ASSESSMENT OF FLASH FLOODS FLOWING TO NILE MAIN STREAM BETWEEN ASWAN AND ASSIUT

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ملخص

يمر نهر النيل خلال الصحراء مع تخطيه الحدود الجنوبية لجمهورية مصر العربية. وحاليا يتم التحكم في المياه عن طريق السد العالي بأسوان. و تصب العديد من أحواض تجميع مياه الأمطار في المجري الرئيسي لنهر النيل أثناء فصل الشتاء المطير علي الصحراء الشرقية والغربية. هذا البحث يهدف لتقييم الفيضانات التي تصل إلي نهر النيل من الصحراء الشرقية والغربية من أسوان حتى أسيوط ومقارنة كميات السريان السطحي وأحمال الترسيبات السنوية للأحواض من الجانبين الشرقي والغربي لنهر النيل. تم استخدام نظام المعلومات الجيوجرافية GIS في تحليل بيانات مياه الأمطار المجمعة والمعلومات الطبوغرافية التي تم الحصول عليها من بيانات بعثات الأقمار الصناعية. ثم التحقق من النتائج باستخدام صور الأقمار الصناعية. كما تم استخدام طريقة التحليل الإحصائي للمعاملات الموروفولجية لمستجمعات الامطار وتم حساب حجم أحمال الترسيبات المتوقعة من الجانبين الشرقي والغربي. وخلصت الدراسة إلي أن عدد أحواض التجميع الرئيسية التي تصب من الصحراء الغربية أكثر بحوالي 130% من عدد أحواض التجميع الرئيسية التي تصب من الصحراء الشرقية وأن أحمال الترسيب التي تتدفق وتصب في نهر النيل بداية من أسوان وحتى أسيوط من الناحية الشرقية تكون حوالي 2.30 مرة أكثر من التي تتدفق من الناحية الغربية وان أجمالي أحمال الترسيبات تكون 215000 طن/العام ، وهذا يعني أن معدل الترسيبات الطولية يكون حوالي 360 طن/كم/العام. ولقد أثبت هذا البحث أنه كان من الأساسي أجراء الاستقصاء عن العلاقة بين حمولة الترسيبات والتغيرات المورفولوجية لقطاعات النهر علي امتداد منطقة الدراسة. وعلاوة علي ذلك أكد هذا البحث علي أهمية دراسة تأثير نوعية الترسيبات ومدي ارتباطها بملوث معين علي جودة مياه النهر.

ABSTRACT

The River Nile passes through a desert as it crosses the Egyptian southern borders. The water is regulated by the High Aswan Dam (HAD). Many watersheds drain to the Nile main stream during the rainy winter season from the Eastern and Western deserts. This paper aims to assess the floods flowing into the Nile from East and West side from Aswan to Assiut and compares the runoff potential and sediment load for the sheds of both sides. The geographic information system (GIS) was used for analyzing the collected rainfall data and topographic information obtained from the satellite missions. The results were verified using the satellite images. A statistical analysis was carried out for the morphological parameters of these catchments and expected sediment load from the bank sides was calculated. The study concluded that the number of main sheds draining from the Western Desert was about 130 % more than those from the Eastern Desert and the sediment load flowing to the Nile reach from Aswan to Assiut from the east side was found to be about 2.30 times more than that from the west side and the total sediment load is 215,000 ton/year, which means a longitudinal deposition rate of about 360 ton/km/year. The paper proved that it was essential that an

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investigation of the relationship between the sediment load and the morphological change of the river sections along the studied reach be conducted. Furthermore, it established the importance of studying the influence of the sediment quality, in terms of the load of a certain contaminant, on the river water quality.

KEYWORDS: Flash Flood; Upper Egypt; Morphology; River Nile; Sediment load

1. INTRODUCTION

The River Nile is the main source of water in Egypt therefore most of the population is concentrated along its banks. Starting from South Egyptian borders, the Nile flows through a desert with no tributaries adding to the controlled flow that was allowed to pass through its section from the HAD.

Through this long distance a few wadis seasonally flow to it during the rainy season from the Eastern Desert and the Western Desert and drain directly to the main stream of the Nile with no control structures. Only in a few locations does it flow through an artificial channel that has been mainly constructed for flood protection measures. These wadis may cause threats to the River Nile banks and the human lives and properties at these wadis' outlets.

