Eco. Env. & Cons. 20 (3) : 2014; pp. (1171-1180)
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ISSN 0971–765X

Studying runoff and water erosion by using GeoWEPP model in Sheikh Badr region – Syria

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(Received : 10 April, 2014; accepted 12 May, 2014)

ABSTRACT

The water erosion of the soil is a major factor of the land degradation factors in the coastal cliffs in Syria, and it represents a threat to soil, water, plants and the environment in the long run, where it gets the loss amounts importance of nutrients and organic matter in the surface layer of the soil and then deposited in the end on the roads, wells and waterways. For a reduction from the problem requires the knowledge about the water erosion rates and an understanding of the factors (the characteristics of each of the soil and the plant, climate and topography) and mechanical and hydrological processes that lead to the soil erosion, and there is a need to understand the interaction between these factors and processes together that cause soil loss, and understand Erosion phenomenon is not easy in natural conditions especially if the region is complex from where soil, topography, and multi vegetation cover as like the Syrian coastal conditions so this study came to shed light on an important side from the soil conservation sides, it is the water erosion, from through GeoWEPP model application that works within an program ArcGIS and compare it with EU report " CoLD (2004)" that used only ArcGIS for the study of water erosion of the soil in the area of Sheikh Badr. Showed the results of the study that the use of physical models such as the GeoWEPP Model in order to study the amount of erosion will help to determine the areas most vulnerable to erosion and will show the impact of the suitable maintenance procedures to mitigation of this phenomenon, while the descriptive study, like the report CoLD (2004) could be a beginning point to shed light and determine areas and watersheds that can be the subject of the depth studies of the phenomenon of erosion and determine the means of appropriate management these regions for the management of the water erosion.

Key words : *GeoWEPP, CoLD (2004), the Water Erosion, Arc GIS.*

Introduction

The water erosion of the soil represents a major environmental problem that increases year after another worldwide and especially in Syria, where the soil constituents have been removed to another places by rain water and flood, which pollutes the canals, rivers and springs, and to exploit necessary nutrients factors of the soil, so there must be political and technical procedures of soil repair and protection from the water erosion suitable for this problem, so we must know soli specifications towards this phenomenon, besides the topographical nature of the area, and sort of the plant cover and the management, where the integrate between GeoWEPP and ArcGIS is an active mean to study the water erosion in order to develop soil saving scenarios along the water cliffs to apply long lasting environment principles for management and protection of the natural resources.

There have been too many studies worldwide, by using GeoWEPP as a mean to study soil water erosion, where a Chinese study has showed through results model deposit of small water canals in Sichuan basin hills, where the GeoWEPP model is a useful to impose an active policy in order to com-

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plete remedy for the small water cliffs from erosion and surficial current throughout place and time (Jinjun *et al.*, 2012).

While there is a study in North Carolina showed that the GeoWEPP has a very big ability to apply in construction sites, but there is a need to study more to be sure of the results widely(Moore, *et al.*, 2007).

Furthermore, through these studies in Turkey-Malaysia – Iran for the expectation of the result deposit and the surficial current within water cliffs, that model GeoWEPP is one of the greatest models, not only for deposit results, but also to limit racked soil amount and the potential erosion places, besides that the integrate between GeoWEPP and ArcGIS is a very good merit that provides water cliffs management with digital information and the super planning shapes(Yuksel, *et al.*, 2008); (Ebrahimpuor *et al.*, 2011); (Ahmadi *et al.*, 2008) Respectively.

The results of an American study that carried out upon three water cliffs, burnt, cut and natural Gabon has shown that this model has the ability to model water erosion through researchers by comparing GeoWEPP simulation results along with field measures for the three cliffs, to evaluate model accuracy of GeoWEPP in the surficial current and the soil erosion (Covert, 2003).

Another study that has been carried out in Spain showed through simulation deposit results and water erosion upon temporary water canals for southern east dam of Spain the ability to use GeoWEPP model to study soil erosion (Espigares *et al.*, 2009).

Where there are too many studies that carried out about water erosion herein Syria, especially in the coastal region and the Syrian Desert, there was a agricultural research station in Mahesh region in Homs countryside to study rain water harvest and soil erosion by USEL Plots through Syrian Desert conditions and also the effectiveness rate of repair procedures to reduce soil water erosion. And according to another study model WEPP has been used in modeling water erosion in Mazar Al Qatriyyeh in Latakia region, where the small plot have been used to evaluate and calibrate model entries (Youssef Ali, 2009).

