

A Brief Review of Drainage Network and its Role on Urban Flooding in Kolkata

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Abstract : *Kolkata has every characteristics of a riverside city as it is surrounded by marshes, tidal creeks swamps and wetlands. The rational characteristics of Kolkata makes its drainage problem inevitable as the land elevated towards the west and is gradually tilted towards the marshy land of the east which has now been partly reclaimed and developed into salt lake city. The Hooghly River flows along the western margin of the city. In general, the natural slope within the city area is in west to east direction i.e. away from the river. Though Kolkata poses flat terrain topography, the river side levee is still the highest part of the city. It is interesting to note that the entire drainage and sewerage network planning of the city is based on this east ward slope of the land. The existing system is old and cannot cope with the excessive storm flow occurring in the monsoon period. The outfall channels carrying the entire city's waste and storm water are heavily silted-up causing the pump stations pumps to function inefficiently. As a result frequent flooding in the city during monsoon season posing environmental and health hazards. This paper discusses the Network of the drainage and sewerage systems of Kolkata Metropolis along with their basin network, their development, and its role in urban flooding.*

Keywords : *Marshy Swamps, Urban flood, Vulnerability, Discharge, SWF, DWF*

Introduction

The phenomenon, of urban flood has in recent times engaged the attention of planners and administrators because of its disastrous consequences for the urban settlements in terms and damages to life, property, and urban infrastructure. In India many of our large urban agglomerations Such as Greater Mumbai, Delhi, Kolkata and other areas have used to living with flood as a matter of annual routine. Potential climate changes are likely to cause an increase in the number and intensity of- flood events causing growing demand for space for rivers, creeks, and other water- as receptacles of flood water. As a result it influences the vulnerability of urban areas to regular seasonal flooding and the consequential social and economic damages in the affected areas. It has been the experience in most cities that intensity of flooding has a certain relationship with 'unplanned' growth of' the urban areas under situations of tremendous demographic pressure. Unplanned land use and other anthropogenic impact influence the peak discharge as well as reduce infiltration of water into the ground, and accelerate run off to ditches and streams.

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Kolkata is one of the five major Metropolitan Cities of India and capital of the State of West Bengal. The city is located at 22°30' North Latitude, 88°30' East Longitude, and is the main port of entry in North Eastern India. It is 120 km from the Bay of Bengal and stands on the bank of the River Hooghly (Ganga). It has an area of 206.08 sq km and has a population of 1.49 crores as per the 2020 survey. The city receives 300 mgd (1360 Mld) of water supply through a distribution network of about 3000 km length, and discharges about 1800 Mld wastewater in the dry season. The existing sewerage network covers a length of about 1610 km and the length of open drain is about 950 km. The city is more than 300 years old and its sewerage and drainage system is about 140 years old.

The Rationale of the Study

Bose (1966) finds the environment and health in the Kolkata metropolitan region. In his research he shows how the outfall system plays a vital role in wastewater management. The paper highlights the exploration, identification and documentation of outfall issues related Kolkata core area and suburbs. Munshi (1975) describe the stage wise expansion of Kolkata metropolitan area and its adverse effects in our daily livelihood. He also highlights how the poor people become marginalized in every aspect of social facilities. He also analyzed different stages of development and agony of people in chronic period. Nath (1990) focuses on the drainage, sewerage and water disposal in Kolkata. He analyses how this outfall system are becoming more nonfunctional which leads to multi problem. He also urges to make proper steps for excavation and renovation of outfall network to get rid of these waterlogging issues. Dasgupta (1991) studied the management of storm water drainage as well as he highlights the role integrated planning for storm water management. The paper concludes with improved planning techniques, timely policy intervention along with strong feedback management. Bose (2008) focuses on the management of storm water drainage as well as highlights how the outfall system plays a vital role in this management issues.

Chattopadhyay(2009) analyses the role of solid waste management and its relation with chronic water logging in Calcutta. He has suggested some of strategically viewpoint of reuse of solid waste to reduce the duration of waterlogging. Murmu, (2021) describe the heritage sewer networks of Kolkata and ascertaining their coping potential under growing urban pressures in recent times. This research made a he study and showed the role of sewer networks, relation with outfalls, and its decaying nature due to some emergent developmental issues.

Drainage Network

The principal features of the existing drainage basin layout for the CMC area were delineated in the Master Plan for water Supply, sewerage and drainage in Kolkata Metropolitan District (1966-2000) prepared by CMPO. Based upon the east Bank areas and the proposals of Irrigation and Waterways Department, Government of West Bengal, for the West Banks areas, the Master Plan reviewed the drainage proposals of the entire metropolitan area after thoroughly studying the topographical, land use and available outfalls, and proposed 23 drainage basins for the entire

metropolitan area. These are as follows: Tollygange Panchannagram Basin, Tolly's Nullah Basin, Northern Salt Lake Basin, Keorapukur Basin, Howrah Basin, Sonarpur Arapanch Basin, Konnagore Sub Basin, Southern Salt Lake Basin, Manikhali Basin, Sunti Basin, Churial Basin, Nacol Basin, Magrahat Basin, Rajapur Basin, Manicktala Sub Basin, N.W. Riparian Basin, Kolkata Basin, Boinchitala Basin, Bagjola Basin, Ichapore Basin, Khardah Basin, Begor khal Basin. The entire CMC area is divided into 8 (eight) major drainage basins. (KMDA, 1990)

The major drainage basins, and Canal network and boroughs covered under each basin are in Table 1

