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Effect of urbanization on coastal flash floods

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ABSTRACT

Flood events are considered one of the most dangers natural disasters that can cause people to be homeless as their homes destroyed due to such events. The previous point is not only the negative effect of flood disaster, but also floods can cause destruction of infrastructures, loss of life and economic impacts as well.
Creation of new communities and consequently has its adverse effect of flood event. Urbanization of the northern coast in Egypt is not only a necessity but also it's a fact.
Urbanization of rural area which are threaten by floods increase the total volume of water and increase the flood wave velocity as well.
The paper discusses the positive and negative effects of urbanization. The paper analyzes a selected watershed in the northern coast of Egypt.
The aim of this research is to examine the changes in the flood characteristics of flood event such total volume of flood, total volume of sediments, peak discharge, and time to peak.

Keywords: urbanization; coastal flash floods; flood disaster

INTRODUCTION

Urbanization of rural area in the north Northern coast of Egypt has increased rapidly in the recent years due to touristic and development requirements. This urbanization has both positive and negative effects. The positive effects are represented in development of new communities, giving a chance to new jobs, increasing the total number of tourists, and increasing the national income.

On the other hand, one of the most important negative effects which the research project reported in this paper is its effect on the flood event.

This effect is represented in increasing the numerical value of some flood characteristics represented in the peak flood rate, the total flood volume, and the water depth of the flood wave.

Although some previous study (Elhanafy et al, 2008) has ranked the driving upstream discharge as one of the most important control in determining the flood wave at the outlet station, but from the research project reported in this paper it will be demonstrated the effect of land coverage as an important control.

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Land cover characteristics have changed rapidly in the recent years especially in the last two decades in for Baghoush watershed at Wadi Algraola as a direct result of urbanizat ion. The Land cover of Baghoush watershed which lies in the Northern coast of Egypt were acquired and studied to monitor its effect on flash flood characteristics.

These characteristics were studied for two different missions of aerial photographs and topographical maps that been taken in years 1991, and 2011.

Surface runoff, volume of water and sediment yield from Baghoush watershed and its sub - watersheds were determined and analyzed for the two different missions. Also their effect on tourist villages, highways, railroads, and new cities was demonstrated.

STUDY AREA

Many regions in Egypt had been suffered from wild torrent flash floods. These regions are Sinai Peninsula, Red Sea Coast, the Western-North coast of Egypt, and some regions in Upper Egypt near the Nile valley.

In the Western-North coast, the flash floods had swept lot of Bedouin's vegetation and homes away, and had damaged part of coastal highway, railway and internal road, and building in some projects near the coast. The study area is locate d in the Western-North coast of Egypt, 51-Km. East of Matruh City, as illustrated in Figure [1]. Baghoush watershed at Wadi Algraola covers an area of about (13.0 Km2) and the outlet station of the three major watersheds lies at a distance of about 700 m. from the Southern boundary of Baghoush tourist village. The watershed is characterized by light slope for about 2250 m from the outlet station to reach a height of about 60 m (A.S.L.) followed by steep slope to reach a height of 140 m (A.S.L.) at only distance of 300 m from the end of light slope.
The studied area is a small part of Matruh basin. Sedimentary rocks are of common occurrence, accounting for approximately 75% of the earth's exposed land surface, and about 87% of Arab Republic of Egypt. sedimentary rocks are formed from sediment deposits when lithification, or consolidation of loose materials into solid rock, occurs. The drying process associated with exposure creates joints or cracks which are perpendicular to the original bedding planes and have no lateral movement.

There are two categories of sedimentary rock. The first category includes rocks that are clastic or fragmental, such as shales, sandstones, and conglomerates. The second category includes sedimentary rocks formed from chemical and o rganic sediments precipitated from solution. Rocks formed from these sediments include limestones, gypsums, and salt. Sandstone deposits are resistant to the forces of weathering. Joint patterns, having the appearance of rectangular blocks, can be easily o bserved since there is little soil cover. Cliffs may occur where sandstone overlie weaker sedimentary rocks, wind erosion and blowing sand may modify these vertical elements, rounding and carving them into streamlined shapes. In Baghoush, the lack of resid ual soil cover allows the joints in sandstone to have maximum control over the drainage pattern. Thus, it is usually an angular dendritic pattern, medium to coarse in texture.

