Urban Flood: Case Study of Bhopal

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Urban Flood

Flooding in cities originates from high flows and may be due to sudden meteorological disturbances. Human activity influences the frequency and severity of floods, Physical damages and the consequences of pollution caused by urban flooding now days are challenges. Blocked drainage pattern and encroachments in low lying areas make urban flood more disastrous.

The destruction of the wetlands may also contribute to moderate floods. The only place where flood water can go is over its normal riverbanks and into low lying areas where it cause major damage. The purpose of planning strategies is to put forward a set of approaches for flood mitigation and management with due attention to Bhopal flood occurrence so that it would be helpful for other similar urban flood in the future.

Urban flood mitigation is a site-specific task, needs institutionalised approach through local governments under integrated concern of various concepts, measures, and techniques.

Profile Of The City

History

A cartographer's definition of Bhopal would read 23016'N and 77036'E with a maximum elevation of 550 meters above MSL spreading over seven hills. Historically, Bhopal was also the name of a Muslim princely state in central India. Bhopal, being capital of Madhya Pradesh, is the ideal base for discovering the rich historical and cultural legacy of the state. Close to the city and easily accessible by road and rail are incident sites of great dynasties, forts, monuments and cave sculptures, some of the finest examples of Indian art and architecture, chronicled in stone of the states unique heritage of fine antiques. It is the 11th century city Bhojpal, founded by Raja Bhoj, but the present city was established by an Afghan soldier, Dost Mohammed (1707-1740). His descendants build Bhopal into a

* Contributed as Bhopal city team under National Coordinated Project of NIDM (Gupta, Anil K. and P.G. Dhar Chakrabarti, *Disaster & Development*, 3 (1):1-14, 2009)

beautiful city. The 284.90 square kilometers of undulating landscape of Bhopal, well punctuated with water bodies lies sand-witched between the Malwa plateau on the north and the Vindhyas to its south. Bhopal, the City of Lakes has stuck to its name because of twin lakes, i.e. Upper and Lower lakes, which provide livelihood and add to scenic beauty. The wide stretched landscape gives this city a beautiful look, housing one of Asia's largest Mosques, Taj-ul-Masjid. The old monuments in the walled city symbolize the aristocratic part of Bhopal. The upper lake presents perfect setting for water freaks in the city.

Table 1: salient features of Bhopal at a glance

Latitude & Longitude	23°16'N and 77036'E
Planning area	601 sq.kms.
Municipal area	286 sq. km.
No. of Wards	66
Population (Census 2001)	1437354
Population density	663 persons per sq. km.
Literacy rate	79.8%
Work participation rate	10.3 %
No. of water bodies	18

Few state capitals in India have a history as eventful as Bhopal. The city of Bhopal has witnessed many changes since it was found by the Afghan soldier Dost Mohammed in the year 1708. The city has been through many phases, gentle as well as turbulent, prosperous as well as disastrous. Bhopal has been a city in which one finds traces of cultures as different as those of Buddhists, Hindus, Mughals and Afghans, all of which have been blended to perfection, providing Bhopal a distinct identity.

The genealogy of Bhopal can be tracked back a millennia, when it was Bhopal, the 11th century city of the legendary. Raja Bhoj , who has the credit for the construction of the Upper Lake. In the early eighteenth century, an Afghan soldier, Dost Mohammed Khan flees Delhi in the chaos following the death of the Mughal Emperor Aurengzeb in 1707. A beautiful Gond queen Rani Kamlabati seeks his successor after the murder of her consort. After the demise of the last Gond queen, Dost Mohammed Khan took over the reins of power and builds for himself a capital, some 11 kilometers from present day Bhopal, christening it Islamnagar, 1819 to 1926 was the era of the famed Begums. During the period of British hegemony over India, Bhopal was the second largest Muslim state. It was in this period that Bhopal witnessed the arrival of the first train and the formation of a modern municipal system. In 1949 it acceded to the Indian federation and on November 1, 1956 saw itself as the capital city of the newly carved state of Madhya Pradesh. Madhya Pradesh was originally the largest state in India until November 1, 2000 when the state of Chhattisgarh was carved out.

The city of lakes, Bhopal, is comprises of old Bhopal and new Bhopal. Both the new Bhopal and the old Bhopal have its own cultural and social importance. Being the capital

of Madhya Pradesh, it is indeed one of the important cities of the country. The origin of the city dates back to the eleventh century when Raja Bhoj founded the Bhojpal City. Bhopal has been ruled by several famous dynasties like the Mughals, Rajputs and the Afghans. The city is gifted with natural landscape and beautiful manmade structures like monuments, lakes, temples and mosques along with contemporary buildings like new Vidhan Bhavan, Judiciary complex etc . Bhopal, city combines scenic beauty, historicity and modern urban planning.

Bhopal today presents a multi-faceted profile, the old city with its marketplaces and fine old mosques and palaces still bears the aristocratic imprint of its former rulers, among them the succession of powerful Begums who ruled Bhopal from 1819 to 1926. Equally impressive is the new city with its verdant, exquisitely laid out parks and gardens, broad avenues and streamlined modern edifices. It is greener and cleaner than most cities in the country.

Topography

Bhopal has the undulating topography with hilly terrain that hops in quick drainage of surface water. In the rainy season water passes quickly through the drains and joins either in lakes or low-lying areas. The main rock types is the Deccan trap and basalt that holds soil up to few inches and allow growing vegetation. The eroded soil deposition at some of the places provides deep soil strata but below that the stony strata exist. However, maintaining of vegetal cover and holding of water in such condition is difficult as the fractured rocky strata do not hold water and thin layer of soil is not sufficient to hold the vegetal cover. The black cotton soil has less water holding capacity and upper layer of the soil quickly dried up that suppress the vegetation. In summer this problem intensified as most of the vegetation becomes dried and soil develops deep cracks due. Although surrounding area of the lake has sloppy land with ridges and furrows that drains storm water in the lake during rainy season.

Hydrology

Bhopal city is embedded with 18 water bodies of diverse sizes, located in and around the city. However, people are more familiar with only 5-6 water bodies because of their proximity to the city dwellers. Bhopal city receives water supply through lakes, especially Upper Lake and Kolar resevoir. Some irrigation reservoirs such as Hathaikhera, Kerwa and Laharpur, earlier located in the outskirts of city, have now become an integral part of the city due to expansion of city in all the directions. Following are the water bodies of Bhopal:

Table 2: Water bodies in and around Bhopal

Name of water body	Water Spread Area (in ha)	Present Use
Upper lake	3100	Water supply and recreation
Lower lake	129	Raw water supply and recreation
Shahpura Lake	96	Recreation
Motia Tank	1.89	Recreation
Siddiqui Hassan Tank	1.0	Recreation
Munshi Hussain Khan Tank	1.2	Recreation
Lendiya Pond	1.5	Recreation
Sarangpani Lake	4.2	Recreation
Kaliasote Reservoir	126	Irrigation
Laharpur Reservoir	350	Irrigation
Hataikheda Reservoir	113	Irrigation
Halali Reservoir	1625	Irrigation
Kerwa Reservoir	524	Irrigation
Kolar Reservoir	2850	Potable water supply & Irrigation
Char Imli Pond	1.2	Recreation
Ayodhya Nagar Abandon stone Quarry ponds (4 Nos.)	6.0	Recreation
Damkheda village pond	2.4	Potable water Recreation
Neelbad Abandon Stone Quarry Pond	4.5	Recreation

With rapid urbanization and consequent changes in the demographic structure especially during second half of last century all these water bodies have become subjected to various environmental problems. This resulted in deterioration of water quality through inflow of sewage, solid waste dumping, flourishing growth of invasive aquatic plants and, depletion of bio-diversity and other anthropogenic activities. The historical pond of Siddiqui Hussain has become abandoned due to siltation and excessive growth of terrestrial and aquatic plants. A part of this pond has been illegally refilled for construction of residential houses. There are four abandoned stone quarries

in the outskirts of the city near Neelbad and Ayodhya Nagar, which has been converted into small ponds. These ponds receive spring water and maintaining water level round the year. Damkheda village pond is being used by the villagers/residents for water supply, nistar and other secondary purposes besides recreational use:

Land Use

Provision of open spaces, green areas, green belts in master plans is important for city health. Landscape parks, plantation along roads, trees in public spaces maintain the micro climate within city. Native vegetation of Bhopal's uneven terrain includes trees, saplings, shrubs and also plants in wetlands help to make Bhopal green all over. Plantation helps to manage flooding and rain water retention. Vegetation of flood prone areas should be considered in flood management plans.

Distribution of land use in the Planning Area is determined by the Town and Country Planning Department, which formulates perspective development plans for the city, outlining issues, priorities and goals for managing urban growth. The first Bhopal Development Plan 1991 – BDP 1991 (addressing the period 1975 – 1991) - established broad guidelines for the city's development, which have been carried over —- with a few modifications —- into the next plan, BDP 2005. A feature of the first plan was it's attempt to integrate environmental issues in growth management. The Plan identified sensitive areas and adopted measures to ensure their protection. This approach is reflected, to a certain extent, in BDP 2005. BDP 2020 is currently under preparation.

The BDP lays down the basis / guidelines for development by making broad allocations of land for various sectors of growth —- residential, commercial, industrial etc. Based upon this, Bhopal Municipal Corporation may prepare Zonal Plans detailing provision of infrastructure, circulation …etc. The Urban Local Body, Bhopal Development Authority and the MP Housing Board are responsible for implementation of Development and Zonal Plans. In keeping with the physical characteristics outlined above, relatively low-rise development, interspersed with dense vegetation, has been promoted in the city so far. BDP 2005 anticipated the city to grow to a population of 25 lakh by the end of the perspective period. However, this projection has not been realized, and growth pressures have been less than anticipated —- due, in large part, to the bifurcation of the State, as well as the stabilization and consequent deceleration of industrial growth.

Current land use in the planning area, reflecting the city's unique locational context is presented in Map 3.4 (based on satellite imagery - May 2005 - 5.8 mts. resolution). The main features of land use in the Planning area are as under:

- Bhopal Municipal Area occupies about 286 sq. kms within the planning area extending over 601 sq. kms. The area lying outside the Municipal boundaries is largely rural, with 58 % (18,605 hac.) of the land area being agricultural and fallow land. Most of the cropped area seen is located to the north, east and south east within the planning boundary.
- Of this area, another 27% is barren and open land / quasi land. Scattered village settlements occupy barely 2.2 % of the land area.
- Only .85 % of the area (Planning Area excluding Municipal Area) lies under urban land uses —- ribbon development along the road leading to Vidisha to the North, and Kolar road to the south. The main thrust of development is along Kolar road, due to the availability of ground water in the area, as well as the proximity to Mandideep industrial area.
- Nearly 3,338 Hac. or 5.6 % of the land area falls under water bodies (rivers, lakes, ponds, reservoirs…etc) and marshy lands. (Based on pre-monsoon satellite imagery, May 2005)

Land use allocations, as per the BDP 1991, for the urbanized area of the Planning Area are given in the table below. Level of implementation, and allocations made in BDP 2005 are also given:

Table 3 : Land use Variation (1975 – 91) and Allocation – 2005

Land use	**Land allocation, BDP 1975 -1991 (Hac)**	**Habited area, 1994 (Hac)**	**% of Total Area**	**Level of Implementation (%)**	**Proposed Area, 2005 (Hac)**	**% of Total Area**
Residential	4050	3660	46.2	90.37	8190	46.48
Commercial	405	243	3	60.0	650	3.71
Industrial	1135	692	8.73	60.96	1389	7.93
Public and Semi-public	1215	912	11.5	75	1258	7.18
Public Utilities	280	200	2.5	71.42	488	2.78
Recreational	1415	1153	14.55	81.48	2925	16.71
Transportation	1620	1062	13.4	65.55	2600	14.85
Total	**10120.0**	**7922.0**			**17500**	**100.00**

Source: Bhopal Development Plan, 2005

With regards to the above land use allocation, recreational land uses account for nearly 15 % of habited area —- reflecting forest and forested slopes, water bodies…etc, which have been excluded for development, in the midst of the city. Public and semi-

public uses account for 11.5 % of habited area, indicating the administrative function of the city, as well as large cultural institutions located here.

Forest Cover of Bhopal

The planning area of Bhopal covers about 22% (601 sq.km.) of the total geographic area of the Bhopal district (2772 sq.km) and covers the entire Bhopal city and its immediate surroundings. The forest cover of Bhopal district accounts for 15.87% of total geographic area as against the forest cover of 8.2% within the planning area.

(sq.km.)

	Bhopal District Area	**Planning Area**
Total Geographic Area	2772	601
Green Cover	440	49.27
Percent	15.87	8.25

Source: Forest Survey of India

Vegetation Status (Planning Area)

Vegetation High Density	13%
Marshy Vegetation	4%
Vegetation Low Density	83%

Vegetation Type	**Area (sq.km.)**	**Percent**
Vegetation Low Density	40.78	82.76
Marshy Vegetation	6.28	12.75
Vegetation High Density	2.21	4.49

The planning area of Bhopal includes the following categories of green cover

1) Recorded Forest Area

The recorded forest area is defined as the "Geographic areas recorded as forests in Government records'. It is categorized into Reserved Forest and Protected Forests and falls under the State Forest Department.

There are four patches of Reserve Forest and Protected Forest (RF/PF) falling partially and/or wholly in the planning area and covers 0.35% (2.10 sq.km.) of the planning area. The RF/PF's are mostly located towards the fringes of planning area. The details of RF/PFs are as follows:

Forest	Area (sq.km.)
Rozibeh Protected Forest	0.08
Bhopal Reserve Forest	1.68
Raisen Reserve Forest	0.31
Bhopal Reserve Forest	0.03

2) Revenue Forest

In addition to the above, a number of revenue forests designated as Chote Bade Jhad Ka Jungle or Narangi Kshetra or simply defined as forest in the revenue records are found in the planning area. These areas are under the administrative jurisdiction of the District Collector. Since technically they cannot be used for any other purpose, they tend to be neglected, and consequently encroached. The total area of revenue forests within the municipal limits of Bhopal is about 1.95 % (11.75 sq.km.) of planning area.

