International Journal of
Scientific Engineering and Technology Research

ISSN 2319-8885
Vol.03,Issue.10
May-2014,
Pages:2187-2191

www.semargroup.org,
www.ijsetr.com

Computing Flood Discharge for Daungnay Ungaged Watershed

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Abstract: Flood hazard is one of the most harmful natural disasters in the world, and it is significant to obtain information on flood characteristics for disaster mitigation as well as vulnerability assessment. Estimation of runoff for a watershed can be carried out by a number of empirical hydrologic methods. In this study the Soil Conservation Service (SCS) curve number method is used to predict runoff depth. SCS dimensionless unit hydrograph (SCS-DUH) is adopted to formulate flood discharge. Arc-GIS software is used to develop Digital Elevation Model and to extract watershed for Daungnay creek. There are 24 sub-basins in this watershed. Each subbasin is modeled with its own parameters. Muskingum Stream Routing method is used to predict the changing magnitude of flood as a function of time at the points along the watercourse for various design return periods. The requisite discharge data for the inundation model is produced from the rainfall-runoff modeling utilizing HEC-Hydrological Modeling System (HEC-HMS).

Keywords: Topographic Map, Digital Elevation Model, SCS CN, SCS-DUH, HCC-HMS.

I. INTRODUCTION

Daungnay creek is a tributary of Ayeyarwaddy river and is located in Magway Region across the highway. The length of Daungnay creek is about 15.31 miles and its longest tributary length is about 12.93 miles. As Daungnay is sand creek, flash flood often occurs and damages villages around it. A flash flood is a localized phenomenon. It is generally caused by heavy or excessive rainfall in a short period of time and it is characterized by a rapid occurrence, often with little or no warning. Thus flash floods have developed as one of the most dangerous natural disasters in the world. Heavy rains fell in Magway Division. Motor road was blocked as Daungnay Creek near Daungnay Village became swollen due to the heavy rains. Usually flash floods occur in streams and small catchments with a drainage area of a few hundred square kilometres or less. Such catchments may respond rapidly to intense rainfall rates because of steep slopes and saturated soils. The rapid nature of flash floods makes the damage more severe than from normal floods. Hence, flash flood forecasting is necessary to assist in reducing the damage. According to present assessment data approximately 35,734 people have been affected in Magway region, with about 150 people killed during flash floods and about 2,500 houses totally destroyed. To avoid these events, this research program intends to mitigate flash flood hazards.

II. PROCEDURE FOR DIGITAL ELEVATION MODEL

In this study, the topographic (1:50000 scale and contour interval 10 metres UTM) maps are used as the ground data of the study. Digital Elevation Model (DEM) is generated from source data such as contours, elevation points and river in Arc-GIS software. The processing of digital elevation model is described in Fig1 and Fig 2 show Digital Elevation Model of the study area.

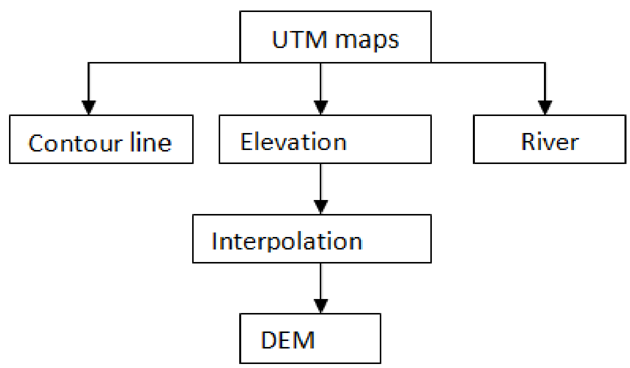

Fig1. Processing of digital elevation model.

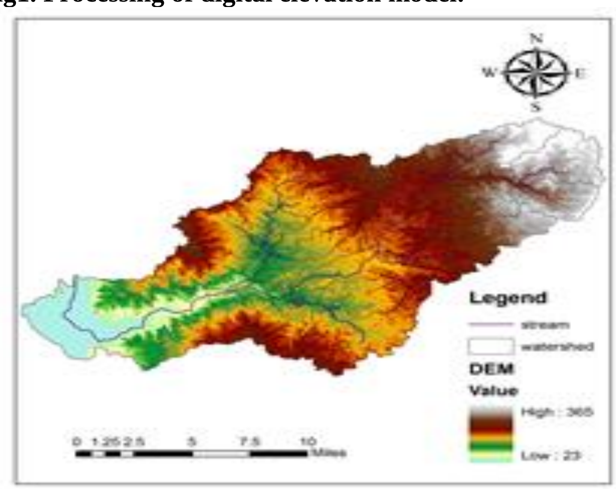

Fig2. Digital Elevation Model of the study area.