The Western North coast of Egypt is considered as arid region, it is characteri zed by less than 20 inches of annual rainfall but sometimes it exceeds this value . Precipitation is higher in winter months when temperature is relatively low. In such arid regions the landform are generally more rugged and without significant soil develop ment over rock features. In these regions the lack of both precipitation and vegetation results in slower weathering, but when storms occur they tend to be severe, thereby causing rapid erosion of any materials that may have disintegrated (Elhanafy, 1999).

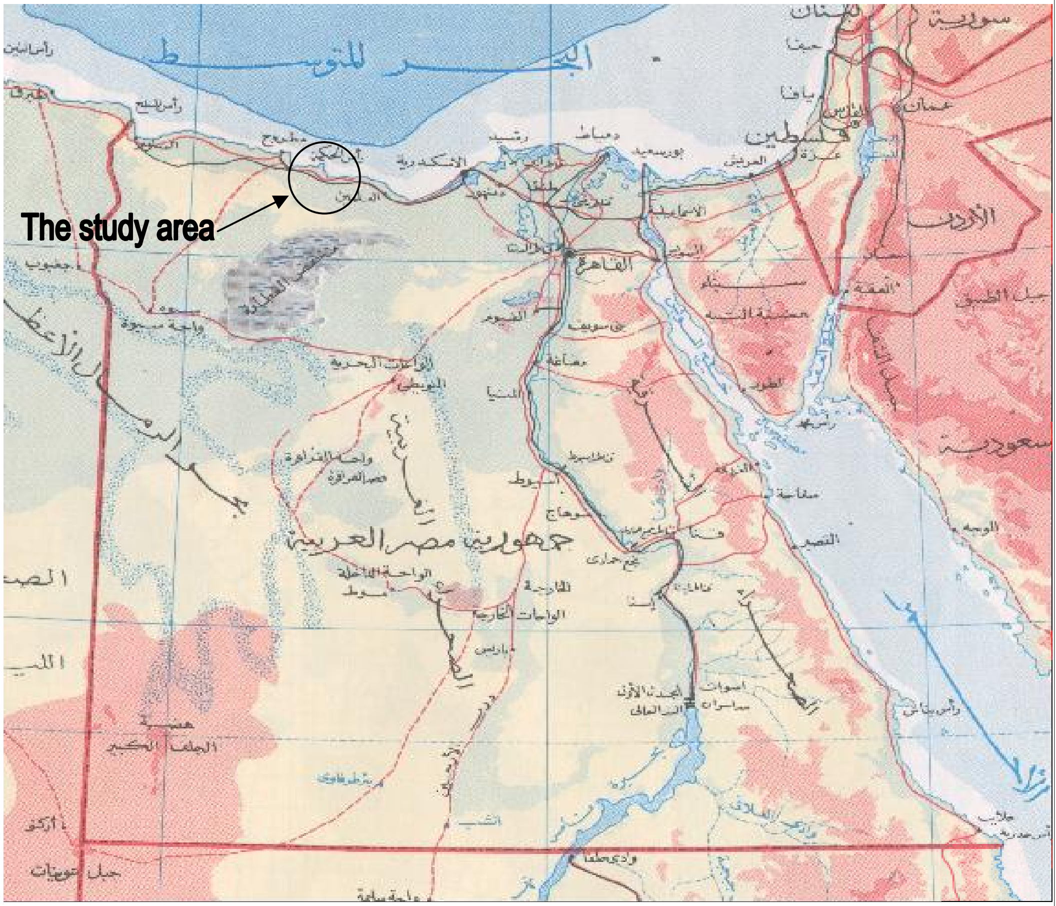

Fig. [1] Topographical map of Egypt

MODEL DESCRIPTION

Washmo model consists of two models: one describing the hydrology of the watershed and the other describing the associated detachment and transport (Ward et al., 1979). The hydrology model mainly describes a design storm hydrograph. This model simulate the hydrologic response of a watershed with only a limited number of calibrated data such as, rainfall amount, soil conservation service (SCS) curve number, storm duration, average overland flow slope, the hydraulic length of the watershed and land use coverage. Two unit hydrograph procedures are incorporated in this model. A procedure based on Haan's dimensionless unit hydrograph equation, which is provided for use in urban areas. A second procedure based on double triangle concepts which have been included for use in agricultural and forested watershed (Overton and Troxler, 1978; Overton and Crosby, 1979). On the other hand, sediment yield in tons can be determined by using the modified version of the Universal Soil Loss Equation (USLE) which developed by Hann et al., 1978 (Ward et al., 1979).

DATA ACQUISITION

Maximum rainfall amount (in mm.) in one day at Mersa Matruh station was found to be 103.5 mm. at December, 13, 1990. According to Meteorological data that have been recorded by General Meteorological Authority of Egypt, while it was found to be 98.80 mm. at 2011. Land use for the two aerial photograph missions and topographical (1991 and 2011) was interpreted and used with soil characteristics for the study area, collected from field investigation, laboratory analysis, and sedimentary rock's topsoil characteristics given by Way (1978) to determine Soil Conservation Services- Curve Number (SCS-CN), which represents the runoff potential of an area for the watershed, was determined by using Hann and Barfield, 1978 approaches, see Tables 1 and 2.

