

This is another factor that affects the size of the earthquake damage. Level of underground water both damages the foundations of building (Al Sefry & Şen, 2006) and leads to liquefaction (Gates & Ritchie, 2007) that causes sand pumping from the ground and structural collapses and failures like tilting, settling and demolition (Bolt, 2004; Mhaske & Choudhury, 2010). Liquefaction mostly observed in river floodplains and lacustrine sediments increases the damage level on settlements and occurs in moderate and massive earthquakes under suitable conditions (Demirtaş & Erkmen, 2000). In this respect, areas where underground water is deep were identified as suitable places and vice versa.

Measurements on underground water depth of the study area were obtained from Municipality of Iskenderun. Later, data points were transformed into Spatial Data with the help of Kriging Method via Geostatistical analysis tool ArcGIS 10.

5.5. Slope Suitability Classes

As it is known, high slope levels during the establishment and development of cities cause some restrictions. In areas where slope is high, urbanizations slows down even may halt

(<http://www.rri.wvu.edu/WebBook/McBride/section3.html>). Moreover, secondary disasters like ground movements could be experienced in case of higher slope values. Thus, buildings constructed in areas where slope value is higher should be supported by engineering schemes. However, this increases the cost of construction and negatively affects buildings unless would be necessary precautions are taken.

There is no standard information about the influence of topographic properties on earthquake intensity. Hence, results composed of the effect of slope value on settlements were taken into consideration to determine the slope suitability classes (<http://www.rri.wvu.edu/WebBook/McBride/section3.html>). Slope values were separated into 4 different suitability classes based on contour line datasets with a scale of 1:25.000 obtained from General Command of Mapping.

5.6. Suitability Classes for Distance from the Sea

As mentioned before, one of the conditions that increase earthquake damage is the proximity of underground water to sea. One of the places where underground water is too close to the ground is sea coasts (Derinöz, 2004; Susam et al., 2006). Areas close to sea coasts are regarded as having higher liquefaction risks compared to other areas, since liquefaction risk increases when underground water is too close to the ground (Demirtaş & Erkmen, 2000). Also, there is a strong relationship between freshwater resources and sea water. When freshwater resources are used more and more; sea water that is salty permeates into freshwater resources and building foundations are damaged more (Akıncıtürk, 2001) due to saltwater intrusion (Atalay, 1986; Özler, 2001). So, sea coasts are determined as unsuitable areas for settlement as above mentioned problem would be another factor facilitating the destruction of buildings in case of an earthquake. In order to determine the suitability classes for distance from the sea in this study area with a 9.58 km coastline, intervals ranging from 0-100, 100-200, 200-300, 300 metres and above were generated.

6. Analysis and Assessment

Iskenderun Settlement suitability map was generated by using multi criteria decision-making tool in raster calculator in order to transform the 10 digit factor maps generated by means of suitability classes for the study area.

