Influence of Seasonal Flashfloods on Terrain and Soils of El-Qaa Plain, South Sinai, Egypt.

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ABSTRACT

El-Qaa plain lies in the southern part of Sinai Peninsula extending along the Gulf of Suez. It occupies an area of about 3300 (km^2).This plain is suffering from seasonal flashflood that can roll boulders, tear out trees, destroy local people buildings and scour out new channels. Flashfloods are among the most frequent and costly natural disasters in terms of human hardship and economic loss. Terrain units of El-Qaa plain were interpreted by draping satellite ETM+ image over Digital Terrain Model (DTM).These units could be categorized into sand sheet, outwash plain, inter-ridged sand flat, wadi bottom, wadi outlet, dry valley, delta ,dry &wet sabkhas, ridge, rocky hill, cuesta , peniplain, rock outcrop ,footslope , bajada & alluvial fans ,inclined lime stone, marine spits & heads and water bodies. On the other hand soils of ElQaa plain were classified into Calcic Haplosalids ,Gypsic Haplosalids ,Lithic Haplocalcids , Lithic Torripsamments , Typic Aquisalids,Typic Haplodurids,Typic Torripsamments and Typic Haplocalcids. Arc Hydro Model was used with the aid of DTM for deriving slope, flow direction, basins, flow length and flow accumulation. These derivations influence directly the flashflood behavior. Universal Soil Loss Equation (RUSLE) was used to estimate soil loss in El-Qaa plain using GIS spatial analyses. The minimum mean soil loss belonging to water erosion was determined by 1.23 ton\hectare\year, meanwhile the maximum one was estimated by 5.08 ton\hectare\year.

Keywords: Digital Terrain Model, Remote Sensing, GIS , Universal Soil Loss Equation.

INTRODUCTION

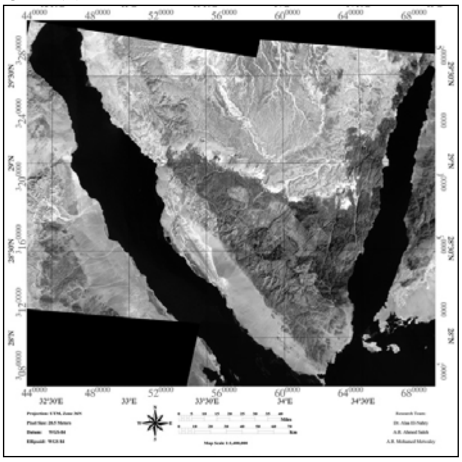
Decision-makers operating at different scales of interest and responsibility have to deal with different types of environmental problems and seek solutions to handle the complexity of natural and human actions causing these problems .The linkage of environmental assessment tools, Remote Sensing (RS) and Geographical Information Systems (GIS) and their capability in handling available geo-spatial data sources to prepare valid model input parameters for applications at various spatial and temporal scales are in high demand. Flashfloods are among the most frequent and costly natural disasters in terms of human hardship and economic loss. As much as 90 percent of the damage related to all natural disasters (excluding droughts) is caused by flashfloods and associated debris flows. In response to such hazards related to soil erosion, especially from agricultural land, the development and implementation of techniques for natural resource management were fostered by interest groups and policy-driving organizations to support decision-makers in countries worldwide (Troeh et al., 1999).

MATERIALS AND METHODS

Digital Image Processing

Digital image processing of Landsat ETM+ satellite image using ENVI 4.1 software includes the following items: Data manipulation including image stretching, filtering, and histogram matching.Rectification of satellite images.Producing image mosaic from satellite Landsat 0.7 ETM+ images that cover South Sinai Peninsula using pixel based mosaic, Figure (1). Clipping El-Qaa plain from South Sinai mosaic using ARC GIS 9.0 as shown in Figure (2).

Figure (1): Mosaic of South Sinai Governorate



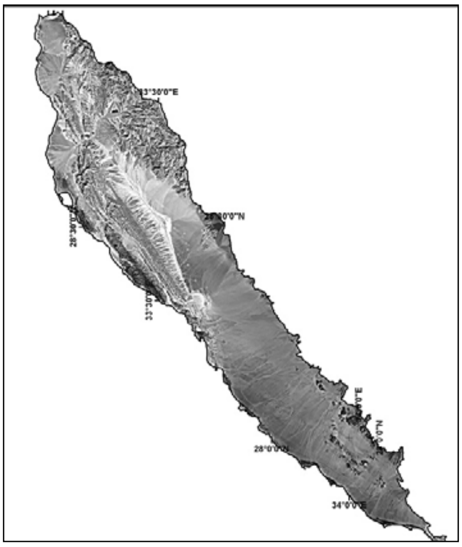


Figure (2): El Qaa plain

Field Studies

Field studies include the following works:-

1-Reconnaissance, semi detailed soil survey. 2-Verification of the primary mapping units.3-Tracing and monitoring locations of gullies, rills and sheet erosion.4-Digging 30 representative soil profiles,150 augers and 10 mini pits.5- Soil and water sampling.