Table 1 Definition of SCS hydrologic soil groups

A	These soils with a high infiltration rate. They are chiefly deep, well-drained sands or gravels. (Low runoff potential).
B	These soils with a moderate infiltration rate when thoroughly wet. They are chiefly moderately deep, well-drained soils of moderately fine to moderately course texture.
C	These soils with a slow infiltration rate when wet. They are chiefly moderately deep. Well-drained soils of moderately fine to moderately course texture.
D	These soils with a very slow infiltration rate. They are chiefly clay soils with a high swelling potential, soils with a permanently high water table, soils with a clay pan at or near the surface and shallow soils over nearly impervious materials. (High runoff potential)

Table 2 Runoff Curve Number for selected agriculture.
(Antecedent rainfall=1.4-2.1 inches).

Land Use Description	Hydrologic Soil Group			
	A	B	C	D
Commercial, row houses and townhouses	80	85	90	95
Fallow, poor condition	77	86	91	94
Cultivated with conventional tillage	72	81	88	91
Cultivated with conservation tillage	62	71	78	81
Lawns, poor condition	58	74	82	86
Lawns, good condition	39	61	74	80
Pasture or range, poor condition	68	79	86	89
Pasture or range, good condition	39	61	74	80
Meadow	30	58	71	78
Pavement and roofs	100	100	100	100
Woods or forest thin stand, poor cover	45	66	77	83
Woods or forest, good cover	25	55	70	77
Farmsteads	59	74	82	86
Residential 1/4 acre lot, poor condition	73	83	88	91
Residential 1/4 acre lot, good condition	61	75	83	87
Residential 1/2 acre lot, poor condition	67	80	86	89
Residential 1/2 acre lot, good condition	53	70	80	85
Residential 2 acre lot, poor condition	63	77	84	87
Residential 2 acre lot, good condition	47	66	77	81
Roads	74	84	90	92

The area of each sub-watershed, lengths of main streams and overland flow lengths for the two different missions, see Figure 3 and Figure 4, were measured by using Planix –5000 digitizing area-line meter, electronic digitizer. On the other hand, slopes for mean streams and mean slopes for overland lengths were determined from the topographic map of the study area that been established by the military Survey Administration (with scale 1:25,000). These measured values were tabulated in Tables 3 and 4 for different missions, 1991 and2011, respectively.

