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EVALUATION OF URBAN DRAINAGE NETWORK PERFORMANCE UNDER DIFFERENT CLIMATIC AND LAND USE CONDITIONS USING HEC-HMS

M.H. Masum*[1], J. Hossen[2] and S.K. Pal[3]

ABSTRACT

Unplanned urbanization along with city's changed landscape causes urban drainage changes and also fall short maintaining its capacity. This study therefore aims to evaluate the performance of drainage pattern under different land use and climatic conditions. Mahesh khal is taken as a study area, a major drainage canal connected with Karnaphuli River. This study analyses land use pattern of the study area with the data collected through field investigation and also gathered from the secondary sources using GIS tool. Chattogram city holds monthly average rainfall of around 243 mm and therefore totalling 2919 mm in a year which is about to increase 5% - 6% by the year2030. Out of total 8.59 square kilometres of total land areas 5.12 square kilometres areas of land occupied as vegetation and open areas which was about 60% of the total area in 1988 but unfortunately within the 30 years of time span the areas lost its 28% of the vegetation and open. Moreover the peak discharge found for 2, 5, 10, 25, 50 and 100 years return period were 19.8, 29.4, 35.8, 44.1, 50.4 and 56.5 m^3s^{-1}. The study also found that the peak discharge decreases with the increase of Roughness values because the canal with high roughness values indicates high weeds which will give more resistance than a clear canal. The results also revealed that peak discharge increases with the increase of Curve Number (CN) value and percent (%) impervious which indicates that landuse changes has great impact on urban drainage runoff as CN value and percent (%) impervious are related with landuse patterns of the urban areas.

Keywords: *CN, HEC-HMS 4.2, ArcGIS 10.4, Runoff, impervious, rainfall etc.*

Introduction

Hydrologic cycle is greatly affected with the growth of urbanization in many ways such as increases percent impervious areas(Lee & Chung, 2007, Schuelet, 2000), surface runoff, decreases vegetation and open space, infiltration of runoff into soils and base flow, withdrawing water (Chung, Park, & Lee, 2011),water quality replacing indigenous vegetation with irrigated ornamental vegetation etc. (Guan, Sillanpää, & Koivusalo, 2016; G. Krebs et al., 2014; Paule-Mercado et al., 2018; Pitt et al., 2008; Song & Chung, 2017). This conversation leads to change in physical, chemical and biological disturbance of the watershed of a drainage system (Giacomoni, M.H. Gomez, R. Berglund, 2014; Paule-mercado, Salim, Lee, & Memon, 2018; Yao, Wei, & Chen, 2016). Nowadays floods events are more frequent and devastating as the rate of urban growth is so rapid than urban drainage system (Chen, Hill, & Urbano, 2009; Hénonin et al., 2010; Kourtis & Baltas, Vassilios A. Tsihrintzis, 2018; Schmitt, Thomas, & Ettrich, 2004). Again flooding is directly linked with heavier storms is more likely to be increased with climate change (Blair & Sanger, 2016; IPCC, 2008; Sara C. Pryor & Scavia, 2014). Moreover climate also contributes in increasing precipitation, rising temperature and sea levels resulting multiplying the effects of the events (Walega, 2013). Therefore understanding the relation between land development and climate change on storm water runoff is particularly essential from practical point of view and is socially justified (Paule-mercado et al., 2018; Walega, 2013). Monitoring, analysis and subsequent implementation of the preventive measures in order to integrated management of the urban drainage runoff (Paule-mercado & Lee, 2017; V A. Tsihrintzis & Rizwan, 1998).

Transformation of precipitation into storm runoff is a complex hydrological process which requires nonlinear and dynamic transitions which includes soil type, infiltration, percent impervious, evaporation, evapotranspiration, land use conditions etc. (Wang, Asce, Altunkaynak, & Asce, 2012; Xu, 1999; Yokoo, Kazama, Sawamoto, & Nishimura, 2001). Nowadays Sustainable Urban Drainage Solutions (SUDs) or Low Impact Development (LID) have taken attraction because the concepts considers

[1]PG Student, Chittagong University of Engineering & Technology, Bangladesh,
*Corresponding Author (e-mail: mehedi.ce.cuet@gmail.com)
[2]Student, Chittagong University of Engineering & Technology, Bangladesh
[3]Professor, Chittagong University of Engineering & Technology, Bangladesh