In this research, we have chosen the most vulnerable of water erosion region in the Syrian coast according to CoLD (2004) report, where over (38 %) of the complete area of Sheikh Badr region in Tartous governorate are unstable regions due to the soil surficial erosion because of the human activities, the bad management, and the wrong usage of agrarian lands. Thus, there must be a great care by applying an appropriate programs to limit the impact the soil water erosion to achieve a long lasting environment. The usage of GeoWEPP model in this study aims at evaluating surficial current volume and soil loss result besides displaying the added value provided by GeoWEPP from CoLD (2004) report (CoLD, 2004).

Material and Methods

Study area

Sheikh Badr region, located Northern East of Tartous Governorate, on longitude (36°) and latitude (34°), (35) km far from the governorate, (550) m. rises up sea level, of total area about (20279) Hectare (202.79) sq.km. it is subjugated to the Mediterranean climate impact that characterizes with hot and humid summer, and cool or cold rainy winter, where rain rate reaches to more (850 – 860 mm.), most in winter time, but for wind, northern east to eastern wind prevails in winter time, while western south to southern wind prevails the rest of the year. The annual average of wind speed is (3.7 m/sec), but there are no differences between day and night temperatures, summer time or winter time. The average of temperatures in summer is approximately (30 – 35%), and around is approximately (5 – 10 %) in winter time. But the humidity is high most of the year, the main resource of humidity is The Mediterranean, about (69%) of annual average relative humidity.

Botanical Cover and Management

The total area of the study region reaches (20279) hectare (202.79) sq.km. so the arable area forms around (13250) hectare, the botanical cover consists of natural cover of oak, pine trees and other sorts, spine, thyme, chamomile trees. So according to planting lands such as: olive, citrus, grape, apple, tobacco, wheat and other harvests.

Study Materials

GeoWEPP

GeoWEPP has developed a corporate project between agricultural research service department, Purdue University and national soil erosion research laboratory USDA for expecting deposit result and surficial current upon the water cliff level, GeoWEPP – WEPP – TOPAZ (topographic Parameterization), where land cover, land usage, cliff, climate, soil and management of main model files, which contained within WEPP files, while TOPAZ program deals with (DEM) map of study region, where TOPAZ defines channels according to inclinations, so according to (8) adjacent dotted cells upon (DEM) map, where channels networks have been organized or the shortest channels (MSCL) and smallest drainage (CSA), and after defining (Grid Channel), we can deal with sub-water cliffs within the total cliff to benefit from all ArcGIS abilities to analyze digital outputs as target grids.

ArcGIS

GeoWEPP model characterizes with its ability to work within ArcGIS environment, where outputs as Grid layers represents soil lost by the area unit as a portion of Tolerable Soil Loss (TSL) and areas that produce loss values more or less than Tolerable Soil Loss, where deposit result data and surficial current of each pixel within textual files or grids have been produced, so the textual files indicate to the annual average of rain fall and rain hurricane numbers, total surficial current, soil loss and deposit result for all partial cliffs and also all water cliff.

WEPP

WEPP requires four input files contain attributions, climate, soil and management in order to describe each of cliff form and topography, soil specifications, land cover and climatic characterizations of study region accordingly.

CoLD, 2004 report

Sheikh Badr region was chosen as one of the most leading region to study water erosion at the Syrian coast according to multiple standardizations (geographical site–water cliffs – area "volume/form" – inclination/hydrology – botanic cover/soil/geology – erosion processes – land utilities – population density – human activities – data availability – financial support), all previous standardizations have given a certain dotted value, after that there was targeted grids formation for each standard, and then accumulate them upon each other to find final value (final grid) represents areas that more and less water soil erosion vulnerable, upon it the soil maintenance priorities through time programs and suggestions that suit study region conditions and nature in order to avoid agricultural soil deterioration and the natural conservatives and also maintaining the water resources of the pollution resulted from the agricultural soil as chemical and organic pollutions and others, as Map (2).

Study methods

Setting Grids

According to ArcGIS, setting of all Grids with measurement (1/50000), by combining axis into cliff (WSG_1984_UTM_Zone_36N) as suit study region, then converting unit of Grids display Decimal degrees into Meters, and finally converting all Grids of different formations (Raster, Shape file...) into a unified (asc) formation to enable input with required formation as GeoWEPP.

