



GIS spatial model based for determining actual land degradation status in Kafr El-Sheikh Governorate, North Nile Delta

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Received: 8 October 2017 / Accepted: 5 December 2017 / Published online: 13 December 2017
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Abstract

Degradation factors cause serious limitations to agricultural productivity of land of Kafr El-Sheikh Governorate, North Nile Delta. Therefore, there is a need for identifying the soil degradation types due to soil natural pedological process. This research work aims to determine the actual degradation status in the investigated area using Geographic Information Systems (GIS). Based on soil physiographic units, 160 soil profiles were dug, soil samples were collected and analysed, then soil classification was established. The results demonstrated presence of many potential degradation processes; (soil compaction, water logging, salinization and sodification). It was noted that one of major factors of land degradation in the area was soil sealing. Therefore, Fuzzy model were established to calculate the changes of land use land cover in the last three decades to assess quantitative land degradation caused by soil sealing. Land degradation caused inappropriate agricultural practices mainly associated with conservation measurements absence; improper time use of heavy machinery, over irrigation, and human intervention in natural drainage.

Keywords Change detection · Model builder · Soil degradation · Soil sealing · Urban sprawl

Introduction

Land degradation identified by (FAO/UNEP 1978, 1984; Warren and Agnew 1988; Lal and Stewart 1990; Wim and El-Hadji 2002) as process lowers potential and/or current soils agricultural capability. It can be defined as the decline in soil quality caused through its misuse by human (Lal and Stewart 1990) or a process that describes human induced phenomena, which reduce the current and/ or future soil capability (Ayoub 1991). Land degradation is the temporally or permanent lowering of the production capacity of land and added that desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from adverse

human impact and climate changes (UNEP 1992). The geo-chemical land degradation processes especially salinization, alkalization and sodification are broadly occur in the areas of arid and semi-arid climatic zone (Condom et al. 1999; AbdelRahman et al. 2008). The water logging and subsequent salinization and/or alkalization are the major land degradation processes in irrigated agriculture lands of arid and semi-arid conditions (Dwivedi et al. 1999).

The study area is located in north part of the Delta of Egypt which is one of the oldest agricultural lands in the world. The study area falls in the hyper arid zone the average annual rainfall (mostly falls in winter) is (6.5 mm/year). The maximum/minimum mean annual temperature is (26.4/11.0 °C) (Egyptian Meteorological Authority 2016). The study area is threatened by soil compaction, water logging, alkalization and salinization (El Gabaly 1972; Gad and Abel Samei 1998; El Kassas 1999; Shalaby and Moghanm 2015).

Geology of the area is considered as a portion of a major downward characterized by unstable shelf region of north Egypt (Shata and Fayoumy 1969). The geomorphological units south of El Borollus Lake include fluvio-lacustrine and alluvial plain landforms (Enain and Sh 1997).

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The irrigation and drainage network exist in the area since 1820 (Wahab et al. 2010). The network is composed of river Nile, canals, and ponds. Its flow direction is from south to north with regional slope gradient of less than 1%. However the natural drainage system is insufficient to drain the soils and therefore artificial system is required (Abdalla et al. 1990). The discharge of the water table drains showed great variations with time, being high just after irrigation, decreasing rapidly and often ceasing completely before the next irrigation (Abdel-Dayem and Ritzema 1990). A strong relation was found between the discharge of the lateral drains and the crop cultivated in the drainage unit (PADT 1987–1989, part IV). Abdalla et al. (1990) stated that the discharges of the subsurface drainage system, in combination with the natural drainage, control the salinity level of the soil. According to Abdel-Dayem and Ritzema (1990) since the beginning of this century the use of water per unit area in the Nile Delta of Egypt has increased sharply with the gradual introduction of perennial irrigation. Consequently the natural drainage system could no longer cope with the increased percolation losses and land became waterlogged and/or salt-affected (Abdel-Dayem and Ritzema 1990). To overcome these problems the Egyptian Government is implementing an intensive land drainage programme to provide the whole Nile Delta with subsurface drains. The original design criteria were established in the early sixties (Abdel-Dayem and Ritzema 1987). The inefficiency of the system established is the main cause of the degradation problems in the area (Wahab et al. 2010). Therefore installation of the subsurface drainage system is highly recommended in such areas. This recommendation is deduced from the results of Abdel-Dayem and Ritzema (1990) which indicated increasing the crop yields significantly by “10% for rice, 48% for berseem, 75% for maize and more than 130% for wheat” and the study attributed the yield increase to “the decrease in soil salinity, the effect of improved water and air conditions in the root zone”.

Kafr El-Sheikh Governorate is located north of Nile Delta, and occupies an area corresponding to 3742 km². Kafr El-Sheikh has undergone social, environmental, physical and economic changes associated with population increase and the demand for food and energy (El Baroudy and Moghanm 2014). Geographic Information Systems (GIS) showed acceptable results in numerous application in agriculture (Formaggio et al. 1992; Pedron et al. 2006), especially in face of databases lacking detailed soil surveys and other physiographic data (Silva et al. 2010; Vital et al. 2014; AbdelRahman et al. 2016). GIS helps to manage spatial data, delimits mapping units using various components of databases. GIS facilitates graphical representation and minimizes degree of complexity and subjectivity of the areas (Assad et al. 1998; AbdelRahman et al. 2016). Population growth is the most significant factor effecting urban sprawl in Nile Delta (Mohamed et al. 2015), agriculture sector is

representing a corestone in the national economy of Egypt and Nile delta’s soils are the most high capable and suitable for agricultural in Egypt (Abdelhafez and Hamdi 2001). Agricultural land is approximately 4% of Egypt’s total area while remaining area of land is arid desert 96% (Belal and Moghanm 2011). Egyptian government is proceeding a horizontal urban expansion and reclaiming new land in desert areas along with and nearby Nile Delta fringes. This could help to redirect loss of old and highly capable Nile Delta agricultural land (Belal and Moghanm 2011; AbdelRahman et al. 2017). This work aimed to highlight different land degradation types in the area either in-situ or off-situ soil degradation using GIS and remote sensing (RS). Soil sealing is one of the major off-situ land degradation which has negative impacts on agricultural soils. And to asses it, this work aimed to evaluate loss of soil productivity by urban sprawl, which considered as soil degradation factor meaningful to desertification caused by soil sealing in the area. Land use land cover change detection technique was used to monitor soil sealing in agricultural land among dates 1996, 2006, 2016. The evaluation of soil capability lost to urban sprawl applied through land evaluation systems (Lepsch 1991).

Materials and methods

A number of three Landsat satellite images were used in this study to cover the study area in three different dates (1996, 2006 and 2016) as shown in Table 1 to study the soil sealing caused by urban sprawl in the study area. Topographic maps at scale of 1:25,000 covering the study area, produced by the Egyptian General Survey Authority (EGSA) were converted to a digital format.

The methodology flowchart (Fig. 1) show the proposed approach using fuzzy model to determine soil sealing, caused by urban sprawl, in fuzzy model Arc GIS model builder and to generate overall land degradation using weighted average model.

In the fuzzy logic for overlay analysis, for each criterion, each cell is evaluated as to whether it is in a specified class or not. And it can be used to define clear class boundaries and definitively assign cells to specific classes. Each cell is assigned as being target (1) or not target (0) for each criterion. The data is read in numerical format. These numbers represent different types of surface features and the connection with different numbers implies where the polygon borders are. Therefore the construct fuzzy model employed the membership functions of classification.