Laboratory Analyses.

Soil color dry and wet was determined by the aid of Munssel color charts (Soil Survey Staff, 1951).Soluble cations and anions, Electric conductivity EC Ds/m, $CaCO_3$ %, Gypsum %, O.M %, pH in 1:2.5 extract were estimated due to Rowell, 1995.

Soil Water Erosion Modeling

An estimation of soil loss due to water erosion was generated using the Revised Universal Soil Loss Equation RUSLE (Renard et al., 1997). Equation could be presented as follows:

$$A = RKLSCP$$

Where A = the soil loss, ton/ha/year, R = the rainfall erosivity factor, K = the soil erodability factor, Ls = the combined slope length factor, C = the cropping management factor, and P = the erosion control factor.

RESULTS AND DISCUSSIONS

Digital Terrain Model of El-Qaa Plain

Degital Terrain Model was used to represent terrain relief of El-Qaa plain and its vicinities as shown in Figure (3).Satellite ETM+ image was draped over Digital Terrain Model to get the feel of natural 3 D terrain, the better understanding of the geomorphologic units and to facilitate extracting these units, Figure (4).

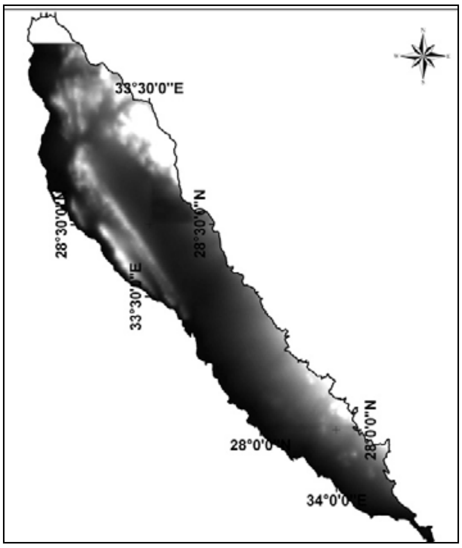


Figure (3) DTM of ElQaa plain

Terrain and Associated Soils of El-Qaa Plain

El-Qaa plain constitutes several geomorphologic units; each of which is characterized by a particular assemblage of landforms. Environmental conditions, including both exogenetic and endogenetic factors have their influence on the geomorphology and associated soils of the

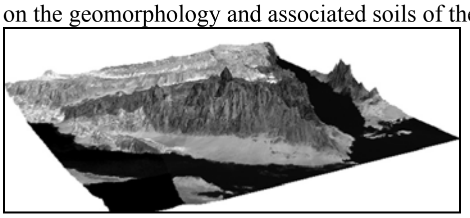


Figure (4) Draping satellite image over DTM

Geomorphologic units and their associated soils is presented in figures 5 and 6 and the following lines:-

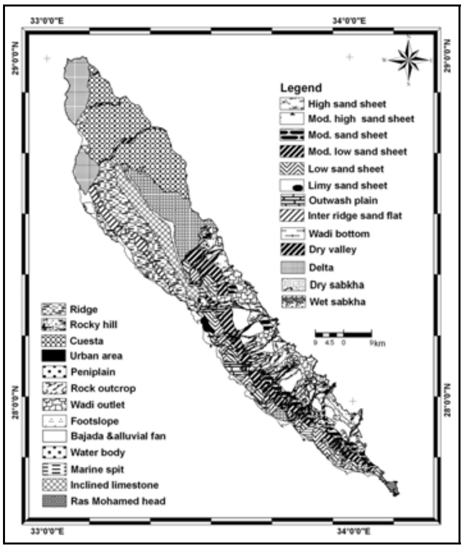


Figure (5) Geomorphologic map

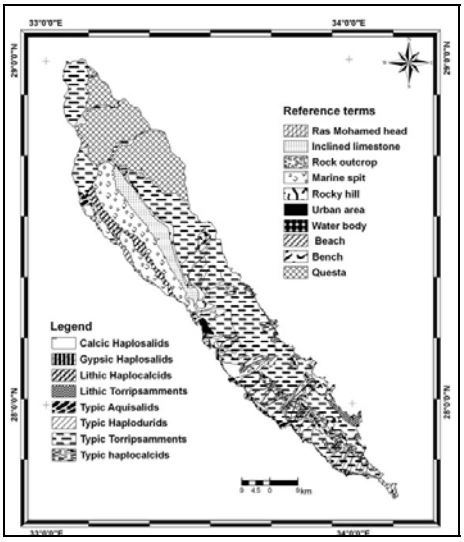


Figure (6) Soil map

Sand Sheet

Stratified poor sorted sand deposits believed to be formed when windblown materials settle on areas of patchy rocks. Sand sheet could be categorized to high, moderately high, moderately, moderately low, low and limy sand sheet. Soils of this unit are classified as ***Typic Torripasmments.*** and ***Typic Haplocalcids***