3) Large scale plantation

The Capital Projects Administration through forestation and plantation activities has planted 516 identified centers with 12 lakh trees over last 20 years. The plantations are done on road sides, barren hills, identified parks etc. The plantations were also done over 986 ha of land under Bhoj wetland project. The CPA has proposals for greening more parts of the city and surrounding.

4) Recreational Parks in Bhopal

To cater to its population of more than 18 lakhs, Bhopal has a total of nearly 100 public parks varying in size, utilization, upkeep and maintaining agencies. In 1971 when the CPA became active, the Bhopal city was brought under heavy plantation through integration of several gardens into city developing plan. To name a few parks within the Bhopal city, the following gardens provide green lung to the fast growing city.

(i) Kamla,
(ii) Kilol,
(iii) Vardhman,
(iv) Firdaus,
(v) Nilam,
(vi) Mayur,
(vii) Chinar,
(viii) Ekant and
(ix) Rose Garden.

Ekant Park is spread over an area of 600 acres and is heavily planted to give it a forest impression. However, other parks still have scope of more woody plantations.

5) Protected Area-Van Vihar National Park

Van Vihar National Park is declared a national park in 1983, and covers an area of about 445 ha. It is located at the foot of Shyamla Hills, overlooking the Upper Lake. Van Vihar National Park, Bhopal is the only ex-situ conservation area that has been given provisional recognition by the Central Zoo Authority (CZA). Though, this area has been notified as a National Park in order to provide adequate legal protection, it is being managed as a modern zoological park. Here the captive wild animals have been kept in near natural habitat setup. Amongst the animals found here the tiger, white tiger, lion, bear, white bear, jackal, hyena, crocodile, alligator, turtle, peacock, drongo and python are preserved. The vegetation statistics derived from the satellite image interpretation of the planning area that about 66% area of VVNP is non vegetated and only 33% area falls under vegetal cover. This data attracts the urgent attention towards the condition of VVNP. The national park is highly degraded and needs afforestation activities to be undertaken.

The table showing green cover within planning area is given below.

Green Cover	Area (sq.km.)	Percent of Planning Area
Recorded Forest Area	2.10	0.35
Revenue Forest	11.75	1.95
Van Vihar National Park	4.45	0.74
Recreational Parks and other green areas	31.00	5.15

Forest Types of Bhopal

The forest, within and around Bhopal city is young and of southern tropical dry deciduous type. The forest found in Bhopal is mainly of three types:

- Deciduous teak forest
- Foot hill teak forest
- Mixed forest

The major species found in this region include the following

Table 4 : Major Tree Species found in the Planning Area

S.No.	Common name of tree spcies	Botanical Name
1.	Teak	Tectona grandis
2.	Salai	Boswellia serrata
3.	Jhingan	Lannea grandis
4.	Dhaman	Grewia tilliafolia
5.	Tendu	Diospyrus melanoxylon
6.	Bhirra	Chloroxylon switenia
7.	Palash	Butea monosperma
8.	Khair	Acacia catechu
9.	Reunja	Acacia leucophlea
10.	Raibans	Dandrocala musstrictus
11.	Katangibans	Bambusa arundinacia

Source – Bhopal Development Plan 2005

Forest Status & Restoration Activities in Progress

The RF/PF is located towards the periphery of planning area and comprises of low dense vegetation. These are under jurisdiction of State Forest Department and require attention towards afforestation and better management towards achieving the good density, healthy forests.

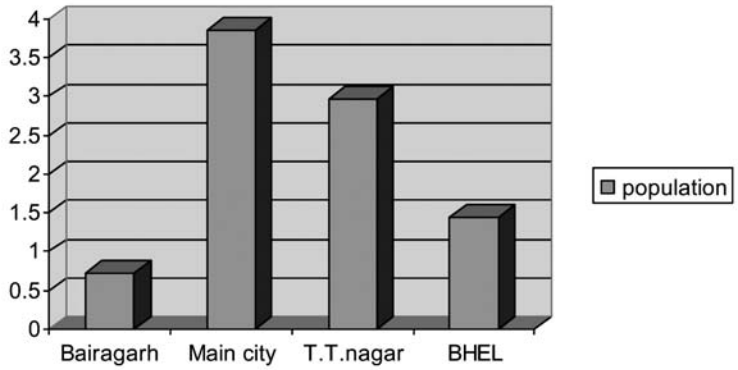
The current management practices of Van Vihar National Park are based on CZA guidelines. The area consists of degraded hillocks with intervening forest patches. The vegetation in the area is scanty with lot of denuded patches. The CPA carried out around 40 ha (8.76% area) of miscellaneous plantations. However, more afforestation needs to be done. The area is also infested with weeds such as lantana and parthenium. Weed eradication has been done only on small scale to make space for fodder growth. The fodder farm and grass plantation being done is not sufficient to meet the requirements of resident animals and needs to be scaled-up.

The existing revenue forests which are presently not under the ownership of the forest department needs protection. Such open and degraded forests, includes under stocked forests, blank and medium stocked forests which can become under stocked due to increase in biotic pressures which includes illicit felling, indiscriminate grazing etc.

Rainfall pattern

Bhopal has fewer records of flood, in the year 1973 and 2006 flood occurrences resulting in loss of life and property due to high rate of uncontrolled urbanization. The average yearly rainfall (2006) recorded in Bhopal district is 1154.2 mm. The Bhopal and its surroundings receive 900- 1200 mm average and normal precipitation. However, Bhopal has faced severe drought on account of less precipitation (Below 800mm) in the year 2000 - 01 and 02. The recharge of rain water for the Bhopal is very important because the water supply of the town depends on the rain water collected in lakes.

Demographic and settlement pattern: As per census 2001, the total population of Bhopal city is 1437354 distributed in 66 wards. As per Master plan 2005 (Census 1991), a study of existing residential built up areas has revealed that the net residential density varies between 113 persons per hect. to nearly 2286 persons per hect, The highest density would continue in central area. A gross density of nearly 305 persons per hectares has been adopted as a basis of assessment of requirement at sector level which will give approximately a net residential density of 610 persons per hect.



Areas wise Population density (as per master plan 2005, census 1991)

The city is bifurcated in two. Old Bhopal with its crowded markets, huge mosques and palaces represents the pristine glory of the bygone era. To the south beyond the lakes is New Bhopal with its broad avenues, high-rise offices and leafy residential areas presenting examples of the marvels of the modern era. The major location of work centres within the planning area included state capital complex on area hills and district administration centre and main business centres in the old city area. The BHEL, the public sector undertaking unit, trade and commerce establishments, in new market, M.P. Nagar, Old city and Bairagarh. First city survey was conducted in 1916

after the enactment of Municipal act. Upto 1956 the areas under Bhopal Municipal limit was very small, but after that few more surrounding villages were added to it. The total area under Bhopal municipal limit reached to 71.23 Sq. Kms by 1975. At present total area under Bhopal Municipal Corporation is 285 Sq. Kms. In 1983, Bhopal Municipal Council got the status of Municipal Corporation, with total 56 wards. Presently, city is demarcated into 66 municipal wards (14 zones). A total area of the present planning area as per Bhopal master plan 2005 is 601 Sq.kms. The limit of present planning area Bhopal covers, areas of Bhopal Municipal Corporation, Bairagarh, B.H.E.L, and 135 urban & rural villages .

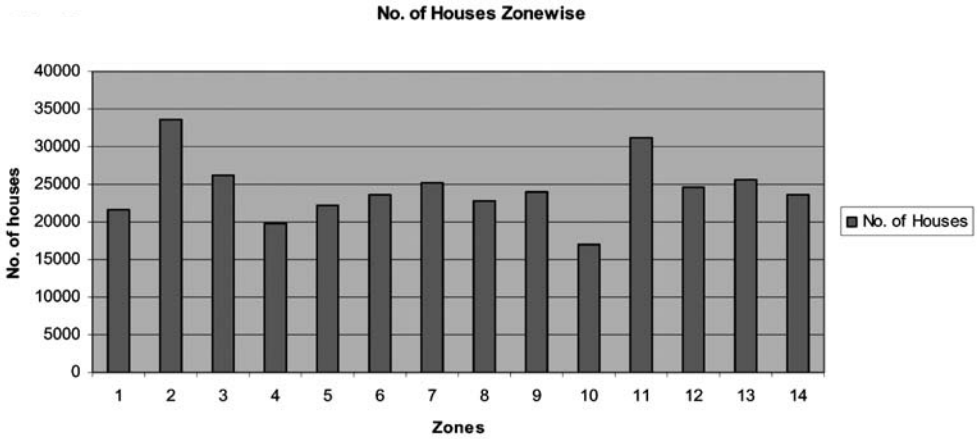


Figure 2: Zone-wise information of no. of houses

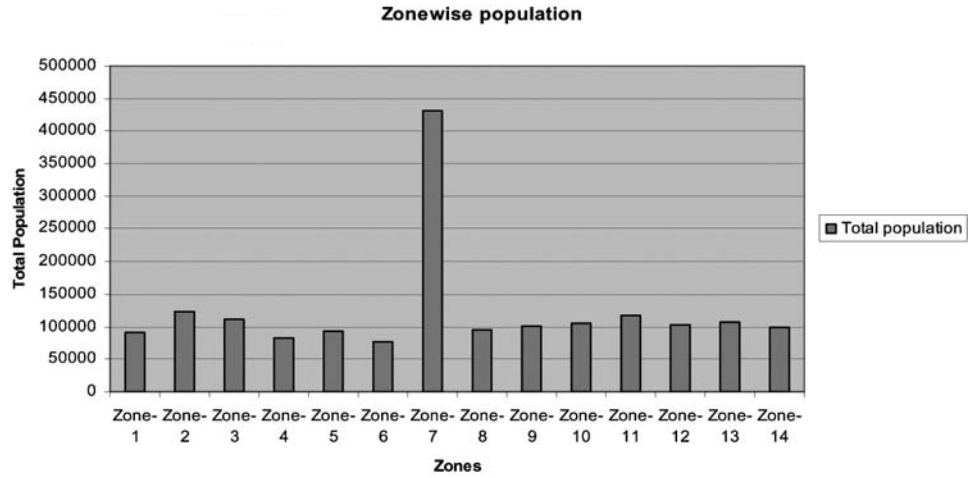


Figure 3: Population distribution among 14 zones (66 wards)

Slum Population

As per studies carried out by the Directorate of Town and Country planning nearly 1.7 lakh population is living in jhuggi-jhopdi and slum settlements, occupying strategic and precious locations and critical drainage basin. Certain areas which have become central to the city growth occupying high value land and are subjected to land use pressure due to adjacent commercial areas are proposed to be treated as regeneration areas, few areas are Juggis settlemst in BHEL and other areas, dilapidated areas within the walled city etc. Slum areas in vicinity to water bodies directly affect the water quality. Any discharge from the slum reaches into the water bodies including open defecation adopted by the slum dwellers deteriorating the water quality. Slum settlement in low lying areas choke the flow of rain water causing severe health problems and contaminates the ground water in long term. The residents of juggis are the service population for the work centres and residential areas, distributed in all use zones. Relocation of juggis in the use zones, except in catchment areas of lakes and recreational area and area of proposed roads, shall be permissible (as per Bhopal Master Plan 2005). Although the regulations are formulated but encroachments and avoidance of rules and regulations regarding city planning cause problems and lead to disputes which sometimes results in delays. Considerations to catchment areas in city planning are needed.

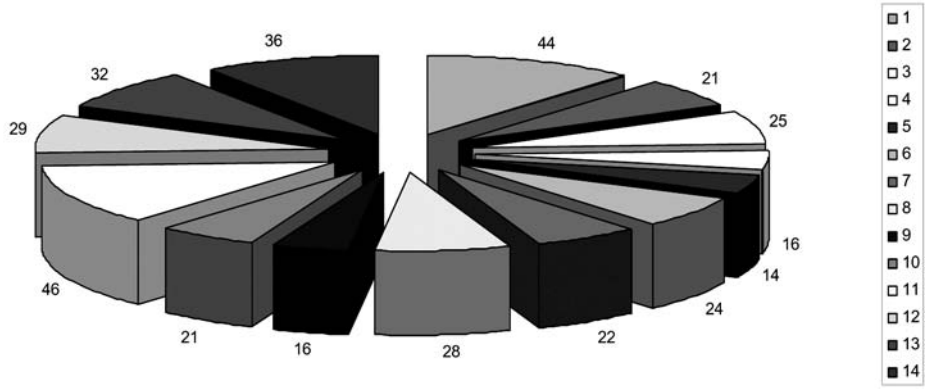


Figure 4: Distribution of Slums in 66 wards (14 zones)

Year	population	increment
1951	102333	
1961	222948	120615
1971	384859	161911
1981	671018	286159
1991	1063662	392644
2001	1437354	373692
	Total	1335021
	average	267004.2

Bhopal Development Plan was published in 1975 for the planning area of 241 sq.kms.The population of Bhopal in 1956 was 85,000 at the time of declaring it as a state capital was confined within the walled city as grown into a metropolis with around 14 lakhs inhabitant in 1993 (1991 census-10.63 lakhs). During the last four decades the urban population of Bhopal has increased at an average decade growth rate of over 70%. Thus the requirements of water, land, infrastructure, traffic and transportation etc. have to be planned for growing demand.

