6 MAJOR SOIL FACTORS CONSIDERED IN LAND EVALUATION
The selected major soil factors from the SDBm are soil organic matter content, pH, carbonate content, cation exchange capacity, salinity, exchangeable sodium percentage, texture, drainage and depth of the soil profile.

6.1 Organic Matter
Organic matter can act as a reservoir that will release nutrients to the soil solution upon decomposition. It behaves somewhat like a sponge, with the ability to absorb and hold up to 90% of its weight in water; also, it causes soil to clump and form soil aggregates, which improves soil structure. The relatively higher content can only be maintained under continuous cultivation when there is sufficient input of organic manure or other organic material such as crop residue. In general, applying organic manure, and other positive agro-management practices, can increase soil organic matter content. On the other hand, the mis-management of soils, especially those suffering from salinity and sodicity problems, contributes to inhibited plant growth. It is noteworthy that soil organic matter influences the availability of micronutrients to plants; particularly those that are largely present as insoluble forms. Organic matter can increase their solubility through the effect on the soil redox potential (Lindsay, 1991). In addition, organic matter can be one of the main nutrients sources; therefore, a strong relationship between nutrient status and organic matter content in the soil exists. In Andalusia, the soil type HU01-Lithic Xerochrepts shows the highest organic matter content of 4.3%, while the lowest value is found in AL5-Vertic Haplargids with only 0.1% organic matter. In El-Fayoum the soil SU5-Typic Haplosalids has the highest organic matter content with 3% and the lowest in content of OM located in SU6-Typic Torripsmment. Considering that, these are characteristic values, and field variability can be high.

6.2 Soil pH
The soil pH is a measure of the acidity or basicity in soils; the pH of the soil solution is very important since it affects the solubility of nutrients such as N, K and P and thereby affects the availability of these nutrients to plants. Plants need nutrients in specific amounts to grow, thrive, and fight off diseases.

Soil pH is considered one of the most important factors influencing the plant uptake of trace elements, with generally higher adsorption (and therefore lower availability) at higher soil pH (Kabata-Pendias. 2001). On the other hand, P is best available to plants when the soil pH is between 6.0 and 7.0.
In Andalusia, about 28% of the area has a pH between 5 and 6.5, and the lowest pH is observed in the soil types GR02-Typic Dystrudepts, SE06 - Typic Haploxerulpts and MA02 - Lithic Haploxerepts. On the other hand, around 22% of the area has a pH above 8, especially in the soil types GR07 - Calcic Haploxerepts, GR10 - Calcic Rhodoxeralfs, AI05 - Vertic Haplargids and GR06 - Typic Xerorthents. In the investigated soils in El-Fayoum, the values of pH ranged from 7.53 and 8.86. The high values are mainly found in the northern part of the studied area, south of Qarun Lake in SU5 - Typic Haplosalids.

6.3 Carbonate Content

Calcium carbonate is a major component of many semiarid soils, as it accumulates in soils over time. Systematic morphological changes occur in these calcic soils, which affects the way water infiltrates in the soil profile. Carbonates can be the dominant sink for trace elements in a particular soil, but the most important mechanisms through which carbonates affect the behavior of trace elements is related to the buffer capacity of soil carbonates. Available CdCO$_3$, Cu$_2$(OH)$_2$CO$_3$, and Zn$_2$(OH)$_2$(CO$_3$)$_2$ are likely to occur in neutral or alkaline soils when these are polluted with these metals (Kabata-Pendias and Brümmer, 1991). That the CaCO$_3$ particles are found in the coarse (primary) and fine fractions (secondary formation). Inactive CaCO$_3$ is more closely associated with the coarse and medium
mineral fractions (sand and silt fractions). In Andalusia, the highest carbonate content was observed in soils that formed from calcareous parent material. Therefore, the concentration of carbonates could exceed 40% in GR07 - Calcic Haploxererts. Regulation of pH in calcareous soils may lead to the fixation of the nutrients, particularly phosphorus, and it also lead to the fixation of heavy metals. On the other hand, carbonate levels close to 0% occur in the acid soils, those that formed from acidic rock, as can be found in SE06 - Typic Haploxerults. Abdel Razek (1998) and Shimaa (2009) reported that the dominant soil characteristic in the El-Fayoum depression is the CaCO$_3$ content, particularly near the depression borders where the soils are calcareous in nature. In El-Fayoum, the carbonate levels of SU3 - Typic Torrifluvents soil types were 2.6%, and reached 39.2% in SU2 - Typic Haplocalcids.