different aspects of the urban drainage system i.e. runoff quality, amenity and recreational value, social and ecological protection etc. Chittagong city is the second largest city of Bangladesh comprising hills formed during tertiary time. Majority of the people along coastal areas living between 0 to 5 meter elevation from mean sea level. It lies at the coastal area and the most prominent natural hazards are cyclone with storm surge, water logging, landslide, earthquake and flash flood are the dominant ones. But at present water logging and landslides are the most burning issues (Islam & Das, 2014). Due to rapid urbanization along with climate change, Chittagong city dwellers are facing water logging problem in last few years. The average rainfall of Chittagong is 3378 mm which is quite high than other locations in Bangladesh. Mostly rainfall occurs between May to October. In July, the precipitation reaches its peak, with an average of 743 mm (BMD, 2017).Naturally hydrological condition of an area comes first as it directly involve in water logging events (Zhang & Pan, 2014). The land use patterns of an area have influences over the hydrological condition while the increasing urbanization reduces water body and natural streams. There is an increasing trend observed for land use change due to migrating people from rural parts and this has an advance effect on the hydrological condition of city areas which sooner or later leads to water logging (Mohit & Akter, 2014). Chittagong city saw at least 12 canals vanish in the last 48 years, during which time the waterlogging problem accelerated. A mere 22 canals were found to be emptying into the Karnaphuli River and there was no trace of 12 canals in the premier port city where 8 of the 22 existing canals are also dying (Chowdhury, 2017). In recent years, major canals lost 42% carrying capacity due to siltation, with 87% of the existing silt traps being dysfunctional (Hussain, 2017). Over 14,000 ponds and other water bodies have disappeared is last 18 years in Chittagong. According to a survey conducted by District Fisheries Department in 1991, the number of water bodies in Chittagong city was 19,250 while the Featured Survey conducted by CDA in 2006-2007 indicated existence of 4,523 water bodies there. About 100 sq. km. water of Chittagong city is pumped out through five canals- Chaktai khal, Mahesh khal, Sub area khal, Monohar khal and Hizra khal.

Scientists have given much concern about the functionality of the traditional drainage system due to its adverse effect on environment. In traditional urban drainage system, surface runoff from impervious areas may increase the occurrences of frequent flooding also may cause sudden rise in water level and may cause poor water quality in natural water bodies. As the rainfall diverted through pipe system in traditional method, the total amount of infiltrated underground reduced which causes depletion of the ground water table (Grimm, 2007,EA, 2007). There is also limited capacity and flexibility of traditional drainage system to adopt urbanization effect and climate vulnerability(P. Krebs & Larsen, 1997). Hence the concept Sustainable urban drainage (SUDs) comes to mitigate these problems. Sustainable urban drainage (SUDs) refers to management of water in small scale and facilities surface runoff in a more sustained way focusing on maintaining good health, preserving water resources and protecting biological diversity and natural resources (Bruijn et al., 2009; Mcdonald, 2018; Willems & Olsson, 2009; Zhou, 2014). The simplest rational method considering “runoff coefficient” have already been introduced to determine the total runoff. This been done multiplying the coefficient with total rainfall (Zekai ,S., Altunkaynak, 2006). Then imperviousness along with other factors such as time of concentration, soil properties, land use conditions of a catchment have been converted into a regression formulation or tabulated values to have more accurate prediction about runoff. Despite all the attempts, city people are facing tremendous problem related to drainage issues. Water logging are much more frequent during monsoon than that of before. Areas of vegetation have been reduced as result of urbanization. Climate pattern also changes rapidly due to geographical location of the city. Urban drainage behavior also changes with the changes of land use pattern and climate changes. The study has undertaken three objectives to know the behavioral change of the urban drainage under different changed climate and land use pattern.

a. To evaluate the changes of drainage network in different land use and climatic conditions
b. To simulate the existing drainage network by using primary data to replicate real scenario.
c. To evaluate the performances of the existing drainage network in different land use and climatic conditions.

Methodology

Study Area

Mahesh Khal, one of the major khal in Chattagram city connected with the Karnaphuli River is taken as study area as shown in Fig. 1. The catchment lies between latitude ($22°17'49.751"N - 22°20'22.2612"N$) and ($91°46'30.6948"E - 91°48'45.2412"E$) and occupies the area about 8.578 Km^2 (857.8 ha) with 16.37% inclination. The canal is located in between Sadarghat and Khal 10 station. The study area is classified in 17 catchment (Sub-Basin) and these area is mainly used for commercial and residential purposes. 31.52% of the area is vegetation and open space, 14.97% is water body and 53.51% is build up area. The length of the canal is about 6.3 Km considered for this study and divided into 6 reaches. The canal collects the natural flow along with water draining from Sub-Basin area at the upstream and finally discharges into Karnaphuli River at downstream. Total 11 points have been selected for collecting data i.e. cross section, bottom materials, tide table, discharge etc.

