



Mumbai Floods- Case Study on Floods in Reclaimed City

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Abstract

The process of urbanization has induced rapid changes in the land use leading to many infrastructural and environmental problems, one of them being the frequent flooding during the rains in Mumbai. The urban land use of the Mithi river catchment in Mumbai and its effects on the river, its drainage and flooding events in the catchment area specifically in conjunction with the July 26, 2005 flood event in Mumbai city. The river has been polluted by dumping of raw sewage, industrial waste and municipal waste into the river. Besides this, illegal activities carried out discharges of unauthorised hazardous waste along the course of this river. Also, the retaining wall built along the Mithi river has cut-off the mangroves and left them for dying. The authorities tried to make some changes, awareness and rules to maintain the river clean but that doesn't change the scenario. This year in the very first month of the monsoon, the city received the highest ever rainfall in the decade with the main SWD and the Mithi river overflowing, water logging in various parts and the resulting worst situation putting a stop on

the city. Following the damage caused by severe floods in Mumbai in the past, the BRIMSTOWAD Project was initiated by the Municipal Corporation of Greater Mumbai (MCGM). Engineers and Researchers, under this project, studied the storm water drainage system of Mumbai in detail and submitted a report in 1993 to MCGM giving suitable recommendations, but they largely remain unimplemented. However, this is not the first time that Mumbai has received heavy rains and this won't be the last and Mumbai may see the same situation this year, and next year and the next.... If regular and perfect precautions are not taken.

Introduction

We choose this as the Mithi River also known as the Mahim River has been in the news for the over flooding and reclamation of the area and how polluted it has been over the time. The Mithi River is a sewer on the island of city Mumbai, India. The sewer is seasonal and rises during the monsoons. The overflowing lakes also contribute to the sewer flow which is stopped by various obstructions. This river originates from the overflow of Vihar lake and also receives the

overflow from the Powai Lake. It flows through the residential and industrial complexes of Powai, Sakinaka, Kurla, Kalina, BKC, Dharavi and at last Mahim. After the 26th July 2005 deluge, it has become very important to look after the Mithi River. As Mumbai was built by reclamation of land which joined the 7 major islands, Mithi river was the only way out for the storm water and drainage water. Over and over the years for the build-up area and new land for the development the river was reclaimed. The highest number of land reclamation took place in the past 40 years in the city's more than 300 years of history of reclamations. The major reclamation works are the Bandra Kurla Complex Land Reclamation, the Airport Reclamation and the Bandra Worli Sea link constructed near the exit of the river. As discussed, Mumbai we can see that there will be high demand of land against the availability and thus we see that over the period of years, in Mumbai 50% of the land from the beaches, lake sides, hillocks, inter-tidal zones and mangroves were eaten-up to favour urban use.

Findings

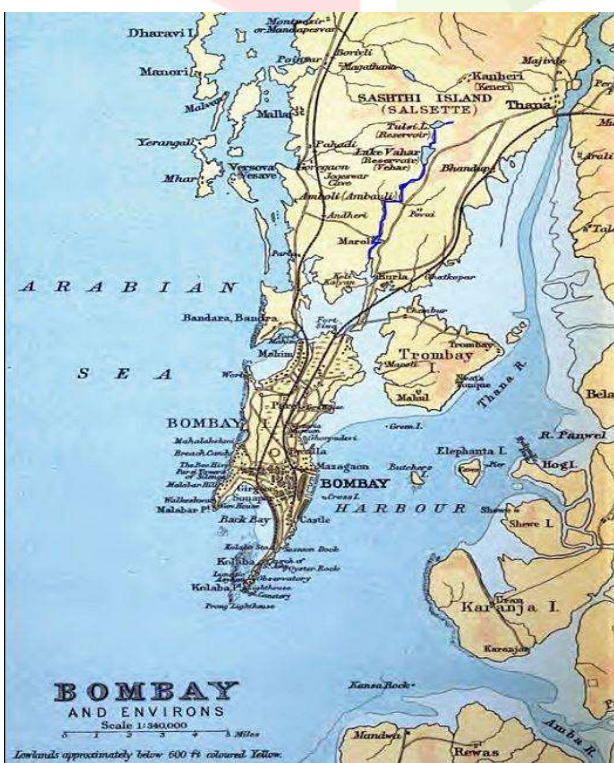
Mumbai city receives seasonal rainfall for four months, from June to September. Average rainfall is 2500 mm, of which 70 per cent is during July and August. Mumbai is lined on the west by Arabian Sea and is intercepted by number of creeks (Mahim, Mahul and Thane creeks), rivers (Mithi, Dahisa, Poisar and Oshiwara rivers, and their tributaries) and a complex nallah (drain) system. The Storm Water Drainage (SWD) system of Mumbai comprises a hierarchical network of roadside surface drains (about 2000 km length, mainly in the suburbs), underground drains and laterals (about 440 km length in the island city area), major and minor channels (200