III. THE PROCESS OF EXTRACTING HYDROLOGIC INFORMATION

Watersheds can be developed from a digital elevation model (DEM). Fig. 3 illustrates the flowchart for the process of extracting hydrologic information, such as watershed boundaries and stream networks. In this study, the watershed includes 24 sub-basins ranging in size from 0.27 to 37.97 square miles.

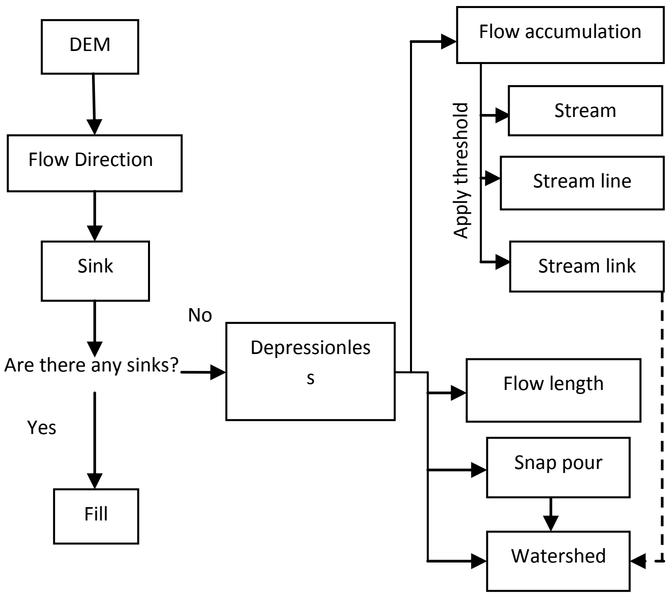

Fig3. The Process of extracting hydrologic information.

IV. METHOD AND MATERIALS

A. SCS Curve Number (CN) Method

The runoff curve number method is a procedure for hydrologic abstraction developed by the USDA Soil Conservation Service. In this method, runoff depth is a function of total rainfall depth and an abstraction parameter referred to as runoff curve number or CN. The curve number varies in the ranges 1 to 100, being a function of the land cover (woods, pasture, agricultural use, percent impervious, etc.), hydrologic condition, and soils. The runoff curve number method was developed based on 24-h rainfall-runoff data. The SCS Runoff Curve Number (CN) Method is used to estimate runoff depth.

$$Q = \frac{(P - Ia)^2}{(P + 0.8S)} \qquad (1)$$

$$Ia = 0.2S \qquad (2)$$

$$S = \frac{1000}{CN} - 10 \qquad (3)$$

B. SCS Unit Hydrograph

Unit Hydrograph Method can be used for estimating peak flows and hydrographs for all design applications. A typical application of the SCS method includes the following basic steps:

Step1. Determination of curve numbers that represent different land uses within the drainage area.

Step2. Calculation of time of concentration to the study point.

Step3. Using the unit hydrograph approach, the hydrograph of direct runoff from the drainage basin can be developed.

$$T_L = \frac{L^{0.8}(1000 - 9CN)^{0.7}}{1900CN^{0.7}Y^{0.5}} \qquad (4)$$

$$T_p = \frac{\Delta D}{2} + T_L \qquad (5)$$

$$Q_p = \frac{484QA}{t_p} \qquad (6)$$

C. Muskingum Stream Routing

Channel routing technique has been developed to facilitate the final step in the rainfall-runoff modelling process. Muskingum method, one of the most popular hydrologic streams routing procedure, is based on the concept that the storage in a channel through which a flood wave is being routed is proportional to a weighted sum of inflow and outflow. This method has been widely adopted for steep slope watersheds that have small floodways, which are regions where flash floods typically develop and evolve.

D. Soil Type

Soil properties influence the process of generating runoff from rainfall and must be considered in methods of runoff estimating. In the study area, there are eleven soils type. Fig 4 describes soil classes of the study area and Table I shows soil types, groups and textures.

