URBAN FLOOD MONITORING AND MANAGEMENT

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Introduction:

Increase in urbanization leading to climate changes and human activities have resulted in flash flood scenarios and high intensity rainfalls in the city. Recent calamitous floods have spawn way for many Flood management projects aiming towards development of stronger flood monitoring and smarter flood protection systems.

Study area

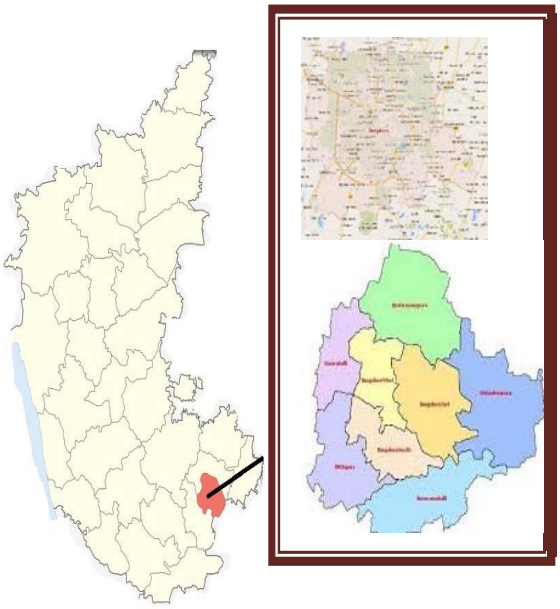

Fig no: 1-Study area

Bangalore is located in the south east region and meteorologically it is a part of south interior Karnataka it is almost equidistant from both the eastern and western coasts of the South Indian peninsula. It has 12.591North latitude & 77.571East longitude. It has an altitude 920m above sea level .The mean annual rainfall is about 975 mm with about 60 rainy days a year. It is located 100 km from the Kaveri River. No major perennial rivers run through the city, though the Arkavathi and South Pennar cross paths at the Nandi Hills, 60 km (37 mi.) to the north. River Vrishabhavathi, a minor tributary of the Arkavathi, arises within the western part of the city flows through the city. The rivers Arkavathi and Vrishabhavathi together carry much of Bangalore's sewage. A sewerage system, constructed in 1922, covers 215 km² (133 mi²) of the city and connects with five sewage treatment centers located in the periphery of Bangalore.

The Bangalore Corporation is called the BBMP (Bruhat Benagalooru Mahanagara Palika). The BBMP is divided in 8 zones i.e. North, East, and West, South, Bommanahalli, Mahadevpura, Rajarajeshwari Negara and Dasarahalli zone as shown in the figure:

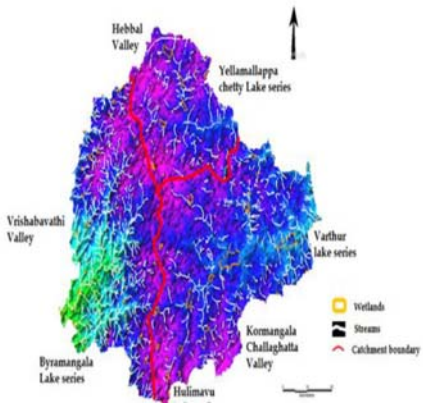

Fig no: 2 Map showing valleys of Bangalore

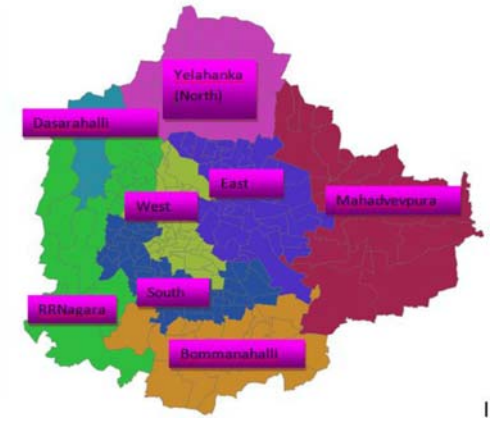

Fig no: 3 Map showing different Zones of Bangalore

Storm water scenario

The zones in core area are demarcated by natural topography into four major watersheds Catchment area namely