Catastrophic flash flooding has recently become very common in the Red Sea areas, particularly where storms hit large settlements. In these areas, flood protection cannot be provided resulting in great damage to life and property. Such floodwater can be an important renewal source of water if properly managed to meet a part of the water demand for a multitude of uses in these areas according to Masoud, 2004 [1].

The floods resulting from the runoff could be evaluated based on the catchment characteristics and the storm properties. In spite of the fact that most of the area in the Upper Egypt is subject to almost the same storm pattern, different storm pattern could be observed along the North coast, Red Sea Mountains and Sinai. Therefore, the morphological parameters will be the key factors when assessing the sheds flowing from both sides of the Nile into the main stream.

The Nile reach flowing from Aswan and Assiut is subject to the flows coming from most of the main wadis located in the Eastern and Western Deserts. Therefore, this situation was addressed through the study and the feeding wadis were defined at both sides.

Infrequent surface water flow in wadi system may cause natural flash flood hazards but it can be managed to valuable water resources throughout an appropriate decision support based on effective methodologies. The term 'flash floods' identifies a rapid hydrological response, with water levels reaching a peak within less than one hour to a few hours after the onset of generating rain event (M. Saber et al, 2010) [2].

2. DATA COLLECTION

In order to predict the effect of the flash floods on the River Nile main stream for the above mentioned stretch, data about the study area was first collected from different sources to be used during the analysis. The study area extends from the city of Assiut in the North (27^{o} 15' 00", 31^{o} 15' 00") to the city of Aswan in the South (24^{o} 00' 00", 33^{o} 00' 00"), as is illustrated in Figure 1.

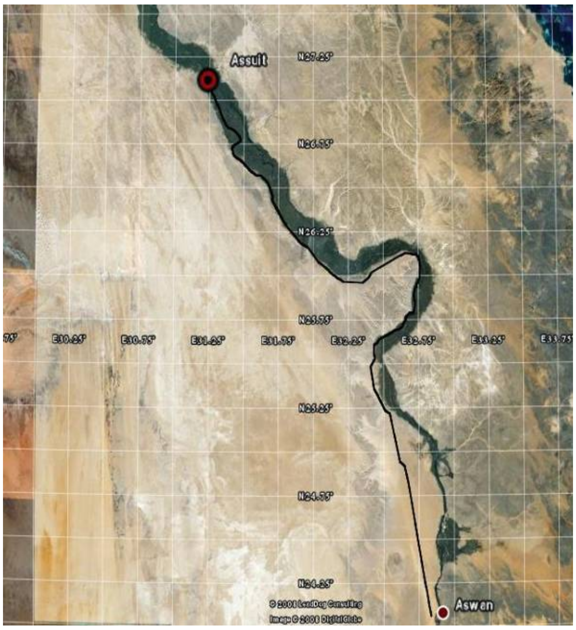

Figure 1: The study area

All of the catchments flowing into the Nile at this part flow from the west and east sides that are draining from the desert hills, where most of the land cover is a bare soil and the rainfall events rarely occur. The study area is lacking the presence of meteorological stations that is well distributed all over the study area to represent its metrological characteristics. Therefore, the global data base from US space agency NASA was used to give a picture about the rainfall of the area, as is shown in Figure 2.

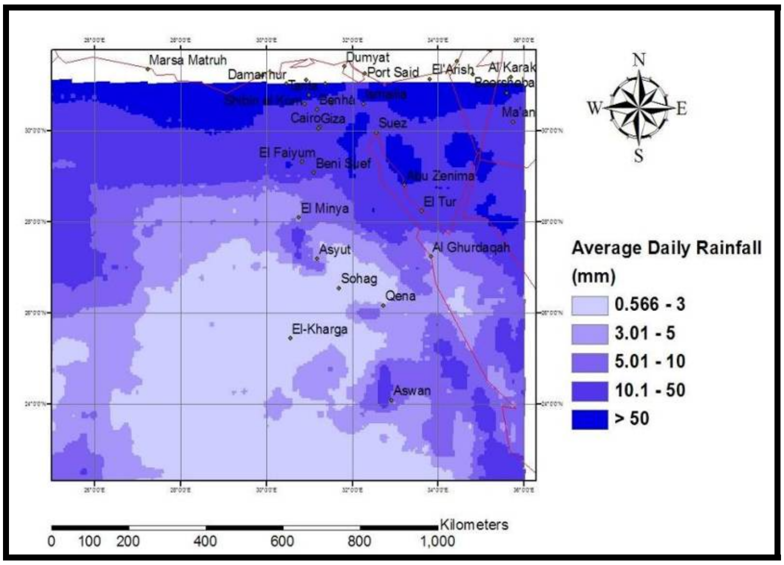

Figure 2: Average daily rainfall distribution for Egypt. Source, US space agency NASA