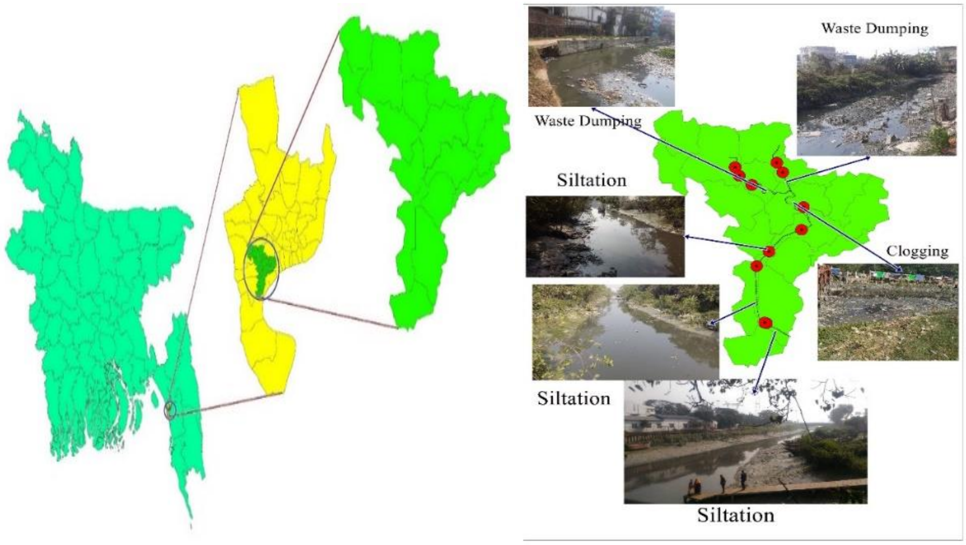

Fig. 1. Study area (a) location of study area showing Mahesh Khal (b) physical conditions in different place.

Methods

The methodology showing in Fig. 2 starts with collection of primary and secondary data. Primary data includes cross section, side slope, bottom slope, bottom materials, tide level, discharge of the canal also types of land use land cover (LULC), flow path etc. Due to lack of data, the cross section of the canal was taken manually. Total 11 study points were selected for data collection. The bottom width of the canal was divided into several strips and depth of the bottom of the canal was determined by rope with a mass attached at the bottom of the rope.

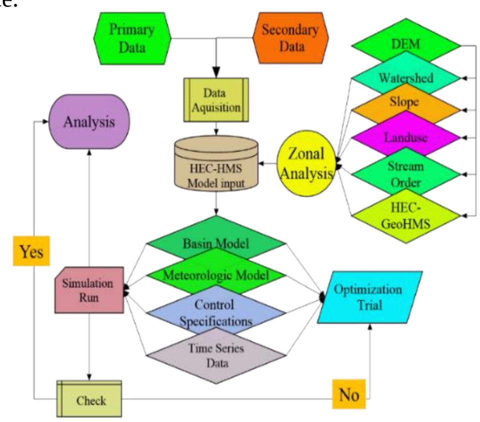

Fig. 2. Details Methodology

The length of the canal was determined by ArcGIS 10.4 using field calculator. The average bottom slopes were determined using GPS and adjusted with data found from HEC-GeoRAS. Bottom materials were investigated physically and recorded for the selection of Manning's n. Field land use and land cover data were recorded in different locations for accuracy assessment of the land use map prepared from DEM by ArcGIS 10.4. Field investigation was also included opinion survey for problem identification, flow pattern of the canals, causes of overflow etc. Secondary data are collected from different sources. Digital Elevation Model (DEM), Land use map, soil data map, precipitation, tide tables, discharge etc. are the main secondary data used for the study. Secondary data and their sources are given in Table 1.

The equation used for the calculation of the time of concentration for the watershed has been taken from literature and is specified in Eq. (1) (Thompson, 2006).

$$Time\ of\ Concentration, t_c = \frac{FL}{A^{0.1} \times S^{0.2}}$$

Eq. (1)

Where,

t_c(min) = Time of Concentration

L (Km) = Length of the stream

A (Km^2) = Sub-basin area.

S (m/Km) = Overland slope

F = 58.5 When A in Km^2

SCS unit hydrograph was adopted for flow routing under transform method. For the purposes the required data is lag time (min) and the calculation is based on empirical equations mentioned in Eq. (2).

$$Lag\ Time, t_{lag}(h) = \frac{2.587 \times L^{0.8} \times (\frac{1000}{CN} - 9)^{0.7}}{1900 \times H^{0.5}}$$

Eq.(2) (Schwab, G.O., Fangmeier, D.D., Elliot, W.J., Freveret, 1993)

Where,

L (m) = Hydraulic watershed length = $110A^{06}$

A (ha) = Sub-basin area.

CN = Curve number.

H (%) = Average sub-basin land slope.

=Calculated based on (Chow, 1964)

i.e. $H = \frac{100 \times CI}{A}$

Eq. (3)

(C is the summation of the length of the contour lines that pass through the watershed drainage area on the quad sheet and I is the contour interval) .

Table 1. Necessary Data Sources of the Study

Data	Source	Address	Resolution /Periods /Others
DEM	United States geological Survey (USGS)	https://earthexplorer.usgs.gov/	30m
Land Use Map	GlobeCover	http://due.esrin.esa.int/page_globcover.php	1 : 500000
Soil Data Map	Food and Agricultural Organization (FAO)	http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116	1000m
Precipitation	National Aeronautics and Space Administration (NASA) Bangladesh meteorological department (BMD)	https://earthdata.nasa.gov/ www.bmd.gov.bd	2018
Discharge	Bangladesh Water Development Board (BWDB)	https://www.bwdb.gov.bd/	2018

The USDA Natural Resources Conservation Service (NRCS) method previous, known as SCS has been used for the computation of storm water runoff rates, volumes and hydrograph. The NRCS Curve Number (CN) is the key component of NRCS method which depends on soil permeability, surface cover, hydrologic condition etc. The most commonly data used for CN value is the June, 1986 Technical release 55 – Urban Hydrology for small watershed (TR-55)(USDA, 1986).