Fuzzy logic overlay analysis emphasis on defining the problem, breaking the problem into sub models, determining significant layers, reclassifying and transforming the data within a layer, Weigh the input layers then analyzing the added or combined layers

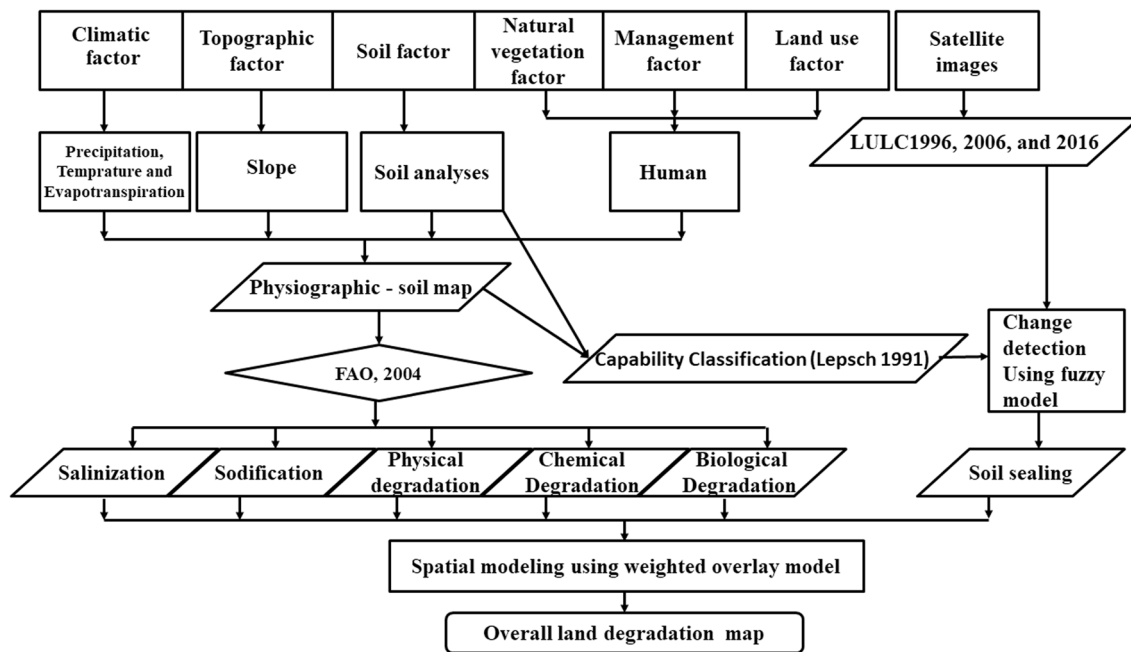


Fig. 1 Methodology flowchart

Table 1 Spectral characteristics of used Landsat satellite images

Landsat 1996 Bands	Wavelength (µm)	Landsat 2006 Bands	Wavelength (µm)	Landsat 2016 Bands	Wavelength (µm)	Resolution (m)
Band 1—blue	0.45–0.52	Band 1—blue	0.45–0.52	Band 1—ultra blue (coastal/aerosol)	0.435–0.451	30
Band 2—green	0.52–0.60	Band 2—green	0.52–0.60	Band 2—blue	0.452–0.512	30
Band 3—red	0.63–0.69	Band 3—red	0.63–0.69	Band 3—green	0.533–0.590	30
Band 4—near infrared (NIR)	0.76–0.90	Band 4—near infrared (NIR)	0.77–0.90	Band 4—red	0.636–0.673	30
Band 5—shortwave infrared (SWIR) 1	1.55–1.75	Band 5—shortwave infrared (SWIR) 1	1.55–1.75	Band 5—near infrared (NIR)	0.851–0.879	30
Band 6—thermal	10.40–12.50	Band 6—thermal	10.40–12.50	Band 6—shortwave infrared (SWIR) 1	1.566–1.651	30
Band 7—shortwave infrared (SWIR) 2	2.08–2.35	Band 7—shortwave infrared (SWIR) 2	2.09–2.35	Band 7—shortwave infrared (SWIR) 2	2.107–2.294	30
—	—	Band 8—panchromatic	0.52–0.90	Band 8—panchromatic	0.503–0.676	15
—	—	—	—	Band 9—cirrus	1.363–1.384	30
—	—	—	—	Band 10—thermal infrared (TIRS) 1	10.60–11.19	100×(30)
—	—	—	—	Band 11—thermal infrared (TIRS) 2	11.50–12.51	100×(30)

$$\mu_S(x) = \begin{cases} \left(\frac{ax+bx_1}{x_2-x_1} \right) & x_1 < x < x_2 \\ c; & x \leq x_1 \\ 1 - c; & x \geq x_2 \end{cases}$$

In which μ_S is the fuzzy number representing membership degrees of a given parameter. Values x_1 , x_2 , and x are the boundary values of each severity class, dependent on the parameter’s ranking scheme. Membership values 0 for urban and 1 for non-urban features.

Soil—physiography

Physiographic map of the study area has been produced using physiographic analysis (Zinck and Valenzuela 1990) by combining Sentinel 1 and DEM derived from topo sheets scale 1:25,000 integrated with SRTM 1 arc second. The soil profiles locations were selected in transects to cover all mapping units. Collected soils samples were analyzed according to (USDA 2012). Soil Taxonomy was produced using (USDA 2014).

Land degradation

Land degradation methodology (FAO 2004) was used to Measure each unit rating of degradation to assess the actual natural vulnerability of land degradation. The current values of (soil depth, bulk density “BD”, EC, ESP and pH), and topography, management factors and climatic values were used to assess actual soil degradation. Arc GIS model builder used to generate all different types of soil degradation processes in the area. Kriging geostatistics techniques used to generate the spatial variability factors of soil properties integrated in the model to generate soil degradation maps.

The application of the parametric approach on different units resulted in estimating the risk of soil degradation and the soil degradation status. The general form of the used parametric formula of Universal Soil Loss Equation (USLE) is (FAO 2014; FAO/UNEP and UNESCO 1979):

$$D = f(C, S, T, V, L, M),$$

where; D=soil degradation, V=natural vegetation factor, C=climatic factor, L=land use factor, S=soil factor, M=management factor, and T=topographic factor.

The values of the variables are chosen in such a way that solving of equation gives numerical indication of degradation status.

Climatic factor:

Climate is an influential factor in the different degradation processes

$$C' = 1/100 \sum_{i=1}^{12} U^3 \left(\frac{PET - P}{PET} \right) n,$$

where U = the mean monthly wind speed at 2 m height, PET = the potential evapotranspiration, P = the precipitation, N = the total number of days in the month.

Human factor:

The application of excessive irrigation without an adequate drainage, irrigation with poor quality water and poor leveling of irrigated land, are human factors increasing the salinization hazard. Crop which cover a low percentage of the soil surface, and some types of cultivation with heavy

machinery, increase the risk of physical degradation. Irrigation on vulnerable soils and puddling of paddy fields are also factors increasing the risk of physical degradation.

Soil factor:

Clay percentage is a very important factor affecting structure stability.

$$\frac{zf + zc}{c}$$

In which; zf = % fine silt (2–20 μm). Zc = % coarse silt (20–50 μm). C = % clay.

Topographic factor:

Level topography, as for chemical degradation is an important factor influencing physical degradation, because it increases infiltration.