6.4 CATION EXCHANGE CAPACITY
Cation exchange capacity represents the number of exchangeable cations per dry weight that a soil is capable of holding; it is highly dependent on soil texture and organic matter content, also related to pH and carbonates. Clay content is important because these small particles have a high ratio of surface area to volume so the heavy soil textures, which contain a high proportion of clay, have a high CEC too. In Andalusia, the lowest CEC (1.2 meq/100g) is found in the coarse sandy soil such as GR03 - Typic Xerorthents, while the highest values are found in the heavy clay soils, where it reaches 50.4 meq/100g (in the soil type CO02 - Typic Haploxererts). Vertic Torrifluvents SU1 and Typic Torrifluvents SU3 show high values of CEC; it can reach 45.5 meq/100g in these soils. The same trend can be found in El-Fayoum, where the values of CEC are only 4.1 meq/100g in SU6 - Typic Torripsamments which have a low clay content, and the highest value is situated in SU1 - Vertic Torrifluvents (high clay content) with 42.6 meq/100g.

6.5 SOIL SALINITY
Soil salinity is the salt content of the soil. Salinization can be caused by natural processes such as a shallow saline water table and the presence of mineral sediments (may be of marine origin, volcanic sediments or due to aridity). In some cases, Vertisols, for example, soils are naturally high in exchangeable sodium percentage (ESP) throughout the soil profile (Syers, 2001). Salinization can also be caused by artificial processes such as irrigation, because poor irrigation water quality and low irrigation efficiency that contribute to increased soil salinity and sodicity. Spatial information on soil salinity at the medium scale is increasingly needed, particularly for better soil management and land use planning (Rongjiang
and Jingsong, 2010). If excessive amounts of salt are taken up by the plant, the salts will accumulate and reach toxic levels, mainly in the older, transpiring leaves, causing premature senescence and reduced yields. The growth rate of plants under salt stress differs strongly between plant species, and sometimes also between cultivars (Jacobsen et al., 2012).

In Andalusia, salinity problems have been observed in some natural land use areas (i.e SE05, HU06 and AL04), which show a high concentration of salt and are mainly located on SE05 - Typic Fluvaquents where the electric conductivity can reach 30.8 dS/m. A great variation was observed in the electric conductivity (EC) values in the El-Fayoum depression, where EC values ranged from 1.7 to 54.0 dS/m; the highest value was observed in the SU5 - Typic Haplosalids which is adjacent to the coast of Qarun Lake. In addition, it has been found that a close relationship exists between elevation and water table depth: in low-laying areas the groundwater table is much closer to the surface than in areas with a higher elevation, in agreement with Ali and Abdel Kawy (2013). When the groundwater table is closer to the surface, the problems with sodicity and salinity will be more severe because poor drainage means that less salt can leached.

6.6 Exchangeable Sodium Percentage
Crescimanno et al. (1995) showed that an exchangeable sodium percentage (ESP) above 15% is considered to negatively affect soil structure and hydraulic characteristics. Soil sodicity is the term given to the amount of sodium held in the soil, this can be expressed in different ways: ESP, or sodium absorption ratio (SAR = $\frac{[Na^+]}{\sqrt{[Ca^{2+}] + [Mg^{2+}]}}$), with concentrations in meq/L). Sodicity affects soils through two related phenomena: swelling and dispersion. In Andalusia, the calcic soils have low ESP values, but saline soils have high values where the ESP ranges from 0.2% in GR07 - Calcic Haploxerepts to 14.3% in SE05 - Typic Fluvaquents. According to Ali (2005), the El-Fayoum depression has a high risk of salinization (45% of the total area), sodification (7.5%), and physical degradation (25%). In El-Fayoum, the ESP value varied from 5.3% in SU6 - Typic Torripsamments, to the highest reported value of 17.9% in SU5 - Typic Haplosalids.