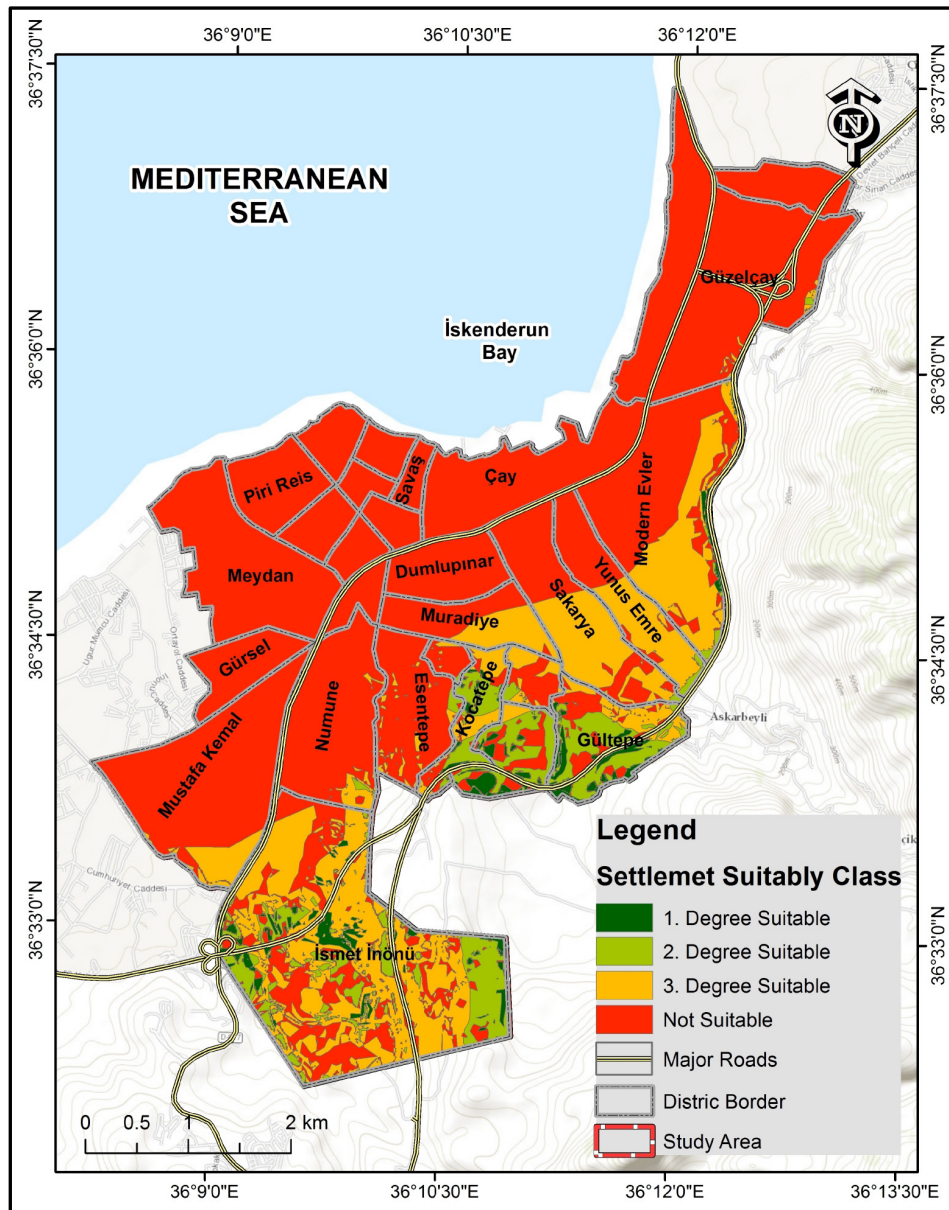


Fig. 2. Settlement Suitability Map of Iskenderun

In the study area, places with 1st degree of suitability covers 3 % of the whole area while 2nd degrees and 3rd degrees cover 7 % and 21 %, respectively. On the contrary, 69 % of the whole area consists of places with no suitability (Fig. 3). Unsuitable areas cover a wide range along the coasts lying between northern and southern parts of the study area. In this regard, the most suitable areas in terms of ground conditions are the neighborhoods such as Gultepe, Buluttepe and Kocatepe together with some sections of the neighborhoods such as Yıldırımtepe and Ismet Inonu located in the study area (Fig. 2).

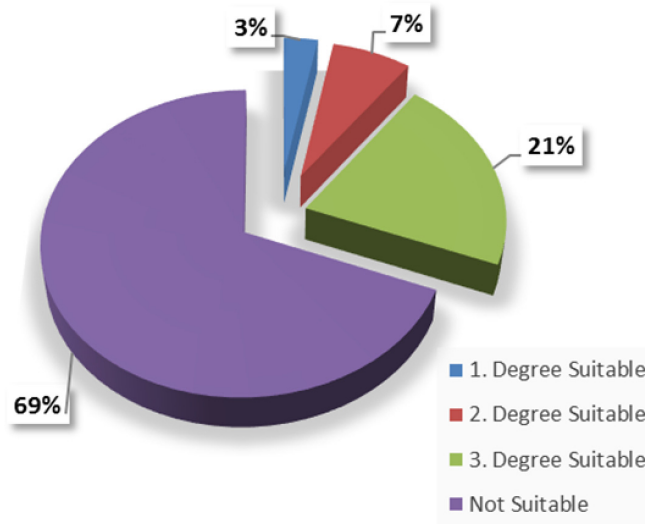


Fig. 3. Suitability degrees rates of Iskenderun

7. Discussion and Conclusions

Since selection of site is an important issue in establishing new settlements, many settlements with faulty foundations were obliged to be relocated in the long run. However, it is not possible for this study area to be relocated in present time. It is out of question to relocate Iskenderun that was founded many centuries ago and have a well-established history. Considering the fact that reality of earthquake is a constant threat to areas with no settlement suitability due to local ground characteristics, the best solution is to increase the strength of existing constructions and start urban renewal. Investigation of settlement suitability map of Iskenderun shows that a significant part of Iskenderun has 69 % unsuitability for settlement in terms of ground conditions. Hence, it is required to test the earthquake reliability indices of buildings in this study area by various tests and demolish unreliable ones in order to construct new buildings as soon as possible. Unless these steps are taken and preventive actions minimizing the negative effects in case of an earthquake are not taken as soon as possible, loss of life and property would be more dramatic.

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