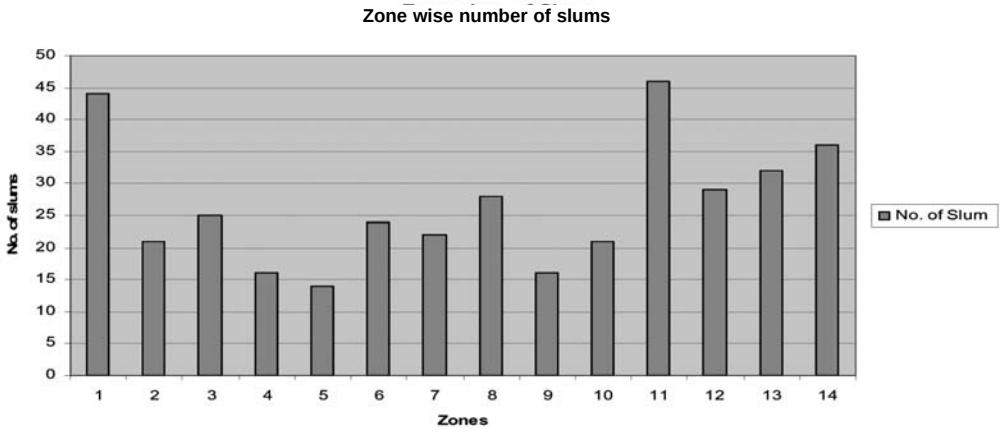


Figure 5: Zone wise number of slums

Socio-economic and cultural importance:

Occupational status, immigration, out migration, religious practices, food habits, climatic adaptation and historical background comprises of socio-economic and cultural statement of any settlement. Bhopal was once a predominantly Muslim city prior to independence, residing in the old city, is known for their sophistication. Bhopal is famous for every big festival such as Diwali, Holi, Eid etc. Bhopal has many monuments and 3 world heritage sites within and outside city limits respectively. The Taj-ul-Masajid is one of the largest mosques in Asia. Bharat Bhavan is the main cultural centre of the city and of the most important cultural centers of India. It has an art gallery, an open-air amphitheatre facing the Upper Lake, two other theatres and a tribal museum. Indira Gandhi Rashtriya Manav Sangrahalaya (National Museum of Man) showcases the various hutments that tribals of across India use for shelter. Bhopal being capital consisting of mixed culture and represent all districts of state.

In terms of economic scenario Bhopal has 10.3 % of work participation rate and the literacy rate is 79.8 %. According to 2001 Census, the city had 898 females per 1,000 males which is almost equal to the State average (Urban) of 912 females per 1,000 population, but it is lower than the other class I cities of the Region which have not been subjected to sudden migration and are socially more stabilized. Bhopal serves a large geographical area and it has extended not as a single city but as a discrete townships of the old city and its periphery, T.T Capital Township: Bairagarh (Location of army cantonment); Bharat Heavy Electrical Limited (BHEL). Township which was set up in the 1960's and was one of the largest public sector engineering companies in India, attracting additional investment and providing a large source of employment in Bhopal and other new areas. There are two industrial estates in close proximity: Mandideep with 32 large and 252 small and medium enterprises; and the newly developing Pilukhedi with 6 large and 3 small and medium sized enterprises. The service sector is becoming increasingly important provides the majority of employment in Bhopal. banks and insurance companies ,hotels and restaurants, hospitals, educational institution and shops. The sectors seems to be growing fast in Bhopal are housing, banking, insurance and education. The state economic development policy proposes Bhopal to be developed as a center for educational and institutional hub at all levels. Now a days Bhopal has become also attracting investors from all over the country.

City Infrastructure With Special References To Drainage

Roads: Bhopal is well connected with other parts of the country through roads, railways and air. Three National Highways are passing through the Bhopal and connecting to different parts of the state and country. As per Master plan 2005, the proposed roads (transportation) will facilitate the traffic in city. For proper traffic and transportation, the existing roads of city should make free from encroachments to serve the growing demand.

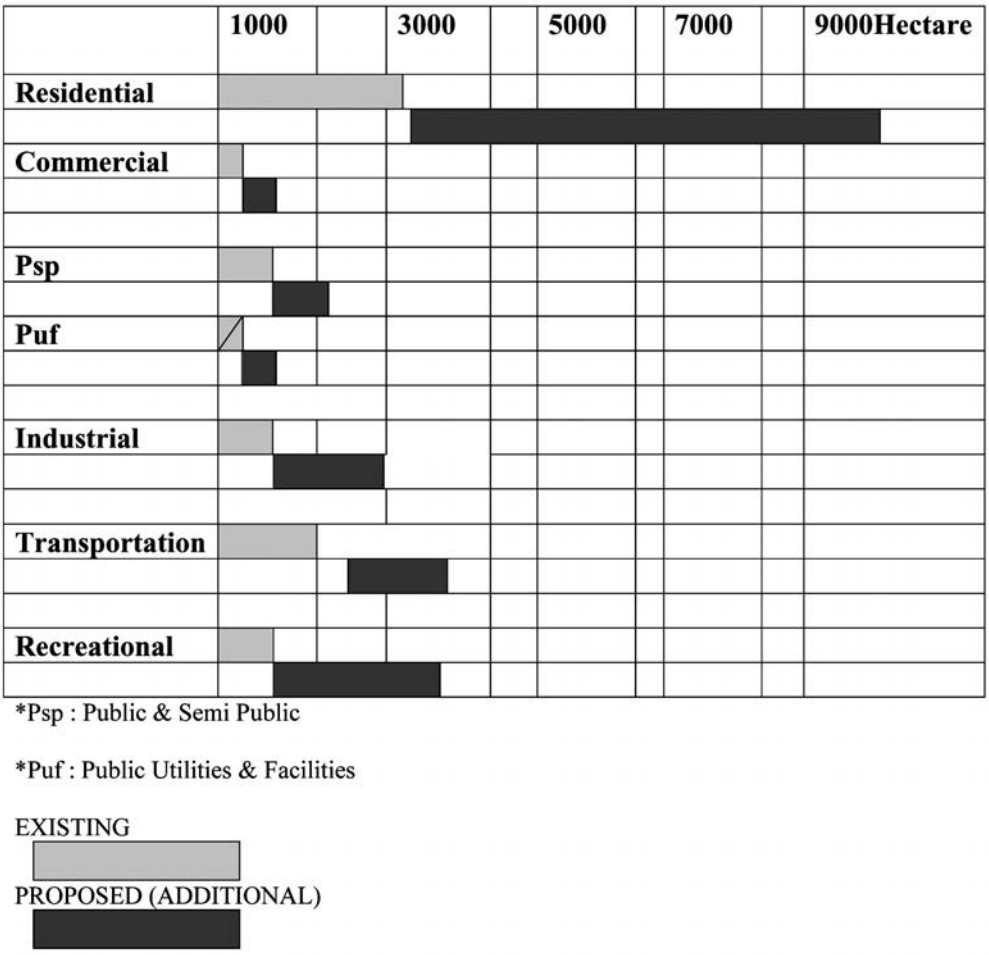


Figure 6: City Level Land use allocation (Bhopal Master Plan 2005)

Solid Waste Management

The Bhopal being an old and developing city, Bhopal Municipal Corporation (BMC) ensures regular cleanliness through collection and disposal of solid waste. Solid waste in different wards is collected using heavy vehicles with number of attendants. Presently in Bhopal open dumping at Bhanpura land fill site of is in practice. Other proposed landfills sites at Admapur Chhawni, raisen road and Fatehpur Dongra at Ratibarh are are identified per instructions of concerned agency.

Table 5: Municipal Solid waste status of Bhopal city

Quantity of waste generated within Municipal limits	500 MT/Day
Quantity of waste generated per capita	300-315 gm
Fleets of vehicles (BMC)	110 Nos.

Growing population contribute to augmentation of solid waste in city that need to manage timely with optimum use of resources under skilled manpower.

In Bhopal, BMC reports the total quantity of waste generated is about 511 MT/Day, in the municipal area of 285 Sq.km. The exact quantity and characteristic of waste produce in Bhopal is not known. Presently Bhanpur village trenching ground is used for dumping municipal waste. There are no proper arrangements for disposal so most of the refuse vehicles do not reach the disposal site. The average per capita generation of solid waste is 300-315gram.

The BMC reports that 60% of the city area is cleaned and swept daily, 30% twice per week and 10% fortnightly. The proposed site for disposal of solid waste are Aadampur chawni near Raisen road and Fatehpur dongra near Ratibad are 44 acres and 40 acres respectively.

Table-6 : Quantification of Solid Waste Generation

Table- Quantification of Solid Waste Generation from Various Sources			
Domestic	**511 MT/day**	**Vegetable & fruit market**	**25MT/day**
Commercial	38 MT/day	Construction	3 MT/day
Hotels & Restaurents	12 MT/day	Garden	0.75MT/day
Institutional	55 MT/day	Industrial Waste	105 MT/day
Bio-medical waste	3 MT/day	Slaughter	5 MT/day

Municipal Solid Wastes (Management & Handling) Rules, 2000 (MSW Rules) are applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid.

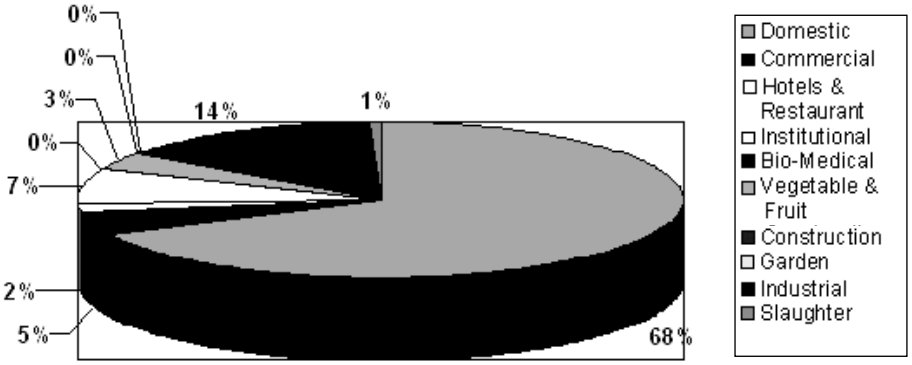


Figure 7: Quantification of solid waste generation from various sources: Bhopal city

Waste generation and Composition

Total quantity of waste generated in the country (based on weighment exercise by local bodies) is not reported. However, Ministry of Urban Development in its manual on solid waste management (year 2000) has estimated waste generation of 100,000 MT. CPCB with the assistance of NEERI has conducted survey of solid waste management in 59 cities (35 metro cities and 24 State capitals - 2004-05). The details Municipal Solid Waste in the Bhopal city are given in Annexure- 1

Table 7: Municipal Solid Waste characterization

Name of City	Compostables (%)	Recyclables (%)	C/N Ratio	HCV* (Kcal/Kg)	Moisture (%)
Bhopal	52.44	22.33	21.58	1421	43

Source: www. cpcb.nic.in

Drainage system

Bhopal is falling within the Betwa river Basin, which is a tributary of Yamuna River system..The part of Yamuna river basin is falling in the Madhya Pradesh Territory, but river Yamuna is flowing mainly in the State of Uttar Pradesh. The major tributaries of the Yamuna basin having catchment area in the Madhya Pradesh are as follows:

Fig - 8 Municipal Solid Waste Characterizations

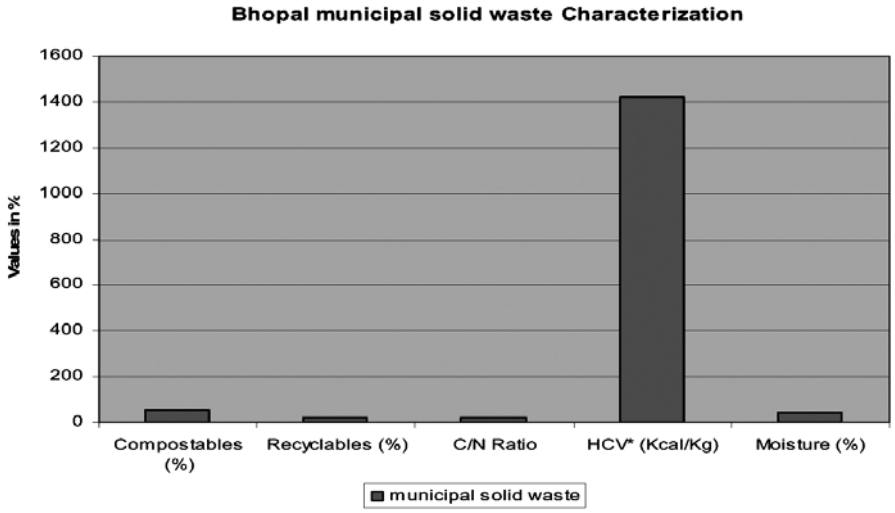


Fig-9 -Zone wise information of Waste Generation

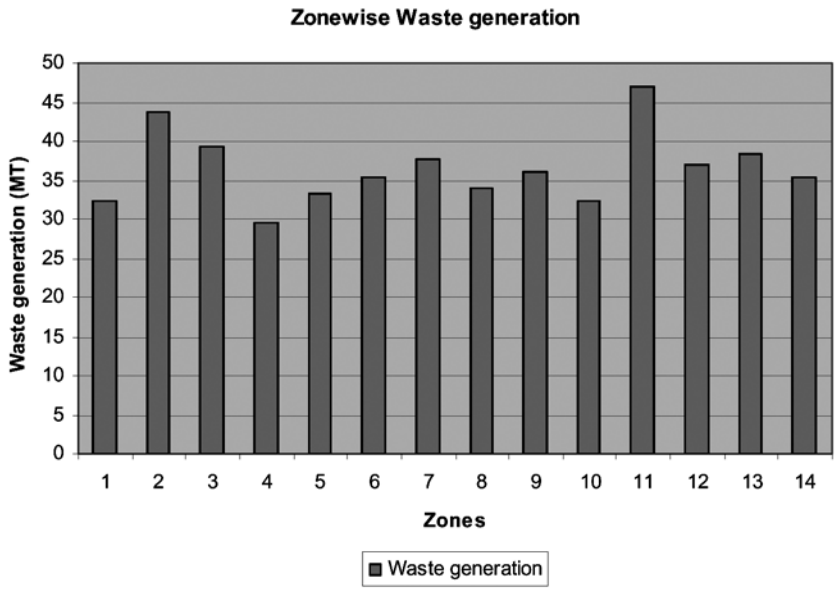


Table 8: Yamuna basin having catchment area in the Madhya Pradesh

Chambal River	Baghain River
Dhashan River	Paisuni River
Kunwari River	Sone River
Parvati River	Hasdeo River
Sevan River	Kali Sindh
Ken River	Tons River

Bhopal, the capital of Madhya Pradesh is one of the metropolitan town discharges water into the river Betwa through small tributaries.