Table 1. Borough Wise Major Drainage Basins, Canals and Tributaries

Major drainage basins	Canals and Tributaries	Boroughs covered
Manicktala Basin	Circular Channel Beliaghata Channel New Cut Channel Kestopur Canal Eastern Drainage Channel	III
Kolkata Basin	Dry weather flow Channel Storm water flow Channel Central Lake Channel.	II, IV, V, VI, VII, VIII and XII (part)
Hooghly Basin		I (part) and XV (part)
Tollygunge Panchannagram. Basin	Tollygunge Panchannagram(TP) Main Canal Intercepting Channel Lead Channels Guniagachi Branch Channel Suti Canal	XI (part) and XII (part)
Tolly's Nullah Basin	Tolly's Nullah Boat Canal Keorapukur Canal Western Channel Rania Canal.	IX (part), X, XI (part) and XIII (part)
Manikhali Basin	Manikhali Canal Begore Canal Parnasree Canal CPT Canal Santoshpur Canal Jinjira Canal	IX (part) XIV (part and XV (part)
Churial Basin	Churial Canal Churial Canal Extension Kalagachia Canal, Suti Canal.	XIII (part) and XIV (part)

Source: I&W Department, Government of West Bengal, 2009

DRAINAGE NETWORK OF KOLKATA CITY AND ITS SUBURBS

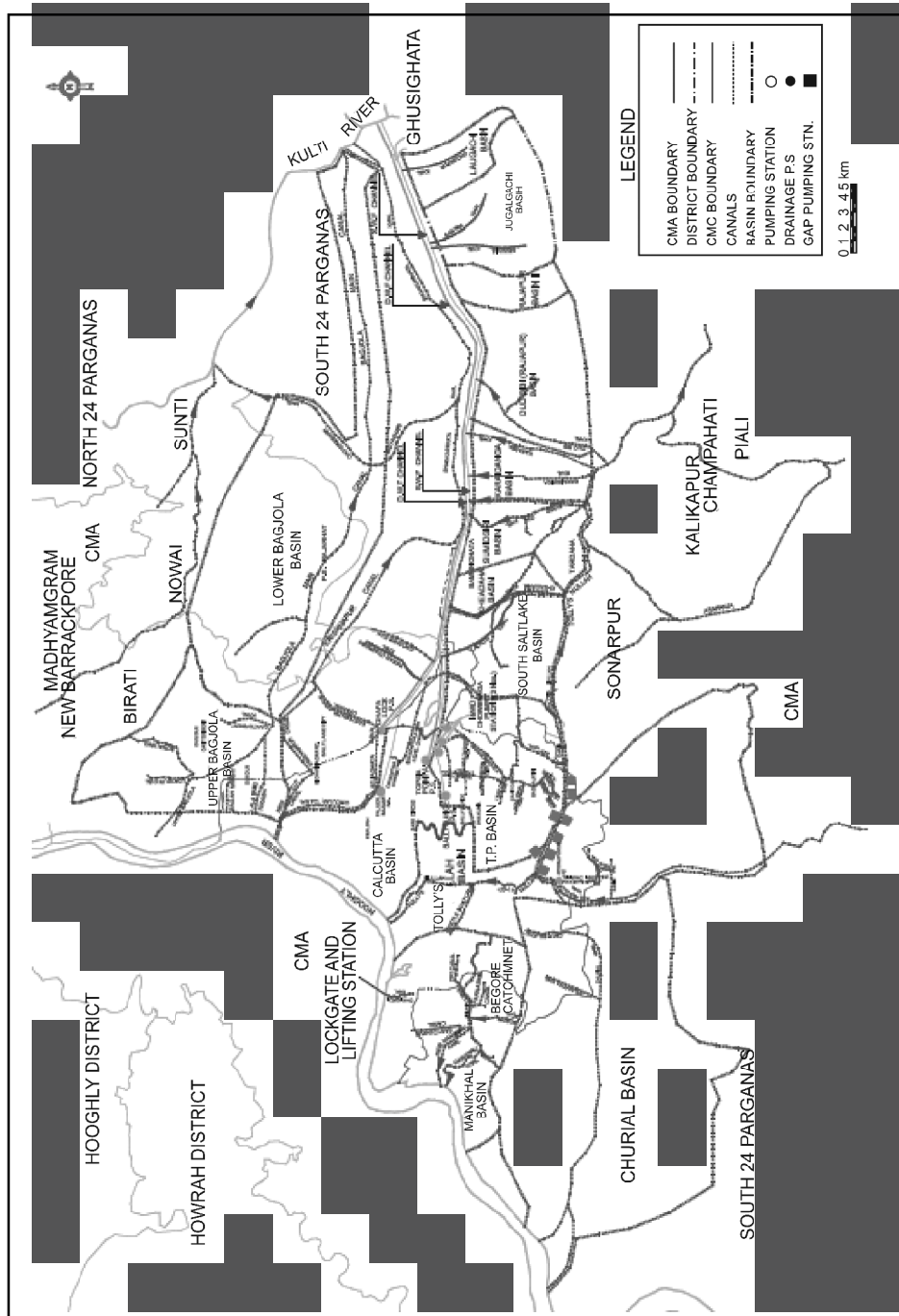


Fig-1

Source: Sewerage and Drainage Master Plan, CMC, 2008

Drainage congestion in the above basins are now severe due to rapid urbanization, improper planning of drainage system in the newly developed areas, siltation in the canals due to poor or no maintenance and reduction in carrying capacity of the channels besides human encroachment (Munshi 1975).