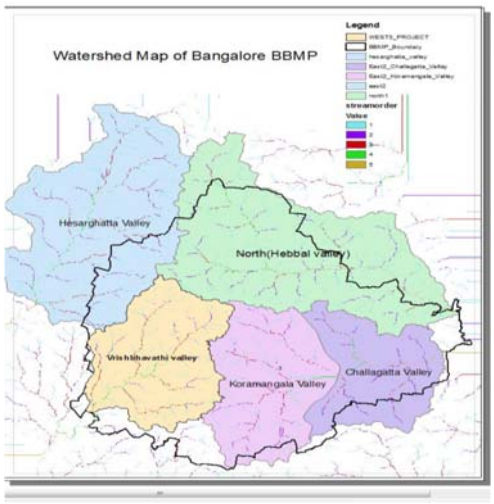

Fig No: 4 watersheds of Bangalore

Vrishabhavathi valley catchment, Koramangala valley catchment, Challghatta valley and Hebbalvalley catchment .Three of the valleys Vrishbhavathi valley, Koramangala valley and Chellaghatta valley, run in north to south direction.

A fourth major valley, referred to as the Hebbal valley forms the drainage zone of the north of theridge and runs in the northern direction. As shownin Fig: 3:

Drainage network of Bangalore

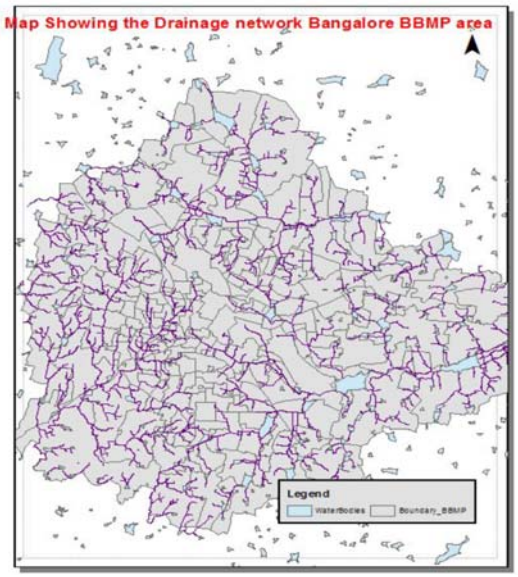

Fig no: 5 Drainage map of network of Bangalore

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The drainage system of Bangalore city comprises of 840 km length of Drainage network which includes primary and secondary drains. . The Drainage system has box type trench on either side of the road, these drains further connect to the secondary drains and then to the open channel drains lined with concrete retaining walls. According to survey done by the BBMP (Bangalore Mahanagara Palike), the average depth of the drainage system varies from 1.5 m to 5.8m and average width varies from 2 to 9m, however the larger drains have max width upto 48m.(source BBMP Master plan) (Ref:2)(fig no:4)

Floods in Bangalore

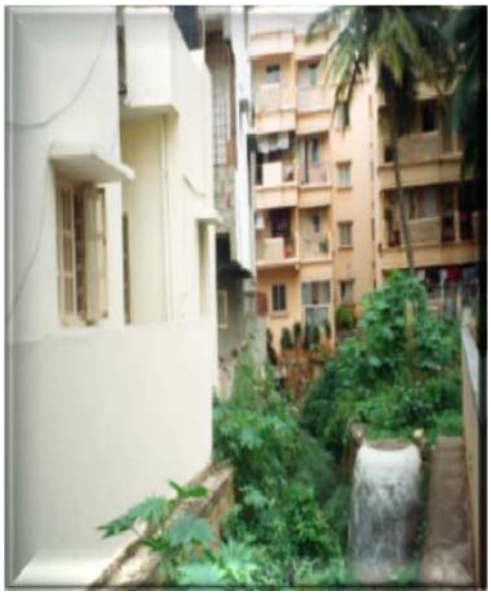
Since past few years during rainy seasons Bangalore city & its agglomerated ULB's areas are experiencing severe flooding problems at several locations resulting in submergence of low laying areas causing water stagnation at several locations, submergence of foot paths (restricting pedestrianmovements), and traffic hold ups for several hours,extensive damage to both life and property .This is mainly because of climate change and due to rapid urbanization. Growth of population in Bangalore during the last few decades has reached its peak.

There is an increase in the construction activities to meet the demands of the rising population.