Soil sealing

To determine soil sealing, land use land cover change detection technique was applied upon Landsat satellite images of 1996, 2006 and 2016. NDVI was applied to extract the agricultural land. Normalized difference building index (NDBI) was applied to extract urban areas. Meanwhile Neural Networks and Support Vector Machine; two different supervised classification techniques were applied to monitor the changes of the LULC. To determine quantitative soil sealing, Land Use Capability Classification (Lepsch 1991) was used to determine land evaluation. The result of this formula is called the Normalized Difference Vegetation Index (NDVI). Written mathematically, the formula is:

$$NDVI = (NIR - VIS)/(NIR + VIS).$$

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (–1) to plus one (+1); however, no green leaves gives a value close to zero. A zero means no vegetation and close to +1 (0.8–0.9) indicates the highest possible density of green leaves.

Normalized Difference Built-up Index (NDBI) is used to extract built-up features and have indices range from –1 to 1.

$$NDVI = (NIR - SWIR)/(NIR + SWIR).$$

The Specific band designations differ from Landsats 5, 7 and 8 (Barsi et al. 2014). Band details and spectral characteristics are illustrated in Table 1.

Results and discussions

Physiography

Marine plain, flood (Alluvial) plain and fluvial-lacustrine plain are the main landscapes types dominating the area as

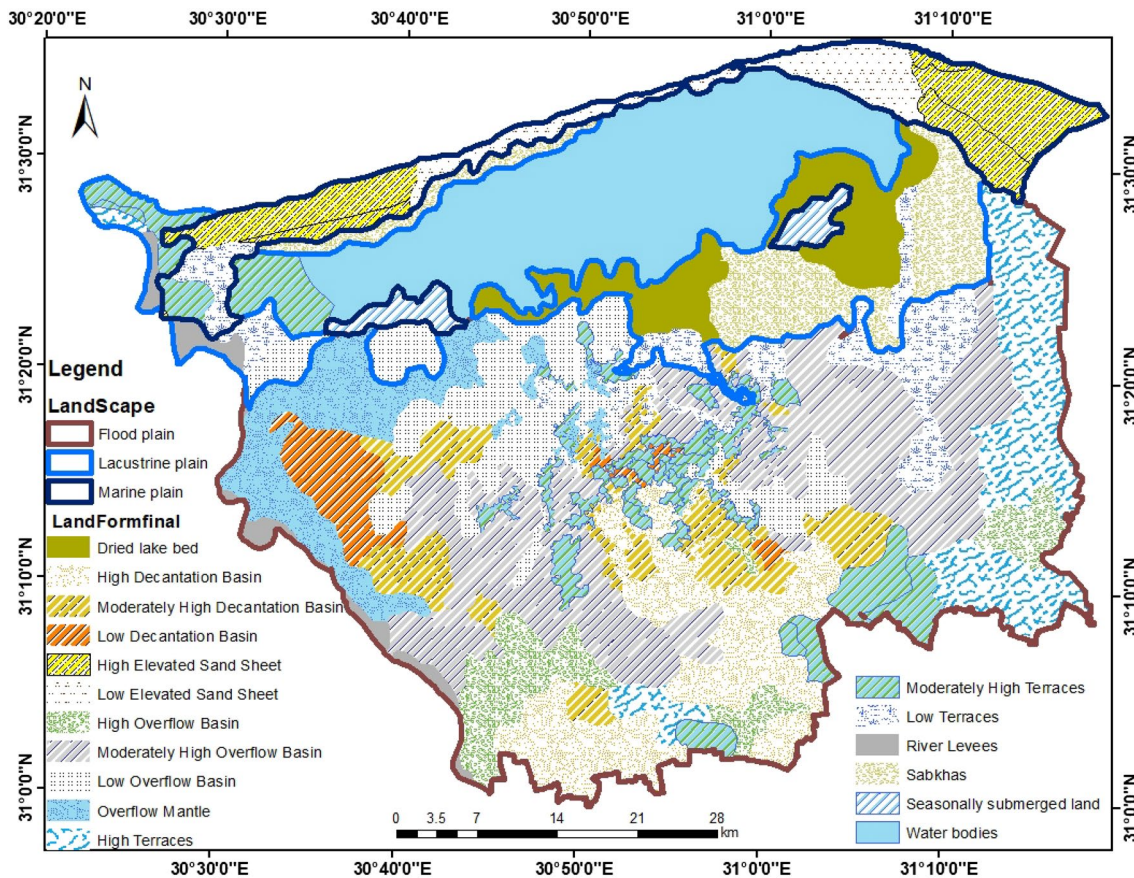


Fig. 2 Physiographic units of the studied area, modified after Darwish and Abdel Kawy (2008)

showed in Fig. 2. Eleven landforms have been recognized in the area shown in physiographic map (Fig. 2) i.e. (dried lake bed occupied 4.8% of total area, high decantation basin 7.5, moderately high decantation basin 5.2%, low decantation basin 2.2%, high elevated sand sheet 4.8%, low elevated sand sheet 2.6%, high overflow basin 3.9%, moderately high overflow basin 14.6%, low overflow basin 7.3%, overflow mantle 5.4%, high terraces 7.1%, moderately high terraces 7.4%, low terraces 5.4%, river levees 1.4%, sabkhas 5.6%, seasonally submerged land 1.2%, boroullous lake 13.8% of the total area while turtle backs is occupied 0.2% and man-made terraces 0.4%).

Soils

Soils samples from 160 soil profiles were collected and analyzed and morphologically studied for soil classification purpose. Soils were classified into three orders (*Aridisols*, *Entisols* and *Vertisols*) and ten great groups were identified as shown in Fig. 3.

The field work survey of soil profiles morphological and pedological studies and analytical data, reveals the main characteristics of different mapping units as following:

Soils of alluvial plain (flood plain)

Soil profiles are deep and soils drainage conditions are poor to well. Soil texture classes are clay for most profiles and silty clay for the subsurface layers. The BD, as an indicator of compaction, ranges between 1.29 and 1.49 g/cm³ and increases with profiles depth. Calcium carbonate content ranges between 1.01 to 5.76% in different profiles layers. pH values ranged between 7.90 and 8.70 in the studied profiles. EC of saturation paste extracts for all profiles is ranged between 0.57 and 7.91 dS/m. OM content ranges between 0.26 and 2.97%. High values of upper layers' OM in some soil profiles may be due to continuous addition of organic manures in these cultivated soils. The cation exchange capacity (CEC) ranges between 33.35 and 47.99 meq/100 g soil, this is reflecting effects of high clay and organic matter content. The main portion of the exchangeable cations in these soils is occupied by Calcium. ESP values range between 3.63 and 14.73% in different soil profiles layers. Available nitrogen ranges between 5.65 and 63.2 ppm in the Pedon surface layers and available phosphorus ranges between 3.5 and 31.7 ppm. High values of N and P were found in surface layers of all soil profiles. Available

potassium ranges between 224 and 397 ppm in different studied soil profiles. Based on Pedon morphological features of this unit and chemical analysis, the soils are classified as *Sodic Endoaquerts*, *Sodic Haplotorrerts*, *Typic Aquisalids*, *Typic Haplocalcids*, *Typic Natrargids*, *Typic Salitorrerts*, *Typic Endoaquerts*, *Typic haplotorrerts*, *Typic Torrifluvents* and *Vertic Torrifluvents*.