Urban drainage systems are essential infrastructure that helps to reduce the risk of flooding and pollution of receiving water. To design such systems, understanding is required of the concepts, design inputs and processes associated with both the quantity and quality of rainfall runoff, in-sewer processes. In case of Bhopal flood conditions emerge due to the inadequate capacity of the receiving area to contain the high flow brought down from the upper catchments due to heavy rainfall. However, there is no major river flowing through the Bhopal area but there are several streams and streamlets draining the area. Out of these the Kolans River drains into the Upper Lake (Bara Talao) and Kaliasot, which is its outlet, later becomes the tributary of the river Betwa. Patra nallah constitute the outlet of the Lower Lake (Chhota Talao). In general, drainage pattern in the area is dendritic (tree like branching) in the plains and sub-parallel in the hill ranges, controlled by joints. At places, drainage is straight and is mostly controlled by joints. Trellis pattern of drainage is developed in respect of river Kolans. Close meandering pattern is seen in respect of Kaliasot, in its lower reaches due to low relief and thick alluvium. Typical dendritic type of drainage is developed in respect of river Kaliasot and Kerwa because of the homogeneity of the bedrock, which is Deccan Trap.

The detailed geomorphologic investigations of the area have revealed the presence of various landforms associated with Vindhyan Sandstone and Deccan Trap, viz;

- Structural landforms mostly comprise of cuesta, escarpments (fault scarp/fault line scarp) and hogbacks.
- Denudational landforms consisting of residual hills dissected plateaus, Mesas, buttes, pediments and pediplains.
- Depositional landforms such as in filled valleys, alluvial and colluvial fills.

Accumulation of water in low lying areas resulting from heavy rains with poor drainage because of hard surface rocks can cause flooding. Drainage pattern in urban area plays a crucial role to mitigate flood. Rain water harvesting can be adopted in Bhopal city to conserve and utilize rain water for further use.

The Upper Lake is the lifeline of Bhopal controlling risk of flood in the city and it is one of the major sources of potable water supply to the city. Bhopal City has experienced the flood situation in the year 2006 due to high intensity rainfall on 13th -14th August. On the contrary, in recent past, Bhopal city has faced the severe water crises in the year 2002 due to considerably less than average rainfall during 3 consecutive Year i.e. 2000, 2001 & 2002, when water level in Upper Lake reached to abnormally low water level even below dead storage level and water supply was affected badly in the city. After 6 years, the city again faced almost same situation in the Year 2008 due to less rainfall. The rainfall in Bhopal city was recorded 697.4 mm during June – September 2008, which is less than 456.8 mm from average rainfall of 1154.2 mm. Presently Bhopal city is facing water crises problem as water level has been drastically reduced in upper lake and reached to below dead storage level of 503.53 m. Bhopal Municipal Corporation is facing difficulty in taking desired quantity of water from upper lake for water supply to city. Presently, water supply is being provided every alternate day instead of daily supply. This situation is likely to be further degraded during coming summer season.

Existing Drainage Condition

A reconnaissance survey of major drains conducted by Tata Consultant Engineeing revealed that most of the drains have adequate capacity to carry storm water, except 3 (as mentioned below), which cause floods in some areas. However, many of the city drains, though theoretically have the capacity to carry storm water efficiently, do not do so and cause local flooding. The drains, and a description of the areas, which contribute to their flow, are given below.

Patra Nala receives flow from a number of small channels running across the city, like Gaji Khan Ka nallah, Piriya nallah, Kale Bhairon ka nallah, Maholi ka nallah, Mahamai Bagh ka nallah, Ashoka Garden nallah, Ghunsi nallah, etc. Patra nallah after collecting the Stormwater from these channels discharges to the Islamnagar River, 18 km from Bhopal, which finally flows into the Halali River. The entire network of Patra nallah is about 50 km. Patra Nala drains almost entire Old City

Saket Nagar Nala or Anna nagar nala receives flow from New market, Part of Malviya nagar, 74 banglows, Part of South T.T. Nagar, Tulsi nagar, shivaji nagar, Maharana Pratap

nagar, Rachna Nagar, Gautam Nagar, Kasturba nagar, Anna Nagar Habib Ganj Area, Saket nagar, Shakti Nagar, Narayan Nagar, Barkhera pathani, Arera colony, University, Katara hills, Vidya nagar, Baug Mungaliya etc are the major parts of the city. Saket Nagar Drain ultimately merges into Hathaikheda reservoir. The overflow of Hathaikheda reservoir outfalls into the Ajnal river, which ultimately joins Betwa River

Banganga Nala receives flow from Part of Shamla hills, part of Professor's colony and Civil Lines, Jawahar Chowk, 45 Banglows, North T.T.Nagar, and area behind Governor House. Banganga nala merges into Lower Lake (Chota Talab) over flow, of which outfalls into the Patra Nala, which ultimately joins Halali River. (Source: Report on SW Master Plan, TCE, Bhopal Office)

Water Supply Status

In Bhopal city the supply of water is through PHE department and Bhopal Municipal Corporation. There are 10 water treatment plants through which 65 MGD of treated water is supplied daily. The distribution of water from the upper lake, operation and maintenance of water treatment plant is under Bhopal municipal corporation whereas the operation and maintenance of Kolar water treatment plant is the responsibility of public health engineering dept. (PHED) of M.P. Apart from this water is also supplied to the bulk consumers from the upper lake such as B.H.E.L (Bharat Heavy Electrical Limited), M.E.S. (Military Engineering Services), Central railways etc.

Table 9: Water Source and supply

S. no.	Source of Water	Area Covered	No. of Treatment Plant	Daily Water Supply (MLD)
1.	Kolar Dam	1100 Quarters,Hoshangabad,Board Office,Maida Mills,Pulpukhta,Bharat talkies triangle,Bus stand Sindhi colony,Shanjanhabad,PGBT Tanks,Nupur KunjAnd Saket Nagar.	1	155.0
2.	Upper Lake	B.H.E.L,MilitaryEngineeringServices, Central Railway, Strawproducts, Janhagirabad,Shanjanhabad, Ibrahimpura,Baredi,Noor Mahal etc.	9	96
3.	Ground Water (Dug wells, tube wells, and hand pumps)		-	22.5

Storm Water

On an average the rainfall of Bhopal is of medium intensity. The natural drainage of storm water is comparatively good in New Bhopal one of the cause is sparsely populated settlements. In old Bhopal areas, the drainage is provided mainly by Patra nallah which receives flow from number of small channels running across the city, like Gaji Khan ka nallah, Ashoka Garden nallah, Jinsi nallah, Maholi ka nallah, Mahamai Bagh ka nallah, kale Bhairon ka nallah etc. Patra nallah after collecting the stormwater from these channels discharges it to the Islamnagar river near Bhopal, which finally flows in to the Halali river. Large portion of the city in the central region discharges storm runoff to Upper Lake and Lower lake. There are number of nallahs around the catchment area of Upper lake like Gora, Bhisan khedi, Lakhapur, Kolans inlet Iitkhedi, Bhesa khedi, Bairagarh, Khanugoan, Prempura and SAF nallah which drains strom water of city. Except rainy season these are remains dry.

Three major streams drain storm water from Bhopal. In the north-eastern side river Halali carries the drainage and on southeastern side River Kaliasote carries it, both these rivers drain to the river Betwa. In the southwestern side the drainage is carried by many small nallahs, which ultimately drain in to Kolar River. In New Bhopal area the storm water flows into Shahpura Lake.

Due to high intense rainfall in August 2006 Bhopal city got flooded in 24 hours and affect the public life and business seriously.

Water logging problems within the core urban areas and low lying area need to rectify, as the ultimate discharge of storm water and sewage of entire Bhopal is in the Betwa river either directly or indirectly.

Drains (including storm water) in the catchment area of Upper Lake and Lower Lake are as follows:

Table 10: List of Nallahs

S.no.	Name of Nalla	Peak flow lit/sec
	Upper Lake	
1.	Bairagarh bus stand nalla	15.370
2.	Lokhedi Nalla, Behind Petrol pump	23.380
3.	C.T.O nalla – Halalpur nalla	3.0
4.	Sehorenaka nalla	13.657
5.	Shiren Nalla	34.1
6.	Indra nagar nalla	6.940
7.	Sehore naka phatak road nalla,kumhar pura	13.518
8.	Khanugoan Nalla	2.314
9.	Karbala garam gaddha Nalla	9.26
10.	Kotra nalla, Behind pump house	36.00
11.	Nehru nagar nalla	3.00
12.	M.N. Borban nalla	3.00
13.	Kohefiza-housing board nalla	6.00
14.	Laukhedi Sainik colony Nalla	2.00
	Lower Lake	
15.	Badh ganga nalla	9.685
16.	Hindi Granth academy Nalla	16.133
17.	MVM Nalla	57.00
18.	Police line nalla, Near Khatlapur temple	1.426
19.	Jahangirabad Nalla, Near S.B.I Training centre	10.670
20.	Jahangirabad Nalla 1, (Near Extol)	57.00
21.	Jahangirabad Nalla 2 (Behind Vardan)	64.00
22.	Jahangirabad Nalla 3 (Near Saraswati school)	10.67
23.	Bhagwan Sahay Marg Nalla	0.37
24.	Bhagwan Sahay Marg Nalla (Near Masjid)	7.01
25.	Bhagwan pehchan Herbal	0.25
26.	Bhagwan Sahay road (Near Masjid)	10.67
27.	Bhagwan Sahay road (Near school)	8.45
28.	Nalla Batham Samaj Near Mandir	9.51
29.	Nalla near peepal wali galli	1.125
30.	Nalla Bhagwan Sahay Road Galli no 2	1.10

S.no.	Name of Nalla	Peak flow lit/sec
31.	Nalla Bhairao Mandir (Drain -1)	4.58
32.	Nalla Bhairao Mandir (Drain -2)	0.30
33.	Ginnauri Mandir Nalla	26.8
34.	Nalla near pump house,Ginnauri area	77.81
35.	Nalla near Health club, Ginnauri area	19.3
36.	Nalla near pani ki chhakki	134.63
37.	Dhobi ghat area,near sulabh complex	8.25
38.	Dhobi ghat area, Near vaishnav Bhawan	0.799
39.	Dhobi ghat area, near Neem Tree	2.70
40.	Dhobi ghat area, near House no 45	2.88
41.	Dhobi ghat area, near square appartment	0.800
42.	Dhobi ghat area, near M.L.B Hostel	3.250

Floods In The City

Cause

Bhopal experienced intense flooding during August 2006 due to heavy rainfall and poor storm water drainage system in the city. August 2006 received 775mm rainfall in Bhopal, crossing the previous record of the highest rain fall of 767mm in august 1973.

The seasonal total rainfall for Bhopal in 2006 went up to 1150.8mm as much as 408.9mm more than the normal expected till in this season. Along with heavy rainfall other factors that are responsible for the flood in the Bhopal were (a): lack of sewage network; (b): improper drainage system; (c): construction along drains and lake banks; (d): negligence in pre monsoon cleaning and maintenance of drains; (e): missing links of drainage system as per geography;(f): choking of road side and city drains; (e): dumping of solid waste into drains

The prime reason for the flooding in the city however is complete failure of storm water drainage system of the city during the rainfall. It has been observed that Nullahs in most flood affected areas were blocked by construction of houses. There are about 100 slums situated on 8 big Nullahs of the city. Due to continuous negligence over the years, several illegal structures have come up on Nullahs. The blockades in these nullahs have resulted in heavy water logging in the area.

The 286 sq. km. of undulating landscape of Bhopal, well punctuated with water bodies lies sandwiched between the Malwa Plateau on the north and the Vindhyas to its south.

Bhopal with an population of 14.37 lakhs came to a position of absolute standstill owing to the unprecedented rainfall of 225 mm during the 6 hours on 13th-14th August 2006. Although the average yearly rainfall recorded (2006) in Bhopal district is 1154.2 mm.

Among the various factors that influence the urban environment in city like Bhopal during sudden crises like flood are as follows:

- Encroachment in major portion of low lying areas and encroachment on either side of the nallas thereby reducing its cross section
- Illegal construction along main roads and extension in commercial areas.
- Densely inhabited areas without enough breathing space.
- Lack of civic sense and habits of littering cause chaos.
- Absence of buffer zone around water bodies.
- Lack of synchronization of services in old and new settlement.
- Dumping of solid waste in open grounds should be prohibited, for e.g. Govindpura Dusshera ground is adjacent to medical college, school, community centre having proper road connectivity to BHEL and new Bhopal but nearness to large patch of slums create nuisance due to unavoidable activities by them and open dumping of solid waste on ground which encourage street animals that leads to traffic disturbances. Such encroachments during rain accelerate water logging and gradually contaminate ground water that can be termed as delayed impacts of urban floods.
- Avoidance to manage demand and supply of land.
- Lack of awareness and absence of efforts to recharge rain water at household and community level.

In addition to the above mentioned, several drains in the city are constrained in the smooth evacuation of run-off waters due to the following reasons:

- Indiscriminate dumping of solid waste into the drains
- Large scale discharges of sewage, raw sewage or septic tanks overflows into the drains.
- Dumping of construction debris and waste in to the drains
- Silting of the drains
- Blocking of drains due to poles/pipes/stones/polythene being used to cross the drains.
- Lack of adequate maintenance of drains channel and associated structures (e.g. culverts etc.)

- Flat land adjacent to the nallas
- In adequate cross section resulting in lower flood carrying capacity Lower Manning's coefficient due to roughness of surface of drains which cause lower velocity and flow through drains, thus reducing carrying capacities of the drains.
- Inadequate slopes of the drains which impede velocity, thus the carrying capacities

The Bhopal city's drainage system was unable to cope on 14 August 2006 rain. The nullahs and open drains were clogged with garbage.

Constructions on the flood plains of the nullahs make worsen the problem. The high flow of rain water with garbage blocked the sewage system and all water lines were contaminated. Bhopal's Lower Lake, Shahpura Lake, and Motia Talab were all overflowing.

Bhopal face horrible due to scarcity of planned spaces and pressurised infrastructural services. High density in old Bhopal is much more vulnerable. In such areas due to lack or absence to zoning regulation, the number of causalities per disaster would be more than in less dense areas .Uneven topography with lush green areas of Bhopal is an important tool that should exploit to regulate urban development as per the extent of damage anticipated.