Result and Discussion

Land Use Analysis

Remote sensing and GIS technique is the most important tool for studying the land use and land cover analysis. Large land area can be mapped with low cost and rapidly with high accuracy. Major three land use classification have been identified for the study area and results are presented in the Fig. 3 and Table 2.

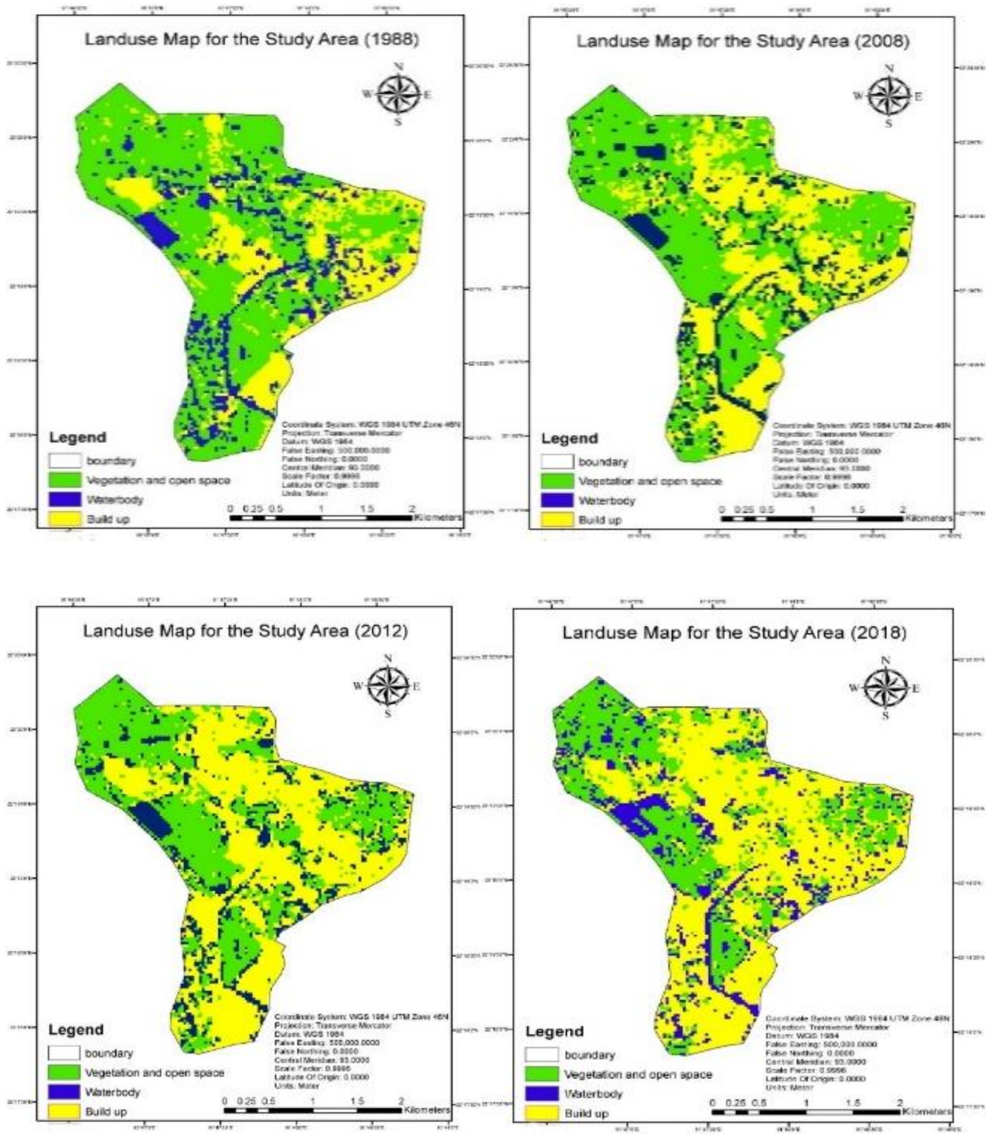

Fig. 3. Land use maps of the study area for the year 1988, 2008, 2012 and 2018

Table 2. Land use analysis of the study area

Type of land use	Area-1988 (%)	Area (sq km)	Area-2008 (%)	Area (sq km)	Area-2012 (%)	Area (sq km)	Area-2018 (%)	Area (sq km)
Vegetation & open area	59.64	5.1219	48.85	4.19	36.71	3.15	31.52	2.7072
Water	15.34	1.3176	14.37	1.2339	14.41	1.24	14.97	1.2852
Build up	25.02	2.1483	36.78	3.159	48.88	4.20	53.51	4.5954

The classification process was repeated for respective year. The generated classified land cover map was verified using ground data and Google earth. The Fig. 3 shows the Land use maps of the Mahesh khal watershed area from the year 1988 to 2018 with different interval. The Fig. 3 clearly illustrated that build up areas are increasing in an alarming rate whereas open and vegetation areas is decreasing day by day. Table 2 shows the detailed result obtained from the land cover classification of three types of land use analysis.

