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ROLE OF WATER BODIES IN MITIGATING URBAN FLOODS: A CASE STUDY IN MYSURU CITY

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ABSTRACT

Urbanization poses numerous challenges to city administrators, planners and policy makers, of which urban floods are becoming increasingly a major challenge. Certainly due to such unexpected floods there are records of loss of lives, shelter and many more damages that are unique to a particular floodplain and flood type. Many low laying areas in Mysuru City such as, Srirampura are frequently suffering from urban floods. Hence a study on urban floods has been taken up in Srirampura 2nd stage of Mysuru City. The main drain existing in the locality frequently overflows leading to flooding in the nearby areas. The study included collection and analysis of rainfall data from Karnataka State Natural Disaster Monitoring Centre (KSNDMC) and District Statistical Office Mysuru, field data and satellite images from United States Geographic Survey (USGS) website. The study reveals that flooding occurs only when the rainfall intensity exceeds 20mm/hour. The analysis in the present study indicates that the construction of large water body with the available land (4.6 acres) to a depth of 4.4m can mitigate flood up to a rainfall intensity of 32mm/hour or 170 mm rainfall in a day(The maximum daily rainfall recorded in the last three decades in that area). The construction of such water body not only helps in mitigating floods but also helps in improving ground water recharge and moderating microclimate in the surrounding areas.

KEYWORDS: *ArcGIS, Kirpich, KSNDMC, Rational, USGS, Urban Flood*

Article History

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INTRODUCTION

Flood is the most common and recurrent natural disaster in our country. Floods in an urbanized landscape refer to the partial or complete inundation from the rapid accumulation or run-off resulting in the damage to property and loss of biotic elements [1].In India urban flooding has become more frequent due to both human factors and hydrological factors. High intensity, short duration rains are responsible for flash flooding in urban areas. Blocked drainage system due to rubbish and non-biodegradable wastes decreases drainage capacity [2]. Solid waste disposal into the open surface drains results in increased hydraulic roughness and decreased drainage capacity. In Chennai, uncontrolled development due to urbanization has led to encroachment of major drainage channels, marsh lands and urban water bodies resulting in frequent flash floods [3]. Chocked drains and unauthorized encroachment of three lakes that existed within heart of the city resulted in a major flood in Bangalore city during 2005[4]. Urban runoff isa complex phenomenon which depends upon many factors like intensity of rainfall, slope of the catchment, shape, land use pattern and many other parameters. The best management practices should include increase in pervious areas and provision of detention ponds which results in increase in depression storage[7].Water bodies like tanks and ponds will serve many environmental functions including flood and soil erosion control and are useful for irrigation, drinking water supply and groundwater recharge. Recognition is needed for water bodies in planning policies and process to help protect, conserve and revitalize this precious source [4]. Urban flooding affects economy, environment, and health of people and also causes traffic congestion and pubic inconvenience. Many low laying areas in Mysuru city like Srirampura are subjected to frequent flooding. Since the majority of urban flooding is due to encroachment of urban water bodies for development activities, there is a need to study the role of water bodies in mitigating urban floods. It can also be controlled by creating sponge cities, covering roof with vegetation, separating rain water from sewers, permeable pavements etc.

STUDY AREA

Mysuru, well known as Karnataka's cultural capital, rests on the southernmost tip. It lies between latitude $12^0 14'$ N to $12^0 22'$ N and longitude $76^0 33'$ E to $76^0 42'$ E with an altitude of 740m. The current study focuses on the Srirampura 2^{nd} stage. The main drain passes through Srirampura 2^{nd} stage having a catchment area of 12.24sq.km. The study area is shown in Figure 1.