The source of topographic data was the digital elevation models (DEM) obtained via stereographic images from the space shuttle "Endeavour". This digital terrain model covers all the earth and it is available on Internet site of the United States geological service (USGS) under the name of data SRTM (Shuttle Radar Topography Mission) with a 90 m x 90 m pixel size on ground, as is illustrated in Figure 3.

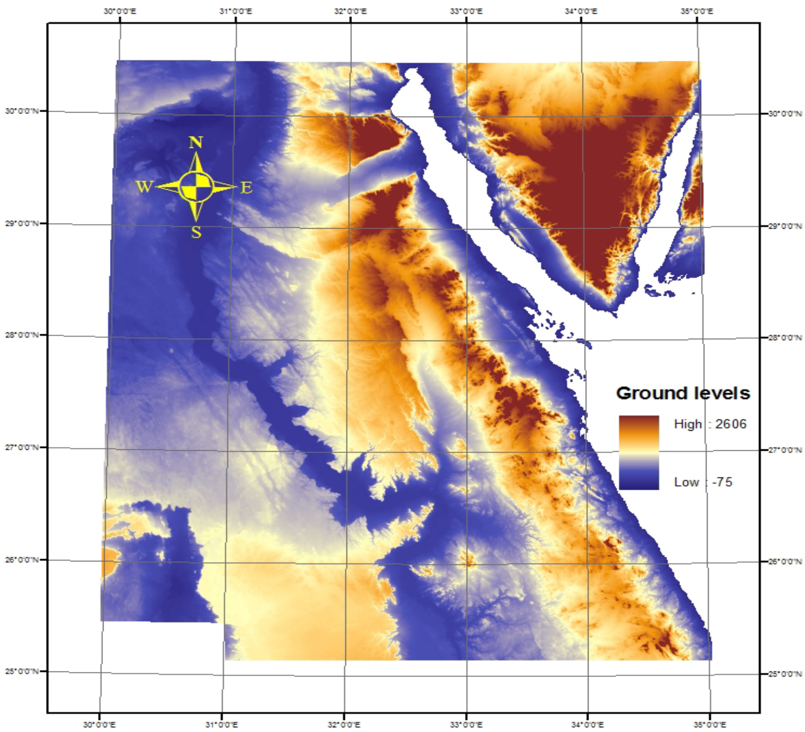

Figure 3: Digital elevation model (DEM) for Egypt

3. THE MORPHOLOGICAL ANALYSIS

As the rainfall variation in Upper Egypt is limited, as is clear in Figure 2, especially the area that may contribute to the wadis flowing into the Nile. Hence, the analysis will be focusing on the comparison between the morphological parameters of the main wadis flowing from the both sides of the Nile at the stretch under investigation.

Rapid advances in computer, remote sensing, GIS, and the spatial data management coupled with the increasing availability of digital geographic information, offer an unprecedented opportunity to harness the potential of such technology integration for computer modeling of the environment to improve our understanding and management of mountain regions (Burrough, 1986 [3]; McCullagh, 1988 [4]; Moore et. al., 1991) [5].

In order to obtain all physiographical characteristics of the basins, information concerning levels, areas, slopes, morphometric parameters, along with the drainage pattern were determined based on the available DEM. The digital terrain model was integrated in the Geographical Information system (GIS) for the calculation of the geomorphologic characteristics; some of these important characteristics are;

- Catchments basin boundaries

The catchment delineation for the study zone is shown and projected on Ikonos satellite image for catchments greater than 50 km^2 that may be considered as main and effective watersheds, as is shown in Figure 4.