km and 87 km length, respectively) and 186 outfalls, which discharge all the surface runoff into rivers and the Arabian Sea. Of the 186 outfalls, there are 107 major outfalls in the city, which drain to Arabian Sea directly, 4 at Mahim creek and 4 at Mahul creek. There are 29 out-falls in western suburbs draining directly into sea while 14 drains into Mithi river which ultimately joins Mahim creek. The Mithi river constitutes a major component of the city's SWD system. The location of the river is important from the point of view of the city as it serves as a dividing line between the city and its suburbs. Thus, its flooding has direct or indirect repercussions on the disruption of the traffic on the five transport corridors viz. Central Railways, Western Railways, Western Express Highway, Eastern Express Highway & the Harbour Railway Line. The storm water drainage of the river is encroached upon by a large number of huts, storages, processing industries, workshops and scrap yards situated along its banks. These settlements make it difficult even to define the path of the river. Direct discharges of the untreated sewage, wastewater, trash from the unauthorized settlements and industrial effluents flow into the river's course and choke it up, thus raising the level of water during heavy rains. Also, the reclamation of land along the banks of the river has also reduced the width along the run of the city causing reduction in the discharge and overflow of water. A report by the state states that the 18km long river width has been reduced nearly 50% and the mangroves on both sides of the river have decreased by 70% between 1966 to 2005. The History of reclamation work is also so complex that the present picture of Mumbai that we see now was not the actual plan. The

reclamation plan has not even done to its full extent whereas it's just the 1/6th of the original plan. This reclamation doesn't give equal and directional flow to the water in the drainage system and thus the city faces problems over and over years as more and more land has been concretised. The city was planned to have 50% of runoff and 50% percolation. But after the concretisation which is about 90% of the city, the percolation rate is now almost 0%. This makes the runoff water 100% and thus the drainage system is already above being used over their limits.

Discussion

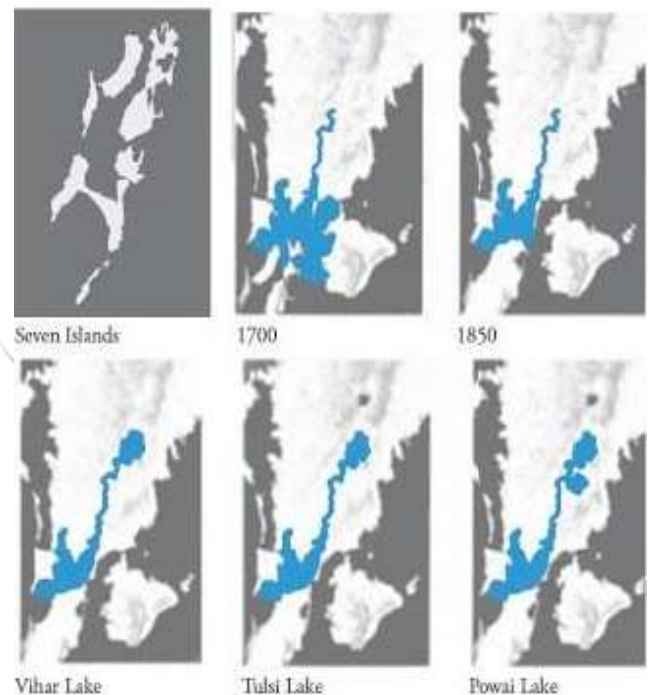
The compromised behaviour of the public body has led to many problems of which Mumbai floods is one of the major issues faced by the island city. Mumbai being the financial capital has never stopped the development plans and for such development plans the city development authority have done many reclamations works over the development of the city. This all started right from the British Era when Mumbai was not a complete island, it was divided into 7 different islands which were divided by Arabian Sea.



History of Reclamation

When these islands were connected by the process of reclamation, the overflow stream from the Powai Lake and Vihar lake formed the Mithi river. This was the only outlet or some form of discharge channel for the storm water drain in the rainy season and as a sewage outlet in the rest of the year.

Over the period of time the various reclamation work happened in the past 300 years after the merging of islands. But from a report we see that in the past 40 years the reclamation work has been doubled or more than the rest 300 years. This reduced the width of the river and reduced the discharge flow and at times of rains the water overflows the channel. The overflow results in flooding and hence it stops the lifeline of the city.