TABLE 1: Soil Types, Groups and Textures

Table I Soil Types, Groups and Textures

soil	Texture	Group	Condition
alluvial soil	Loamy sand	A	Good
gravelly red brown savanna soil	Sandy loam Clay	C	Good
light red brown forest soil	Sandy loam Clay Loam	C	Fair
light yellow brown forest soil	Sandy loam Clay Loam	C	Fair
meadow alluvial soil	Sandy loam Clay	C	Fair
meadowish red brown savanna soil	Sandy loam Clay	C	Good
primitive crushed stone soil	Loam Clay	D	Fair
red brown savanna eroded soil	Sandy loam Clay	C	Good
red brown savanna soil	Sandy loam Clay	C	Good
yellow brown forest soil	Clay Loam, Silty Loam, Sandy Clay	D	Fair
shallow red brown savanna soil	Sandy loam Clay	C	Good

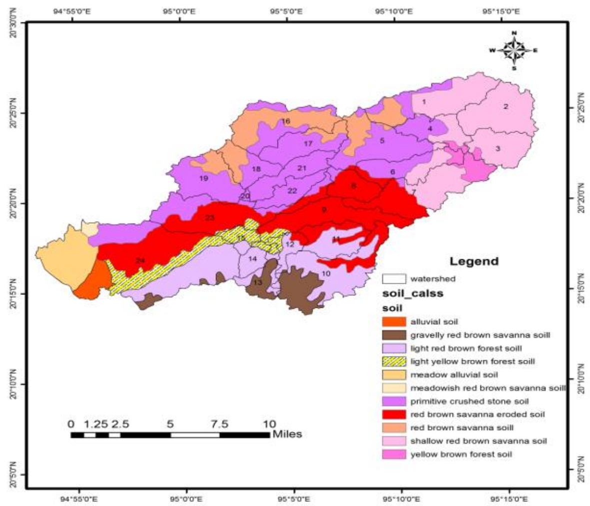

Fig4. Soil Map for the Study Area.

V. HYDROLOGIC MODELLING

Hydrologic modeling systems (HEC-HMS) was developed by the U.S Army Corps of Engineers. HEC-HMS is new generation software for precipitation runoff simulation. HMS has four main components: basin model, meteorologic model, control specifications and input data. The basin model contains information relevant to the physical attributes of the model, such as basin areas, reach connectivity, or reservoir data. The meteorologic model holds rainfall data. The control specifications section contains information pertinent to the timing of the model and the input data components stores parameters or boundary condition for basin and meteorologic

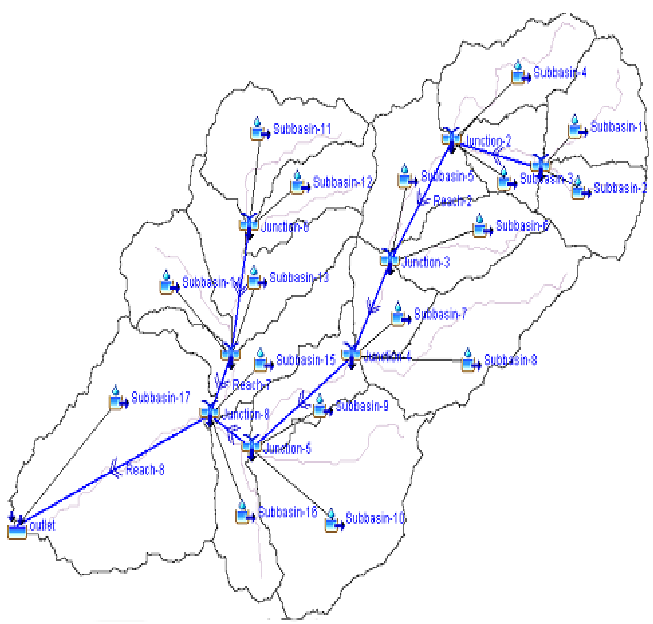

Fig5. Schematic diagram of HMS model.

models. To edit a basin model, SCS unit hydrograph transform method is adopted for calculating runoff in HMS. SCS-CN and Muskingkum method are used for loss method and routing method, respectively. In meteorologic model components, runoffs that correspond to different return periods and maximum precipitation are predicted using rainfall data as input to frequency storm. The time span of a simulation is controlled by control specifications, which include a starting date and time, ending date and time, and computation time step. The simulated runoff values can be used as the produce hazard maps. Fig. 5 shows schematic diagram of HEC-HMS model for Daungnay ungaged watershed.

VI. RESULTS

Table II describes curve number for respective sub-basins. The soil group classification, cover type and the hydrologic condition are used to determine the runoff curve number, *CN*. The *CN* indicates the runoff potential of an area when the ground is not frozen. If a watershed or drainage area cannot be adequately described by one weighted curve number, the composite CN can be determined by analyzing each one individual curve number and area in sub-basin.Fig.6 describes the values of composite curve number. Basin lag time quantifies the time lag between the middle of the rainfall excess period and the peak discharge at the outlet of a watershed. It is computed using SCS-DUH equation. Fig.7 shows lag time for the respective sub-basins Table III. Flood Discharge and Volume for 10 Years Return Periods and Table IV. Flood Discharge and Volume for 50 Years Return Period.