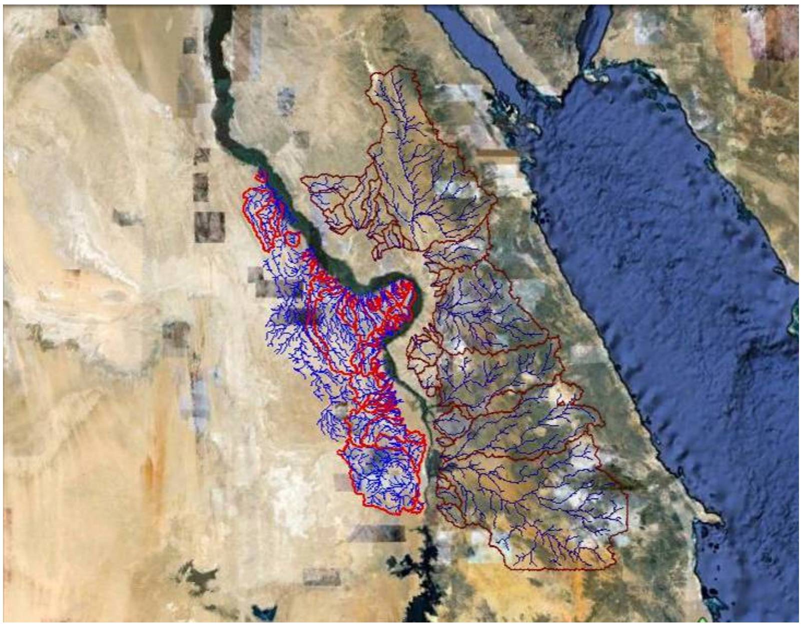

Figure 4: Catchments Delineation projected on Ikonos Satellite Image

- Drainage pattern

The drainage pattern of the streams was also delineated and is presented in Figure 5.

- Longest flow path length
- Average slope
- Area of the basin

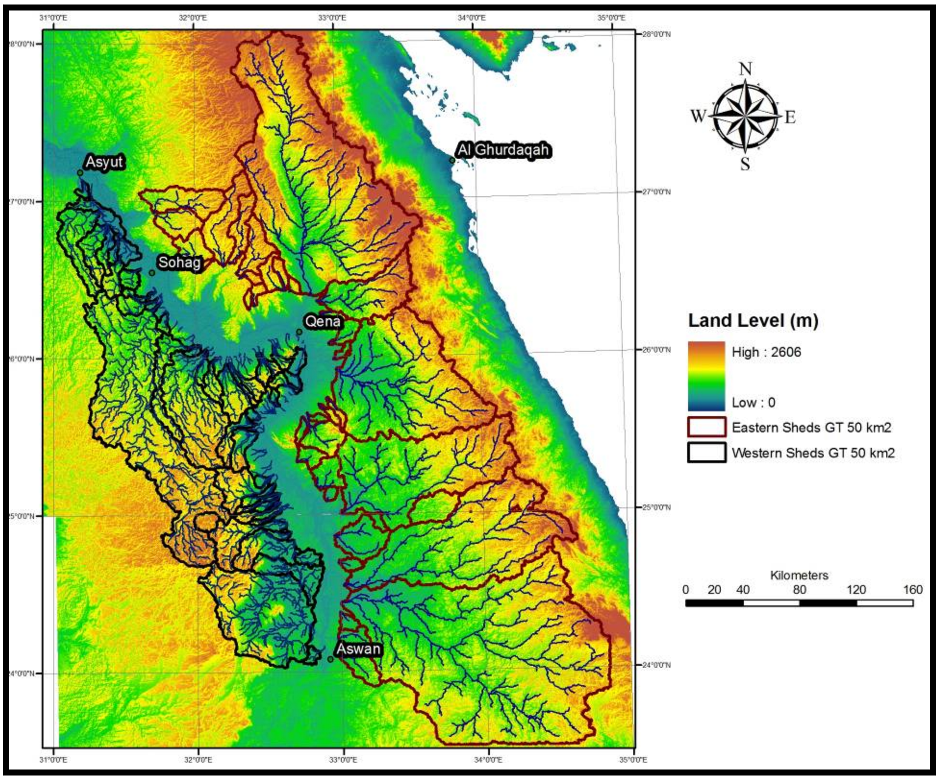

Figure 5: Drainage pattern for the catchments basins

Verification was made for the drainage pattern using satellite images and a sample is shown in Figures 6 and 7. It is very clear that the Eastern Desert flow paths are well defined and clearer on the satellite images than those of the Western Desert.