Soils of lacustrine deposits

Soils texture are clay for all pedons and profiles depths are moderately deep to deep soils and drainage conditions are poor and moderately to well-drained. Calcium carbonate

content ranges between 0.37 and 4.32% in different layers of all soil profiles. pH values ranges between 7.70 and 8.60 in all pedons. EC of saturation paste extracts is ranged from low to extremely high (1.23–86.0 dS/m). The high values of ECe are found in which high EC value of water table under aridity conditions. OM content ranges between 0.27 and 3.71%, and its highest values are found in the upper layers of studied pedons. Continuous addition of organic manures for these cultivated soils could be the main reason of OM’s high value. CEC ranges between 31.33 and 48.77 meq/100 g soil in the studied soil profiles. High values of CEC are correlated with high content of OM and clay contents. The main portion of the exchangeable cations in these soils is formed

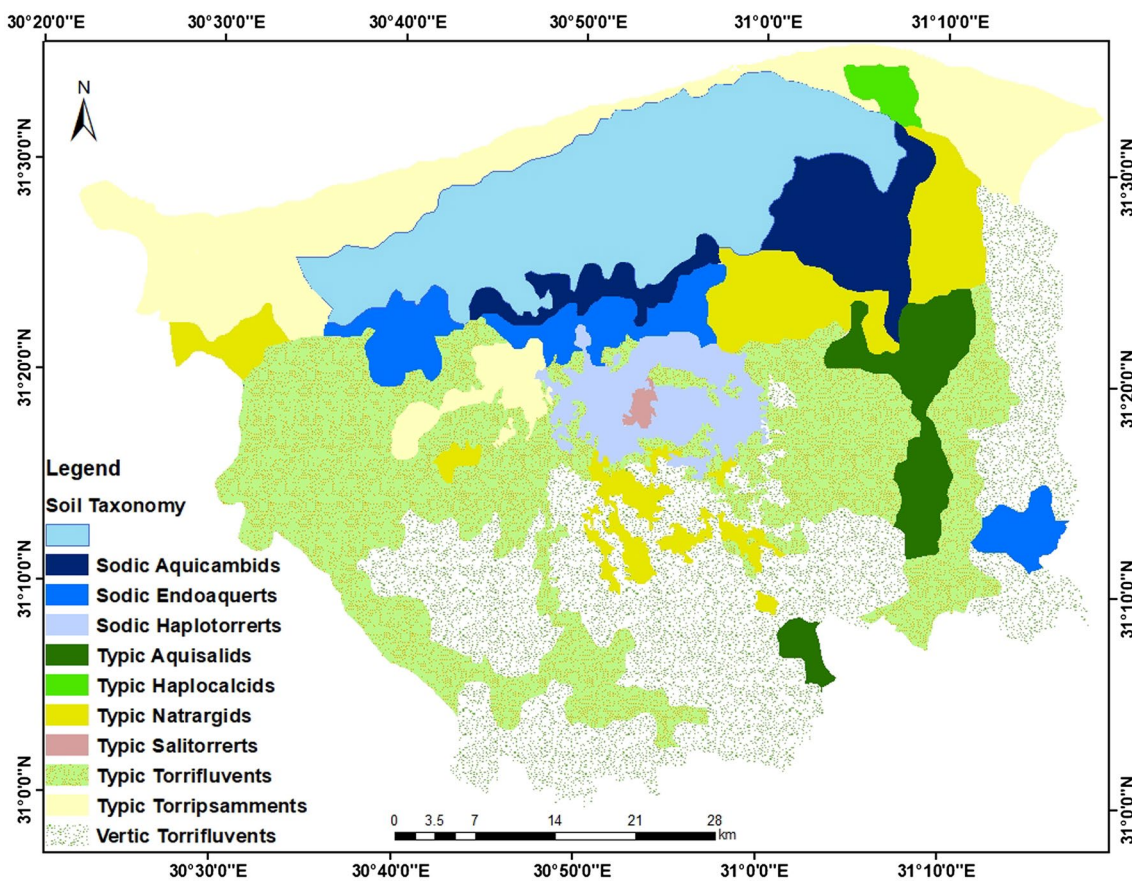


Fig. 3 Soils units of studied area

Table 2 The total area of the main soil characteristics

EC (dS/m)	Area (%)	ESP (%)	Area (%)	Soil depth	Area (%)	OM (%)	Area (%)
0–2	13.0	< 6 Non-sodic	30.8	30–60	6.0	< 0.86	12.9
2–4	32.9	6–10 Sodic	8.0	60–90	22.4	0.86–1.29	39.8
4–8	4.9	10–15 Moderately sodic	18.6	90–120	23.0	> 1.29	18.7
8–16	17.2	15–25 Strongly sodic	6.3	> 120	20.0		
> 16	3.3	> 25 Very strongly sodic	7.8				