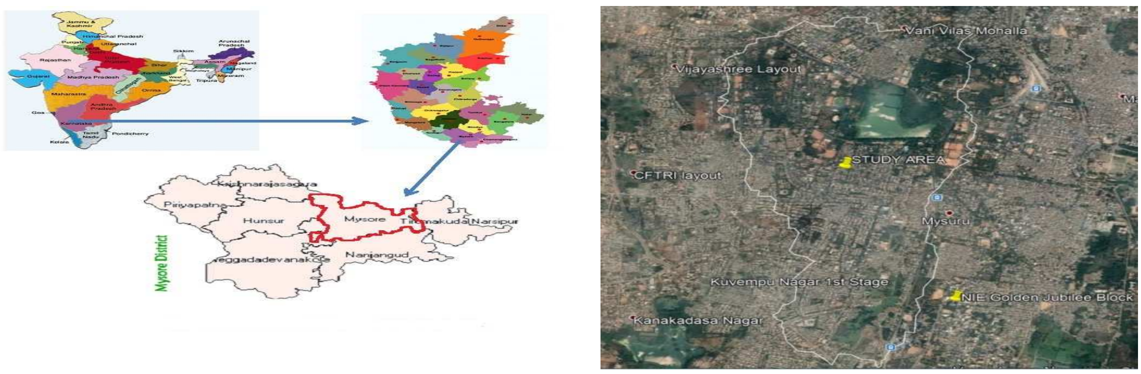

Figure 1: Study Area.

METHODOLOGY

Mysuru City rainfall data from 2010 to 2017 were gathered from Karnataka State Natural Disaster Monitoring Centre, Bengaluru and Mysuru District Statistical Office. The rainfall data obtained for the last 8 years was of 15 minute interval and was analysed and processed to achieve maximum rainfall intensity at 15,30,45 minute intervals up to 24 hours. Further daily rainfall data were also collected from 1991 to 2019. The methodology adopted for a catchment without sufficient water bodies is as shown in Figure 2.

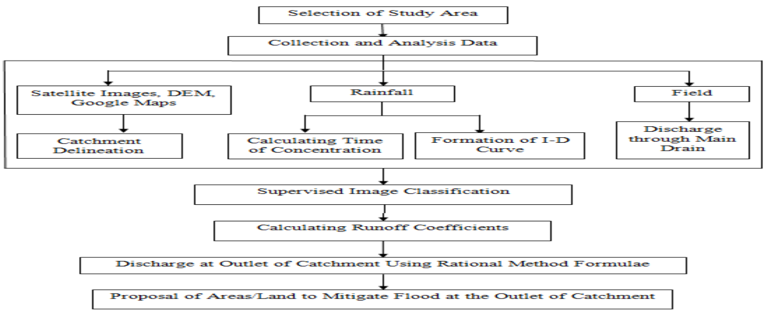

Figure 2: Methodology for a Catchment without Sufficient Water Bodies.

According to collected data maximum rainfall occurred on 26th of September 2017, which was 170mm in 24 hour duration.

Time of concentration is calculated by Kirpich method

$Tc = 0.01947 \times (L^{0.77}) \times (S^{-0.385})$

Where, L = channel flow length S = dimensionless main channel slope

Satellite imageries and digital elevation model data were obtained from USGS website. The present physical conditions of the catchment were taken by Google earth pro and field visit. Catchment is physically delineated for the particular outlet point of interest. The existing storm water drain was identified in the flood affected area and various parameters required like width, depth, slopes, type of bed surface and overall condition of drain were collected by physical inspection.

Water carrying capacity of drain was calculated using discharge equation,

$Q = A \times V$

Where,

Q= Discharge in m^3/s

A= Cross-section area in m^2

V= Velocity in m/s.

Estimation of Velocity using Manning's formulae

$V = (1/n) \times Rh^{2/3} \times S^{1/2}$

Where,

Rh = Hydraulic mean radius.

n = Manning's roughness coefficient.

Image classification was carried out using band 2, 3, 4 and 8 of Sentinel 2. The satellite image of the year 2019 was classified to obtain Land Use Land Cover map of the catchment area. The land was mainly classified into 5 different land use cover like built up area, parks and gardens, water body, open land and uncultivated land. The attributes of the created LULC maps yielded area under particular land use type. The composite run off coefficient is calculated by considering the area under particular land use type.

The formula for runoff coefficient is as follows:

$$C_w = \sum_{j=1}^{n} C_j A_j / \sum_{j=1}^{n} A_j$$

Where,

Cw= Weighted runoff coefficient.

Cj= Runoff coefficient for area j.

Aj= Area of land cover j (km^2)

n= Number of distinct land uses

The urban catchment flood discharge is measured using a rational method, which is considered acceptable for catchments up to 50 sq.km [3]. The specific catchment under study is about 12.24 sq.km in area. Thus the method can be used effectively.