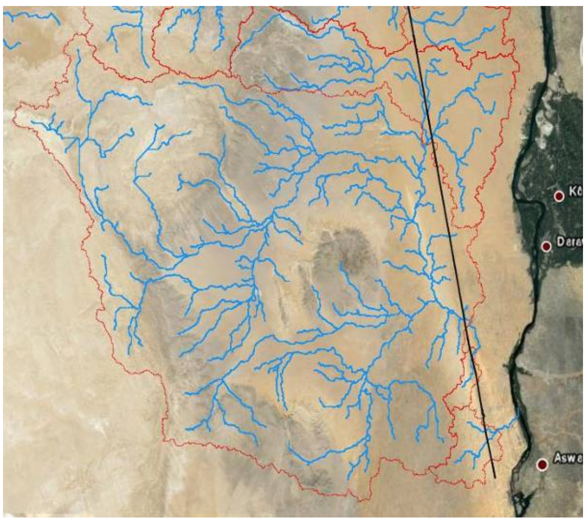

Figure 6: Western Drainage pattern verification

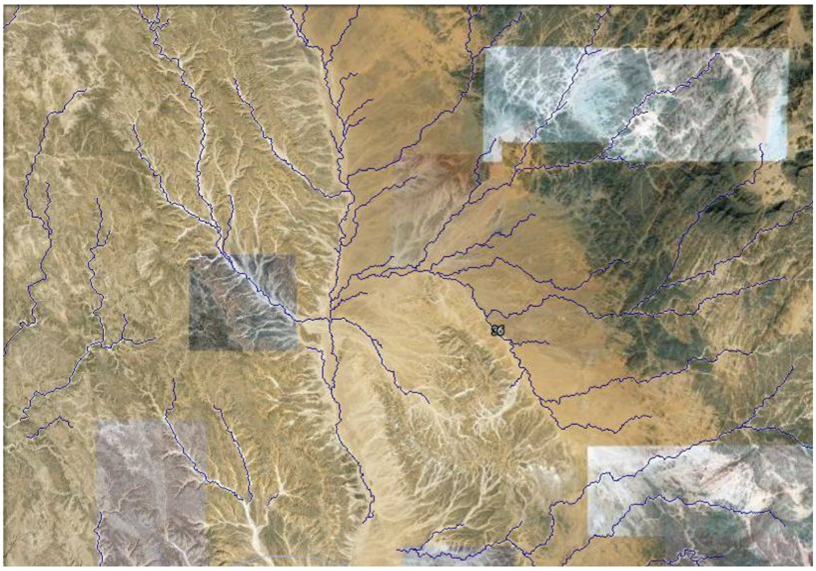

Figure 7: Eastern Drainage pattern verification

4. SOIL LOSS (SEDIMENT) ANALYSIS

The last secret of the Nile is the amount of sand carried by the river from High Aswan Dam to the sea. This value is estimated to be in the range of 10–100 kg/s, but the exact quantity is unknown. Furthermore, it is unknown which part of the total sand load is transported as bed load and which part as suspended load. The suspended-load measurements before HAD construction, at Gaafra ~km 34, below Aswan, revealed that sediment concentrations were as large as about 4 kg/m3 during the periods of high flow. After the construction of HAD, maximum concentrations are only in the range 0.03-0.1 kg/m3 (Abdel-Fattah Amin et al, 2004) [6].

The Universal Soil Loss Equation (USLE) is a mathematical model used to describe soil erosion processes. The USLE is one of the main models used by United States government agencies to measure water erosion. The USLE was developed in the U.S. based on soil erosion data collected beginning in the 1930s by the USDA Soil Conservation Service (now the USDA Natural Resources Conservation Service). The model has been used for decades for purposes of conservation planning both in the United States where it originated and around the world.

The (USLE) predicts the long term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system and management practices.