The formation of tank beds into layouts, inadequate size of drains, increase in sewage generation, improper networking and maintenance of drains, dumping of garbage debris into drains, improper gradient,obstructions due to laying of utility lines/ across water ways, lack of awareness about importance of waterways, discharge of large quantity of sewage and industrial waste has led to this situation Fig no 7. Due to this the city is under extreme consequences during the time of heavy Rains

Fig No: 7 Encroached Drainages in Bangalore BBMP

Bangalore often experiences short duration but high intensity rainfall incidents causing flash floods In
view of the above facts, It is hazardous for the social and environmental attributes of the city and the city is under serious threat .Management of Flood is the only solution.



Urban Flood Management

The urban flood management system should be an integrated management system, in which proactive managerial strategies should be adopted. The proactive disaster management involves multidisciplinary agencies like the government, non-government private agencies. It also involves effort and time, Budget, equipment's, facilities and human resources .Strategic framework on integrated flood disaster management namely: 1) preparedness before flood impact such as flood forecasting and warning; 2) readiness upon flood arrival; 3) emergency responses during flood impact and; 4) recovery and rehabilitation after flood impact (Ref:1) should be practiced. The urban Flood management for Bangalore city is the responsibility of the Municipal Corporation. The Municipal Corporation of Bangalore is called the BBMP (Bruhat Bengaluru Mahanagara palike). The city also has many emergency departments which are of concern to the management of flood. For example Control rooms of BBMP, Fire services, the police; the city hosts many NGO like civil defense etc. All these departments can be integrated and involved to manage the floods in the city. Urban flood risk can be evaluated by understating the urban dynamics. In order to capture the dynamics of the varying climate, weather& rainfall a dense network of sensor suitable for the urban environment is needed. The urban flood monitoring has to rely on in situ monitoring. Various technologies like Remote sensing, satellite imagery, fiber optic, sensors etc. are

available which gives accurate near real time data.

We have initiated a project in association with civic authorities to monitor, model and forecast urban flooding for Bangalore. Rainfall is being monitored through 100 GPRS enabled Telemetric Rain Gauges at a density 1 to 4 sq km area in the city which is a unique model in the country. Meso-scale Rainfall forecast and high intensity and heavy rainfall alerts are being generated and sent at near-real time to the concerned authorities. Using rainfall Data and meso-scale forecast a Simple hydrological model for flood forecasting have already been developed and will be launched soon

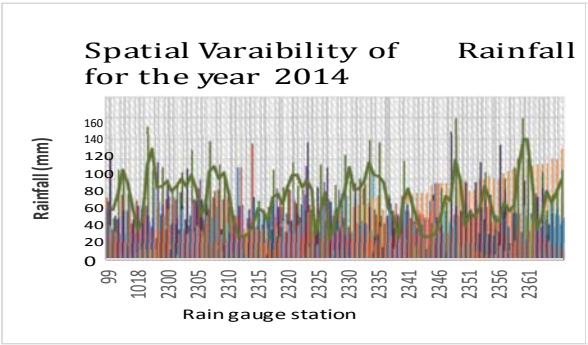
Variability of Climate and Rainfall in Bangalore region

Temperature increase

Temperature data for last 40 years for a particular station in the central Bangalore (Ref :) is referred and the graph shows an increase in the temperature trend of the city. This along with other climatic factors has led what is called the Urban Heat Island effect .Ref fig no: 9

Rainfall Variability

Due to the increase in temperature and other anthropogenic activities high intensity short duration rains occur causing flash floods. Recently Bangalore has witnessed flash floods. The rainfall variability during the monsoon 2014 is plotted as shown fig no 8. The Max daily rainfall recorded is 140.5 on the 9 th Nov -2014 and the Average daily rainfall is recorded to be 62mm on that day.