Files installations

Attributions file

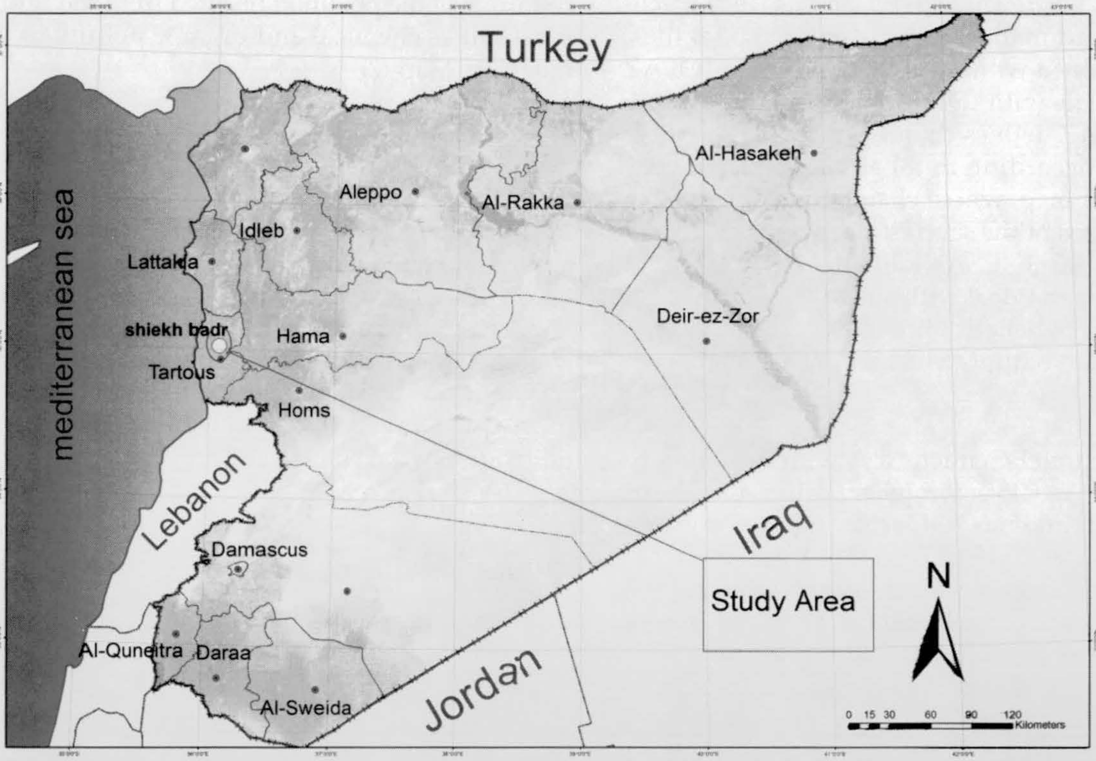
Inclination file has been installed according to important indications of inclination as (bending – form – range – destination), where GeoWEPP model benefits from TOPAZ model to generate partial cliffs out of main cliff depending on (DEM) data. In this study the partial cliffs and attributions have been driven from DEMS 30M using TOPAZ model according to soil Grids and (Soil, land use Maps) with measurement of (1/50000).

Climate File

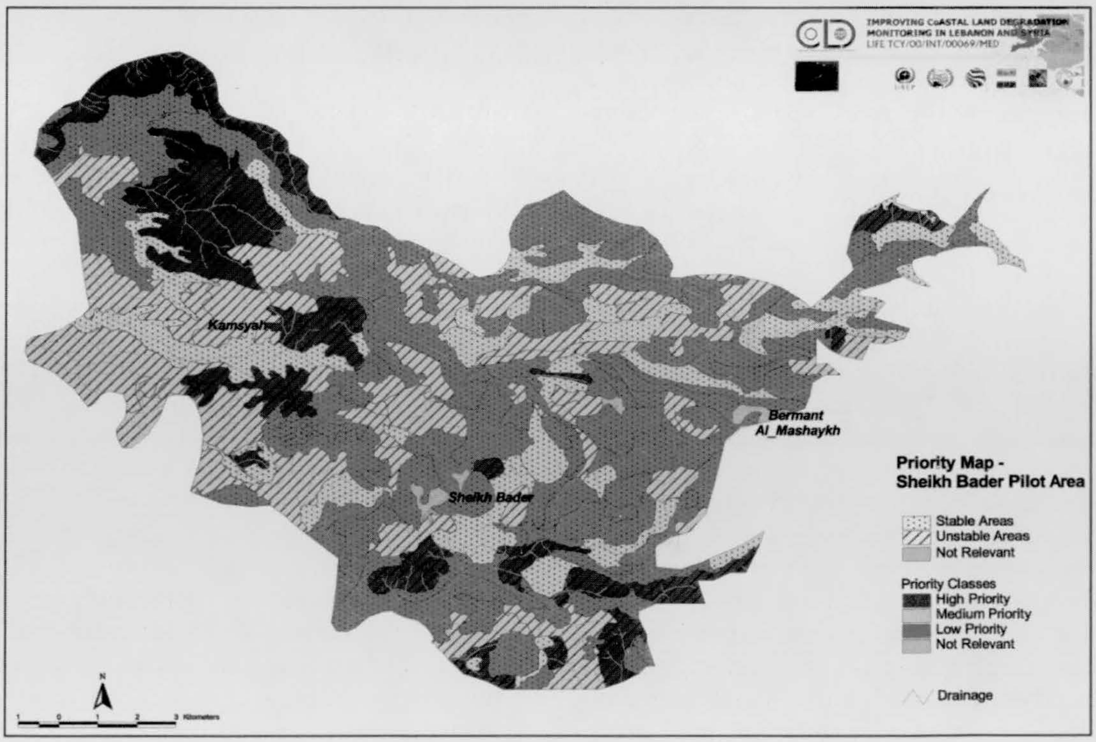
Through web site:
http://forest.moscowfsl.wsu.edu/fswepp, which related to American environment research organization, where its data base PRISM, through the Rock Climate application, which specifies position climate variation at the mountainous regions. Where climate file was installed to include monthly values of rain fall, temperatures, rainy days, sea level height, so all climatic data driven from meteorological station of the study region (sheikh Badr – Tartous) have been installed, then downloading WEPP/GLOGEN, which generates the climate for certain site and time.