Table 11: Flood occurrences in Bhopal

Year of occurrence	Rainfall recorded	Affected areas
30 august 1973	284 mm in 24 hours	—
13th-14th august 2006	225 mm in 6 hours/ 321mm in 24 hours	— shown in map

Flood Affected Areas

The worst affected areas during the 2006 flood in Bhopal were the low lying ones and near the major Nullahs in the city, including Mahamai Ka Bagh; Garam Gaddha; Dwarka Nagar; Bagh Farhatafza; Kammo Ka Bagh; Shankar Nagar; Ram Nagar; Indira Nagar and Rajendra Nagar. Besides Gautam Nagar And DIG Bungalow Area Were Also In Inundated. Water Logging was also reported from Banganga; Tila Jamalpura; Atal Ayub Nagar; Chhola Kainshi Krishna Nagar; Khushipura; Chandbarh; New Kabadkhana.

Slum areas on Chhola Road, Tila Jamalpura, Banganga, Gandhi Nagar, Shahja, Ashoka Garden , Chandnbarh, Kainchy Chhola, Atal Ayub Nagar, Anna Nagar, Chhola, Dwarka Nagar, Aishbaug, Kammu Ka Baug, Bafnacolony, Kaji Camp , Tilla Jamal Pura, New Kabad Khana, Sindhi Colony, Kali Basti, Kapada Mill, Shankaracharya Nagar, Nav Bahar Colony, Nishat Pura, Noormahal, Payga, Harsh Vardhan Nagar , Rahul Nagar, Pampapur, Ambedkar Nagar Durga Nagar, Bheem Nagar and Slums of BHEL area faced flooding.. Besides, water also entered in the slums of Naya Basera, Panchsheel Nagar, Rajiv Nagar, Pumpapur, Gautam Nagar Slums, Arjun Nagar , Shanty Nagar, Bagh Mugalia and Bagh Sewania. Slum people, lower and middle income group people residing in low lying area are mostly affected due to flood in old city.

Some newly developed localities mainly those on sides of Ayodhya bypass such as Shivkalp, Abhinav Homes were inundated along with the localities of New Bhopal which included colonies at 6 no bus stop, 10 no bus stop, Manisha market, Shahpura and parts of Arera. Middle and high income group people residing in new Bhopal aera are also partially affected.

Intensity

About 60% of city areas in Bhopal were affected by the floods in between 14th till 20th August, 2006. Most of the low lying localities were inundated as water entered up to 2-3 feet in houses. Basements of various commercial building in Old Bhopal faced New Bhopal saw inundation.

The floods in 2006 have caused an estimated loss of more than Rs. 85 crores to public and private property in Bhopal district. According to reports received from government bodies including BMC and PWD the loss to public properties have been of about Rs 35 crores. Besides this, estimated loss to private properties has been of about Rs. 52 crores as reported by IL&FS Ecosmart in their report on Comprehensive Environmental Management Plan (September 2007)

Areas / Localities Prone to Flooding

As per discussions with the Municipal Engineering staff it was reported that Ambedkar nagar, part of Sudama nagar, Chawani area behind Bharat talkies, area behind Grand hotel and Capital hotel adjoining to the Patra Nallah, Gurbaksh Ki Tallaiyya, Ashoka garden, Old Subhash nagar, some parts of Chola Kainchy, Mahamai ka baug, Pushpa nagar, Nishatpura, which are areas falling along the Patra drain get flooded for about 8 to 10 days after heavy rains. The depth of the flood waters rises upto about 1 to 1.5 feet.

The areas adjoining the Upper Lake, falling in Bairagarh sub city is also remain under threat of flooding for almost the same or longer durations.

Some Emerging Issues

These can be summarized as follows:

- The indiscriminate dumping of raw\sewage and septic tank over flows into the city's natural drainage network is not only impeding their capacity to drain run-off waters efficiently, but more critically, is leading to the rapid degradation of the area's surface water bodies.
- This, in turn, is impacting the water quality in the region's rivers —- most notably the Betwa River, which receives discharges from a large part of the city
- Indiscriminate dumping of waste and construction debris in the Nallahs needs to be curtailed
- Maintenance of the drains —- including de-silting, improvement of drain geometrics (slope and cross section) needs to be improved —- is poor.

Loss of life and property

Based on survey, 26 people and 39 cattle were killed in flood affected areas of Bhopal and crop damage of 6660 hect.

Damage to about 8728 kuccha and pucca house covers 2566 juggis, 7261 kuccha house and 80 puuca houses. The total 72.52 crore rupees government's property loss and about 5502.66 lakhs rupees of private property loss was recorded in survey.

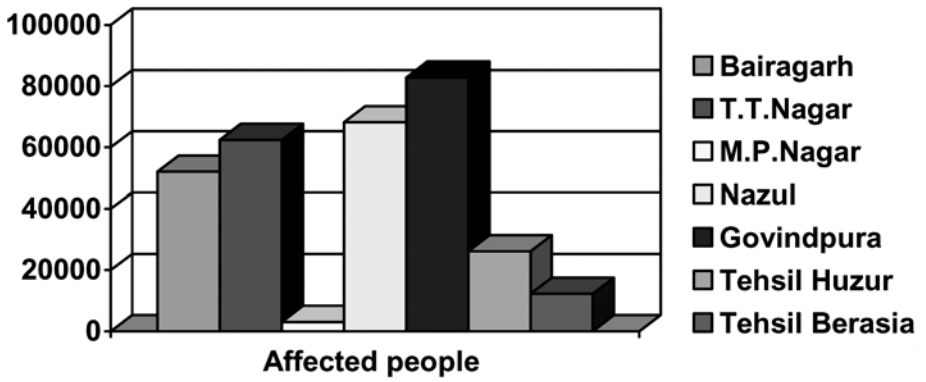


Figure 10: lood affectation

Table 12: Losses due to Flood

S.No.	affected area	affected population	loss of Human life	loss of Animals	damage to houses (Kuccha+Pucca) completely & temporally
1.	Bairagarh	52008	9	18	264
2.	T.T.nagar	62400	3	-	827
3.	M.P.nagar	3044	1	-	272
4.	Nazul	68164	5	-	440
5.	Govindpura	82772	2	2	443
6.	Tehsil Huzur	26164	5	17	4477
7.	Tehsil Bairasia	12240	1	2	2005
Total		306792	26	39+2	8728

- The above table is showing highest flood affectation to people in Govindpura which come under high risk zone (Refer map) might attribute to large encroachments in and around area.

Table-13- Flood affected area

Zone wise	No of wards	Land use in and around vicinity of wards				Flood affected wards (Low/medium/high)		
		resident-ial	commer-cial	indust-rial	slums/ encroac hments (in nos)	low zone	medium zone	high zone
1.	1, 2, 3, 4	✓	✓	—	4	1,2	4	3
2.	5, 6, 7, 8, 9, 10, 13	✓	✓	—	3	8	5	8
3.	11, 12, 14, 15, 16	✓	✓	—	4	15	11, 14	12, 16
4.	17, 18, 19, 20, 21, 22	✓	✓	—	4	—	17, 18, 19, 20, 21, 22	—
5.	23, 24, 25, 26, 27, 34	✓	✓	—	6	—	24, 25, 26	partially affected 27 and 34
6.	28, 29, 30, 31	✓	✓	—	5	—	28, 29	30, 28, 29
7.	35, 36, 37, 38, 43, 44	✓	✓	—	4	—	35, 36, 37, 38, 43	—
8.	45, 46, 47, 64	✓	✓	—	5	—	46	45, 47, 64
9.	32, 33, 48, 49, 50	✓	✓	—	10		32, 33, 48, 50	49
10.	54, 55, 56, 57, 58	✓	✓	—	4		54, 56, 57, 58	55
11.	59, 60, 61, 62, 63	✓	✓	✓	23	62, 63, 61	59, 61	60, 62, 63
12.	65, 66	✓	✓	—	8	66	65	—
13.	39, 40, 41, 42	✓	✓	—	—	39, 40	—	41, 42
14.	51, 52, 53	✓	✓	—	5		52, 53	51

Conclusion : high zone: low lying areas, surrounding area of lakes, medium zone: residential areas having Nallah/culvert in near vicinity, low zone: Agricultural land, sparsely populated settlements including remote areas of city
Source: As per assessment of Bhopal Municipal Corporation (For details refer Annexure1)

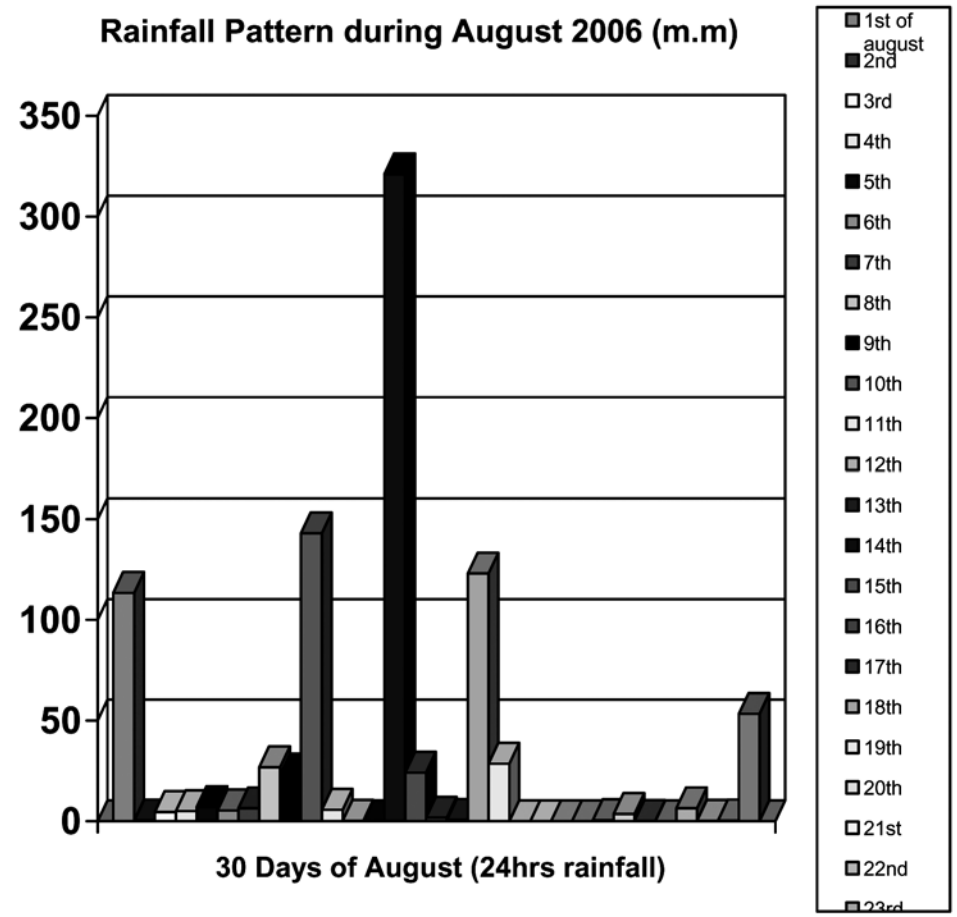


Figure 11: Bhopal city: Sudden flood due to excessive rainfall on 13th &14th of August 2006

Efforts Made To Mitigate And Manage The Floods

Master plan provisions in relation to city drainage/sewerage and carrying capacity management, extent of their implementation including regulatory or voluntary efforts.

As per Bhopal Master plan 2005, following are the specific recommendations for the protection and management of water bodies of Bhopal, which are also in support of flood mitigation.

The upper lake area is the life line of the residents of Bhopal, it needs due consideration in terms of its conservation and management. The catchment area, especially of the upper lake should be properly managed so that the pollution level is

controlled by appropriate measures such as preventive siltation dams and dense plantation along water channel and in the catchment area. The management of solid waste and its disposal should be carefully worked out so that it does not pollute the environment and the water bodies during heavy rains.

The practice of agriculture right along the fringe areas of water bodies in urban areas is proposed to be discouraged so that water is not polluted due to addition of chemical fertilizer pesticide and insecticide. In this way, we can say that such an approach can be adopted to prevent water contamination during flood in urban areas.

The old city of Bhopal is highly dense as compared to other parts of the city. Rigid nature of development plan under reduced legal control and monitoring allow people to modify the construction after permission of local authority. With high institutional changes in Bhopal, migrants and no. of trip to and from Bhopal have been increased drastically which in turn cause pressure on services designed to cater existing population. The built form has achieved higher FAR`s leads to higher occupancy in residential areas means lack of infrastructure and basic amenities.

Encroachments near to water bodies, low-lying areas, under bridges, open grounds encourage illegal activities including misuse of infrastructure and services and are prone to disasters like flood for e.g. wards no 59,60,61,62,63 are highly encroached and come under high risk zone as shown in map. slums-encroachment near to nallahs like ward no 45,47,64 also come under high risk zone and affect surrounding planned colonies like bank colony, Ankur complex etc. Low lying areas of Bhopal city should be properly planned to move people to safer side permanently to save from flash flood in next monsoon.

Various structural and non structural measures for mitigation of flood achievements and shortcomings.

Structural measures for mitigation of flood are land use regulation, building byelaws zoning regulations, widening of culverts, clearing of drains re-densification of affected areas by concerned agencies etc.

Non structural measures are flood prepared measures, local social structure strengthening, action plans for emergency response measures like communication and public information management, search and rescue co-ordination, shelter management, and distribution of food and supplies, contacting and requesting additional support, debris management, financial management, volunteers co-ordination and donations management in coordination with government, semi-government and concerned agencies with people's participation. During Bhopal 2006 flood State government started rescue and relief operation to minimize the ill effects of

urban flood as earlier as possible. Among 66 wards of Bhopal city the flood affected 60 wards consists of 207 basti, 55174 people. From the very first day (14-8-06) the rehabilitation drive started in 19 places and on 18th August, 2006 people get food packets from district administration. Nagar nigam also distribute food packets in flood affected areas. District Jail Incharge and District Home Guard also actively participated to rehabilitate and distribute food packets. Immediate surveys were conducted at household level with 194 survey teams.