TABLE II: CN for Respective Sub-Basin

Sub-basin	Area (sq-mi)	Length (ft)	Basin Slope (%)	CN
1	11.29	25430.21	6.32367	73.75
2	9.17	15099.24	7.29812	71.00
3	5.95	22361.54	5.93370	71.57
4	5.32	8843.99	7.14164	78.36
5	10.45	18248.02	6.51155	80.27
6	6.90	5907.56	5.79943	78.35
7	12.40	21237.14	5.67472	73.06
8	4.03	10600.95	5.15214	72.21
9	8.87	10698.59	5.19875	71.36
10	14.97	16760.43	5.92674	73.63
11	6.11	13401.32	5.51123	73.91
12	2.40	3631.78	5.90494	74.90
13	3.77	8684.83	6.25341	73.33
14	2.30	2090.81	6.24949	76.00
15	2.16	23368.88	5.43341	75.83
16	10.80	68324.41	5.39486	75.87
17	6.27	17348.23	5.82349	81.41
18	4.66	12964.16	4.67742	78.02
19	8.17	33286.12	5.09521	80.91
20	0.27	4536.55	4.59428	84.00
21	4.97	9944.61	4.87366	84.00
22	3.62	2813.41	5.26196	83.87
23	13.31	2937.81	6.61089	75.98
24	37.97	16565.01	6.24949	71.12

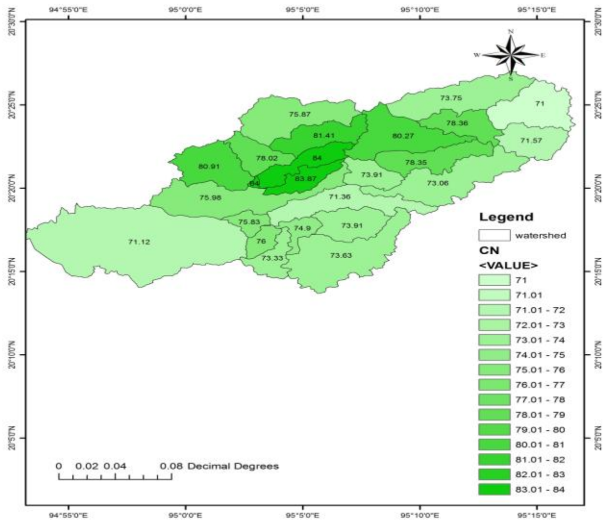

Fig6. Curve number (CN) for respective sub-basin.

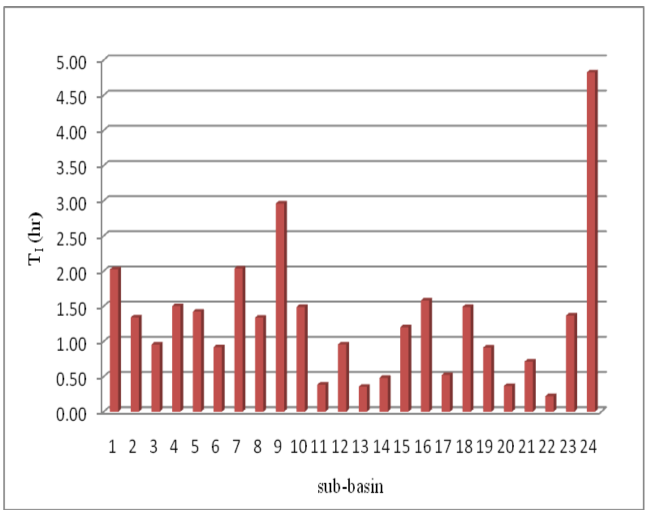

Fig7. Lag time of the study area.