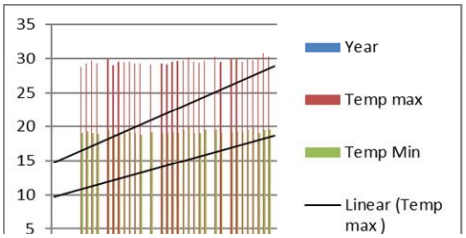


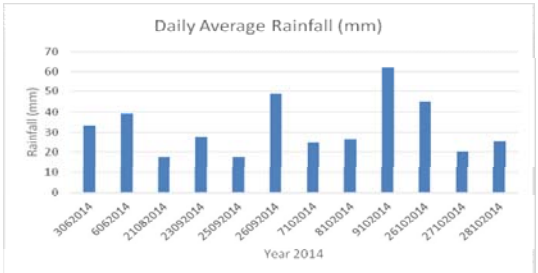
Fig no: 9 Graph indicating the temperature variability in

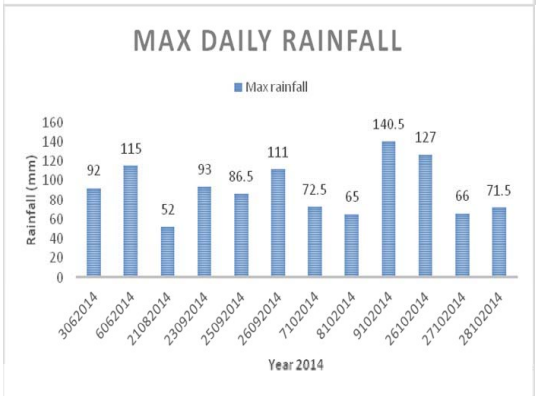
Bangalore BBMP during the year 1973-2014

Heavy Rainfall Case study for vrishbhavathi

Microwaterhsed

Heavy rains have struck bangalore during the month of November. The heavy rains were the effect of HUDHUD cyclone from the south east region. One such event study is made for the November 9 – 2014 rainfalls for the vrishbhavathi watershed region and the run off volume in the watershed is estimated. The vrishbhavathi watershed region consist of 9 rain gauges with the following charecteristics. (Table: no1) (Fig No: 9)





Sl.No	Name	Watershed Area	Length	No of
1	Vrishbhavathi Valley	34sq km	128km	191 nos

Fig no: 11 Ghali Anjaneya temple flooded on Nov 9th -2014

Sl.No	Length	Avg depth of drai	Avg width of drain	Total ying capacity drains	Carr of the
1	128km	2.21m	8.48m	724364.026cubicmtr	

Fig no: 9 Graph indicating Max
Daily rain fall year-2014

Fig: No 10 Map showing the Vrisbhavathi valley drainage network and rain gauge locations with

Drainage characteristic for vishbhavati vally as shown in the table no-2
The flooding in this region specially near the ghali anjaniya temple disrupted the life of southern Bangalore Fig. No-11

The study region is divided in to grids of 1sq. km. Thessian polygons are drown using the Arc Gis 10.1 and weightage average is calculated. The % previous and imperviouness is obtained from the LULC using the GIS Software. Volume of water in each grid is estimated and runoff volue is calculated. By using the rational formula the velocity of flow is also estimated.

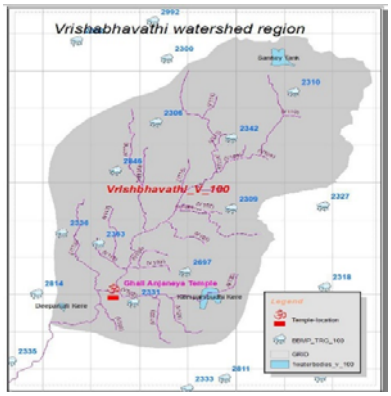


Table no: 3 showing the Runoff calculations for the Nov 9th 2014 Rains in Bangalore