Locating Areas for Preventing Flooding

The area around the overflowing main drain at the outlet of catchment was identified by physical inspection and the area available for creating urban water body was measured.

RESULTS AND DISCUSSIONS

Tools like ArcGIS, Google Earth Pro were used to mark the boundaries of study area. The DEM was delineated in ArcGIS by taking main drain located in Srirampura 2nd stage as outlet. Catchment was delineated by fixing the outlet at the entry of main drain and catchment has an area of 12.24 sq.km. It was identified that Srirampura 2nd stage is a small stretch of land spread within one single catchment area. The Fig 3 better explains it.

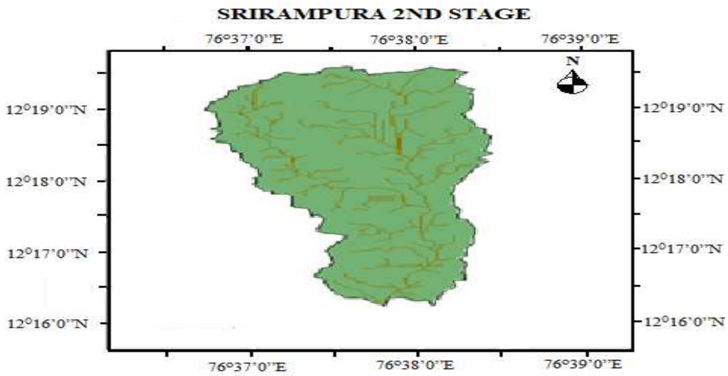

Figure 3: Drainage Pattern of Catchment.

Calculating Time of Concentration with Catchment Outlet in Srirampura 2nd Stage

Time of Concentration = Tc = 0.01947 x (L^0.77) x (S^-0.385)

L=7285.88m, S=0.007686, Time of Concentration = 119.57minutes.

Time of Concentration with catchment outlet at Srirampura 2nd stage is found to be 119.57 minutes. For this time of concentration (Tc) rainfall intensity was found to be 32 mm/hr and is shown in Fig 4.

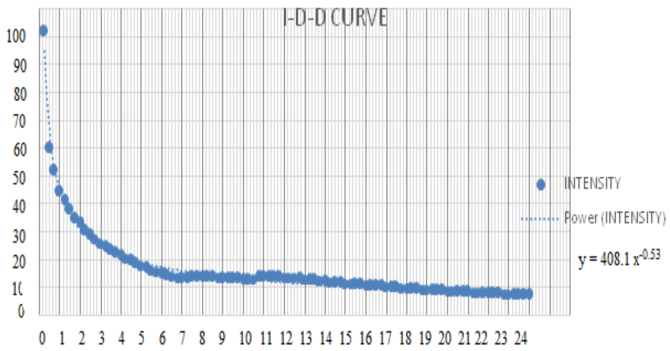

Figure 4: Intensity Duration Curve (2017).

Estimation of Flood Discharge

Image classification is carried out using ArcGIS software. The supervised image is shown in Fig 5 and land use type of the catchment is shown in Table 1.

The dimensions and discharge carrying capacity of existing drain is as shown Table 2.

The flood discharge is estimated using the rational method. The estimated flood discharges of 1,2,…8 years and discharge exceeding the capacity of drain is shown in Table 3.

From the Table 3, it can be seen that up to rainfall intensity of 20mm/hour, the drain has the capacity to convey the discharge (39.89m^3/s) without flooding. Flooding occurs only when the rainfall intensity exceeds 20 mm/hour. From the Table 3, it is clear that flood occurred in 2017, 2014, 2013, 2012 and 2010. Since the maximum excess discharge is 22.92 m^3/s, the water body has designed for this discharge with a duration of one hour. The available land for mitigating the flood near the main drain is around 4.596 acres. The proposed area to prevent flooding is as shown in Fig 7.