Five major factors are used to calculate the soil loss for a given site. Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. The erosion values reflected by these factors can vary considerably due to varying weather conditions.

$$A = R \times K \times LS \times C \times P \quad (1)$$

Where,

A is the potential long term average annual soil loss in tons per acre per year,

R is the rainfall and runoff factor by geographic location and it is taken =75,

K is the soil erodibility factor and it is taken=0.15,

LS is the slope length-gradient factor

$LS = [0.065 + 0.0456(slope) + 0.006541(slope)^2] \times (\text{slope length} \div \text{const})^{NN}$,

Slope steepness %

Const. = 72.5 Imperial or 22.1 metric

The unit Length of slope is in ft.

NN Values				
Slope %	**< 1**	**1 ≤ Slope < 3**	**3 ≤ Slope < 5**	**≥ 5**
NN	0.2	0.3	0.4	0.5

C is the crop/vegetation and management factor and is taken = 0.25;

P is the support practice factor is taken = 0.70.

5. RESULTS AND DISCUSSION

The resulting delineated watersheds showed that number of main sheds draining from the Western Desert is more than those from the Eastern Desert, where the number of main sheds in the Western to the Eastern Desert were 46 to 35. Moreover, it showed that the Eastern Desert main sheds extend almost along the whole width of the desert to the mountain divider at the Red Sea coast. Most of the Eastern Desert sheds were less than 2000 km^2 in area and a few of them exceeded the 6000 km^2, while almost all the Western Desert sheds were below 3000 km^2, as is shown in Figure 8.

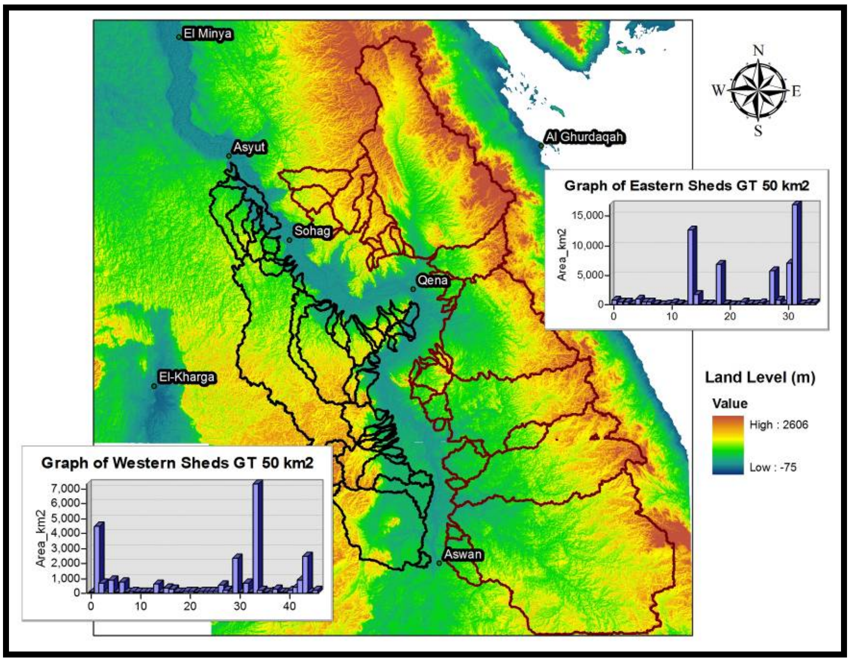

Figure 8: Comparison between Eastern and Western Desert watersheds

The average area of the east sheds was about 1700 km^2 and that of the west sheds area was 581 km^2. The main streams of the eastern sheds showed steeper slopes than those of the western sheds, both were classified into street light symbology (Green, Yellow, and Red) and presented in Figure 9.