Brief Ideas on Drainage Network

The important drainage channels serving the Kolkata Metropolitan District Area are as follows:

1.Dankuni Drainage Channel, 2.Howrah Drainage Channel, 3.Rajpur Drainage Channel, 4. Barajola Drainage Channel, 5. Beghar Khal, 6. Naui Khal, 7.Tolly's Nullah, 8. Boat Canal, 9. Bagjola Khal, 10.Krishnapur Canal, 11. Kolkata Outfall Channel, 12. Beliaghata Canal, 13.Circular Canal, 14. Panchannagram Khal.

List of Canals Maintained by Different Authority

➤ BAGJOLA CANAL	➤ LEAD CHANNEL 9-A
➤ NEWCUT CANAL	➤ LEAD CHANNEL EE1 (MINOR)
➤ CIRCULAR CANAL	Ø LEAD CHANNEL C1C3
➤ BELIAGHATA CANAL	➤ LEAD CHANNEL B2B3
➤ KESTOPUR CANAL	➤ INTERCEPTING CHANNEL
➤ CENTRAL LAKE CHANNEL	➤ SUTI CANAL
➤ TOWN HEAD CUT CANAL	➤ KEORAPUKUR CANAL
➤ BHAGOR KATA CANAL	➤ WESTERN CHANNEL
➤ SWF CHANNEL	➤ RANIA CANAL
➤ DWF CHANNEL	➤ WESTERN CHANNEL EXT
➤ T.P. MAIN CHANNEL	➤ CHURIAL EXTN CANAL
➤ LEAD CHANNEL A3 A4	➤ KOLAGACHIA EXTN. CANAL
➤ LEAD CHANNEL AA1	➤ BEGORE CANAL
➤ LEAD CHANNEL BB1	➤ KALIMATA CANAL
➤ LEAD CHANNEL CC1	➤ CPT CANAL
➤ LEAD CHANNEL DD1	➤ MANIKHAL CANAL
➤ LEAD CHANNEL EE1	➤ SANTOSH PUR CANAL
➤ LEAD CHANNEL A5 A6 A0 A1	➤ TOLLY NULLAH

GREEN = KEIP Phase assistance available for works , Blue = KMC assistance being rendered ,Black = Irrigation may exercise continual vigil , Red = crying for attention, KEIP Phase-II is a distant call, but I & W Deppt. Could do something immediately.

Fig. 2.

Source : Irrigation and Waterways Department(I&W Dept.), 2009

Most of these channels were constructed more than 7-8 decades ago. For example, both Dankuni and Rajapur Channels were constructed in the latter part of the 19th century. Tolly's Nullah, the oldest, said to be the lifeline of the drainage system in the city, was first excavated in 1776.

As a consequence, repairing and maintenance has become a major problem, facing the outfall system in the city, because this task have been grossly neglected in the past, and even today has not received the priority which it deserves.

At present, Tollys Nullah is no more than an insignificant tidal creek, but even until 1909, it was used by a motor launch. This days water is plentiful up to the point where the tidal effects operates but a great part of the channel remains dry or covered with water hyacinth, because a number of authorities maintained this canal ,so always a controversy exist regarding its maintenance. Dasgupta (1991) A stretch of Tolly's Nullah has been renovated but the importance of regular dredging and silt clearance envisaged earlier was lost sight of; it is made only in the upper reaches by setting up cross dam. No arrangements have been made for dredging the lower part of the channel which is getting silted up gradually. The shortfall in the performance of storm drainage in the combined system adopted in South Kolkata has necessitated the provision of relief sewers which, in a way, is effecting a separate system of storm drainage.

Bagjola Channels was another important outfall which had been greatly silted up and affected the discharge into Bidyadhari River. The lining of the canal upto the crossing of Jessore Road had augmented its carrying capacity, but so far not enough has been made in terms of excavation. This to be noted that the two canals - Beliaghata & Circular Canal plays a significant role in drainage system as they separated the eastern part of the city from the rest. It acted as minor storm water channel for the city, and at some points it has 50 m. in width. It was found that during abnormal rainfall the outfall level in the Kulti or Hooghly River flowed much higher than the assumed level. This problem evolved from a large inflow from upstream area, which raised the water level in those storm water channels thereby creating drainage problem in outer and inner areas of Kolkata city, as well as helped to reduce the efficiency of the pumping station.

The discussion in this section would require the reference of the Hooghly River too. The Hooghly River entered the area at Tribeni, moved straight south up to Hooghly-Chinsura and then moved south along a sinuous course upto Mahesh. Down stream of Mahesh it flowed straight up to Bally Khal. The consistence of the Hooghly channel depend more or less on the harmonious interplay of the ebb and flood currents as modified by the curvature of the banks and the width of the river bed. The upland flow usually dominates during August to September. The tidal flood on the other hand dominates during January to April, and together was balanced during May to June. The tidal effects in the Hooghly River extended up stream up to Gupti Para. The Hooghly river in the more recent past used to flow along a braided course of the 'Adi Ganga'. The 'Adi Ganga' stretched from the vicinity of Hastings where it had an outfall into the Hooghly River, passed