Q = 22.22/ (60 x 60) = 79992 m^3

Therefore depth of water required = Volume/Area = 79992/18170.385 = 4.4 m

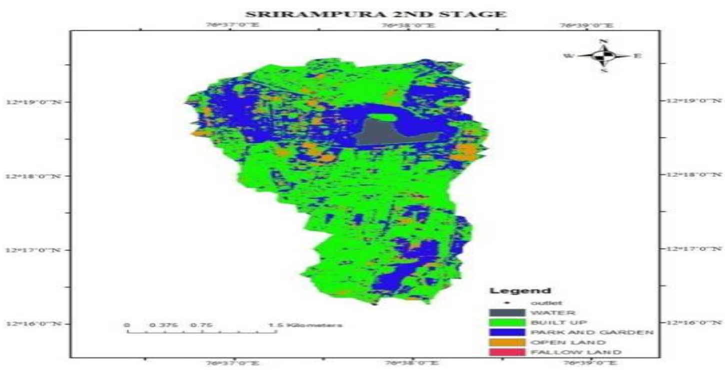

Figure 5: Supervised Image of the Catchment.

Table 1: Land Use Type of Catchment

Sl. No	Land Use Type	Area(km2)
1	Water body	0.2808
2	Built up area	7.3626
3	Park/Garden	3.5093
4	Open Land	1.0231
5	Uncultivated Land	0.0597

Table 2: Dimensions of Existing Drain

Width	4.5m
Depth	1.5m
Area	6.75m^2
Perimeter	7.5m
Hydraulic Radius	0.9
Slope	1 in 147
Velocity	2.193m/s
Discharge	14.80m^3/sec
Discharge for clean concrete surface (n = 0.013)	39.81m^3/sec

Figure 6: Outlet of Catchment.

Table 3: Discharge Exceeding the Capacity of the Drain

Year	Maximum Daily Rainfall (mm)	Rainfall Intensity (mm/hour)	Flood discharge (cumec)	Max Drainage Capacity (cumec)	Excess Discharge (cumec)
2017	170.5	32	62.81	39.89	22.92
2016	70.5	19	37.29	39.89	-2.6
2015	51	14	27.48	39.89	-12.41
2014	43	22	43.18	39.89	3.26
2013	66	24	47.11	39.89	7.22
2012	82	30	58.89	39.89	19
2011	63	15	33.72	39.89	-6.17
2010	53.5	20	41.22	39.89	1.33

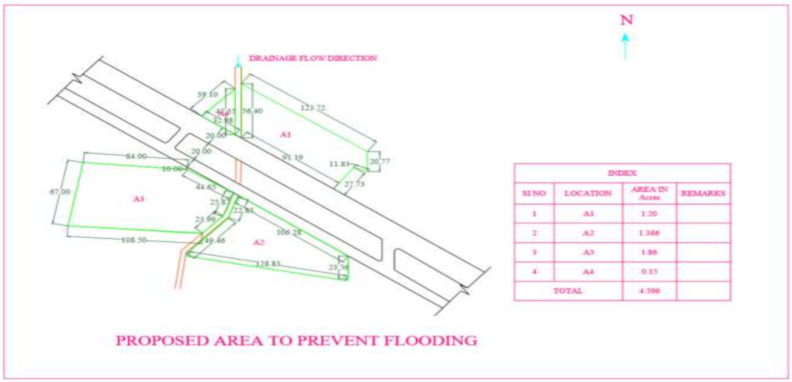

Figure 7: Areas Proposed To Prevent Flooding With Dimensions.

CONCLUSIONS

- Srirampura 2nd stage is a small residential area of about 1 km^2 spread within the low laying zone. The storm water drain existing within affected areas conveys flood water and the drainage area contributing to this zone is 12.24 sq.km
- The estimated flood of 8 years having rainfall intensities of 32,19,14,22,24,30,15 and 20mm/hour produces discharges of 62.81, 37.29, 27.48, 43.18, 47.11, 58.89, 33.72 and 41.22m^3/sec respectively.
- Flooding occurs only when the rainfall intensity exceeds 20mm/hour. The flood occurred in 2017, 2014, 2013, 2012 and 2010. Since the maximum excess discharge is 22.92 m^3/s, it is necessary to mitigate flood.
- The available land for mitigating the flood near the main drain is around 4.6 acres. For this area if water is stored for 4.4m depth for an hour, then the overflow in the drain can be stopped and hence urban flooding in that area can be mitigated.

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