Soil file

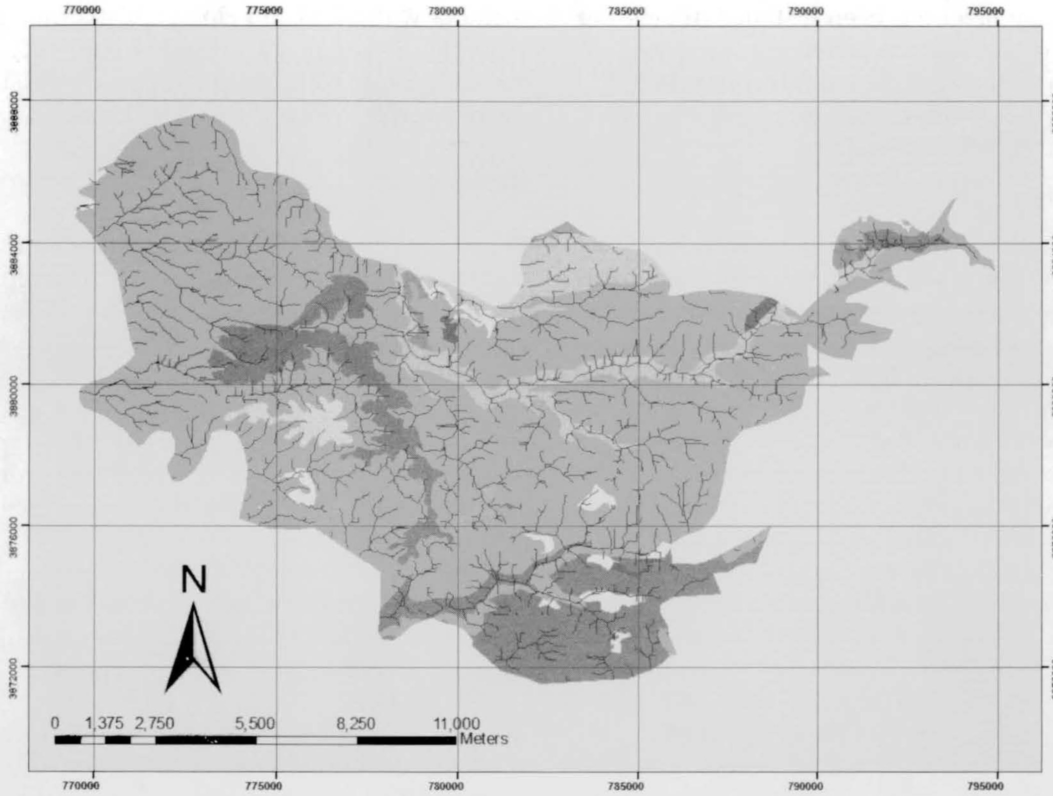
Soil file has been installed within agricultural research organization in Syria throughout gathering samples of soil layers for all secondary cliffs out of water cliff of study region and analyzing them (organic matter – CEC – EC – soil construct – stones percentage – sand and mud percentage) within soil laboratory. So in order to operate GeoWEPP pro-