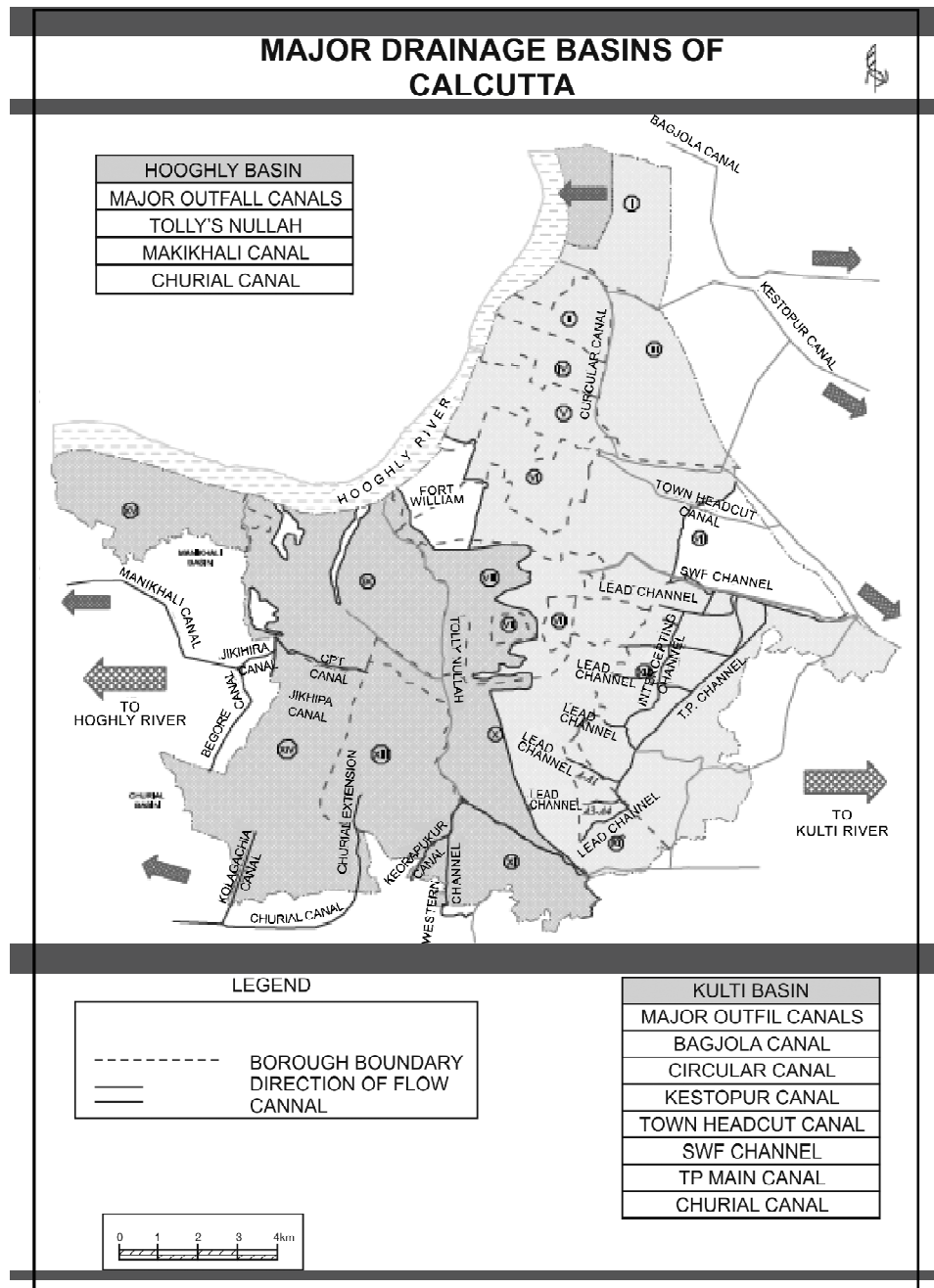


Fig. 3.

Source: KEIP, 2008

through Alipore, Kalighat, Tollygunge, Bansdrone and then serving south by the side of Boral, Rajpur and Baruipur. The stretch from Hastings to Bansdrone was re-excavated in 1776 to save it as a line of navigation by Major Tolly and was known as the Tolly's Nullah.

Principal Canal Network of Kolkata and Suburbs

'Drainage' includes the collection, transportation and disposal of all liquid wastes and all the samples rain water of storm flow from the Kolkata city and its adjacent suburb. Therefore the primary requirements for a good drainage system are:

- Adequacy and suitability of collection works i.e. drainage inlets for transportation.
- Adequacy and suitability of transporting system for quick collection and transportation of the drainage to various disposal points.

Brief Description of Canals/Basin

Circular-Beliaghata-New Cut-Kestopur Canal-Bhangar Kata Canal

At one point of time, Circular Khal was the most important canal for navigation. There was no slope maintained in this khal only because of its easy navigation. It was proposed by 'Tiratra' who earmarked its water flow, but 'Lord Wellesley' refused the proposal. It takes off from the Hooghly river at Chitpur and then bifurcates near 'Gajnabi Bridge' (R.G. Kar Hospital). The eastern branch is known as New Cut canal. In 1910 the Kestopur Canal was excavated extending to the Bidyadhari River. Due to deterioration of the river Bidyadhari, the channel was subsequently extended as the Bhangore Kata canal from Katatala to the Kultigong River. With the provision of navigation locks at the Chitpur and Kult which served as navigation link between the river Hooghly at Kolkata and the Sunderbans for many decades. However it is no longer in use for navigation. Further chitpur lock was also constructed during this year. (Bose, 1966)

The other branch canal from the Circular Bridge known as the Circular-Beliaghata Canal goes up to EM Bypass and from there it is connected with an excavated channel along the south eastern boundary of the Salt Lake City. The length of Circular-Beliaghata Canal is 8.4 km and that of Kestopur-Bhangore Kata Canal is about 39 km. The Circular-Beliaghata-Kestopur-Bhangore Canal now drains a part of the Kolkata city in the north and also the newly established Salt Lake City (Bidhannagar) and a vast rural area on its banks. It is rather been said to be misused for dumping domestic and other municipal wastes. Indiscriminate dumping of various obnoxious industrial wastes by innumerable industrial establishments and small scale units has choked up the canal system totally.