TABLEIII: Flood Discharge and Volume for 10 Years RP

Hydro element	Area (km2)	Peak discharge(m3/s)	Volume (mm)
Subbasin-1	21.47	57.9	31.68
Subbasin-2	18.04	60	33.96
Junction-1	39.51	115.4	32.72
Reach-1	39.51	113.8	32.72
Subbasin-4	24.59	63.4	35.22
Subbasin-3	13.15	63.2	41.5
Junction-2	37.74	102.4	37.41
Reach-2	77.25	212.5	35.01
Subbasin-5	25.28	103.5	45.56
Subbasin-6	20.2	58.3	44.25
Junction-3	45.48	149.6	44.98
Reach-3	122.73	358.3	38.7
Subbasin-8	39.64	59.8	34.5
Subbasin-7	14.32	41.2	33.96
Junction-4	53.96	75.3	34.35
Reach-4	176.69	421.7	37.37
Subbasin-10	56.28	121.4	36.46
Subbasin-9	17.11	36.6	33.58
Junction-5	73.39	157.8	35.79
Reach-5	250.08	568	36.91
Subbasin-13	29.07	146.2	51.63
Subbasin-14	18.22	67.6	45.05
Junction-7	47.29	208.7	49.09
Subbasin-11	26.05	67.7	39.64
Subbasin-12	17.22	61.3	48.02
Junction-6	43.27	126.5	42.97
Reach-6	43.27	125.7	42.97
Reach-7	90.56	296.5	46.17
Subbasin-15	24.26	131.3	45.14
Subbasin-16	18.31	79.6	36.12
Junction-8	383.21	921.4	39.58
Reach-8	383.21	916.6	39.58
Subbasin-17	79.41	200	36.09
outlet	462.62	1113.2	38.98

TABLEIV: Flood Discharge and Volume for 50 Years RP

Hydro element	Area(km2)	Peak discharge(m3/s)	Volume (mm)
Subbasin-1	21.47	108.8	58.72
Subbasin-2	18.04	110.4	61.82
Junction-1	39.51	214.9	60.14
Reach-1	39.51	211.8	60.14
Subbasin-4	24.59	114.9	63.52
Subbasin-3	13.15	110.6	71.78
Junction-2	37.74	184.1	66.4
Reach-2	77.25	389.8	63.2
Subbasin-5	25.28	175.5	76.96
Subbasin-6	20.2	99.5	75.3
Junction-3	45.48	253.9	76.22
Reach-3	122.73	637.6	68.02
Subbasin-8	39.64	108.5	62.54
Subbasin-7	14.32	76	61.82
Junction-4	53.96	136.1	62.35
Reach-4	176.69	753.8	66.29
Subbasin-10	56.28	217.5	65.17
Subbasin-9	17.11	67.1	61.32
Junction-5	73.39	283.8	64.27

Reach-5	250.08	1017	65.7
Subbasin-13	29.07	238.8	84.5
Subbasin-14	18.22	114.5	76.32
Junction-7	47.29	346.8	81.34
Subbasin-11	26.05	118.7	69.36
Subbasin-12	17.22	102.3	80.05
Junction-6	43.27	217.3	73.62
Reach-6	43.27	215.9	73.62
Reach-7	90.56	498.2	77.65
Subbasin-15	24.26	222.8	76.44
Subbasin-16	18.31	144.4	64.73
Junction-8	383.21	1606.3	69.15
Reach-8	383.21	1598.1	69.15
Subbasin-17	79.41	360.2	64.68
outlet	462.62	1952.7	68.39

VII. CONCLUSION

In this study, there are 24 sub-basins in the study area of Daungnay ungaged basin which is extracted by DEM. The soil map and runoff factors such as area, length, slope and CN is determined using Arc-GIS software. It is found that the higher the CN, the higher the runoff potential. From the simulation results, sub-basin 17 has the highest peak discharge which is located near the outlet. Thus proper flood management plan should be made at this sub-basin.

VIII. ACKNOWLEDGMENT

The author wishes to her special thanks to, Dr.Kyaw Moe Aung, Head of Civil Engineering Department (Mandalay Technological University) for his invaluable suggestion, leading and helpful guidance during the period of study. The author would like to heartfelt thanks to her supervisor Daw Aye Aye Thant for her guidance and assistance throughout this study. Very special thank to Dr.Kyaw Zaya Htun (Remote Sensing Department for giving knowledge in GIS analysis and application.

IX. REFERENCES

[1] V. M Ponce, , Engineering Hydrology, principles and Practices, Prentice-Hall, Englewood Cliffs, New Jersey, 1989.

[2] D. Snider, SCS National Engineering Hand-book Section 4: Hydrology. Chapter 16: Hydrographs. U.S. Department of Agriculture. Washington, D.C, 1972.

[3] Zur Erlangung, "Flash Floods and their effects on the development in El-Qaa' Plain Area in South Sinai, Egypt," Ph.D. thesis, Maniz University, 2008.

[4] Ethan W. Knocke, "Modeling Flash Floods in Small Ungaged Watersheds using Embedded GIS,"M.Science. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA, Jan,2006.

[5]R.C. Sorrell, "Computing Flood Discharge For Small Ungaged Watersheds," Michigan Department of Environmental Quality Land and Water Management Division, 2000.

[6] Flash Flood Risk Management, Arun Bhakta Shrestha, Prem Sagar Chapagain and Ragesh Thapa, 2011.