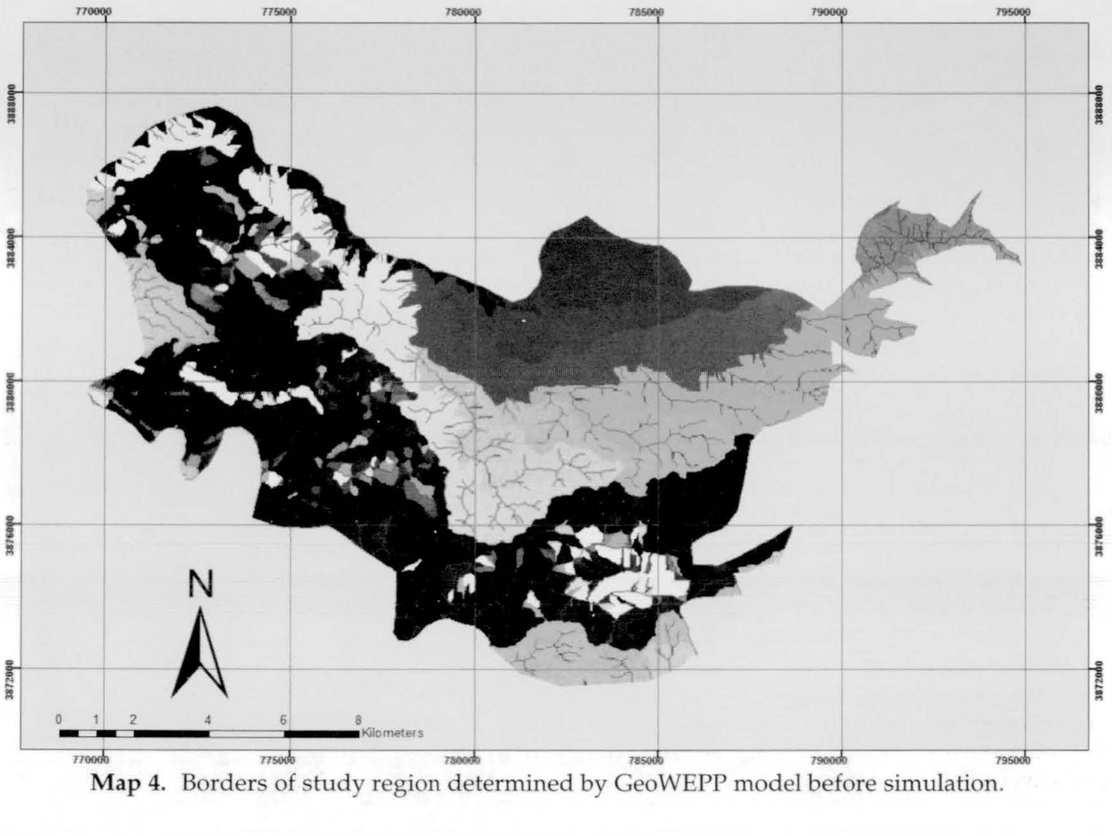
Map 1. Showed study area



Map 2. Water erosion evaluation in Sheikh Badr region (CoLD, 2004)



Map 3. Water flow path networks in Sheikh Badr - study region



Map 4. Borders of study region determined by GeoWEPP model before simulation.

gram, soil map layer has been installed depending on soil file of ArcGIS, then converting it into textual form required for operating models (GeoWEPP – WEPP/TOPAZ, Soilmap.txt – as a bridge between Soilmap and WEPP/TOPAZ.

Landuse file

Both botanical cover density, and botanical remains and trees rests are file data necessary land use taken from field questionnaire and measurements inserted into WEPP model; fret that, management file of different sorts of land use (bushes – dry forest – irrigated agriculture – ranches – rainy agriculture – jungle) have been installed, for all secondary water fall within main water cliff in order to annual simulation, in order to operate GeoWEPP, land use map has been installed within agricultural scientific research organization herein Syria, then converting into (asc) within ArcGIS, and then installing (landcov.txt), according to different patterns for land use at study region, land cov.txt was used by GeoWEPP and WEPP/TOPAZ to limit description that suits land cover layer within GeoWEPP.

Simulation through GeoWEPP

Through GeoWEPP model, and by using the two methods watershed and Flowpath, a complete simulation for complete water shed of study region that contained surficial current measurement and also deposit result evaluation and soil loss.

Results

The area of study region has been divided into three main regions (A,B,C) and then each main region into smaller areas (A1, A2, B1, B2, B3, B4, B5,C1,...,C9) to suit GeoWEPP model in order to apply typical simulation procedure for soil water erosion, after that there has been water shed outlet upon flow path networks that generated by TOPAZ depending on (DEM) map given to study region in order to get results of surficial current and deposit result and also soil loss.