Municipal Corporation provides drinking water and cleans the flooded Bhopal streets, public areas, drains etc. Restoration of all services started to normalize the life. Health department started providing services with team of 25 doctors from 15-08-06 in different affected areas of Bhopal; apart from this many private nursing homes also took part in rescue and rehabilitation drive. Badly affected areas like Pushpa Nagar, Ashbagh, Chandbad etc. got extra facilities from Narayan shri homeopathic medical college. Cross sectional area of current drains is not large enough to adequately drain rain-water runoff causing flooding conditions for homes and roads adjacent to drains/culverts. Bhopal Muncipal Corporation (BMC) had timely initiated measures of cleaning garbage and sediment deposition enters into drains. Nalla widening schemes are under implementation to cope with such flood in future. Some works of widening of the streams have already been done expeditiously after the floods, including removal of encroachments by the side of the streams and that in the channel, by the BMC. The removal of narrow necks i.e. narrow culverts in long reaches still need special attention.

What went wrong? Critical appraisal of city flood mitigation and management in terms of planning, resource, implementation, capacity, enforcement, participation.

From past 10years, rapid unplanned development and influx of population in Bhopal city results in pressure on infrastructure and services like water supply, sanitation, electricity, roads etc. Bhopal is an institutional and educational hub next to Indore in the state which compels city planners, policymakers, engineers to strengthen carrying capacity of Bhopal city in terms of infrastructure & services. Development process in Bhopal is catering existing population without much consideration to disaster mitigation planning that result in losses of recent flood.

The record breaking monsoon rains during August 2006 (the 13th /14th) in Bhopal, sparked off deadly floods in the city causing unprecedented loss of life and property & completely jeopardizing city's life and business (many markets were flooded). Following are some causes that directly or indirectly contribute to flood in Bhopal in 2006.

1. Investigations has reveal that the major cause of the flooding in the city was

"destruction of the natural drainage system of the area by human interventions for housing, business and other activities of development which imposed additional burden on part or whole of the 'natural land drainage system' and accelerated its deterioration.

2. Moreover the increasing growth of the city and its paved areas accelerated surface runoff after storms and requires channels (streams) through the city areas to be of greater discharge capacity than those hitherto served the preexisting.
3. Nallahs in city get flooded due to flash flood then immediately contaminated water spill out in houses that naturally cause damages. So encroachments near such structures should be strictly prohibited
4. Lack of consideration to natural drainage and culvert designing of areas near to lakes and water bodies.
5. Slums are located around nallah/ low lying areas/ along roads and open grounds are prone to flood like Govindpura area which has been recorded as highest number of flood affectation to human lives.
6. Extension of buildings without consideration of building byelaws directly and indirectly affects the total population of city in crises. Violation of zoning regulations in new townships and lack of synchronization with existing services.
7. Bhopal city have terrain in slopes. Rain water in such topography doesn't accumulate for recharging but directly enter in drains and nallas. Recharging of rain water can be done to mitigate the impacts of flood and can further helps to rectify water shortage problem in summer season.

These are the root causes of flooding in this city even though gifted with good natural drainage in account of hills and valleys and undulating terrain. High flows of rain water in undulating terrain carries all type of matter (plastic bags, garbage etc) and choke the nallah/culverts and gradually submerge the slums of low-lying areas due to persistent water logging. August (13-14th) 2006 has flooded Bhopal, killed human and animals destroy built up spaces, agriculture land and business. Impacts of urban floods may be attributed to lack of integrated city planning under rules and regulations. The urbanizing process usually changes the patterns of land use and aggravates urban flood problems. Bhopal city is no more exception.

Strategies for Future to Attain

1. **Assessment of the impact of flood on lives, property, agricultural land - productivity, health, social and economic life of city**

   Areas prone to frequent inundation by floods shall be identified in each ward and

clearly demarcated indicating the highest damages in last occurrence. It will help emergency response teams to identify areas to focus their operations during time of flooding.

2. **Flood Forecasting**

   For understanding of type and cause of flood, a detailed survey of the flood prone areas shall be undertaken to identify the causes of flooding, by a multi-disciplinary team, like irrigation, revenue, forest, agriculture, geological and civil engineering etc. Such site specific study can point out flood prone areas of undulating topography of Bhopal to help flood mitigation in future. Modernization of flood forecasting and warning services to the entire flood prone areas.

3. **Identification of possible preventive approach rather than curative**

   Infrastructure and services like water supply, sanitation, garbage collection and disposal, electricity, roads etc, should be managed effectively throughout the year to deal with crises like flood.

   A single unified command (Agency) with adequate powers to act without fear or favour but accountable to the public, be created for planning, implementing and maintaining the Remedial measures for defense against floods.

   City's surface drainage acts/regulations/rules may be strengthened if need be, for enabling the implementing agency to take appropriate action for the basic objective of "defense against flooding" e.g.-

- Removal of all obstructions coming in the water way (channel) of the stream e.g. long narrow culverts etc like habitation around culverts-slums.
- Deepening and or widening of the channel sections after detailed study and design w.r.t carrying capacity i.e. with proper base slopes and section.
- Creation of diversion channels /relief sewers etc. in special cases i.e. where disturbance is a real nuisance to the community.

4. **Construction of flood shelters and ensuring that public utility installations are above flood level height.**

   It may be noted that 'proper planning in detail by competent & experienced professional, of the remedial measures before implementation is of paramount importance for the success of the same. Hence the suggestions of citizens with expertise and well versed with the development of the city will be of great help. They can also be associated with monitoring of the same.

Besides the said streams the side drains of the city's streets, deserve equal attention & consideration. At present these are conspicuous by their absence or blocking of the existing ones by the inhabitants by covering with concrete. This causes storm run off

high velocity water to flow on the through the roads. This blocking of the road drainage arrangement is the root cause of destruction of most of the roads. In some small areas, citizens on their own have renovated the same and are maintaining it. Hence creation of side drains and keeping these always open, clean and operative needs to be made mandatory by act /regulation /rule.

In the new Bhopal many sewers (carrying foul domestic effluent), laid some years ago by the side of the existing streams have been completely destroyed by building activities. This creates long-lasting health hazard of Malaria, Chicken Gunia besides contamination of ground water. Hence all such destroyed and obsolete sewerage systems need immediate repair/renovation /augmentation to ensure that no sewage is allowed to flow in the streams in the interest of citizens health and sanitation of the area.

During the recent flood one of the main cause of the blockage of the drains/and even the main streams causing heading up of water and creating flood is the floating material plastic/polythene bags e.g. blocking of the main stream at the main culvert of the Hoshangabad road near the eastern end of the Mansarover Shopping Complex. The problem is known to all since long but time has come now to take it seriously and ban the use of plastic/polythene material completely.

The most important aspect is the maintenance of the streams during monsoon to keep these always clear, clean and with adequate slope to cater for minimum flows. This is indeed a difficult task .It needs constant attention, year in year out, by careful workmen specially detailed to keep them clear at all times of the day or night. Many times gratings are provided but these soon trash up or choke and overland flooding quickly results.

Hence it is suggested that a suitable division (Task Force) exclusively for this work, from the available workmen or by addition if needed, may be created for this important work.

For the finances for the above, many agencies besides the Central and State Govt. provide funds for such disaster relief projects, e.g. Central Govt's Disaster Relief Fund, ADB, Urban Renewal Project etc which can be tapped but constraint of funds should not come in the way of such relief works.

The Bhopal Master plan should elaborately take all the aspects of Municipal Solid Waste management including primary collection, storage, transfer, transport and disposal, as recommended by the concerned agency. Indicators to evaluate the improvements achieved by the civic authorities should be identified in consideration to urban flood. Public participation to strongly discourage littering and proper vigilance in all 66 wards of Bhopal city should be mandatory. It is essential that constant close watch on the programme of implementation of the remedial measures be kept, e.g. by a citizen's committee, to ensures its successful completion before the onset of the next monsoon.

Last but not the least; the key ingredient is the collaboration of state and local government with public participation to achieve common goals. Capacity building of the community, protection of the environment at city level, risk management, and implementation at grass root level should be foremost to protect the community. It may be noted that during the 1973 and 1974 flood all the intake works cum pump houses on the Upper Lake were submerged even though the intensity of rainfall was much less than that in 2006 where as the same did not happen in 2006 .This was due to widening of the narrow neck, of the spill channel of the Lake leading to the Bhadbhada spillway, by Bhoj Wet Land Project in 1998-99-a recommendation of the Naronha Committee 1975. In 1975 the Naronha Committee in its report recommended some measures for the safety of the lakes and the city from flooding. Some measures have been implemented. The remaining ones need serious thought now e.g. Spillway of the Lower Lake etc.

In order to ensure that occurrence of such floods in future are prevented, it is not only essential but an immediate vital necessity to ensure that appropriate and adequate remedial measures are planned implemented & maintained before the break of the next monsoon. The assistance of the geographical information system can be a boon in forecasting and spatial planning for preparation of flood mitigation.

The Upper Lake is the lifeline of Bhopal controlling flood in the city and it is one of the major sources of potable water supply to the city. Bhopal City has experienced the flood situation in the year 2006 due to high intensity rainfall in august. On the contrary, in recent past, Bhopal city has faced the severe water crises in the year 2002 due to considerably less than average rainfall during 3 consecutive Year i.e. 2000, 2001 & 2002, when water level in Upper Lake reached to abnormally low water level even below dead storage level and water supply was affected badly in the city. After 6 years, the city again faced almost same situation in the year 2008 due to less rainfall. The rainfall in Bhopal city was recorded 697.4 mm during June – September 2008, which is less than 402.6 mm from average rainfall of 1100 mm. Presently Bhopal city is again facing water crises problem as water level has been drastically reduced in upper lake and reached to below dead storage level of 503.53 m. Bhopal Municipal Corporation is facing difficulty in taking desired quantity of water from upper lake for water supply to city. Presently, water supply is being provided every alternate day instead of daily supply. This situation is likely to be further degraded during coming summer season.

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Annexure 1

Details of Flood Affected Municipal Wards

Zone No.	Ward No.	Rain Affected Ward during 13-14 Aug2006
1	1	Abbas Nagar(Gandhi Nagar),Gaund Basti,Peepalner vipege,Mahaveer Basti,Godarmau,Nayapura,Gandhi Nagar Nai Basti,Sector-3,Gandhi Nagar me Gaund Basti Nut Maratha and Omnagar Basti,Jain Nagar,Halalpur.
1	2	Kailash Nagar,Neelgiri Colony, B-Old &Sainik Colony,T-Ward & Area of near sant ji kutiya, Kumhar Mohalla, Bhainsakhedi, Purani Basti.
1	3	Baragarh Phatak Road Basti, Behind B-old 14 station Road,Near C.R.P.Bairak No. 35-36 Basti.
1	4	Rajendra Nagar,Sanjay Nagar,Rahul Nagar, F-ward Behind Jain MandirShops of Bus Stand ,Indira Nagar,Sehore Naka,
2	5	Koefiza, B.D.A.Housing Board Basti,Misha Apartment,Karbala Road, Khanu Gaon dairy Farm House, Shirin Basti,C-Sector B.D.A., A-12 Housing Board Colony,Kohefiza 40 Quarter ,B.D.A Colony Kohefiza, Ram Nagar Colony, Idgah Hills,fron of G.P.O. Shaheed Nagar,State Bank Chouraha. Sazia Nagar G
2	6	Sazia Nagar, Garam Gadha area,Near jhiran temple,Infront of old R.T.O, Dsjid Nagar.
2	7	Amar Basti,Chowki Emambada Road,Ward No-7.
2	8	Bagmunshi Hussain Khan to Safia College area,Sefia College Road,Bagmunshi Hussain Khan Basti,
2	9	Niyamatpura Road, Ram Nagar,Kindwai Road,Infront of Ram Nagar Colony,
2	10	Majdoor Nagar,Shahjahanabad,Sharma Colony, Majdoor Nagar Basti,
2	13	Bag Mukti Saheb, Shahjahanabad,Indira Nagar and Putli Nagar area,Indra Nagar Baltiwala area,Maszid Fakrauddin area, Bag Mukti Saheb,Old R.T.O,Kachi Maszid Kabitpura,Islami Gate,

Zone No.	Ward No.	Rain Affected Ward during 13-14 Aug2006
3	11	Ganesh Nagar,Paradise Colony,Sharda Nagar Gali No.-19,Near Kamal singh school Gali No-3,Sharda Nagar Balaji C.C. wali Gali,Harijan Basti,Nariyal Kheda, Latif Nagar ward office,Housing Board Colony Sanjay Nagar Jhiriya juggi asti,Nagar Nigam Colony Near Nallah,Sahrda Nagar Gali No-13, Sahrda Nagar Gali No-20,
3	12	Green Park Colony, Firdos nagar, Gautam Nagar,P.G.B.T college area,Rachana Colony,Shobha Ram Bawdiwala, area,Nai Basti Teelajamalpura,Fiza Colony,Krishna Colony,
3	14	Sahu Colony Near Pulia Teelajamalpura, Near Ram Mandir Rajan Bhwan ke Piche Nale ke pas,Kali Mandir area,Mandir se Rajjan Bhwan tak Maszid wali Gali, Sahu Mohalla, subedar Colony, Bholenath Colony, New Gandhi Nagar Main Road,Rajiv Nagar,Vasundhar Colony,Nai Basti,Near Babu bhaiKi Pulia,Congress Nagar and Hanuman Templ;e area,Congrss Nagar nalla area,Berasia Road area,Kali Mandir to rajann Bhwan area,Sahu Mohalla Gali wala Maszid area, Sanskrit Pathshala,Hatila Pahalwan Nalla area
3	15	Kainchi Chola main Road, First Railway Gate to Second Gate including Aadarsh Nagar and Ram Nagar Colony Kainchi Chola,Atal Ayub Nagar, New Aarif Nagar Juggi,Shakti Nagar,Union Carbide,J.P.Road,Nishatpura Juggi-Basti area,Purohit Nagar,Aadarsh Nagar New Block,
3	16	Satguru Complex area,Chinar Estate,Berasia Road, Moon complex to Firoz Gandhi Complex,J.P.Road area,Indra Sahayta Nagar,Choukse Nagri Replaced Basti and some nearest area of the Basti,Houses along with nalla in Rambha Nagar,Railway Patak to Petrol Pump,Rajgarhia juggi Basti,Lodhi Samaj,Machenic Market Rajgathia colony chhola Road Railway line ke beech,Lodhi samaj mandir area,
4	17	Ibrahimpura, New Kabad Khana,Isai Ganj, Pauliwal Hospital Gali,Ahele Adies Colony and Sai Colony Kawadkhana,Baphna Colony behind Sadbhawna trust,Bapna Colony,Sai Colony,Goyal Complex,Kaji Camp