From the year 1988 to 2018 the build-up area increased about 28.49%. Initially in the year of 1988 the build-up area was about 2.15 square kilometres which was 25.02% of the total area of 8.59 square kilometres. The trend of change in build-up areas was slower up to 2008 as compared with the changes found later years. The build-up area was about 3.16, 4.20, 4.60 square kilometres for the year of 2008, 2012 and 2018 which is 36.78%, 48.88% and 53.51% of the total area. Out of total 8.59 square kilometres of total land areas 5.12 square kilometres areas of land occupied as vegetation and open areas which posed the highest portion of the total area and was about 59.64% of the total area in 1988. Within the 30 years of time span the areas lost its 28.12% of the vegetation and open areas. The trend of change is almost same but in reverse order as compared with build-up area and can be termed as alarming.

Data Preparation

The basin and canal parameters were extracted from the attributes table for 17 sub-basins and for canal from ArcGIS 10.4 as prepared earlier and summarized in Table 3. Area, slope, percent (%) impervious are directly derived from ArcGIS 10.4. Hydraulic length, initial abstraction, lag time are derived using respective equation's mentioned in methodology chapter. Curve Number (CN) for each sub-basin was used from TR-55 Curve number Tables. The corrected curve number (CN*) found after optimization trials in HEC-HMS.

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Table 3. Physical properties of Sub- basins used in model

Basin ID	Basin Area, A (Sq. km.)[a]	Basin Area, A (ha)	Slope (percent rise) [b]	Slope, H (%)[c]	Hydraulic Length, L (m) [d]	Curve Number, CN [e]	Curve Number, CN*	Initial Abstraction, Ia (mm) [f]	Percent impervious (%)[g]	Lag Time, lag (min) [h]	d/s of sub basin
S0	0.30	30.20	1990.75	18.85	1523.36	84	79.06	13.45	37	16.38	R5
S1	0.40	40.01	2370.66	22.53	1675.36	80	76.83	15.32	4	17.29	R5
S2	0.47	47.46	1290.76	12.49	1114.83	87	83.56	10.00	63	13.57	R6
S3	0.49	48.88	1742.09	16.59	1134.61	82	78.75	13.71	43	13.92	R3
S4	0.32	31.97	1353.96	13.06	879.52	86	75.85	16.17	73	13.95	R5
S5	0.32	32.03	1429.04	13.74	880.46	87	76.73	15.40	68	13.27	R6
S6	0.59	58.89	1359.65	13.11	1268.81	86	82.59	10.71	56	15.16	R4
S7	0.36	35.65	1785.73	16.99	938.91	82	78.75	13.71	44	11.82	R4
S8	0.49	48.87	1759.47	16.75	1590.26	83	79.71	12.93	38	17.62	R3
S9	0.19	19.02	1909.30	18.11	1044.10	86	82.59	10.71	62	11.04	R3
S10	0.45	44.53	1733.08	16.51	1072.89	85	81.63	11.43	75	12.19	R3
S11	0.37	37.32	1800.65	16.13	965.10	85	81.63	11.43	45	11.33	R2
S12	0.34	33.91	2315.28	21.98	911.22	87	76.73	15.40	37	10.78	R3
S13	0.41	40.93	1489.56	14.30	1019.99	86	82.59	10.71	56	12.19	R1
S14	0.68	68.07	1437.55	13.82	1384.08	83	79.71	12.93	42	17.36	R1
S15	0.44	44.13	1811.36	17.22	1067.12	87	83.56	10.00	78	11.16	R2
S16	0.75	74.71	1872.21	17.78	1463.55	85	81.63	11.43	45	15.06	R5

CN* Corrected CN values;
[a, b, c, d] DEM;
[e]Curve Number Chart; [f]
empirical equation (USACE, 2000); [g]collected from land use map;
[h]Schwab's equation;

Table 4. Reach parameters used in the model

Reach Name	Length (m)[a]	Top width (m) [b]	Depth (m) [b]	Bottom width (m) [b]	Bottom Slope (m/m) [b]	Side slope (1:z) [b]	Manning's n [c]
R1	557.18	39.01	5.63	6.67	0.0011430	0.35	0.04000
R2	935.75	34.51	4.80	11.57	0.0021100	0.42	0.04500
R3	1196.06	39.22	3.51	10.57	0.0045000	0.24	0.04500
R4	1118.85	33.05	3.71	19.56	0.0051300	0.55	0.07750
R5	1601.93	17.27	3.34	8.06	0.0065400	0.73	0.10000
R6	896.04	10.82	2.87	7.20	0.0063700	1.59	0.07000