Tables results (1 – 2 - 3) shows the received annual average of the water shed outlet, which contains (total studied areas of to water shed outlet, the annual rain fall volume average within the studied area, the annual irrigation volume average, the annual average of the evacuated water out of water shed channel outlet within studied area, the annual average of the evacuated deposit out of the water shed channel outlet within the studied area, the an-

Table 1. Annual average received from main area outlet of watershed (A)

78 storms produced 1102.60 mm. of rainfall on an Average Annual basis Average annual Delivery from channel outlet (area A)		
Class	A1	A2
Total contributing area to outlet (Ha)	6843.80	2120.82
Avg. Ann. Precipitation volume in contributing area (m^3/yr)	75459725	23384164
Avg. Ann. Irrigation volume in contributing area (m^3/yr)	00000	00000
Avg. Ann. water discharge from outlet (m^3/yr)	393170457	7345493
Avg. Ann. Sediment discharge from outlet (tone/yr)	239905.0	13031.5
Avg. Ann. Sed. Delivery per unit area of watershed (tone/Ha/yr)	35.1	6.1
Sediment Delivery Ratio for watershed	0.230	0.369

Table 2. Annual average received from main area outlet of watershed (B)

78 storms produced 1102.60 mm. of rainfall on an average annual basis Average annual Delivery from channel outlet (area B)					
Class	B1	B2	B3	B4	B5
Total contributing area to outlet (Ha)	2020.44	625.28	1535.14	1532.88	523.31
Avg. Ann. Precipitation volume in contributing area (m^3/yr)	22277379	6894323	16926463	16901547	5794325
Avg. Ann. Irrigation volume in contributing area (m^3/yr)	00000	00000	00000	00000	00000
Avg. Ann. Water discharge from outlet (m^3/yr)	5957266	2119305	96472	152457	436916
Avg. Ann. Sediment discharge from outlet (tone/yr)	28419.0	8856.5	1626.3	3169.6	1982.1
Avg. Ann. Sed. Delivery per unit area of watershed (tone/Hr/yr)	14.1	14.2	1.1	2.1	3.8
Sediment Delivery Ratio for watershed	0.535	0.735	0.600	0.676	0.532

nual deposit average received for each study area unit from the water shed, the received deposit average of water shed within the study area.