Tollygunge Panchannagram Canal T.P. Canal

T.P. Canal plays a very important role so far as the sewages of Jadavpur, Santoshpur, Kasba, Tiljala area of CMC is concerned. This area was basically a very low marshy land. From 1934-1940,

the area was submerged under water and inhabitants suffered badly, particularly in Kasba and Haltu areas. In 1941, the then Tollygunge Municipality tried to discharge the stagnant storm water into the SWF Channel and therefor authority excavated a new 'Khal' near 'Chowbhaga'. Thereafter they made a scheme for discharging storm water within an area of 33.15 sq. km of which 22.53 km² in urban sector and rest are rural sector. This schedule covered the area namely Budge Budge Rail Line & Tollys Nullah in the East, Salt Lake on the West and North, SWF Channel on the South. The length of T.P. Channel is 6.76 km. Except this there are a large number of Intercepting channel, as well as a number of tributaries criss-crossed with this channel.

The entire basin has a good canal network system. The drainage from the entire area leads to TP Main Canal through a system of lead channels, which may further be divided into fourteen sub-basins. The discharge from T.P Main Canal water is pumped into the SWF channel through three pumping stations at Chowbhaga having a continued discharge capacity of 41 cusec from ultimate discharge into the Kulti River at Ghusighata, 36 km away. The SWF channel, in addition, also caters the storm water discharges from Kolkata basin via Palmer Bridge pumping station and suburban basin via Ballygunge Drainage pumping Station.. The entire system has been developed as a combined system to cater septic tank effluents as well as storm water which ultimately discharged to the nearby drainage courses.

Two Satellite Townships, developed by CMDA exist within this basin namely Baishnabghata-Patuli Township and East Kolkata Township. Drainage networks in both the townships have been developed as separate system. For Baisnabghata-Patuli Township there exists a sewage treatment plan to treat the raw sewage. The treated effluent is discharged to nearby canal. For East KOLKATA Township also a treatment plant was constructed, however, it is not functioning at present and the raw sewage is disposed off to the nearby drainage course.

Silt levels of the cross drainage structure are in places higher than the canal bed level causing serious obstruction in drainage path. Moreover, due to siltation, the bed levels of canal have gone up and at many places invert levels of underground conduits at outfall locations are below the canal bed level which not only obstructs the flow but creates back-flow through the drainage conduits.

Churial Canal

Sewerage area covered under the Churial Canal is 164.989 sq.km (63.70 sq. mile) out of which 141 sq. km (54 sq. mile) is within CMC and 23.33 sq. km (9.01 sq. mile) is rural. Main Khal having length of 17.59 km, passes through Behala to East Barisha and finally meets Hooghly river, through five points sluice with capacity of 28.32 cumec (1000 cusec) under BudgeBudge Municipality. Besides storm runoff, all the drains cater sewage water as well. No underground drainage system persists within this basin. South Suburban East STP constructed under GAP Scheme to treat dry weather flow generated from Tolly's Nullah basin is located within this basin

Keorapukur Canal

Keorapukur canal is a 32 km long drainage canal aligned approximately north-south direction and having outfalls at both ends. The 7.2 km northern section drains to Tolly's Nullah, while the southern section ultimately drains to the river Hooghly via the Churial Canal. The northern section is silted up and this leads to water logging in the monsoon. Another drainage channel in the Keorapukur basin is known as the Keorapukur Western Channel. This is 1.74 km in length and also drains into Tolly's Nullah, through a pumping station.

Begore Canal

The Begore basin comprises an area of 6.1 km², about half of which is the CMC area and about half is bounded by Parnashree Pally and Monikhali channel on the north, Diamond Harbour Road on the east, Biren Roy Road on the south and the road from Maheshtala to Biren Roy road on the west. The Begore Canal drains a highly urbanized part of the CMC area, a low lying detention area known as Jayrampur Jala as well as rural area in Maheshtala Municipality which suffer from acute drainage congestion due to lack of a proper drainage artery.

Manikhali Basin

There are two sewage system exists in Manikhali basin having an area of 54.00 km² (1) New Manikhal of 6.931 km in length (2) old Manikhal having an area of 4.998 km². The drainage system of the entire basin has been developed with surface drains, a limited portion of which is covered. Moreover, considerable length of the existing drains is of unlined section. Besides storm runoff, all these drains carry septic tank effluents also.