[a]DEM
[b]Field Survey
[c]Manning's n chart

Table 5. Others parameters used in model

Storm depth (mm) [a]						
Present	2 year	5 year	10 year	25 year	50 year	100 year
74.13	91.06	122.62	143.57	169.99	189.58	209.06
Others parameters						
Properties					Value	Unit
Catchment Area, A [b]					8.58	Km^2
Overland Slope, S [b]					16.37	%
Overland Slope, S [b]					163.70	m/Km
Length of the stream, L [b]					6.30	Km
Time of Concentration, Tc [c]					107.24	min

[a]IDF curve
[b]DEM
[c]Rational method

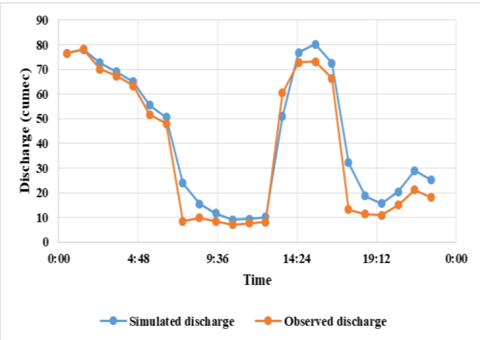
Reach parameters are shown in Table 4. The values are found through field survey. Length, top width, depth, bottom width, side slope are determined direct measurement in the field. Bottom slopes have been determined using GPS instrument with respect to reduced level and finally validated and adjusted with the data extracted from DEM using 3D analyst in ArcGIS 10.4. Manning's n value used for the canal found from TR-55 Manning's n table and validated in optimization trials in HEC-HMS.

Storm depths for different return periods have been shown in columns (2), (3), (4), (5), (6) of the Table 5 for the 2, 5, 10, 25, 50 and 100 year respectively. The storm depths are adopted from IDF curve. Others parameter includes total catchment area for the catchment, overland slope, total length of the canal and the time of concentration etc.

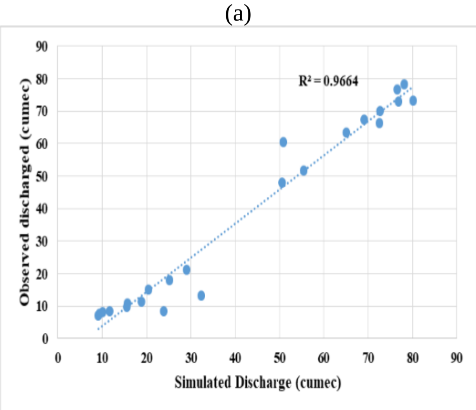
Validation of the model

Successful implementation of hydrological models mainly dependent on how accurately the model is calibrated. Model calibration is done to match the values of runoff volume, peak discharge and time of hydrograph among observed and simulated values and results sown in Fig 4. The model calibration can beconducted both automatically and manually. In the present study, automatic calibration known as.

"Trial Optimization" was used to obtain the optimum parameter values that gives the more similar values among observed and simulated values as manual calibration could be erroneous The assumed parameters undergoes an iterative adjustments under certain boundary conditions. The calibration was done between simulated and observed discharge and the results shown in Fig. 4(a). HEC-HMS model basically calibrated using event based simulation. A particular event (24 July, 2018) was selected for calibration of the HEC-HMS model parameters. The hydrograph generated from the model is compared with the observed direct runoff. Two important parameters Curve Number (CN) and manning's n were selected for calibration. Initial and corrected parameter values are show in Table 3 and Table 4. The corrected and calibrated values are considered for the further analysis and performance evaluation of the drainage system.



(a)



(b)

Fig. 4. Validation of the model (a)Observed and simulated discharge (b) accurecy analysis

The observed and simulated values were assessed using R^2 indicator and the R^2 value obtained after implementation of all calibrated values for this particular event is 0.9664 which indicates good accuracy of the calibration as shown in Fig. 4(b).

Performance evaluation based on present situation

For the simplicity, all the performance evaluation was conducted considering metrological effect only. Tidal effect, metrological effect, backwater effect and inflow were not considered. The reasons behind this approach are not availability of sufficient data set, no future master plan for the study area, limitations of the HEC-HMS model, uncertainties etc. The capacity of the canal has been considered subtracting the average peak tide discharge from actual capacity. Hence the capacity for the canal with respect to metrological consider for further performance evaluation. The cross section considered for determination of the actual capacity is the average cross section of the whole canal. The discharge due to tidal effect have considered the average peak discharge available of the canal throughout the year. The result found that the actual capacity of the canal is 103.85 m^3s^{-1}whereas the average peak tidal height along with inflow has been found 3.75m and corresponding discharge due to tidal effect and inflow has been found 87.34 m^3s^{-1}. Hence the capacity with respect to metrological effect is only 16.51 m^3/sec during the high tide. Such kind of tidal effect cause frequent flooding in these area with limited rainfall.

Performance evaluation varying Curve number (CN)

Fig. 5 illustrates the change of discharge with different CN number varying from 30 to 98 in different return periods. Basically Curve Number (CN) value is a hydrological parameter that used to predict the direct surface runoff. Considering water present in canal for tidal effect, the peak discharge would be within the capacity in present condition and also in 2 years return period for CN values up to 30, 40, 50 respectively but for further increased values of CN, it has found to exceed the carrying capacity limit of the canal. As with the increase of CN values, the impervious areas increase resulting more direct surfaces runoff that's why the discharge has been found higher for higher values of CN.