6.7 Soil Texture
Soil texture refers to the proportions of sand, silt, and clay in a soil. Soil texture is an important soil characteristic that drives crop production and field management. Soil particles may be either mineral or organic but in most soils, the largest proportions of particles are mineral and these soils are therefore referred
to as ‘mineral soils’. The texture based on the relative proportion of the particles fewer than 2 millimeters (fine earth). The basic elements of soil texture are;

- **Sand**, defined as mineral soil particles that have diameters ranging from 2 - 0.02 mm. In Andalusia, the sand content ranges from 1.4%, to 93.9% in soils SE05-Typic Fluvaquents, and HU04-Fluventic Dystrudepts, respectively. In El-Fayoum, the sand content ranges from 13.4% in SU1-Vertic Torrifluvents, to 95.5% in a small area with sandy soil that is located practically in SU6-Typic Torripasment soil type.

- **Silt** can be defined as the mineral soil particles that range in diameter from 0.02 to 0.002 mm. In Andalusia the soil, HU04-Fluventic Dystrudepts have the lowest silt content in with 1.4%, at the other extreme, GR06-Typic Xerorthents has a silt content of 88.2%. In El-Fayoum, silt percentage ranged from 3.2% to 30.7%, in SU3-Typic Torrifluvents and SU6-Typic Torripasment, respectively.

- **Clay** is the soil texture component with soil particles that have diameters less than 0.002 mm. In Andalusia the soil type GR03-Typic Xerorthents has a low clay content of 3.4%, JA05 - Lithic Rhodoxeralfs, on the other hand, has a clay content of 81.0%. In El-Fayoum the soil type with the lowest clay content is SU6 - Typic Torripasment with 5.1% clay, the highest clay content can be found in SU2 - Typic Haplocalcids (with 64.3%). Soil texture has a direct effect on soil chemical and physical properties, and according to Ehab (1988), soil texture is a crucial factor. He observed that fine-textured soils generally have a lower pH and higher organic matter contents. Soil texture also determines the drainage capacity to a large extent.

### 6.8 Drainage

Soil drainage is the natural or artificial removal of water from the surface and subsurface of an area. Soil drainage may determine which types of plants grow best in an area. Many agricultural soils need good drainage to improve or sustain production or to manage water supplies (Haroun 2004). Poor drainage (causing water-logged areas) can often be identified by examining the soil color. In zones dominated by longer periods of saturation, and thereby reducing conditions, there can be mottles that occupy small areas and that differ in color from the soil matrix (olive gray and yellowish red for the Nile alluvial clayey soils, and light yellowish brown and dark reddish brown for the residual calcareous soils).
In Andalusia the area can be divided in different classes, those that have a good drainage (51% of the total area), moderate (29%), poor (14%), and excessive (6%) drainage. Very poor drainage class is observed in SE05 - Typic Fluvaquents, and the excessive class in HU04 - Fluventic Dystrudepts. In El-Fayoum, more than 75% of the studied are have a poor drainage especially in SU5 - Typic Haplosalids and SU2 - Typic Haplocalcids a small area of El-Fayoum that has excessive drainage class and this located in SU6 - Typic Torripsamments.

6.9 Soil Depth
Soil depth is another important soil property; it refers to the thickness of the soil materials that provide structural support, nutrients and water for plants. Soil depth is very critical for plant growth. Any discontinuities in the soil profile, from layers of sand or gravel, to even bedrock, can physically limit to the available rooting depth. It can also create problems when using irrigation. Soil macro- and meso-biota need enough soil to grow and increase physical fertility (Louis, 2011). In Andalusia, shallow soil depths have been observed in the natural land use within the soil type Typic Fluvaquents which are located in AL04, HU06 and SE05 where the depth was 20, 70 and 56 cm respectively. Also in some forest areas, the depth does not reach to 50 cm (GR06 - Typic Xerorthents and HU02 - Lithic Xerorthents, with a depth of 12 and 9 cm, respectively). The largest depths can be found in GR05 - Typic Rhodoxeralfs and SE06 - Typic Haploxerults, with 170 and 250 cm depth, respectively. In El-Fayoum, it is noticed that the water table depth ranges from 0 to ≥150 cm, Most of the deep soil profiles (≥150 cm) are found in SU1 - Vertic Torrifluvents, while the shallow soil profiles are found in the SU5 - Typic Haplosalids. The relation between elevation and the depth of the groundwater has been studied and elaborated.
Pump machine for withdrawal of
Saline crust on the soil surface in the areas adjacent to Qarun Lake.