Kolkata Drainage Outfall (SWF and DWF) Channels

Kolkata lies on the land that slopes towards the east, i.e. away from the river Hooghly. The area is very flat and low, with a saucer-line shape, with scattered local low pockets. During rainy seasons, 100 mm rainfall a day is usual, and sometimes this runoff rate is exceeded resulting in prolonged and extensive inundation. About 115 km² extending from Bagbazar and Manicktala in the north to Tollygunge in the south of Kolkata has extensive sewerage. The storm water and sewage from the entire area is pumped for disposal into two important drainage arteries. Storm Water Flow Channel (SWF Channel) and Dry Weather Flow channel (DWF Channel) that CMC excavated between 1937 and 1939. This system also serves some rural areas stretching along its flow line from the city to the outfall covering an area of about 150 km². This outfalls play a vital role in Kolkata system. The SWF Channel system comprises three separate channels, starting from pumping stations at Ballygunge, Palmerbazar and Dhapa. This system also receives storm water and sewage water from the pumping stations at Chowbagha. These, three channels meet a Bantala and the combined SWF Channels reaches the river Kultigong at Chusighata. Known as the Kolkata Drainage Outfall system, the channels take care of storm water flow of the central, southern and south-eastern parts of Kolkata.

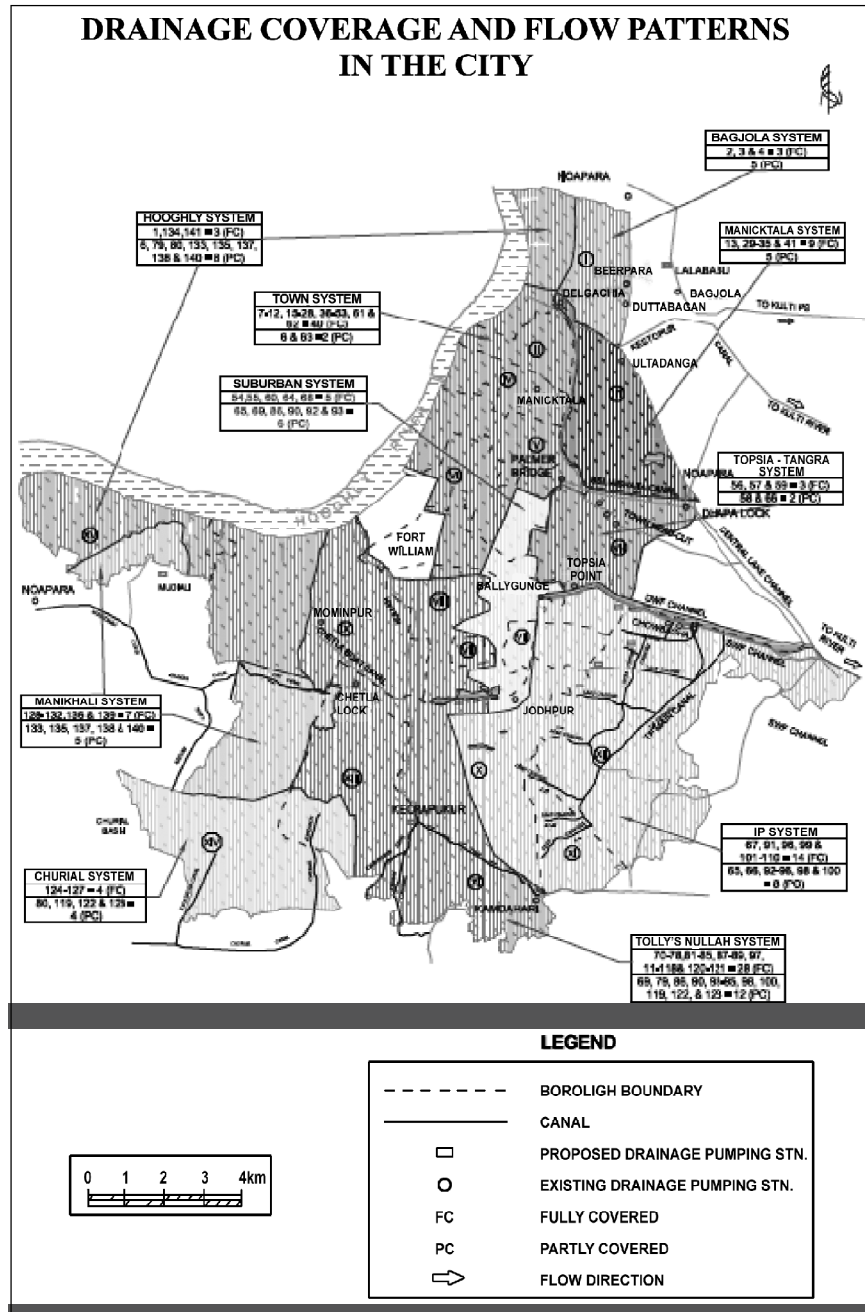


Fig. 4.

Source : KEIP, 2008.

The construction of the SWF and DWF channels split the Bidyadhari into two halves. The southern half which lead to the Matla estuary has been subjected to heavy siltation through tidal action. The drainage of

Kolkata is thus very much dependent on the condition of the Kulti River which has shown signs of progressive siltation (Govt. of West Bengal, Dept. of Environment, 1997)

Tolly's Nullah

In 1778 Mr. Tolly obtained permission to excavate part of the course of the Adi Ganga, a tributary of the Hooghly River, to link up with a new port at Taratala on the Bidyadhari (Government of West Bengal, Department of the Environment, 1997). This channel is still known as Tolly's Nullah. Through no longer used for navigation, but it is still an important waterway, draining a substantial part of the south KOLKATA. It is 27.4 km long, from the river Hooghly end near the old Kidderpore Dockyard (Hastings) and the river Bidyadhari (now almost dead) at the other end near Sambalpur. Its improvement will improve the quality of life of a large number of people living either on its banks or in its peripheral areas. The Boat Canal, a tributary of the Tolly's Nullah, is the main contributor of pollution to the Nullah, which in turn pollutes the River Hooghly. A number of huge pipe and big inlets carrying untreated effluents from the surrounding municipal areas of the nullah have contributed both negative impact like siltation and pollution. Heavy siltation occurs due to disposal of industrial wastes, municipal wastes and carcasses into the Canal.