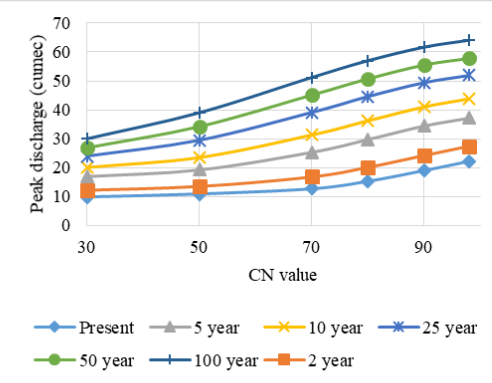


Fig. 5. Variation of discharge with CN value in different return periods

The deviation changes at a constant rate in different return periods for a particular CN value. The average values found for 2 and 100 year return periods are 26 m^3s^{-1} and 50.5 m^3s^{-1}respectively with respect to different CN value. The result also shows that the deviation changes more rapidly up to CN value 70 and for further increase of CN value the deviation is almost same. The average discharge value found for CN value 30 and 90 are 20 26 $m^3s^{-1}$and 43.47 26 m^3s^{-1}respectively.

Performance evaluation varying % impervious

The change of discharge with different % impervious land varying from 30% to 98% in different return periods has been illustrated in Fig 6. Percent (%) impervious indicates the area which will contribute 100% surface runoff without any loss (i.e. infiltration, percolation etc.). The discharge increase linearly with the increase of the % impervious as shown in Fig. 6. The more impervious areas increases, there will be more surface runoff and hence the discharge would be higher that's why the value increases with the increase of % impervious.

The study also found that average value of discharge for 2 year and 100 year return period have been found 18.2m^3s^{-1} and 59.68m^3s^{-1}respectively. The standard deviation found almost same for all return periods and the value is about 3.78. On the other hand, the average value changes from 33.34 to 43.37 $m^3s^{-1}$for the % impervious value of 30 and 98.

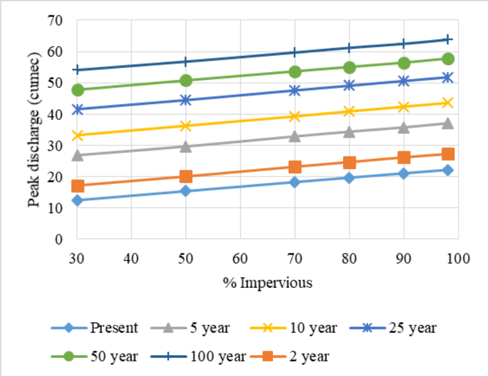


Fig. 6. Variation of discharge with % impervious in different return periods

The standard deviation value found almost same for different % impervious value and the value is about 15.48. The carrying capacity of the canal exceeds almost every values of % impervious for any return periods considering back flow from river. But if tidal water not considered and only meteorological effect considered for carrying capacity of the canal, the canal will be active for all the values of % impervious up to 100 year return period.

Performance evaluation in different return periods

The change of discharge with time has been found in the for different return periods and shown in Fig. 7. For a day period, the maximum discharge has been found from 9am to 2pm. In present situation the maximum discharge value is about 15cumec which increase with the increase of return period and become 55cumec in 100years return period.

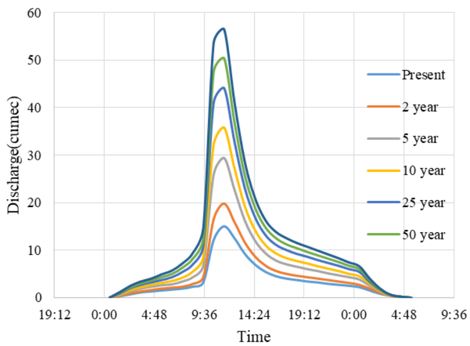
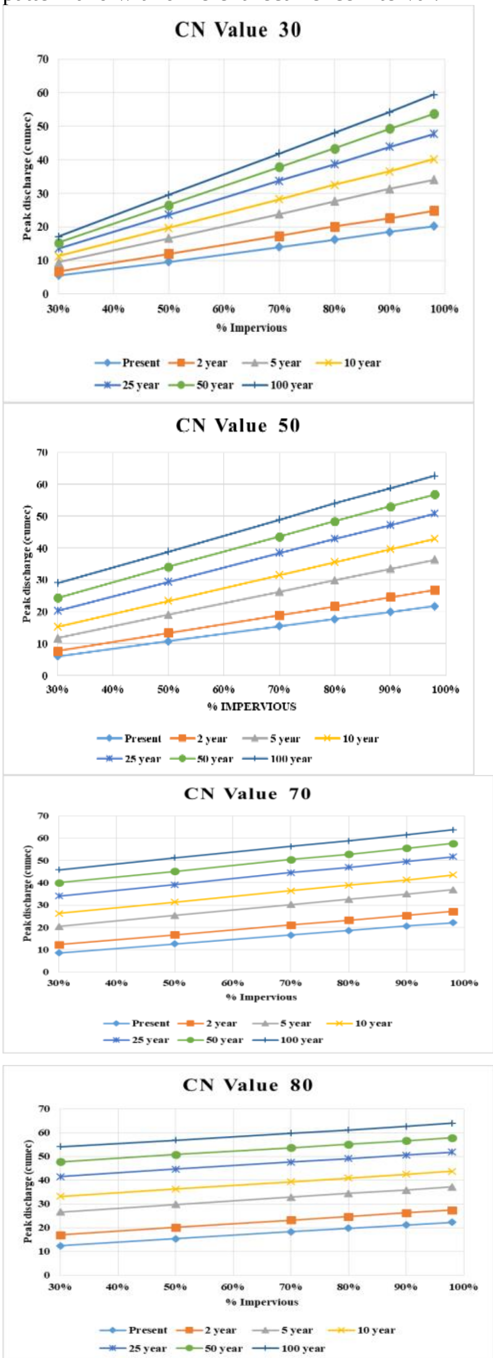