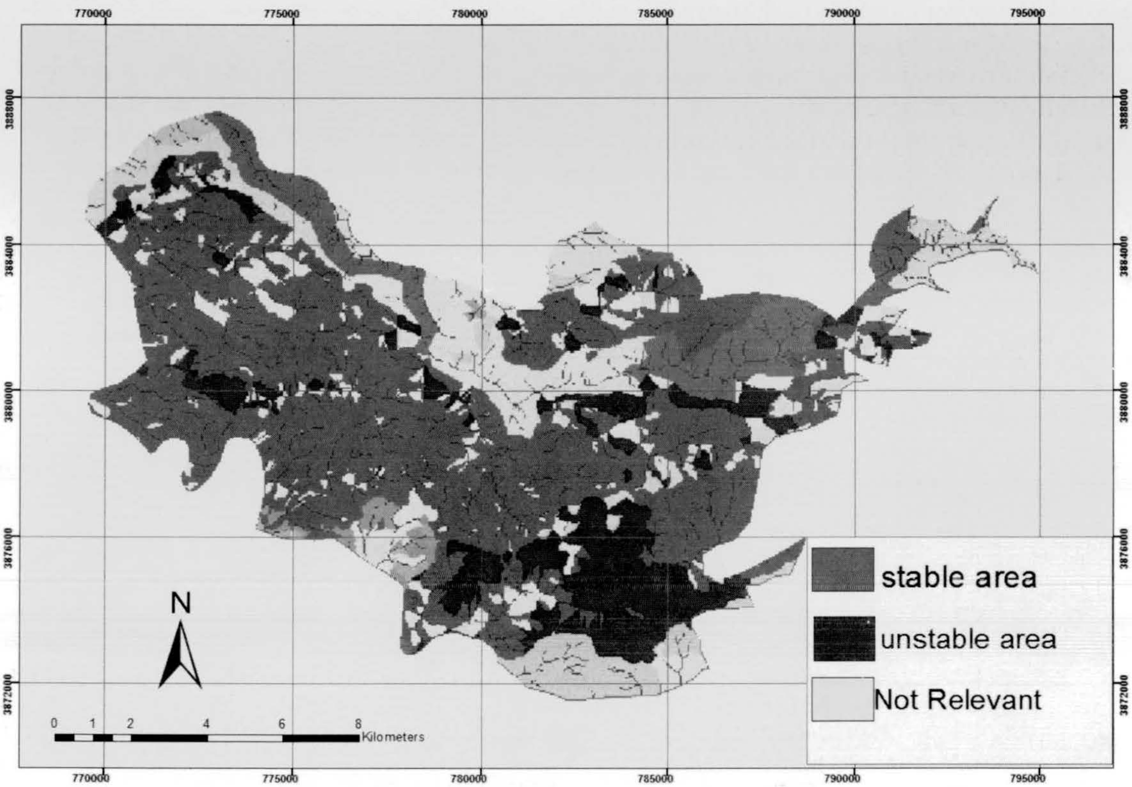
Discussion

Through Tables results (1 - 2 - 3), there is a difference in deposit average received with area unit, where the highest percentage of deposits focuses within area (A1) out of the main area (A) (A1 = 35.1 ton/hec/yr. while area (C2) represents the lowest percentage of deposits (C2 = 0.8 ton/hec/yr). And comparing (Avg. Ann. Precipitation volume in contributing area), along with delivery per unit area of wa-

Table 3. Annual average received from main area outlet of watershed (C)

78 storms produced 1102.60 mm of rainfall on an average annual basis
Average annual Delivery from channel outlet (area C)

Class	C1	C2	C3	C4	C5	C6	C7	C8	C9
Total contributing area to outlet (Ha)	1395.94	346.20	941.59	941.59	580.28	360.22	493.85	50.76	84.00
Avg. Ann. Precipitation volume in contributing area (m^3/yr)	15391633	3817175	10381924	10381924	6398204	3971840	5445188	559680	926131
Avg. Ann. Irrigation volume in cntributing area (m^3/yr)	00000	00000	00000	00000	00000	00000	00000	00000	00000
Avg. Ann. Water discharge from outlet (m^3/yr)	964782	9846	8195688	8195688	240263	754735	859375	10102	282683
Avg. Ann. Sediment discharge from outlet (tone/yr)	6906.7	289.5	10655.2	10655.2	3111.4	3639.2	3196.4	76.7	903.9
Avg. Ann. Sed. Delivery per unit area of watershed (tone/Ha/yr)	4.9	0.8	11.3	11.3	5.4	10.1	6.5	1.6	10.8
Sediment Delivery ratio for watershed	0.318	0.960	0.807	0.807	0.538	0.787	0.744	0.915	0.871



Map 5. Showed unstable and stable regions after Simulation by GeoWEPP

ter shed annual average sediments, we notice that the relation is not always direct, this is why the rainfall volume is not the lonely factor that impacts upon soil erosion, but there are also other factors that related to slops:

Slop Morphology: especially the cliff and slop longitude, where both play a main role in the surficial current formation and in increasing of speed that leads to soil erosion.

Botanical Cover of the Slop: which absorbs the rainfall energy and increasing of transudation average. So management here plays a main role in improving and maintaining the botanical cover through controlling wood decrease, wood fire and disorganized irrigation systems that leads to water erosion besides following appropriate cultivation and maintenance works.

Slop Soil sort: heavy soil prevails in the study area (mud, lime soil – Celtic mud soil), where it reduces water leakage into depth, consequently water accumulation at surface, which is the first step to the surficial current formation, then soil erosion. Therefore, the improvement of soil managing is in the priority of maintenance procedures, besides to cultivation kind and terraces building that aims to reduce slop longitude and cliff or reducing surficial current cliff that in turn leads to soil erosion reduction and maintaining from deterioration.

Figure (1) also shows that it isn't necessary for rainfall density and strength upon soil surface, is the main cause for soil erosion, but there are other factors such as (weakness and absence of botanical cover – bad management for land use, cultivation, etc...) that help form surficial currents and increasing cliff or soil erosion.

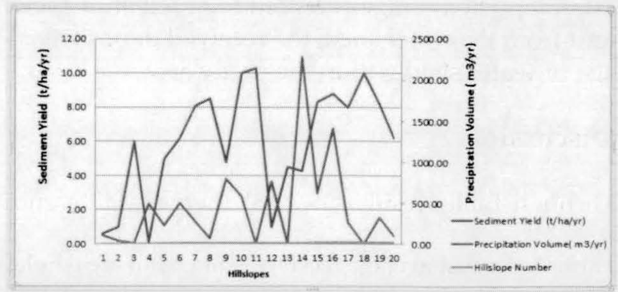


Fig. 1. Relation between precipitation volume & lost soil sediment yield

According to Tables results (1 – 2 – 3) we can classify Avg.Ann. Sed. Delivery per unit area of water shed ton/hec/yr) and (total Avg. Ann. Sed. Delivery per unit area of water shed ton/hec/yr) into four parts according to table (4). And according to land classification vulnerable to soil water erosion as (Beskow, *et al.*, 2009).