The Hooghly Basin

A considerable portion of Garden Reach area (part of borough XV) lies within this basin. The under developed areas are generally low lying pockets and prone to submergence during rains. The existing drainage pattern of this basin is predominantly open surface drains, with Dhankheti canal and Khaldhari canal as the two major drainage outlets. Apart from these, there exist a large number of surface drains which discharge the combined flow directly to the river. Hooghly basin is broadly divided into three drainage sub basins viz. Dhankheti canal sub basin, Khaldhari canal sub basin and Hooghly sub basin.

Bagjola Canal

Bagjola Canal provides the main drainage for a basin area of 164 km², 49.2 km² which is upstream of VIP Road. It crosses several municipalities including Panihati, Kamarhati, Baranagar, North Dum Dum, Dum Dum and South Dum Dum. It does not pass through the CMC area, but part of Borough I. The upper Bagjola Canal runs from B.T. Road in a south-easterly direction for about 9.2 km up to VIP Road through a densely populated area. Beyond VIP Road, the channel is known as the Lower Bagjola Canal; it runs through Rajarhat, Bangore, Haroa etc. areas for a length of about 28.5 km draining a basin area of about 115 km² before discharging to the Kultigong river near Ghurighata through two sluice gates.

Table 2. Salient Features of the Canals and their Problems

Name of Canal	Basin area (km ²)	Length (km)	Basin Feature	Major Problem
Upper Bagjola Lower Bagjola	49.2 11.5	9.2 28.5	Highly urbanized Rural base with rapidly growing. urbanization (New Rajarhat Township)	Acute drainage congestion enhanced runoff reduced cross section
Circular Beliaghata New Cut Kestopur, Bhangore kata khal		47.75	Urbanized Industrial area	Encroachment, reduced cross section and pollution
Dry weather Flow Storm Weather Flow	150	50	Urban as well as rural built up area	Enhanced runoff, siltation and encroachment
Tollygung . Panchannagram. Channel	33	12	Highly Urbanized	Exclusive siltation, liberal encroachment, enhanced runoff
Tolly's Nullah			Urbanized and industrial	Encroachment, reduced cross section and pollution
Begore Canal	6.05	3	Urbanized and industrial area	Acute drainage congestion
Manikhali canal	54	10.93	Urbanized and industrial area	Unplanned growth, encroachment
Churial Canal	165		Upper reaches Urbanized lower reaches rural area	Reduced cross section and enhanced runoff

Source: I&W Dept., 2008

Except these basins, some other basin also has been highlighted in Master Plan. Like Maniktala-Sub-Basin, Howrah Basin, Konnagor sub Basin, Khardah Basin, Magrahat Basin, Southern Salt lake Basin, Suti Basin, Nawi Basin, Rajapur Basin, Bagjola Basin, North West Riparian Basin.

Conclusion

Details networking system of canals or outfalls are discussed in this study, from which one can have an idea the outfall system as well as the role on Kolkata's drainage system. Spatial coverage and system details are shown in table:3. A close relationship between drainage and public health, hence during the monsoon occurrence of frequent flood leads to often health hazards Murmu, (2021). So it is the duty of the authority to take hard steps to remove the storm water by

Table:3 Spatial Coverage of Drainage and flow Patterns in the City

SYSTEM	WARD COVERED		AREAS SERVED	COVERAGE OF UGD* SYSTEM	CANAL STATUS**	KMC's PROJECT COVERAGE
	FULL	PART				
TOWN	7-12,15-28, 36-53, 61&62	6 & 63	Bagbazar, Shyambazar, Sovabazar, Taltala, Barabazar etc.	100%	SWF Channel / Fair	Project Nikashi
SUBURBAN	54,55,60,64 & 68	65, 69, 86, 90, 92, & 93	Beniapukur, Entally, Ballygaunge, etc	100%	SWF Channel / Fair	Project Nikashi
MANICKTALA	13,29-35 & 41	5	Bhawaniapore, Alipore, Chetla, Kalighat, etc.	90%	Circular Canel / Good	Project Niskashi
TOLLY'S NULLAH	70-76,81-85, 87-89,97,111-118 & 120-121	60, 79, 86, 90, 93, 95, 96, 100, 119, 122 & 123	Cossipore	60%	Tolly's Nullah & its branches / Fair	KEIP (part)
BAGJOLA	2, 3& 4	3	Topsia, Tangra, Chingrighata	30%	Bagiola Canel / Fair	KEIP
TOPSIA – TANGRA	56, 57 & 59	58 & 66	Jadavpur, Kasba, Garia, etc	30%	Circular Canel, Town Head Cut Channel / Fair	KEIP
T P	67,91,96,99 & 101 - 110	65, 66, 92-95, 96 & 100	Chitpore, part of Garden Reach	25%	T.P. Main Canal & its branches / Poor	KEIP (part)
HOOGHLY	1, 134 & 141	6, 79, 80, 133, 135, 137, 138 & 140	Behala, Taratala, Garden Reach	20%	Hooghly River	KEIP (part)
MANIKHALI	128-132, 136 & 139	133, 135, 137, 138, 140		5%	Manikhali Canal & its branches / Poor	KEIP
CHURIAL	124 – 127	80, 119, 122 & 123	Sarsuna, Barisha, Thakurpukur, haridebpur	Not-coverage	Churial Canal & its branches / Poor	KEIP

Source: CMC, 2010

canals/khals for better sanitary and drainage condition for the sake of protecting the environment as well as human health. Now KMC, Authority, KEIP, KMDA, KMWSA, I&W Dept. have taken up some steps to protect khals/canals and their major primarily serving areas. Above table also shows a clear view of the total canal, their cover area, the liable authority as well as the canal status etc.