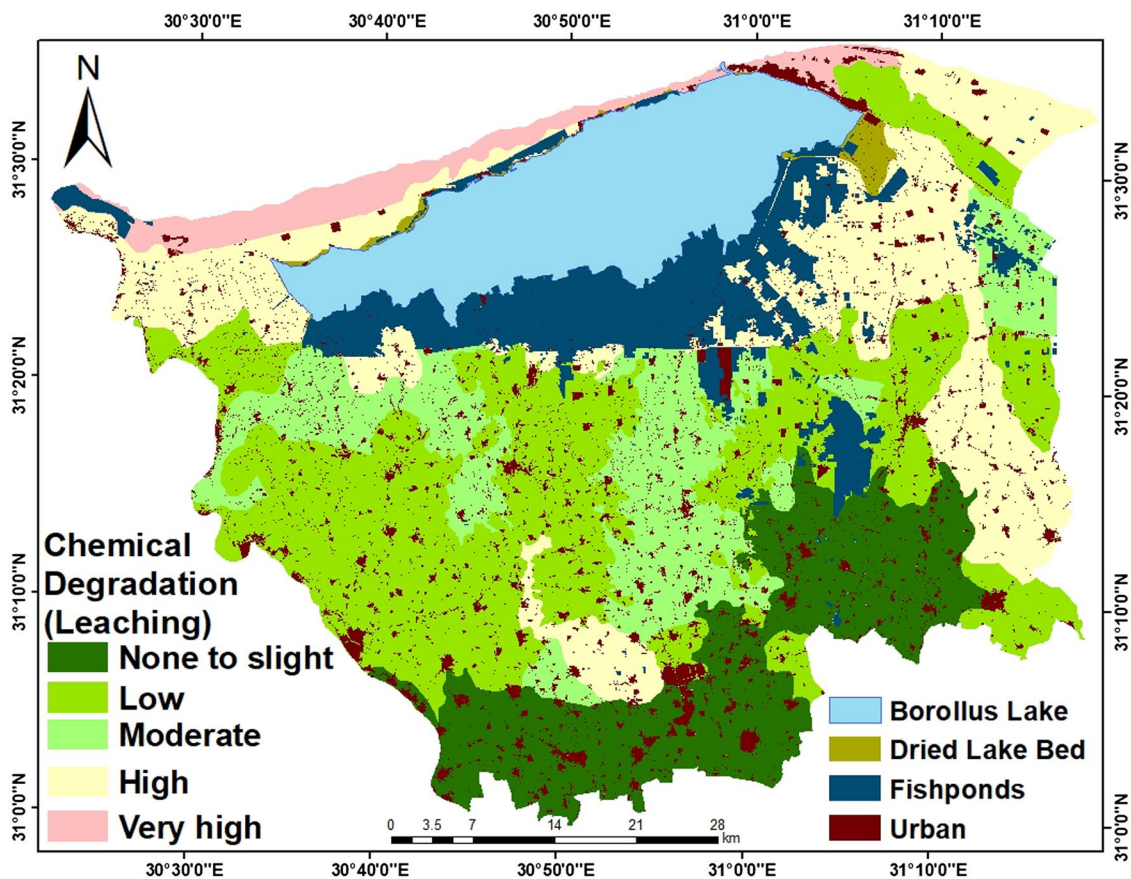


Fig. 4 Assessment of chemical degradation

by Calcium. ESP values ranges between 6.17 and 45.76% in different pedons layers. Available nitrogen is low to high (4.7–29.8 ppm) while available phosphorus content is low to medium (3.7–43.9 ppm). Meanwhile available potassium content is high, more than 250 ppm in all pedons. Based on pedon morphological features of this unit and chemical analysis, the soils are classified as *Sodic Aquicambids*, *Sodic Haplotorrerts*, *Sodic Endoaquerts*, *Typic Salitorrerts* and *Typic Haplocalcids*.

Soils of coastal plain (marine plain)

Soil profiles of this unit are very deep and well-drained. Soil texture class is sandy and structure is single grain. EC of saturation paste extracts is low to moderate. It ranges between 1.98 and 119.86 dS/m. OM content ranges between 0.50 and 2.20%, and it decreases irregularly with depth. High content of OM which found in the surface layer may be due to application of manure to the agriculture soil. The absence

of diagnostic horizons, in addition to the aforementioned evidences of stratification and irregular decrease of organic matter assure that the sand flats occur in Entisols order. CEC varies between 5.3 and 17.69 meq/100 g soil. Dominance of sandy soils, lack of clay and low organic matter content are main reasons of low values of CEC. The main portion of the exchangeable cations in these soils is formed by Calcium and magnesium.

ESP varies between 7.25 and 34.38%. Available nitrogen content is low to medium (6.75–18.9 ppm), while the higher value may be due to the continuous addition of nitrogenous fertilizers to the cultivated orchards in that site. Available phosphorous and available potassium are low values ranged from 4.6 to 15.7 and 71–175 ppm, respectively.

Based on Pedon morphological features of this unit and chemical analysis, the soils are classified as *Typic Torripsamment* and *Typic haplocalcids*. Table 2. Show the total area of the main soil characteristics that were used for studying land degradation status and land evaluation of the area.

Land degradation assessment

The land degradation processes in the studies area were estimated in relation to Pedon depth, water table, BD, EC and ESP. different degradation processes in addition to the overall degradation status were assessed as follow:

Chemical degradation

Chemical degradation in the study area occurs in soils with low cation exchange capacity, which causes loss of its bases through leaching caused by surface irrigation. This loss of bases occurred upon the upper portions of highland of land-form through leaching down to lower horizons beyond the reach of crop roots. Assessment of chemical degradation (Leaching) risk was classified into four classes according to the USLE as shown in Fig. 4; none to slight occupying 13%, low 25.8, moderate 12.1%, high 17.2% and very high 3.3% of the total area.

Physical degradation

Physical degradation risk refers to soil compaction, which is calculated based on bulk density. Assessment of Physical degradation was classified into five classes (Fig. 5) according to the USLE; none to slight occupying 4.2%, low 15.9%, moderate 13.6%, high 17.9% and very high 19.8% of the total area.

Salinization

The risk of salinization in the study area is non to slight to very high. These estimations are based upon the calculated climatic index without considering the salinity of the ground water. The soil, topography and human activity cause higher values for the present state and risk of degradation by salinization. This stress the importance of a appropriate management and sound agricultural practices through appropriate irrigation and drainage techniques. Assessment of salinization risk was classified into five classes (Fig. 6) according to the USLE; none to slight occupying 13%, low