Where it shows CoLD (2004), which studied soil water erosion in Sheikh Badr – Tartous region through remote sensing type and ArcGIS that classified the region into two parts: stable and unstable regions vulnerable to soil water erosion, so there must be priorities for maintenance procedures aim

Table 4. Priority classification according to loss soil sediments amounts

The region	Class	Area Ha	Total Avg. Ann. Sed Delivery per unit area of watershed (tone/Ha)	Total Avg. Ann. Sed Delivery per unit area of watershed (tone/Ha)	Qualitative soil loss class
A	A1	6843.80	239905.0	35.1	Very High
	A2	2120.82	13031.5	6.1	Moderate
	B1	2020.44	2841.0	14.1	Moderate/High
	B2	625.28	8856.5	14.2	Moderate/High
B	B3	1535.14	1626.3	1.1	Slight
	B4	1532.88	3169.6	2.1	Slight
	B5	523.31	1982.1	3.8	Slight/Moderate
	C1	1395.94	6906.7	4.9	Slight/Moderate
	C2	346.20	289.5	0.8	Slight
	C3	941.59	10655.2	11.3	Moderate/High
	C4	941.59	10655.2	11.3	Moderate/High
C	C5	580.28	3111.4	5.4	Moderate
	C6	360.22	3639.2	10.1	Moderate/High
	C7	493.85	3196.4	6.5	Moderate
	C8	50.76	76.7	1.6	Slight
	C9	84.00	903.9	10.8	Moderate/High

Table 5. Priority maintenance according to delivery soil sediments per unit

The area	Class	Qualitative soil loss class	The Priority
A	A1	Very High	Extremely High Priority
	A2	Moderate	Medium Priority
	B1	Moderate/High	High Priority
	B2	Moderate/High	High Priority
B	B3	Slight	Low Priority
	B4	Slight	Low Priority
	B5	Slight/Moderate	Medium Priority
	C1	Slight/Moderate	Medium Priority
	C2	Slight	Low Priority
	C3	Moderate/High	High Priority
	C4	Moderate/High	High Priority
C	C5	Moderate	Medium Priority
	C6	Moderate/High	High Priority
	C7	Moderate	Medium Priority
	C8	Slight	Low Priority
	C9	Moderate/High	High Priority

to reduce soil water erosion, to maintain it from deterioration. So according to previous results a soil maintenance priorities like (use define / suitable management) to reduce the surficial current volume, and also taking care about plantation of olive upon hill slops, and then soil improvement through adding organic matter, and also building block terraces that limits slop longitude & cliff, then reduction of surficial current speed and annual average sediments delivery per unit area of water shed ton/hectare/year, as in Table 5.

Comparing with last studies of soil water delivery in the Syrian coast, what made GeoWEPP model of results, where delivery soil amount overpasses (200 ton/hectare/year) in the coastal mountains due to heavy rainfall and hill slop and cliffs and also slops surface of deteriorated vegetation cover (Nahal, 1984), said AL FAO report in 1980, so AL FAO organization acknowledged that average of soil loss is between (50 – 200 ton/hectare/ year) in the coastal mountains, where the natural vegetation cover is deteriorated, (10 – 50 ton/hectare/year) in the coastal mountains, where the natural vegetation cover less deteriorated, (10 – 50 ton/hectare/year) in the coastal plains, where surficial erosion prevail in this region, but the trench and valley erosion are relatively found at some parts, where some land glides upon hill slops and cliffs.

As came in the report of (PAR/RAC 1992) that the regions far from Tartous coast were classified as vulnerable to medium and high delivery (30 – 60 / 50 – 100 ton/hectare/year) respectively.

Suggestions and Recommendations

Throughout this study, it is clearly occurred that water delivery phenomenon, which spreads out wide areas in the Syrian coast needs to qualitative and quantitative evaluation to limit their risk. So multiple means and developed software and information to evaluate this phenomenon demands applying various models upon the region needed study, so GeoWEPP model enables us to study deeply the region, where we can define water flows and surficial water sheds networks, and also the soil delivery amount for each hill slop in the study region, that no other models accredited by CoLD (2004), which depends on GIS environment without physical model to evaluate water delivery, but this kind of reports provides basic image about the region vulnerability range of delivery by using specialized software & information as GeoWEPP simulation according to various scenarios of maintenance procedures and also the climatic changes.

In this research, a basic study was carried out in Sheikh Badr – Tartous by using GeoWEPP model along with some scenarios suitable for study region of changing land use or terraces building or others procedures available in Sheikh Badr – Tartous region.

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