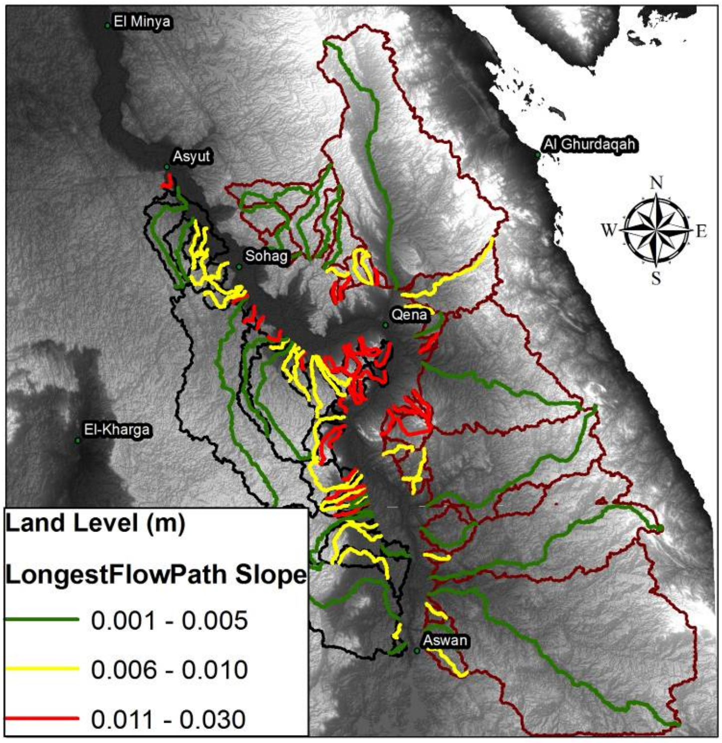

Figure 9: Longest flow paths slopes for the watersheds

The sediment load was calculated for the watersheds of the Eastern Desert and the Western Desert using the universal soil loss equation mentioned previously and the results were presented in the Figure 10 as sediment load from each side of the Nile is presented in tons/year. The eastern watersheds carried a load of about 150,000 ton/year to the Nile reach from Aswan to Assiut, while the western sheds carried a load of about 65,000 ton/year to the same stretch from the west side.

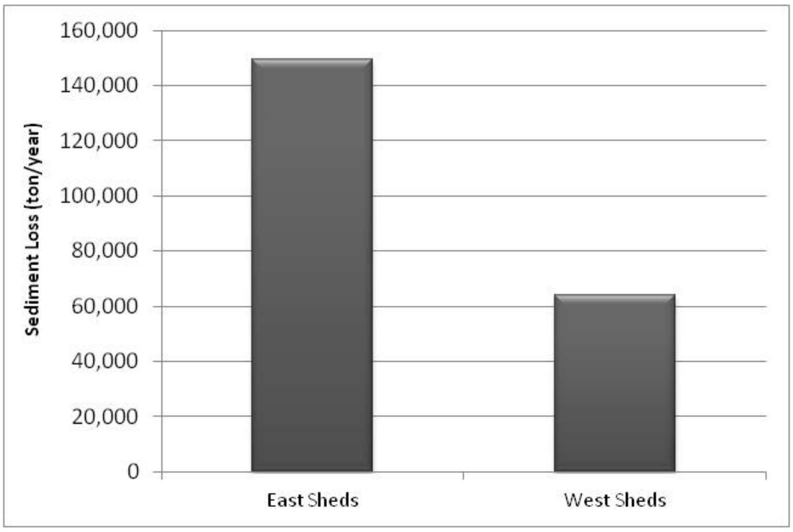

Figure 10: Calculated sediment from the East and West sheds

6. CONCLUSION

From the above mentioned discussion, it is possible to conclude that the flow paths of the water sheds join together before reaching the flood banks of the River Nile into few numbers of main, huge and high risk catchment outlets. Nevertheless, the flow paths of the Western Desert were more staggered that they formed catchment attacking the Nile bank from the west side in many locations.

Though the Eastern Desert is the main source of floods flowing to the River Nile along the distance from Assiut to Aswan, the long distance of their main flow paths could give enough time for an early warning system to be established for estimating the magnitude of the flash flood resulting and hence take the necessary measures for the protection of lives and properties at the outlet. The Western Desert spreads its flash floods along the west bank of the Nile in many locations but with low peaks that could be mitigated by a flood protection structures with medium cost and/or collected to drain to the Nile through channels in few locations.

As a result of the morphological characteristics study of the eastern and western watershed concluded that the number of main sheds draining from the Western Desert was about 130 % more than those from the Eastern Desert and the sediment load flowing to the

Nile reach from Aswan to Assiut from the east side was found to be about 2.30 times more than that from the west side and with an average longitudinal deposition rate of about 360 ton/km/year. This may affect the navigation channel section of the Nile and the intake structures distributed along the east bank. Accordingly, it is recommended to investigate the relation between the sediment loads flowing into the Nile channel and the morphological change of the river cross sections for the reaches affected by the wadies' outlets. Furthermore, the influence of the sediment quality, in terms of the load of a certain contaminant, on the river water quality should be studied.

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