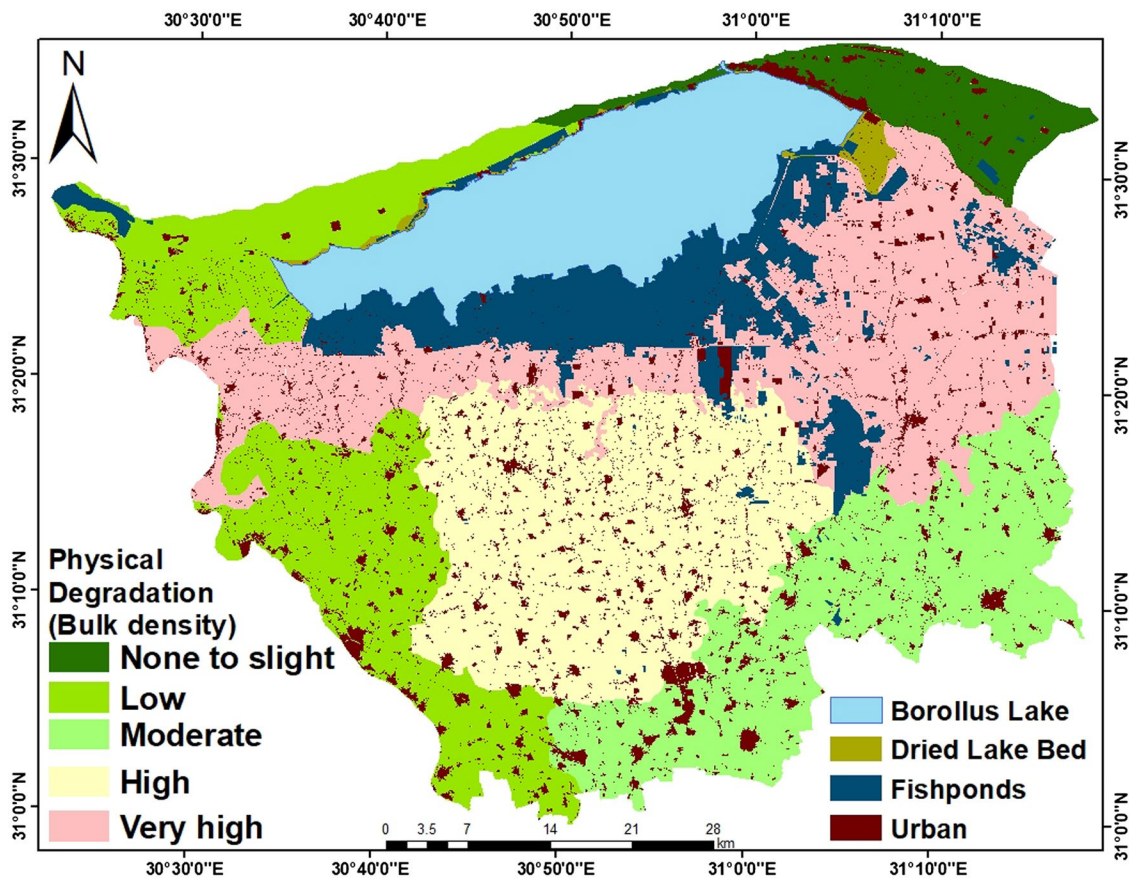


Fig. 5 Assessment of physical degradation initial levels

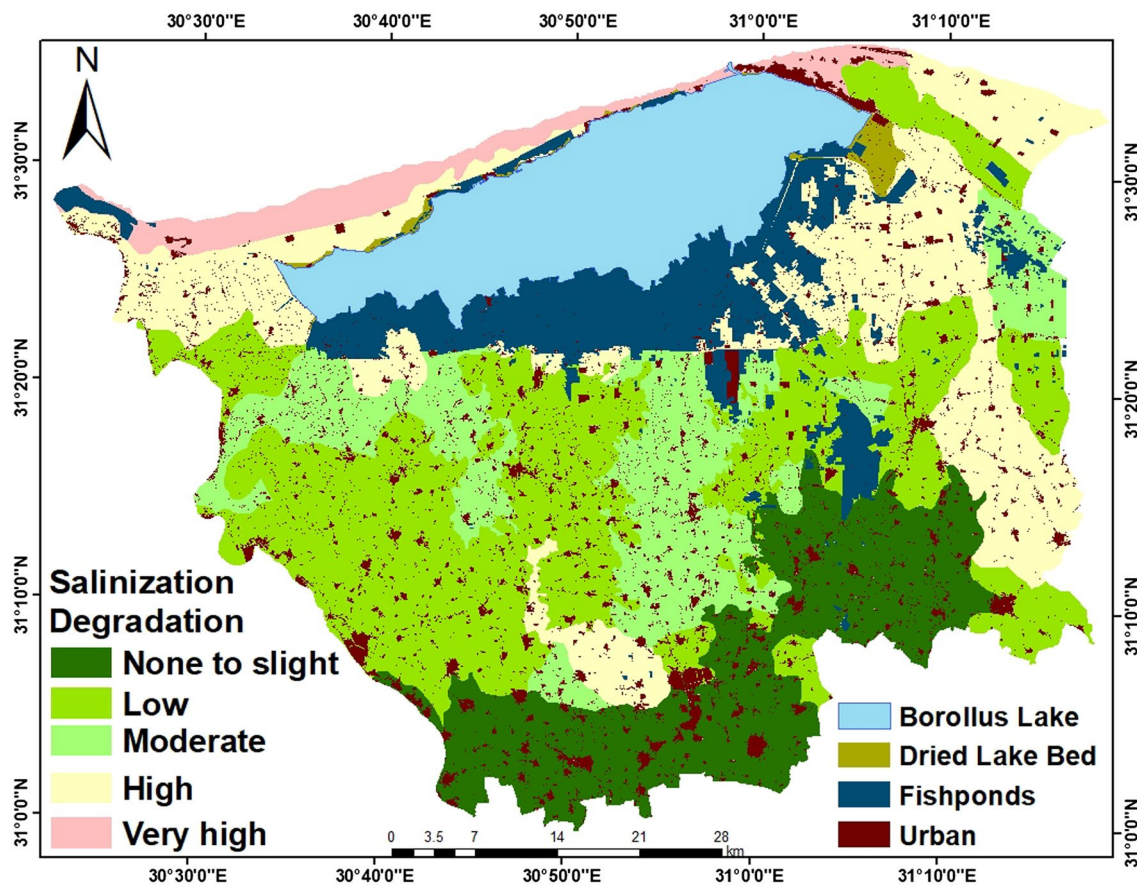


Fig. 6 Assessment of salinization degradation

25.8%, moderate 12.1%, high 17.2% and very high 3.3% of the total area.

Sodification

The present state of sodification in the study area is non to slight to very high. These estimations are based upon the calculated climatic index without considering the alkalinity of the ground water. The soil, topography and human activity cause higher values for the present state and risk of degradation by sodification. Assessment of sodification was classified into five classes according to the USLE as shown in Fig. 7; none to slight occupying 30.8%, low 8%, moderate 18.6%, high 6.3% and very high 7.8% of the total area.

Water logging

Water logging is a serious problem in the north part of the study area and around the lake. It is mainly caused by sea-water intrusion and surface irrigation. Assessment of water

logging was classified into five classes as shown in Fig. 8; none to slight occupying 7.8%, low 15.7%, moderate 20.8%, high 21.2% and very high 6% of the total area.

Soil sealing

Soil sealing was calculated based on changes in agricultural land caused by urban encroachment through the last three decades. The results showed that highly and moderately fertile agricultural land has decreased by (5.9%) of the total area or 20,207 ha through the last three decades. Change detection technique was used to map the changes of land use land cover in the study area during the last 3 decades (Fig. 9). Capability and suitability classes characterized by good (C2), moderately suitable (S2), and Fair (C3) which is marginally suitable (S3) depending on soil’s physio-chemical properties. During 1996–2016, soil sealing took place on (12.4 of the total area) 46,401.4 ha from the study area through urban sprawl and fishponds constructions. It is expected that the urban sprawl will be increased to 6.9%

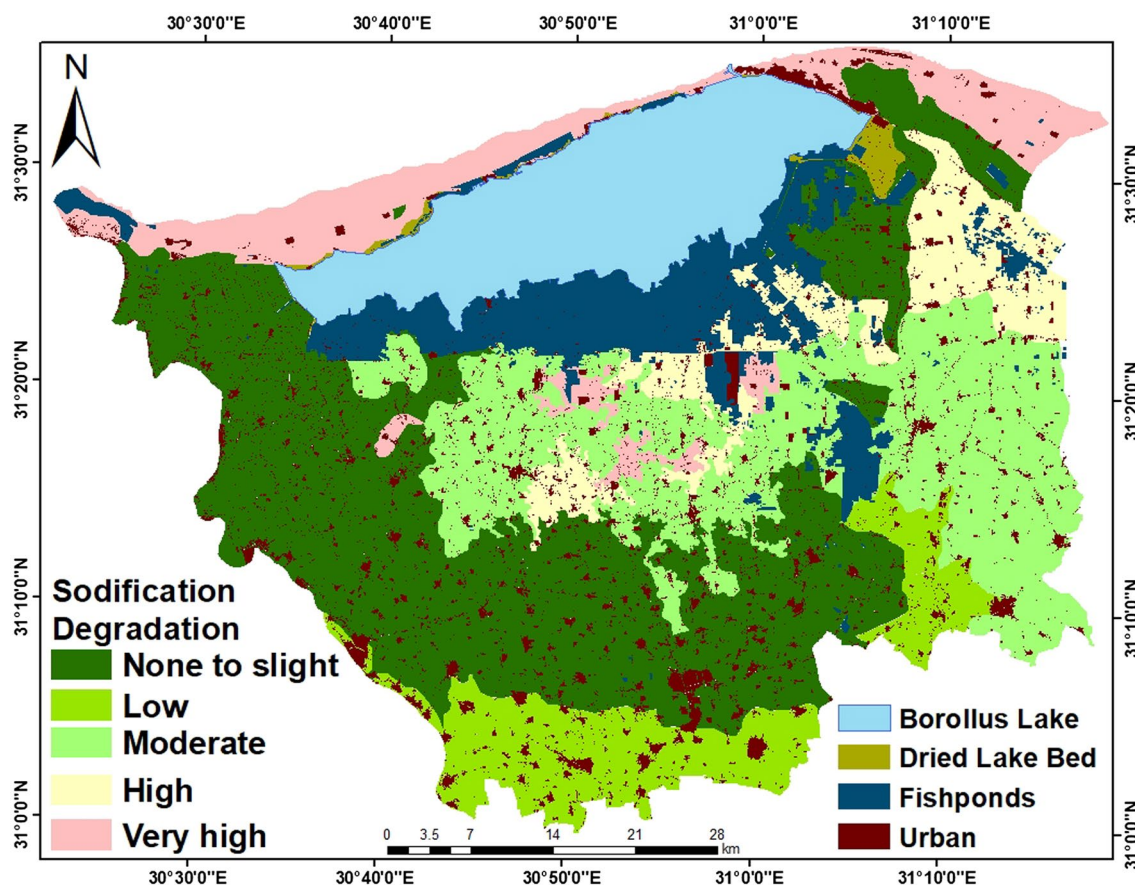


Fig. 7 Assessment of sodification degradation

by 2020, this means that additional 3742 ha of productive soils will be lost from high capable soils from the study area.