Low laying	Rain	Drain id	Volume (M3)grid	%imperviOUS	Run off co-efficient	Run off Volume(M3)	Carrying capacity(SWD)	Check flood	0 (m3/SEC)	V M/SEC
	89		1143.370915	97	0.915957	1047.2791	16382.61707	FALSE		
	89	V121,V122	4162.113416	98	0.925664	3852.71737	2849.461074	TRUE		
Ranganaa circle BHEL Road	89	V100	11606.0954	94	0.891022	10341.2896	46877.17386	FALSE		
	89	V100 ,V101	22350.25648	98	0.934601	20888.5626	57248.59188	FALSE		
	89	V102, V121 , V122	21827.22931	97	0.92107	20104.4147	44438.90288	FALSE		
	161	V119	26317.89626	97	0.916146	24111.031	2156.001269	TRUE		
Vital nagar near kempegaowda nagar	229.5	V102,V103,V104,V117, V118	73314.47546	97	0.918239	67320.188	81437.72687	FALSE		
Rudrappa garden sambrudhi nagar	89	V103, V104	22599.62739	89	0.839317	18968.2436	8818.998666	TRUE		
Metro layout ward no 131 near Nayand	20.5	V119	3717.251674	98	0.933095	3468.54868	6925.798639	FALSE		
	140.5	V100, V117,V118	57275.63357	95	0.903757	51763.2677	80714.31245	FALSE		
	140.5	V100, V104, V105, V116	40761.17438	95	0.897166	36569.5474	47058.51187	FALSE		
	57	V105, V106	13777.38718	97	0.915418	12612.0664	7969.59843	TRUE		
Bhakshi garden	57	V106	6040.071449	100	0.948547	5729.2887	3478.665276	TRUE		
	20.5	V119	3575.217945	98	0.928182	3318.45229	4475.181073	FALSE		
	140.5	V116, V117	40683.63249	95	0.895245	36421.8168	4475.181073	TRUE		
12thcross Gubana layout industrial	57	0, V106,V107, V115,V116,V1	14119.85572	97	0.922142	13020.5144	4475.181073	TRUE		

area										
		100 ,V106, V107, V108, V108	13803.54456	99	0.940385	12980.6409	4475.181073	TRUE		
	57		6352.882615	100	0.95	6035.23848	4475.181073	TRUE		
	57	V116	13998.72962	94	0.8875	12423.8725	4475.181073	TRUE		
8th cross 6 block sankrappa garden	57	V115,V116,V116A	14638.39782	97	0.920077	13468.4564	4475.181073	TRUE		
	57	V100,V111, V112, V115	15252.56063	98	0.928805	14166.6606	4475.181073	TRUE		
	57	V100 ,V109,V111	11587.10719	93	0.878112	10174.7731	4475.181073	TRUE		
	57	V206	2.418463837	96	0.908466	2.19709327	4475.181073	FALSE		
5th main 8th cross N.R Gardenchology	57	V116	24.53811737	97	0.918907	22.5482409	4475.181073	FALSE		
	57	V112	26.59779472	96	0.914355	24.319814	4475.181073	FALSE		
	57	V112,V113,V114	16054.18064	96	0.909654	14603.7525	4475.181073	TRUE		
	57	V100 ,V110, V111	14887.2962	96	0.908457	13524.468	4475.181073	TRUE		
	57	V110	11898.37102	86	0.806593	9597.14132	4475.181073	TRUE		
	57	V203	227.6165543	98	0.925207	210.592341	4475.181073	FALSE		
	57	V112	6833.766897	95	0.901735	6162.24365	4475.181073	TRUE		
	57	V112, V114	16123.19712	98	0.93367	15053.7382	4475.181073	TRUE		
	57	V100	8650.402232	97	0.921981	7975.5037	4475.181073	TRUE		
	57	V202	2.885945035	100	0.95	2.74164778	4475.181073	FALSE		
	57	H100	393.1733757				4475.181073	FALSE		
			1073416.876			***947040***	***500335.2***		***263.1***	***7.737***

The following was observed after the analysis

- Area of the watershed=34sq km volume of water generated in the vrishbhavati watershed on nov 9th 2014=1073416.876 cubic mts
- Runoff volume=947020.070 cubic mts/sec
- Carrying capacity at point A=724364.026 cubic mtr
- The runoff volume is more than 1.5 times the carrying capacity of the drain at the outlet.

Conclusion

It is necessary to have a good monitoring system in order to have a good strom water management system. A Good early warning and alert system can be useful to predict floods. By using the data from the 100 telemetric rain gauges, the run off volume at the vrishbhavati vally is calculated and it is evident that the existing drainage network is not accommodative for the huge run off generated on the nov 9th 2014 heavy rains. Due to this the city life was distressed leading to great loss. Bangalore being susceptible to such situation a good strom water management practices is inevitable. Urban flooding is an upcoming problem and an integrated system with technology driven solution is the need of the decade.

Reference:

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Problem of civil and environmental engineering, faculty of science and technology. Nakhon pathom rajabhat university, Nakhon, Pathom- 73000, Thailand.

2. Master plan remodeling of strom water drains in eight zones of Bruhat Bengaluru Mahanagara palike

3:http://en.wikipedia.org/wiki/Bangalore_geography and environment

4. http://www.tutiempo.net/