The study shows that while the total built up area of the city in the 1970s was 195.01 sq. km, as against the total area of 632.6 sq. km, it shot up to 338.38 sq. km in the 1990s, and 385.67 sq. km in 2011. This has caused an unprecedented loss of natural landscape due to land use change in favour of built-up area for urban use, created after eating up more than 50 percent of Mumbai's beaches,

lakes, vegetated islets, hillocks, inter-tidal zones and mangroves. This has been witnessed most intensively and extensively in the northern and eastern periphery of the city.

The original plans for the reclamation of Mumbai had a huge open ground, holding ponds and proper planned roads and water systems. But due to the political benefits and environmental researchers' opposition the work in which the mountains of the islands were to cut and make Mumbai a proper flat land was not even done and the work at many places did not have proper levels. Even the authorities didn't have a contour map of the geology of the city. Further reclamation works were done over the period of years and the city which we see now was formed.

Not having proper ideas, not having proper plans, made the work of making the drainage work useless. The elevation of the city was not equal thus at many places the elevation was high and at some low. These low-lying areas are now the most vulnerable zones of the city where just a few mm of rains, water logging and drainage problems are seen.

The drainage levels of the outflow were also not planned according to the tide levels. Over 300 outflow pipes only 6-10 pipe were above the mean high tide level and 20-40 were between the mean high tide and mean low tide level and the rest all had levels lower than the low tide level itself. Also, the capacity of the drainage was too low and as the percolation decreased that water added on to the system. The BMC and MMRDA made a committee which formed BRIMSTOWAD which was given work to carry out the modification of the system. The current capacity has been doubled but the system still doesn't have the overall capacity.

Recent Reclamation

These are some recent reclamations which are adding up and making this city vulnerable. Being the financial capital, many aspiring workers come to the city in need of work and those who fail they settle up in the slums. Dharavi the largest slum of this city is situated near the banks of the river and the city see's many more slums that have developed over the years without any municipal or other authorities giving relief package or settlement or any kind of rehabilitation to them.

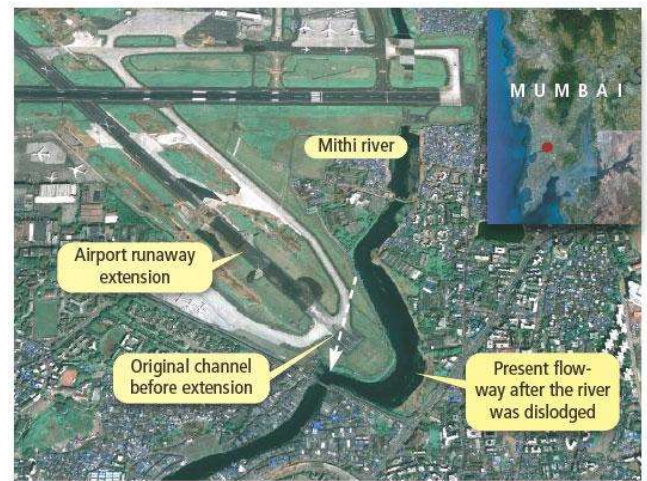
The MMRDA was appointed as the "Special Planning Authority" for planning and developing the Bandra-Kurla complex in 1977. It covers 370 hectares of once low-lying land on either side of the Mithi River, Vakola Nalla and Mahim Creek. The area had poor surface drainage and was severely affected by pollution in the Mahim Creek. One of the important features of the channelization of Mithi river and Vakola Nalla was to improve water carrying capacity and reduce pollution but this didn't go as planned. Mithi River for about 4.5 km of its length from Mahim Causeway to C.S.T. Road Bridge and its tributary Vakola Nalla, for 2.5 km of its length, have been channelized for an average 60 m and 40 m bed widths respectively, thereby improving the hydraulic features of these two important water courses in the BKC area. The land which was reclaimed had 18% of residential area and rest for the commercial use. As we see the MMRDA was also into improving the water carrying capacity and reducing pollution but the awareness was not made seriously and thus causing the pollution and dumping waste into the river and thus reducing the channel carrying capacity and causing obstruction in the flow. The development of the BKC was

important for the business district and commercial hub.