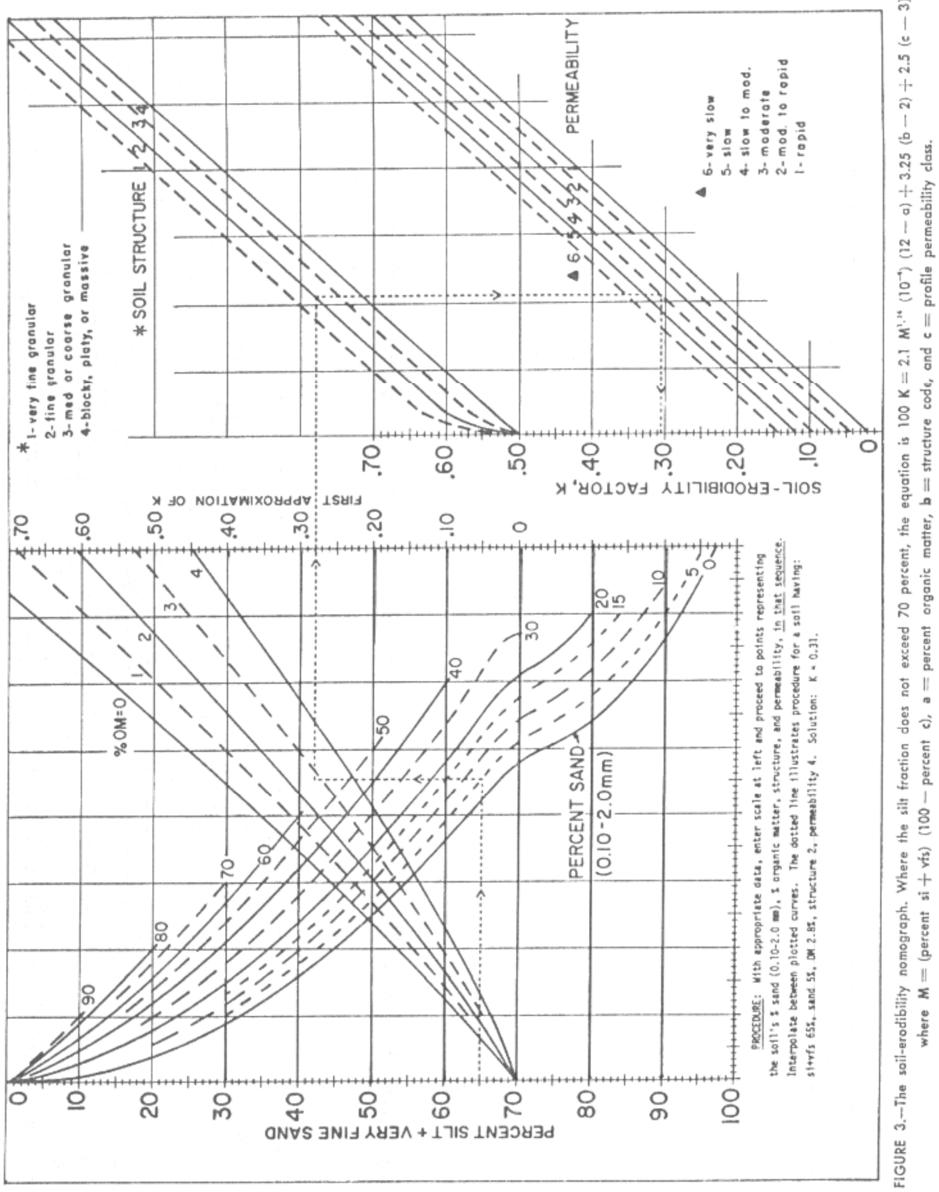

Figure (2) soil erodibility nomograph (Wischmeier and Smith, 1978)