Fig. 7. Variation of discharge in return periods

Performance evaluation varying CN value with % impervious for different return periods

The graphs in Fig. 8 illustrate the change of pick discharge with respect to change in land use pattern and with different recurrence interval.



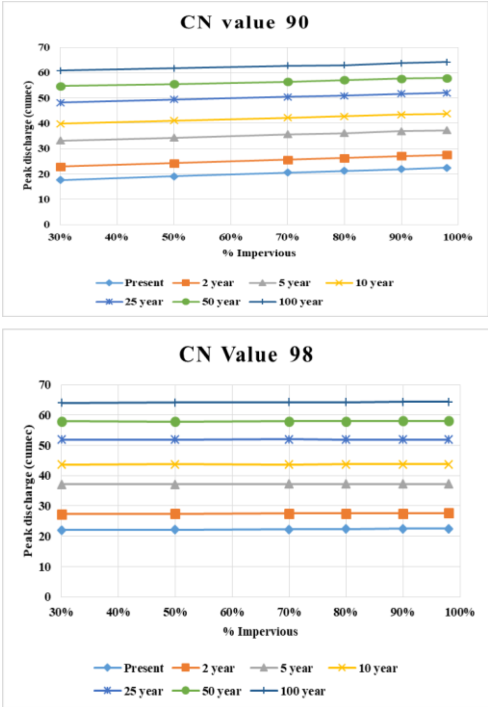


Fig. 8. Variation of peak discharge with different CN values

The CN, represent the change in land use pattern has been considered to be varies from 30 to 98 considered for worst situation. For CN values 30,50,70,80,90,98 in present situation, the total discharge capacity will exceed for % impervious 90%,80%,70%,60%,30% and 30% respectively considering metrological effect only.

Similarly for the return period 2 years the values found 80%,70%,60%,40%,30% and 30% respectively. In this line of context, for 5 years return period the limiting % impervious values would be respectively 50%,40%,30%,30%,30% and 30% and for 10 years return period % impervious values found 50% for CN value 30 and 30% for rest of the CN values. For return period 25 years, 50 years and 100 years it has been found that the discharge will cross the maximum capacity for % impervious values near about 30% only.

Conclution

Rapid growth of urbanization and dense population has great effect on every sector of environment including increased percent impervious areas, surface runoff, decreased vegetation, open space, water quality, and also in physical, chemical and biological disturbance of the watershed of a drainage system. The build-up area increased about 28.49% from the year 1988 to 2018. It can be easily predicted that the build-up areas will increase and reach to above 90% of the total area within short time span if no measures are taken and checked back to ensure sustainable urban planning. Within the 30 years of time span the areas lost its 28.12% of the vegetation and open areas. The trend of change is almost same but in reverse order as compared with build-up area and can be termed as alarming.

The result found that the actual capacity of the canal is 103.85 m^3s^{-1}whereas the average peak tidal height along with inflow has been found 3.75m and corresponding discharge due to tidal effect and inflow has been found 87.34 m^3s^{-1}. The peak discharge would be within the capacity in present condition and also in 2 years return period for CN values up to 30, 40, 50 respectively but for further increased values of CN, it has found to exceed the carrying capacity limit of the canal considering water present in canal for tidal effect. The average values found for 2 and 100 year return periods are 26 $m^3s^{-1}$and 50.5 m^3s^{-1}respectively with respect to different CN value. 90 are 20, 26 $m^3s^{-1}$and 43.47 26 m^3s^{-1} respectively.

City Planners must pay attention on implementaion of SUDs in urban areas in order to control quality, quantity and aminity values of the urban drainage discharge. Moreover soft measures need to be implemented to decrease the runoff discharge from urban areas. Rainwater harvesting, well setup, using porous pavemnt etc. can be implemented to decrease urban runoff and to increase the runoff quality and aminity.

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