Due to some constraints canals could not play an effective role at the time of excessive storm water flow, one of the main constraints to effective drainage of the canals is the build up sediment. There is no regular maintenance, resulting in a gradual reduction in hydraulic capacity. The accumulation of silt throughout the years which is caused by the encroachment that makes the canal becomes ineffective. Hence at the time of monsoon, canals can play a role as a good outfall system for Kolkata city. It therefore should be desilted throughout the year and cared properly and looked economically then the canal is sorted out to be the best effective part to remove the curse of the water logging problem.

From the above discussion a glimpses of the then condition of the drainage and sewerage system has been discussed. Different committees proposed their plan and recommendation which was initiated and implemented from colonial period to till now, but this urban flood problem was still become a chronic problem for city dwellers in the monsoon period. Under these circumstances, it is now dawning on the planners and policy makers and urban managers that what is needed is an integrated and comprehensive urban planning and not just the conventional ad hoc fire-fighting approach. Special mention needs to be made in this context of 'urban water harvesting plan' which is now being strongly advocated in many cities for flood proofing as well as water retention for drinking, fire-fighting and other urban water uses. A judicious combination of structural and non-structural responses, including institutional, economic, financial, and social efforts is essential. Coordination (horizontal and vertical) between various institutions and administrative bodies is equally important to Kolkata.

References

- Authority, C. M. (1966). Master plan for Water-Supply Sewerage and Drainage, Kolkata Metropolitan District. Metcalf & Eddy in association with Engineering Science Inc., USA.
- Bear, L. (2011). Making a river of gold: Speculative state planning, informality, and neoliberal governance on the Hooghly. *Focal*, 2011(61), 46-60.
- Beckert, S. (2004). Emancipation and empire: reconstructing the worldwide web of cotton production in the age of the American Civil War. *American Historical Review*.
- Bose, P. C. (1966). Environment and Health in the Kolkata Metropolitan Region. *Royal Australian Planning Institute Journal*, 4(4), 152-157.
- Bose, S. (2008). Adaptive and integrated management of wastewater and storm water drainage in Kolkata—case study of a Mega City. In *Adaptive and Integrated Water Management* (pp. 341-355). Springer, Berlin, Heidelberg.
- Chattopadhyay, S., Dutta, A., & Ray, S. (2009). Municipal solid waste management in Kolkata, India—A review. *Waste Management*, 29(4), 1449-1458.

- Dasgupta, B. (1991) *Kolkata Urban Future: Agonies from the Past and Prospects for the Future*. South Asia Books.
- Furedy, C. (1984). Survival strategies of the urban poor—scavenging and recuperation in Kolkata. *GeoJournal*, 8(2), 129-136.
- Grover, B. P. C. (2016). Geochemical modeling of the speciation, transport, dispersal and fate of metal contaminants in water systems in the vicinity of tailings storage facilities (Doctoral dissertation University of the Witwatersrand, Faculty of Science, School of Chemistry).
- Gokhale, S., & Kapshe, C. (2016). Review of decentralized planning initiatives and urban local government functions in India. *Dynamics of Local Governments: A Comparative Study of India, UK and the USA*. *Local Government Quarterly*, 85.
- Manual, C. P. H. E. E. O. (1993). *Manual on Sewerage and Sewage Treatment*. Ministry of Urban Development, New Delhi.
- Munsi, S. K., & Munsî, S. (1975). *KOLKATA metropolitan explosion: its nature and roots*. New Delhi: People's Publishing House.
- Murmu, S. K., Islam, N., & Sen, D. (2021). The heritage sewer networks of Kolkata (KOLKATA) and ascertaining their coping potential under growing urban pressures. *ISH Journal of Hydraulic Engineering*, 1-11.
- Nath K. J. and A.Majumdar 1990. "Drainage, Sewerage and Water Disposal in KOLKATA", in S. Choudhuri (ed.), *Kolkata the Living City*, Vol. 1, the Past, Oxford University Press, Oxford, pp. 2-4.
- Nair, P. T. (1986). *Kolkata in the 17th century* vol. 1.
- O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., ... & West, J. (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global environmental change*, 14(4), 303-313.
- Pal, A. (2006). Scope for bottom-up planning in Kolkata: rhetoric vs.* reality. *Environment and Urbanization*, 18(2), 501-521.
- Parkinson, J., & Mark, O. (2005). *Urban storm water management in developing countries*. IWA publishing.
- Plan for Metropolitan Development 1990-2015, Kolkata Metropolitan Development Authority, August 1990.
- Rehabilitation of Critical Sewers in Kolkata, KEIP, March 2006, PMC
- Sen, R. (2019). *Birth of a colonial city: Kolkata*. Taylor & Francis.
- World Bank. (1993). *World Development Report 1993: Investing in Health*, Volume1. The World Bank.