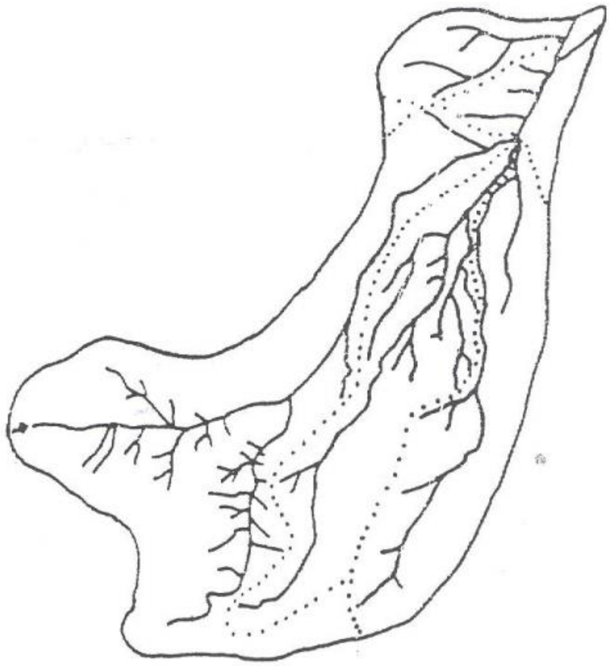

Figure (3) Drainage Pattern of Baghoush Watershed at 1991.
Scale of 1: 40000

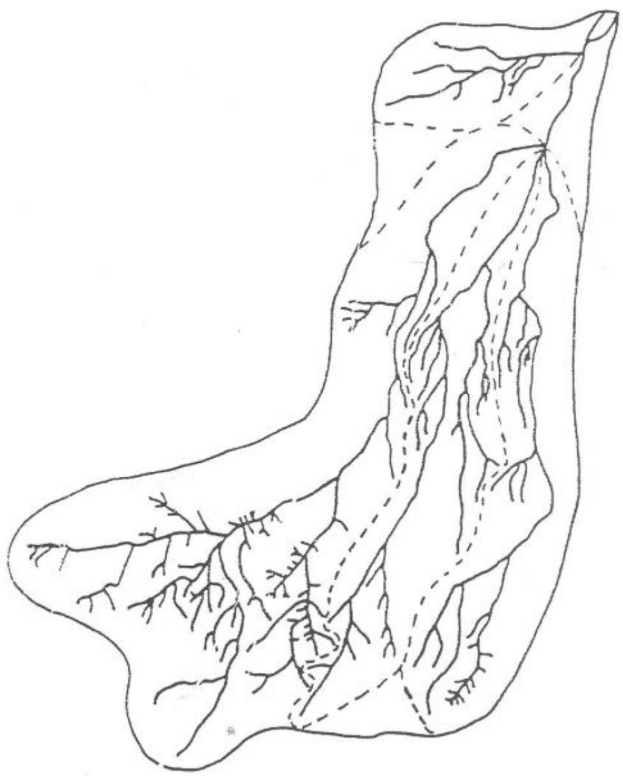

Figure (4) Drainage Pattern of Baghoush Watershed at 2011.
Scale of 1: 60000

Table (3) Hydrological and Land Coverage Parameters that been Extracted From Aerial Photographs, 1991

Hydrological Parameters	A (ha.)	Hydraulic Length (m.) and slope (%)	Overland flow Length (m.) and slope (%)	Land coverage (%)		
				Agric.	Forest.	Grass.
Sub 1	272.43	4846.48 2.23 %	885.05 2.86 %	2.84	0	.10
Sub 2	261.34	5061.83 2.23 %	921.6 1.84 %	8.54	0	.10
Sub 3	620.93	6050.82 1.9 %	940.69 2.1 %	4.12	0	.10
Sub 4	108.43	1632.41 1.65	484.85 1.32 %	2.73	0	.10

Table (4) Hydrological and Land coverage parameters that been extracted From Aerial photographs, 2011

Hydrological Parameters	A (ha.)	Hydraulic Length (m.) and slope (%)	Overland flow Length (m.) and slope (%)	Land coverage (%)		
				Agric.	Forest.	Grass.
Sub 1	272.77	4450 2.88 %	1211 1.1 %	1.5	0	.10
Sub 2	291.46	4953.5 2.88 %	1454.5 1.26 %	3.7	0	.10
Sub 3	640.99	5419.2 2.88 %	2650 2.91%	7.8	0	.10
Sub 4	82.05	1523.6 4.15 %	542.5 1.75 %	6.6	0	.10

The soil erodibility factor, K, was found to be 0.14 at 1991 while it is found to be 0.07 at 2011 . This factor was determined by using soil erodibility nomograph given by Wischmeier and Smith, 1978, see Figure 2. Percentage of agriculture, forests, and grasses land coverage for each sub-watershed and for each mission were tabulated in tables 3, and 4. Sieve analyses of soil samples were studied and the particle size distribution of sediment flow was found to be as follows in table 5.