Overall land degradation

The quantification of overall land degradation (Fig. 10) was produced by Arc GIS spatial model by a combination of degree and relative extents of the degradation types. It varies from low to very high as shown in Table 3, where more than 50% of the units vary from moderate to very high.

Soil degradation severity levels are found to be associated with landforms. It is high levels in the areas covered by clay flat, overflow and decantation basins, and over flow mantle. While it is facing low severity levels of degradation in soils of river terraces, sandy remnants, and turtle backs.

The obtained results reveal that actual soils degradation status of river terraces in flood plain has slight to moderate and slight to high chemical and physical degradation respectively. Soils of overflow mantle and decantation basin are subjected to moderate physical and chemical degradation status. While soils of decantation, over-flow basin and moderate and high river terraces of fluvial-lacustrine plain and levees have a moderate physical and chemical degradation. But low river terraces in the fluvial-lacustrine plain have high physical degradation and slight chemical degradation. These results are in agreement with the study done by Wahab et al. (2010) in the study area.

The main cause of sodification in the area is lack of irrigation schemes management, usage of saline irrigation water and inefficient drainage. The salt accumulation in the area is mainly occurs under arid condition. This also may be caused

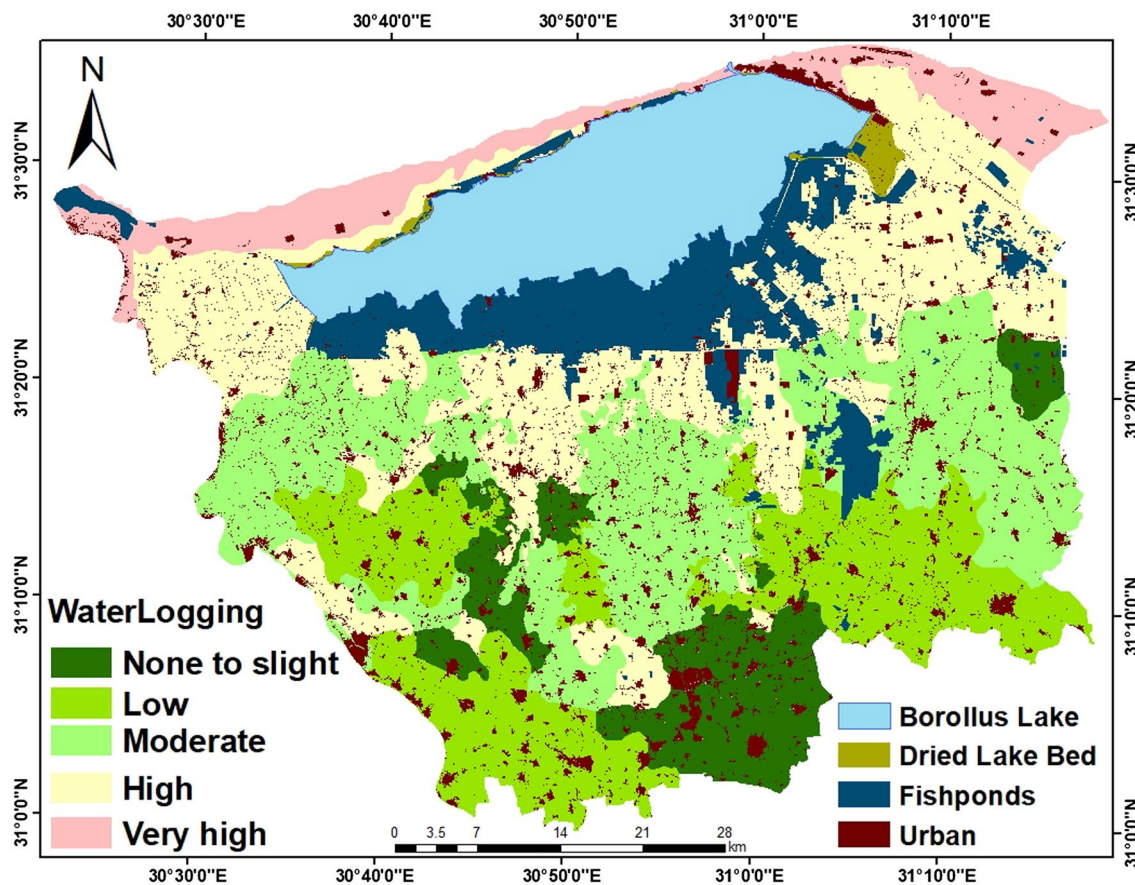


Fig. 8 Assessment of water logging degradation

by sea water intrusion. Under the inappropriate agricultural activities i.e. use of heavy machinery, soils with low structure stability are having high soil compaction. Misuse of irrigation techniques, especially in heavy clay soils and inefficient drainages are causes of water logging in the area. Table 3 is shown that water logging, compaction, salinization, and sodification processes are occurring in the area. The actual status of land degradation was estimated by using the universal soil loss equation 2004. The obtained data reveal that, the rates of studied soil degradation processes are slight to very high.

Land degradation rates were estimated by (Darwish and Abdel Kawy 2008) for the investigated area and the study was based on comparison between land characteristics which studied in 1963 and 2009, and it was found that different types of soil degradation hazards are low to high. The extent

of soil degradation types was estimated based upon correlation between physiography and soils. Classes of degradation hazard in the study area, total area (%) for the different types of the quantitative degradation soils.

The results indicated that the class of very high degraded soil occupies 19.8, 3.3, 7.8 and 6.0% of the total studied area for physical degradation, salinization degradation, sodification degradation and water logging degradation respectively. While class of high degraded soil occupies 17.9, 17.2, 6.3 and 21.2% respectively. The class of moderately degraded soil relatively occupy large portion of the studied area as shown in Table 3. This means that more than 50% of the total area is subjected to different types of land degradations. This is alarming for increase the awareness of the importance of soil management practices.