Outwash Plain

A flat or gently sloping surface of fluvial sediments deposited by streams spread over the mountainous area . The soils of this unit are classified as ***Calcic haplosalids***

Inter Ridges Sand Flats

A type of sedimentary rock that contains a large quantity of weathered quartz grains restricted between elongated ridges. The soils of this unit are classified as Lithic *Haplocalcids.*

Wadi Bottom

The wadi bottom represents the sediments surface over the plain crust. Soils of this unit are classified as ***Typic Haplocalcids***

Wadi Outlet

These deposits were found at the wadi mouth, almost coarser than the other deposits that can form the fans. Wadi outlet occurs after heavy rains that flow from the uplands brings down coarse textured sediments. Soils of this unit are classified as ***Typic Torripsamments.***

Delta

Large deposit of alluvial sediment located at the mouth of a stream where it enters a body of standing water. Soils of this unit are classified as ***Typic Torripsamment***

Bajadas & Alluvial Fans

Consecutive series of alluvial fans forming along the edge of a linear mountain range. This landform normally occurs in arid climates. Soils of this unit are classified as ***Typic Torripsamments***

Alkali Flats (Dry &Wet Sabkhas)

Flat surfaces very rich in salts especially $NaHCO_3$ .Plants that exist in this community have special adaptation to survive in the presence of high salinities. Alkali flats are sub divided into dry and wet sabkhas. Soils of this unit are classified as ***Typic Aquisalids & Gypsic Haplosalids***

Peniplain

Landform did not reach to the plain stage yet, it is formed by the action of water erosionSoils of this unit are classified as ***Typic Haplodurids.***

Foot Slopes

Inclined surfaces representing the foots of the southern triangular mountains. Depth of these soils is ≤ 50 cm, soil texture class is coarse sand, saturation percentage of these soils ranges between 21 – 22,pH values tend to be slightly alkaline (pH values are 8.0 – 8.4),EC values range between 2.5 to 5.0 dS/m and $CaCO_3$ content ranges between 7.7 – 8.7 %. Lithic contact at 50 cm defined depth of this soil profile. Soils of this unit are classified as ***Lithic Torripsamments***

Miscellaneous Geomorphologic Units ,Marine Spits

Inclined Lime stones. ,Ridge ,Rocky Hills and Cuesta.

Flashflood Hazards

Flashfloods that occur in ElQaa plain can roll boulders, tear out trees, destroy local people buildings, and scour out new channels. ElQaa plain flash flooding is caused by storm rains that are gathering in the multi channels of the southern triangular mountains pouring the collected water in the main flashflood courses.To get the better understanding of the flashflood effects it was very important to use Arc hydro model for getting more information related to slope, flow direction, basins, flow length and flow accumulation which could be considered as the most important parameters that influence the flashflood behavior.

Arc Hydro Data Model

The Arc Hydro Data Model can be defined as a geographic database containing a GIS representation of a Hydrological Information System under a case-specific database. Arc hydro model depends mainly upon Digital Terrain Model (DTM) to extract the required parameters of flow direction, basins, flow length and flow accumulation.

-Flow Direction

Establishing the flow direction in a geometric network determines the direction in which commodities flow along each edge, Greenlee (1987). The flow direction in a network was determined by: 1-The connectivity of the network. 2- The locations of sources and sinks in the network. 3- The enabled or disabled state of features. Jenson and Domingue (1988) .The output of flow direction is an integer grid whose values range from 1 to 128 from the center as shown in Figure (7)

-Drainage Basins

The drainage basins were created by locating the pour points at the edges of the analysis window, where water would pour out of the raster, as well as sinks, then identifying the contributing area above each pour point. Drainage basins areas of ElQaa plain ranged between 0.35- 269.47 km^2 .Total drainage area is 3430.76 km^2 as shown in Figure.(8).