Table 5 Particle size distribution of sediment flow

Particle size (mm.)	Percentage finer (%) 1991	Percentage finer (%) 2011
.060	.0	.0
.200	29.0	86.0
.600	89.0	94.0
2.000	100.0	100.0

RESULTS, ANALYSES AND CONCLUSION

The area and lengths data that have been extr acted from different drainage patterns as well as maximum rainfall in one day, 103.5 mm and 98.8 mm. for the two missions : 1991and 2011 with duration of 24 hours, soil characteristics parameters, and others were inserted in WASHED program as input data separately, i.e. for each mission. The resulted values of volume of runoff, peak runoff rate, time to peak runoff rate, and depth of water for different sub-watersheds and for different missions (1991 and 2011) were tabulated in tables 6 and 7 respectively.

Table 6 Results of Storm Hydrograph Generated from Start of Rainfall for the 1991 watershed.

Results	Volume of runoff x 1000 m3	Peak runoff rate m3/ sec.	Time to peak runoff rate (hr.)	Depth of water (mm.)
Sub 1	237.93	19.91	12.7	87.37
Sub 2	228.38	15.28	13.0	87.43
Sub 3	542.30	34.54	13.1	87.37
Sub 4	94.68	12.56	12.3	87.36

Table 7 Results of Storm Hydrograph Generated from Start of Rainfall for the 2011 watershed.

Results	Volume of runoff x 1000 m3	Peak runoff rate m3/ sec.	Time to peak runoff rate (hr.)	Depth of water (mm.)
Sub 1	254.44	19.17	13.25	93.32
Sub 2	271.87	19.70	13.3	93.42
Sub 3	597.92	54.01	12.90	93.33
Sub 4	76.49	13.94	12.25	93.31

On the other hand, sediment yield, peaks sediment concentration, and time to peak sediment concentration for different sub-watersheds and for different missions were tabulated in tables 8 and 9.

Table 8 Results of storm sedimentgraph generated from Start of rainfall for the 1991 watershed.

Results	Sediment yield (tones)	Peak Sediment concentration (mg./l.)	Time to peak Sediment concentration (hr.)
Sub 1	3839.72	35.88	12.7
Sub 2	2252.48	15.23	13.0
Sub 3	6436.02	16.82	13.1
Sub 4	812.19	43.93	12.3

Table 9 Results of storm sedimentgraph generated from Start of rainfall for the 2011 watershed.

Results	Sediment yield (tones)	Peak Sediment concentration (mg./l.)	Time to peak Sediment concentration (hr.)
Sub 1	1061.96	5.99	13.25
Sub 2	1275.83	6.33	13.3
Sub 3	7945.43	26.25	12.9
Sub 4	476.62	43.15	12.2

Results of storm hydrograph generated from start of rainfall for the whole watershed of the three different missions were tabulated in table 10.

Table 10 Results of storm hydrograph generated from
Start of rainfall for the whole watershed.

Results / Mission	Volume of runoff x 1000 m3	Peak runoff rate m3/ sec.	Time to peak runoff rate (hr.)	Depth of water (mm.)
1991	1103.21	70.55	13.4	87.38
2011	1200.63	92.73	13.10	93.32

Moreover, results of storm sedimentgraph generated from start of rainfall for the whole watershed of the three different missions were tabulated in table 11.

Table 11 Results of storm sedimentgraph generated from
Start of rainfall for the whole watershed.

Results / Mission	Sediment yield (tones)	Peak Sediment concentration (mg./l.)	Time to peak Sediment concentration (hr.)
1991	13340.41	29.52	12.60
2011	10759.84	17.85	13.20

Storm hydrographs and sedimentgraphs for the two missions were plotted as sown in figures 5 and 6, respectively.