Zone No.	Ward No.	Rain Affected Ward during 13-14 Aug2006
4	18	Chola Road Behind Mahakal Mandir,Dulichand ka Bag,Ekta Nagar,and Gali No.1,2,3,and 4,Subhash Nagar,Chhota Makbara Chhola Road,
4	19	Raja ji Kuna area and Bhopal Takies
4	20	Patel Nagar, Hamidia Road,
4	21	Kasera Gali,
4	22	Moti Maszid
5	23	-
5	24	Islampura Basti,Behind Nalla of Sheed School,
5	25	Bhairon Mandir Ke Kali Mandir,Basti Located near Lower lake,Bhagwan saheb Marg Bhoipura,Before Dange Khan Maszid,Near Mahavir Mandir,
5	26	Pratap Nagar,Hastnath Nagar,Behind Gandi Bhawan,
5	27	Banganga rotary club to Jharneswar complex Basti, Behind Barah Aftar Road No. 1 to 14 Basti situated behind it.
5	34	Roshanpura Jhuggi Basti,Shitla Nagar,
6	28	Shastri Nagar, Sarswati Nagarke E.W.S.Aawas, Dwarka Colony near P.N.T., Bheel Kheda Gaon,Gora Gaon,Bisen Khedi, Prempura Gaon,
6	29	Naya Basera,Rajeev Nagar, Ganga Nagar, Gomti Nagar, Sanjay Nagar, Near Gomti Colony,Rajeev Nagar Jhuggi Basti,
6	30	Ambedkar Nagar, Sudama Nagar, Ambedkar Nagar Janta Quarters, Lumbini parisar,Chitragupt Nagar,Aaradhan Nagar,Geetanjali Complex,Ambedkar Nagar Shades,Aradhana Nagar Jhuggi Basti, Near Hazela Hospital,
7	31	Suraj Nagar Jhuggi Basti, Pumpa Nagar Jhuggi Basti, Near Viswa Bharti School,Banjar Basti, Harshwardhan Nagar, Near Nalla, S-500 to 517 near Nehru Nagar, Near BM-56,Near Police Ground Nehru Nagar,Rahul Nagar, Bapu Nagar,
7	35	Near Pr,.School Bhim Nagar,Infront of Mazar,Bheem Nagar,
7	36	Kolipura,Lower part of Aahirpura,Vasundhara Colony,Bank Colony,New Colony near Nalla, Motia Talab, Yadav Aahir Mohalla, Motia Talab area,

Zone No.	Ward No.	Rain Affected Ward during 13-14 Aug2006
7	37	Janhagirabad Bazar(Durga Mandir to Gurudwara),Kumharpura Yadavpura,Khatlapura,Neelampark,Lilytakies Chouraha,
7	38	Yadgare Park,Kewd ka Park, Infront of Extol College,Maszid Gouhar Ali,Patra Road,Seelater House,Bharat Takies, Area of Maszid Ghughu,
7	43	Berkhedi Road,Extol College area,Rashidia School,
7	44	-
8	45	Near Nalla new Subhash nagar,Azad Nagar Jhuggi,Rajeev Nagar,Arjun Nagar,Nehru Nagar,Durga Mandir,Ravidas Colony
8	46	Arjun Nagar, Sudama Nagar, Padnabh Nagar,Moti Nagar, Ambedkar Colony Govind Garden, Acharya Narendra Deo
8	47	Ankur Complex Phase-1,2,3,4,and 5,Shanti Nagar Jhuggi,Shanker Nagar1,2 Meera Complex,Kargil Nagar,Ankir Complex,Mahila Market,
8	64	Jhuggi Nagar, Azad Nagar,Ashok Vihar,Bank Colony,Purana Ashoka Garden,Swdesh Nagar Road, B-Deshmesh Nagar,Samrat Colony,Old Ashoka Garden,Near Sonia Gandhi Nalla, Roopnagar Ghuggi Basti Govindpura near stop
9	32	Shiv Nagar,Chhki Chouraha,South T.T. Nagar, Jhuggi near Stop 1250 quarters, jhuggi behind 81 qurters,Front of Karamchari Bhawan,
9	33	Anjali Complex,Block No.01-19,Jhuggi near P.H.E Office,Jhuggi near 54 Block,Sunhari bag ki Jhuggi South T.T. Nagar,New 228 quarters,Sunhare bag 51,52,block,19,20 Block Chhaki houraha,12,14,15,16 and 17 Block Awas, Shiv Nagar, 81 and 82 Block ,Mayur Park,3 No. Stop Near Bagambri Mandir,
9	48	B.D.Colony,Shivaji Naar,Machana Colony,Sarita Complex,Jhuggi Basti near sidheswari mandir,Ashok nagar jhuggi Basti, 109 Block Shivaji Nagar, 113 Block Shivaji Nagar,
9	49	Madrasi Colony,Jai Bheem Nagar No.2,Near St. Mary School,Behind Milk Dairy area,Houses along with Harshwaqrdhan Pulia,Kumhar Mohalla and Surrounding area,1/1 to 2/1 line,Jhuggi situated Eight Shops of Indir Shoping Center,Houses and Jhuggi situated behind Budh Vihar,patrkar Colony,Area of Behind Panchmukhi Hanuman Mandir,B.D.A. Colony,Shiv Nagar,Durga Nagar,

Zone No.	Ward No.	Rain Affected Ward during 13-14 Aug2006
9	50	E-3, Arera Colony,Ward-50,E-3/1, E-3/2, E-3/3, E-3/28, E-3/122, E-3/23 A Arera Colony,Jhuggi Area Behind Bengali Colony,Kolar RoadShapura Turning infront of 56 Bhog,
10	54	Ravidas Nagar,Padamnabh Nagar,Near pulia area 4-B Saket Nagar,4-A Saket Nagar,2-A,2-B,2-C,Near Nirupama Aprtment,Near Dr, Shankerdyal Sharma playground,Madhav Bal(2-A), Infront of Alkapuri Jhuggi Basti,2-A,2-C,Saket Nagar Jhuggi,Jhuggi situated along Road connected to Shaki Nagar and Saket Nagar,Piplya Pende Khan,Bag-Mugalia16 acre,Near Umega Public High School,Area of Near Gyanouday School,Silai Center Near Bad tree,Near Vinova Bhave School,Kanjar Mohalla Berkheda Pathani,Shanti Nagar,Sabji Farm House,Atal Chouraha,Shyam Nagar Berkheda Pathani,
10	55	Vishwakarma Nagar,Gandhi Mohalla,
10	56	Gautam Nagar,Kailash Nagar,Rachana Nagar,Vikas Nagar,
10	57	Anna Nagar A-Sector behind Bus Stand,Anna Nagar Kaji Camp,Anna Nagar near Meet Market,
10	58	Jhuggi area of Govindpura,
11	59	Rajeev Nagar Jhuggi area,Pragati Nagar,
11	60	Shiv nagarJhuggi Basti,Soumya Vihar Phase-1,Radha Kunj,Vijay Lakshya Homes,Shiv Nagar Jhuggi Basti,Yathakunj Nagar Colony,Samaiya Nagar Phase-1,
11	61	100 Quarters Jhuggi BHEL area,Nehru Nagar Jhuggi Basti near Piplani Maszid,24 Quarters Jhuggi Kachhi Market,40 Quarters Jhuggi near Nalla,Jhuggi Near Nandi Foundation Road,Jhuggi near Piplani Thana,24 Quarters Jhuggi Bast Dhobi Ghat,B.H.E.L Jhuggi Basti area,Nagar Prashasan B.H.E.L Jhuggi area near Maszid,Jhuggi area near nandi Factory,
11	62	Sonagiri A-Sector Infront of ward office,Kalpana Nagar,Daulatpura,Kokta,Anand Nagar,Gupta Colony,ShivKalp Bypass,anand Nagar School Campus,Hathaikheda Dam,Daulatpura section-1Kokta,sonagiri-A,B,C,Sector,Rajat Nagar Colony,

Zone No.	Ward No.	Rain Affected Ward during 13-14 Aug2006
11	63	Aadarsh Nagarjhuggi,Nirza Nagar,D.K.Tawer,Near Mandir Indrapur A-sectorSatnami Nagar Jhuggi aea,J.K.Road,Sundar Nagar,laxmi Nagar,Rajat Nagar,Arjun Nagar,Jheel nagar,Harijan Basti Bypass Road,D.K.Tower Ground Floor J.K.Road,J.K.Egg Factory,Near Shradha Clinic Board,Aadarsh Nagar,Nirza Nagar Colony 135 Chakrawarty,Apsara Complex D.K.Tower Nalla,Indrapuri near A-116 and Mandir,Satnami Nagar Jhuggi basti,Sundar Nagar Colony s.T.D. 114 to 418,Laxmi Nagar ward 62/63,Arjun Nagar Jhuggi Basti,Seel Nagar Jhuggi Basti,Apsara Complex D.K.Tower Nalla,J.K.Road Jhuggi Basti near Mandir,Honda Factroy J.K.Road,Gautam Nagar Jhuggi Basti,Jheel Nagar Jhuggi Basti,Aydhya Bypass Road,Near Tanatan Dhaba,Ayodhya Bypass Road Indus Park Chhatrapati Nagr,Harijan Basti Narela Shankari, Near Indrapuri A/116,
12	65	Shiv Nagar Phase-1,2,3, Gupta Nagar,Sundar Nagar Kalyan Nagar,Shabri Nagar,Rasla khedi,Malikhedi,Semara,Kailash Nagar, Kolua Kala,Santosh gar,(Kolua), Damkheda, Maholi,Bhanpur East,Bhanpur Purva Gaon,Atal Nehru Nagar, Bihari Colony,Chandbadi,Preeti Nagar, Shivshakti gar,Khezra,kataria, Leeldhar,Prarthana Bhawan Road,
12	66	Krishak Nagar,Brij Colony,Rajeev Colony,Gwal Baba Jhuggi Basti Badbai,Krishna Nagar,Panchvati-1,Panchvati-2,Moti Nagar,Ekta Nagar,Palasi(Shanker Nagar) to Dhara Shiv Nagar,Kamla Nagar,Durga Nagar Jhuggi,Goya Colony,Shanti Prakash Nagar,Panna Nagar,Edevkati Nagar,Navibag, Panchvati Phase-3,Geeta Nagar,Nabab Colony,Annu Nagar Jhuggi,Jiya Colony,Vilal Colony,Sundar Nagar near Jhuggi,Prem Nagar, Shriram nagar,Nav-Jeevan Colony(near Chhaki,) Jhuggi behind Nav Jeevan Colony,Chhola mandir Jhuggi(near railway line),Gareeb Nagar Jhuggi, Gareeb Nagar (timber maket)Shanker Nagar Jhuggi Basti(Behind F.I.C.), Udiya Basti,Chandwadi,
13	39	Kapada Mill Ki Chal,Garam Gadha,Nav Vihar Colony and Shankaracharya Nagar,Sourabh Colony,Nehru Colony
13	40	Dwarka nagar,Krishna Nagar, Vijay Nagar Khushipura,Karariya, Hinotia Laxmipuri

Zone No.	Ward No.	Rain Affected Ward during 13-14 Aug2006
13	41	Mahamai Ka Bag, Kampu Ka Bag, Pushpa Nagar,Bag Umrao Dulha,Chankyapuri,Bismillah Colony
13	42	Antyodya Nagar,Bag Dilkusha,Ahmad Ali Ka Janta Quts,House Board, Sonia Gandhi Afkar Colony, Vikas Colony,Ashbag Janta Colony, Jagnath Colony, Sikandarpuri,Bag Farahafja,Gurunanakpura
14	51	Nupurkunj,E-7 near hanuman Mandir,E/7 near Vivek Apartment,Gautam Nagar,P.C. Nagar,E-6 behind Shrivastava Tent House,Near Durga Ji Chabutra, E-7 AjantaAlora,Abhimanyu Apartment
14	52	Shapur B-Sector,Near B-59, Near B-94,Infront of Ayushman Hospital, baba Nagar Panhuch Marg,Jhuggi Basti near Manish Market,
14	53	Ganesh Nagar,Near Durga Nagar Nalla,Near Bawadiyakala railway line,Near Bawadiyakala Nalla,Amrai Housing ward Jhuggi area,aadarsh Nagar,Ahmadpur,Nai Basti Jatkhedi,Misrod

Annexure 2

Table: Zone wise ward name, population, and main area under wards

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
1.	Sant Hirdaram nagar	Mahatma Gandhi	1	32459	Gonder mahu,baragarh kala,Khedi singar choli
		C.T.O	2	17691	Pipalner,M.E.S quater , bhasaddedi, vehata , gurunanak road , tagore road , Berik B-54 , North part Bada talab ka
		Hemu Colony	3	16519	Railway line,Jairam das Marg, Vivakanand Marg,Hospital Road
		Sadhu Vaswani	4	24085	B-52 , Berek,North Part of Vivaknand Marg,Bhasakhedi Gram ka East Sima,Riyan Manzil,Akhada Bag
2.				**90754**	
	Shahajanbad	Koh-E-Fiza	5	17127	Lalghati choraha,Sultania Road, J.A.D chouraha,Karbala & Rizwan Bag Road
		Nor-Mahal	6	16125	Pari Bazar Road,Ali Manzil, Pamisghat Fathgarh Road Modal School
		Malipura	7	13554	Noormahal Road, Bhagipura, Choki Emamwada gate, Pirgate, Moti Masque & Soltania road, Sadar Manzil
		Bag Munshi Hasan	8	16747	Vinava Bhave Road, Shahajanbad Bazar, Islami Gate, Barasia Road,Safia College Road, Bhopal Tikiz,Ali Manzil Road