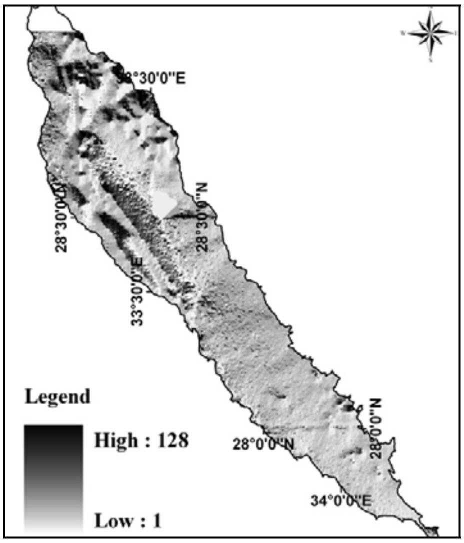


Figure (7) Flow direction

Figure (8) Drainage basins

-Flow Accumulation

Flow Accumulation as shown in Figure (9) might determine how much rain has fallen within a given watershed. it is assumed that all rain becomes runoff and there was no interception, evapotranspiration, or loss to groundwater. The results of Flow Accumulation can be used to create a stream network by applying a threshold value to select cells with a high accumulated flow (Tarboton et al., 1991).

In El-Qaa plain case , cells with a high flow accumulation (1398,411 km) are areas of concentrated flow and may be used to identify stream channels. Cells with a flow accumulation of zero are local topographic heights and may be used to identify ridges.

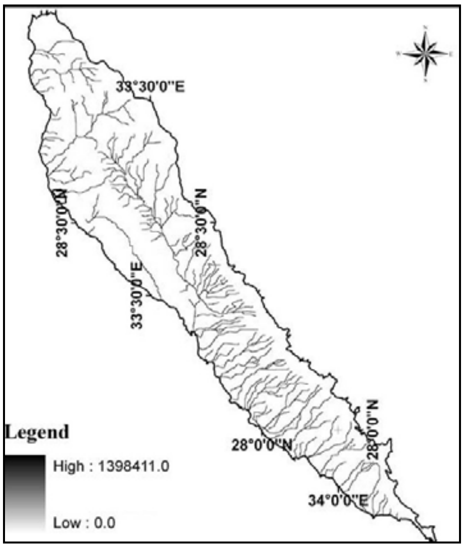


Figure (9) Flow accumulation

Soil Water Erosion Modeling

Figure (10) show erosion rate or soil loss in the different geomorphologic units of El-Qaa plain. It is noticed that soil loss reaches its mean minimum value of 1.23 ton /hectare/year in the soils of limy sand sheet. This may be referred to lime plays an important role as a cementing agent that combined sand particles together preventing them from washing away by water erosion, meanwhile it reached its maximum value of 5.08 ton /hectare/year in the soils of inter ridged sand flats. Maximum mean soil loss may be owing to inter ridged sand flat soils are subjected to higher amounts of flashfloods water that fall on surrounding ridges causing extreme soil losses. Generally the most effected soils by flashfloods were arranged due to the mean loss order of inter ridged sand flats> footslopes >wadi outlet >dry valley>high sand sheet. It is worthily to mention that the most effected soils by the water of flashfloods are those of high elevation with remarkable slopes and/or those lying adjacent to high elevation areas.

CONCLUSIONS & RECOMMENDATION

Erosion problems that resulted from flashfloods can be solved by the farm operator with minimal expense or inconvenience. Modifying tillage practices to keep crop residue on the surface can greatly reduce erosion. A crop residue cover also conserves soil moisture and improves soil tilth and fertility for better crop production. Costs for conservation tillage systems are usually similar to or lower than costs for conventional tillage systems over the long term. Preventing soil erosion helps to ensure the sustainability of the farm operation. A well-planned rotation will improve soil quality and reduce erosion. Legumes in the rotation also add nitrogen and improve soil fertility. In drier areas, forages are harder to establish and may deplete moisture in a short-term rotation (Douwe and Syd, 2001).

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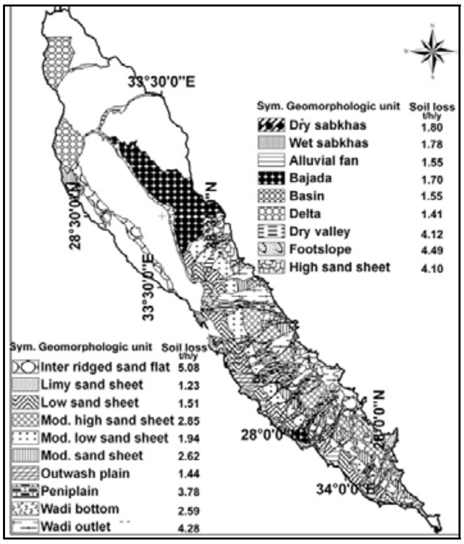

Figure (10) Soil loss in the geomorphologic units

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