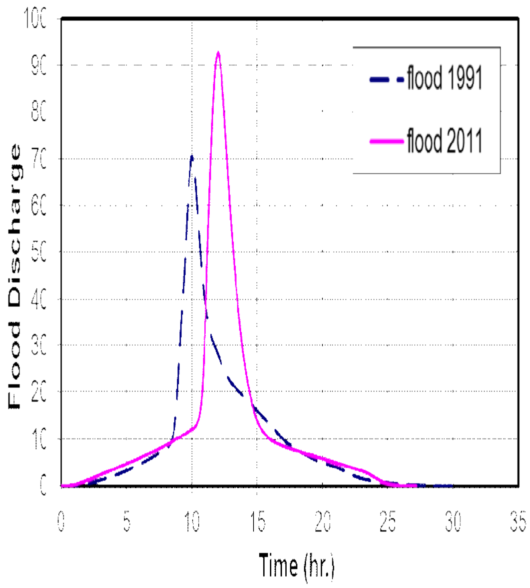

Figure (5) Storm hydrographs for the two different missions.

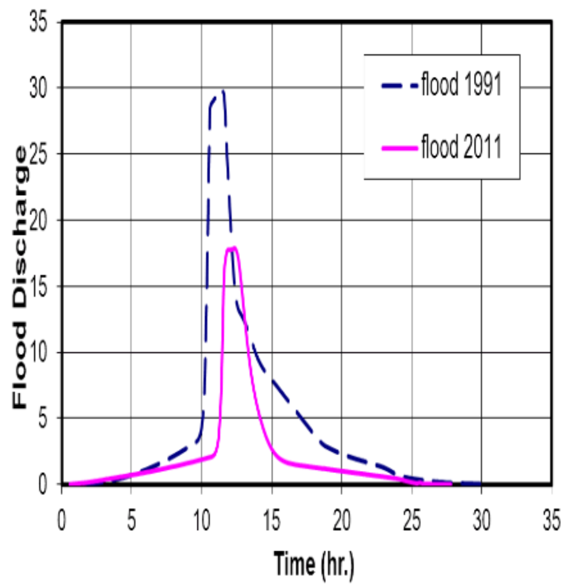

Figure (6) Storm sedimentgraph for the two different missions.

Results of storm and sediment hydrograph that been tabulated in tables 6 to 11 are varied from sub-watershed to another for each year because they are having different land coverage, areas, hydraulic lengths, overland flow lengths, and overland flow slopes. On the other hand, time to peak runoff rate and time to peak sediment conc entration for the years 1991 and 2011 are close because the rainfall amount are about the same (difference of 4.8%).

Although the changes of areas, lengths and slopes of main stream and overland flow and land coverage are strongly differ for the two missio ns of 1991 and 2011, storm hydrographs of Baghoush's whole watershed for these two missions are coincide to each other. Lag time, the time from the center of mass of the effective rainfall to the peak of the runoff hydrograph, for mission 1991 and 2011 is slightly differing. This trend effect on the time to peak runoff rate of the two mentioned missions, the difference is about 80 minutes.

On the other hand, time to peak runoff rate of mission 1991 is less than that mission 2011. This because the average overland flow length for 2011 is greater than 1991. This is due to the shortness the lengths of the gullies and their attached tributaries, as been interpreted from the 1991 and 2011aerial photographs. The peak runoff rate has increased by about 31% although the rainfall for 2011 is less than that for 1991

Also due to urbanization effect the peak sediment flow has decreased by 40 %, also the total sediment yield has decreased by 42%.

From the previous analysis, topography and drainage pattern of Baghoush wa tershed are varied due to the changes of the land coverage, rainfall amount, duration and others. As a result the total volume of runoff, runoff rate, and time to peak runoff have increased. The 2011 storm event on Baghoush watershed affects strongly highw ays, railways and tourist villages than 2011 storm events as shown in the following photographs.

Although the urbanization have its impact on the flood disaster but the recent construction of protection works have saved the new communities and infrastructu res from the flood damages.

RECOMMENDATIONS

It is recommended to use multi temporal aerial photographs for any studied watershed in order to monitor the effect of urbanization on the drainage patterns, flood characteristics and urban planning in that region.
Also using of satellite data for several missions should give more accurate results.

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