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
		Idhal Hills	9	23326	T.B Hospital, Kumharpura, G.A.D Choraha, Paribazar Road, Barah Mahal, Sharma Colony, Infentry Gate, Gufa Mandir
		Babu Jagjivanram	10	15478	Regiment Gate, Mufti Bag, Model Ground, Kachi Mosque, Northan & Jamalpura, Golghar
		Shahajanbad	13	20741	Putlighar, V.T.O, Kaachi Mosque tak Mufti Bag Road
				123098	
3.	Bersiya Road	Gufa Mandir	11	36466	Naveri Gram, Barasia Road Crossing, T.B Hospital ,Slum's of Regiment Road
		Gitanjali	12	20721	Nariyal Kheda, P.G.B.T College Gotam Nagar
		Congress Nagar	14	18928	Barasia Road, B.T.O Road from Nala,Sindhi Colony ka Sangam
		Motilal Nehru	15	20979	Barasia Road Railway Crossing, Chola Road, Union Carbide Road
		J.PNagar	16	13695	Vapana Colony, J.P. Nagar, Barasia Road, Union Carbide Sangam
				110789	
4.	Mangalwara	Ibahimpura	17	22980	Ibahimganj, Hamidia Road, Classified Market
		Ram mandir	18	12326	Mangalwara Cent, Over Bridge, Malgogown Road , Railway Barier line, Mandir kamali, Sabzi Mandi
		Mangalwara	19	12116 12915	Gurubaksh Talaya Road, Jummerati Post Office , Chawani Road, Over Bridge Road, Agrawal Puri Bhander ki Oor

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
		LalBahadur Shastri	20	--	Mandir Kamali Road, Mangalwara, Moulana Azad Road, Itwara Bazar, Over Bridge, Sultania Road
		Mahavir Ward	21	12603	Ghoda Nakkas Road, Budwara, Charbatti, Fish Market, Jhumarati, Door to Loha Bazar, Ibrahimpura Chouraha tak
		Jain Mandir	22	10270	Near to Moti Mosque from Ibrahimpura chouraha, From Pir Bazar Chouraha to Dist Huzur Road, Moti Mosque Tak
				83210	
5.	Aachaya Nrendra Dev	Moti Mosque	23	17976	From Moti Mosque chouraha to Budwara char Batti Tak Purana Kila, Ginnori School, Diwan, Doulat Rai Road,Mata Mandir Se Retghat Gali No 2, Gulam Mehmud Road Hathikhana
		Islampura	24	12129	Moulana Azad Road, Sultania Hospital ke Chouraha, Tak, Moulana Azad Library, Fish Market Tak
		Bhaipura	25	16572	Budhara char Batti Chouraha ginnoriSchool, M.L.B college From Chotha Talab ka Kinara to Sultania Hospital Chouraha
		Vivakanand	27	20065	Old ShimalaRoad,Bhadbhada Road, Jahawar Chok P & T Shed, M.P.S.R.T.C Road

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
		Jawahar Nehru	34	12352	Banganga Road se tagore Bhawan 1250 Road, Malviya Nagar Road, Rajbhawan Ke Piche se Tagore Bhawan
				93527	
6.	Mata Mandir	Ambedkar	28	23395	Gram Bamhori, Gram Vilkheda, Vishan khedi, Gora gaon, Prempura, Bhadbhada Road, Kotra Sultanabad, Near of Lake Gram Kheda
		Tulsi Bai	-	25260	From Kotra Sultanabad main road to Panchsheel Nagar, MACT road, Main road no 3 to main road no 2
		Panchsheel Nagar	30	15264	Gram Amkheda, Bhadbhada main road no 3 to Kotra Sultanabad, Panchsheel road, Barkhedi Kala, Gram Barkhedi khurd, KhudaGanj,Chandanpura, from Singhpur to Chuna Bhatti
		Maulana Azad	31	35577	-
				76101	
7.	**Barkhedi**	Madan Mohan Malviya	35	25519	Lal Ghati Chouraha, Sultaniya road ,G.A.D. Chouraha, Karbala road and Rizvan bagh road.
		Ravindra Tegore	36	189696	Church road, Jinsi Cha. Vaitnary h. Nala. Su. road, South Area.
		JhangiraBad	37	171195	Bhrat Takies Chouraha, Filay Plaint, Jhangirabad, Malviya Nagar, MLA Rest House road gaun Park, Gali Bans Behda

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
		Barkhedi	38	16670	Pul Boghda Railway Crosing to Sultania road Chouraha, Barkhedi Chouki to Pulboghda, Coute Talab Kinare to Bharat Takies Choraha.
		Maharani Laxmi Bai	43	14471 13601	Pul Boghda Mata Mandir, PevdiPura Road Street, Chikload road, Barkhedi Chouraha to Aishbagh Railway Crosing.
		Jinsi	44	-	Church Road, Jinsi Chouraha, Bahoda Gali
				431152	
8.	**Pul Boghda**	Maidamill	45	17996	Jail Road, Jhada, Harjumal Jail Road to Maidamill road press Complex Railway Line, Subhash Nagar Colony to Raisen road , Momin Pura,, Poltriform road
		Netaji Subhash Chandra Bose	46	24810	Behind Maidamill, RailwayLine, Sufiya Road, Sufiya Market to BHEL, Subhash Nagar Railway Line to Raisen road
		Maharana Pratap	47	15365	Maidamill Road, Press Complex road to Railway Line, Habibganj road, MP Nagar, Zone-I & Zone II, Board Office Chouraha, Ankur Complex, Government Colony, Mahadev Apartment, MPSRTC to 7 No. stop
		Gurunank	64	37621	Ashoka Garden to Semrakala Bhargava Industries, Koluakala Gram, Khanti Road, Piliya Nala Road.
				95792	

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
9.	**Shivaji Nagar**	Shivaji	-	17507	Main road No.1, 1250 to 1464 road, Main road No.2 to 1464.
		T.T. Nagar	33	11220	Bhdbhada road, Main road 1 to 1250 road main road 2 to 1250 main road No. 2
		Ravi Shankar	48	19859	Subhash Nagar road, Main road 1 to 1464 main road, Arera Colony road, Char Imli, 5 No. stop, Government Colony.
		Dr. Rajendra Prasad	-	28692	Panchsheel Nagar, Kolar road, Chuna Bhatti, Janki Inclave, Shalimar Chinar street, Chppan Bhog.
		Indira Gandhi	-	24036	Arera Colony, E-1 to E-5 Subhash School, Bithan Market, Habibganj Thana, 10 No. Market, BJP Office
				101314	
10.	**BHEL**	Barkheda Pathani	54	32608	Saket Nagar Road, Barkheda, Sector-A, Bagh Mugalya, Jatkhedi, Laharpur, Amravad Khurd, Barkhedi Pathani, Pipalya Pende Khan
		Saket Shakti	55	14341	BHEL Hospital road, Dashara Ground road, Govindpura, berkheda A Sector road
		Kasturba	56	18751	Old Subhash Nagar Colony Road, to BHEL Hospital Govindpura, C-Sector road , Habibganj railway line and from Hospital road to Press Complex Road, Railway
		Anna Nagar	57	11821	I.T.I. shed, GovindPura, C-sector Road, Habibganj Sector, B-Road

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
		Barkheda, BHEL	58	13133	Audhyagik Khetra Road, Raisen Road, Barkheda Road, Factory Road, Piplani, A-Sector Road, Sufia Market Road, Raisen Road Sangam
		Govindpura	59	13935	Barkheda Pathani Road, Barkheda C-Sector Road, Saket Nagar Road, Barkheda C-Sector Road
				104589	
11.	Sonagiri	Piplani	60	23424	Htaikheda road, Khajuri Khurd Gram, Khajuri kala, Gram Raisen Road
		Goutam budha	61	12424	Piplani a Sector Road, Khajuri kala gram Raisen road, factory Road
		Sonagiri	62	**36779**	Narela Sankari Road, Hatai kheda, Kokta Gram, Sonagiri Road
		IndrapuriPathani	63	45235	Narela Sankari Road, from sangam to ITI road, Raisen road, audyogik road
				117862	
12.	**Bhanpur**	Rajiv	65	35922	Malikhedi, Chola road, khejra baramad gram chola, bhanpura sema, railwayline, and hinotea kachi semra kala, raslakhedi baipas road
		Navibag	66	67866	Badwae gram gondrimao, palasi malikhedi, chola road, second railway crossing to baipas road, chola road , from gram kaveri to railway
				103788	

Zone No.	Zone Name	Ward Name	Ward No	Population	Main Area under ward
13.	**Chand Bad**	Chand Bad	39	17916	Patranala, garamgadda road, kishor takiz, sikandari saray, from bharat takiz to patra railway godam road, Sikandari saray
		Kapda mill	40	25481	Kararea sagida gram seema power house road, textile mill, semrakala nale tak chola road and from kararea to power house railway line
		Bag umrao dulha	41	29302	Ashoka garden, nala purani khanti road, navbahar colony, patra nadi ki kalwart railway crossing tak pilia nala and khanti road sangam
		Eshbag	42	35091	Housing board ke sangam se pilia nale tak, barkhedi railway crossing se raisen road tak, eshbag road ka sangam
				107790	
10.	**12 No. Stop**	Shahpura	51	23621	E-7, Arera colony, 1100 Quaters, Prashasan Academy, E-6 K LIG, MIG, LIG, 11 no. stop, shalimar inclave
		Asha Niketan	52	42035	Shahpura A,B,C Sector, Ayushman, Siddi bhawan, Baba Nagar, Trilanga, Gulmohar, G-1, G-2, G-3, Danapani, Sabjifarm, Bharat nagar, Ishwar nagar, Saibaba nagar, Shahpura gram, Starling Inclave
		Barkatullah	53	33737	Shakti nagar, BHEL road, Saket nagar, Jatkhedi, Nisrod road, babdiya kala, vidhya nagar indus garden, RRL, Habibganj railway crossing se shakti nagar road.
				99393	

Source: http://www.bhopalmunicipal.com

The above table reveals that zone 1, 11, 14 are having highest number of slums which cover Ward no.60, 61,62, 51, 52, 53.
Among 14 zones, zone 7 (Barkhedi) is having maximum population. Ward no. 35, 36, 37, 38, 43, 44 Madan Mohan Malviya ,Ravindra Tegore, JhangiraBad , Barkhedi , Maharani Laxmi Bai , Jinsi covered under zone 7.

Annexure 3

Municipal solid waste: Ward wise information of waste generation

Zone No.	Ward No.	Name of the ward	No. of Household	Waste generation MT
1	1	Mahatma Gandhi	7701	11.55
	2	CTO	4197	6.29
	3	Hemu Kalani	3919	5.87
	4	Sadhu Waswani	5714	8.57
		Total	21531	32.28
2	5	Koh-e-Fiza	4063	6.09
	6	Noor Mahal	8226	5.73
	7	Malipura	3216	4.82
	8	Bagh Munis Husain	3973	5.95
	9	Idgah Hills	5534	8.30
	10	Babu Jagjiwan	3672	5.50
	13	Shajanabad	4921	7.38
		Total	33605	43.77
3	11	Gufa Mandir	8651	12.97
	12	Geetanjali	4916	7.37
	14	Congress Nagar	4491	6.73
	15	Motilal Nehru	4977	7.46
	16	J P Nagar	3249	4.87
		Total	26284	39.4
4	17	Ibrahim Ganj	5452	8.17
	18	Ram Mandir	2924	4.38
	19	Mangalwara	2874	4.31
	20	Lal Bahadur Shastri	3064	4.59
	21	Mahaveer	2990	4.48
	22	Jain Mandir	2436	3.65
		Total	19740	29.58
5	23	Moti Masjid	4265	6.39
	24	Islampura	2878	4.31
	25	Bhoipura	3932	5.89
	26	Rani Kamlawati	3424	5.13
	27	Vivekanand	4760	7.14
	34	Jawaharlal Nehru	2930	4.36

		Total	22189	33.22	
6	28	Ambedkar	5550	8.32	
	29	Tulsi	5993	8.98	
	30	Panchsheel	3621	5.43	
	31	Maulana Azad	8440	12.66	
		Total	23604	35.39	
7	35	Pandit madan Mohan Malviya		6054	9.08
	36	Ravindranath Tagore		4388	6.58
	37	Jahangirabad	4079	6.11	
	38	Barkhedi	3955	5.93	
	43	Maharani Laxmi Bai		3433	5.14
	44	Jinsi	3227	4.84	
		Total	25136	37.68	
8	45	Maida Mill	4269	6.40	
	46	NetajiSubhashChandra		5886	8.82
	47	Maharana Pratap	3645	5.46	
	64	Gurunanak	8975	13.38	
		Total	22775	34.06	
9	32	Shivaji Nagar	4153	6.23	
	33	T T Nagar	2662	3.99	
	48	Ravi Shankar	4711	7.06	
	49	Dr. Rajendra Prasad	6807	10.21	
	50	Indira Gandhi	5702	8.55	
		Total	24035	36.04	
10	54	Barkhera Pathani	-	11.60	
	55	Saket Nagar	7736	5.10	
	56	Kasturba	3402	6.67	
	57	Anna Nagar	2804	4.20	
	58	Barkhera BHEL	3116	4.67	
		Total	17058	32.24	
11	59	Govindpura	3306	4.95	
	60	Piplani	5557	8.33	
	61	Gautam Nagar	2947	4.42	
	62	Sonagiri	8726	13.08	
	63	Indrapuri	10732	16.09	
		Total	31268	46.87	

12	65	Rajeev	8522	12.78
	66	Nabi bagh	16101	24.15
		Total	24623	36.93
13	39	Chand barh	4250	6.37
	40	Kapra Mill	6045	9.06
	41	Bagh Umrao Dulah	6952	10.42
	42	Aishbagh	8325	12.48
		Total	25572	38.33
14	51	Shahpura	5604	8.40
	52	Asha Niketan	9972	14.95
	53	Barkatulah	8004	12.00
		Total	23580	35.35
		Total	341000	511.17

BMC has 110 fleets of vehicles for collecting and transporting waste from collection points to the disposal site. Each of the vehicles is allotted specific area for collection and transportation to Bhanpur site. There are about 1327 nos. of intermediate collection points in the city and 366 nos. of wheel barrow are provided by BMC.