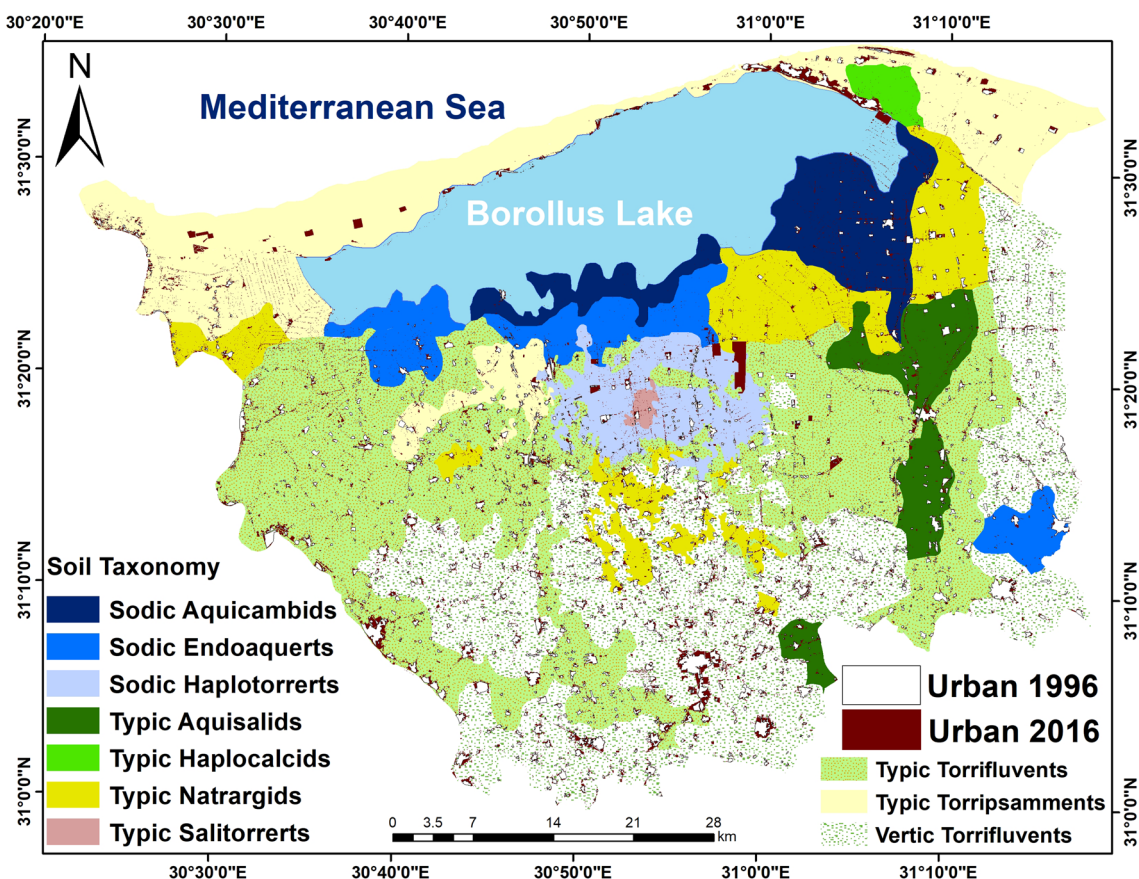


Fig. 9 Soil sealing caused by urban sprawl between 1996 and 2016

Conclusion

Large significant area in the northern part of Nile Delta is subjected to a high physical and chemical degradation. Moreover, salinization, sodification, soil compaction, and water logging processes, are slight to very high in different soil units. This is according to the present values of soil depth, BD, EC and ESP. Due to improper use of heavy machinery over irrigation, and absence of conservation measurements and excessive use of chemical fertilizer soils are threatened by active degradation resulting from soil properties, improper farming system, climate, and relief.

The agricultural soils in the Kafr El-Sheikh governorate are characterized by high soil productivity. However soil sealing threatens agricultural soils potentiality in the area. This is obtained from monitoring changes of the urban growth, therefore, this study suggests mitigating soil sealing by use of diverse media to increase people's awareness of the seriousness of urban sprawl on agricultural land. Legislation which forbids the construction on agricultural land needs to be applied to combat urban sprawl in addition to land reclamation through the horizontal expansion of agriculture in the desert land.

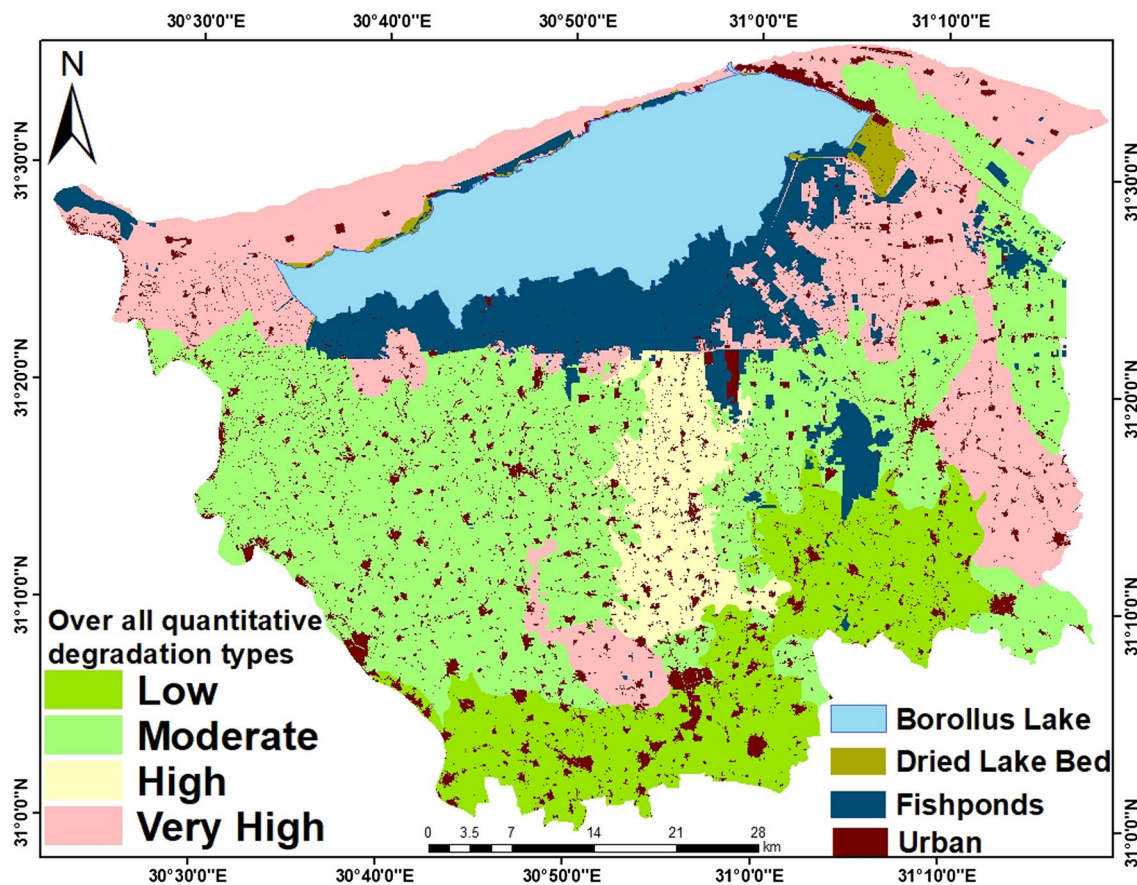


Fig. 10 Overall land degradation status

Table 3 Classes of degradation hazard in the study area, Total area (%) for the different types of the quantitative degradation soils

Degradation class	Physical degradation	Salinization degradation	Sodification degradation	Water logging degradation	Soil sealing	Quantification over all degradation types
None to slight	4.2	13.0	30.8	7.8	0.3	–
Low	15.9	25.8	8.0	15.7	0.2	13.0
Moderate	13.6	12.1	18.6	20.8	3.8	32.9
High	17.9	17.2	6.3	21.2	1.6	4.9
Very high	19.8	3.3	7.8	6.0	0.0	20.6

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