The Reclamation process is an unnatural process and also when we do reclamation it cannot be started today and take in use tomorrow. It is to be seen whether the structure is being accepted by nature or not. The same goes for the Bandra Worli Sea link, the land which was reclaimed near the end of the Mahim creek was taken into use without considering the natural cause. Now in consequence to that we see that the change in the flow of water and obstruction at the exit of the river causes erosion near the banks. This erosion has washed away the beach near Dadar, which was once 50 km. This leads to the coastal region reduction and less obstruction to the sea water for entering the city at times of rain.



The Airport Region was given permission for the extension for the second runway which then overlapped to the path of Mithi river. The path of the river was not to be diverted, instead was to go under the construction. But the authorities diverted it which makes its flow difficult and at such times of high flow the river overflows and washes on the runway. Here is a picture which shows the path which was needed and which is present. This reduced the width of the river at the start which is at the centre of the city.



A study shows that the average width of the river has remained only 10m along the length. This a matter of concern as the water at time of high tide enters the creek and then to the drainage system which increases the water level in the sewage pipes which in turn reduces the discharge.

The waste and the sludge getting accumulated at the bed of river also reduces the flow rate and due to increase in the area of development there is decrease in the area of catchment. So, the decrease in the area of catchment and reduction in the discharge over the same area leads to flooding, water logging and sewage water re-entering the inlet. The major cause of the sludge and waste getting accumulated are the slums where the awareness is low and the locals throw up the waste straight into the river.

The construction of Bandra Worli Sea Link is one of its kind in the history of development of the city. But the location and the reclamation work of the ends of the bridge near the coast at Bandra and near Worli had an increase in the level there and thus affecting the flow rate getting dumped by the Mithi river. Actually, the flow of seawater is obstructed by the piers of the sea link and thus have made the two main natural processes disappear.

1. When there was a high tide the sea water used to wash away the shores which had dumped waste for some period.
2. When there is high tide, the water enters the Mithi river from the Mahim creek which enters the upstream side and when there is low tide the water carries away the sludge and waste along with it.

This process helped the system maintain a natural process of cleaning and thus during rains there was no decrease in the rate of flow of water. But due the pier legs and base the water has stopped filtering the area and thus there is a major loss. Here we can see the catchment area and the developed part of the city,



Earlier 1900's



Present

Lastly the construction of the retaining wall was done for the prevention of erosion along the banks. It was built along the river and cut-off the mangroves from the sea water contact. This

led to the depletion of natural barrier and killing of the same. The court where the reclamation case is being conducted has given a stay order in further building of the retaining wall and also aims to remove and shift the structure back by 50m from the present. This will help in maintaining the width of the river and sustainable growth of mangroves.



Mangroves Separated by Wall

We see some major causes and reclamation in the past 40 years which are reason for Mumbai floods are:

1. Slums along the banks.
2. Bandra Kurla Complex reclamation zone.
3. CST Airport runway extension.
4. Bandra Worli sea-link (at the mouth of the river).
5. Waste dumped into the river.
6. Construction of Retaining wall affecting mangroves growth.
7. Moderating the river course by replacing existing sharp bends with longer gentler bends.
8. Providing Non-return valves for cross drains.
9. Providing Regular maintenance and dredging.
10. Providing smooth transition for waterways near bridges.

Conclusion

“Mumbai was reclaimed from the sea” such a statement is a simplification, however, since the area reclaimed was neither sea nor land, but something in between and thus many problems which came in the long run of the city. Some of the conclusion from the above case study can be drawn and they are:

- 1) Reclamation and encroachment work near and along the banks of the Mithi River have been so severe that they now have made it impossible to go back to the time when Mithi used to flow seamlessly.
- 2) However, BMC and MMRDA should now take utmost care to prevent the reclaim works very strictly.
- 3) The flow of Mithi is let uninterrupted as the terminal is built above the river, without making any changes in its path or area, thus decreasing the rate of flow for a particular area.
- 4) The Mithi can be joined to Mahul Creek via development of a channel which will increase the discharge and the capacity which is required during heavy rainfall periods.
- 5) Both sides from the banks of Mithi should be made reserved as Forest/Mithi reserved areas so that there would be no increase in the slums getting their habitats there, thereby decreasing the further pollution of Mithi. There should be strict laws made as they are for Aarey/SGNP.
- 6) There should be a separate committee / team for which will ensure the cleaning of Mithi and all other outfalls and also as many SWDs as possible. Not only before

the monsoon starts, but throughout the year.

Recommendation

1. Cleaning up of the channel:

Since the natural cleaning of the sludge and waste by the high tide and low tide effect has been reduced and the affected system due to pier obstruction has to be cleaned manually or by the machines.

2. Rehabilitation of the slums:

As the court has ordered that there should not be any habitation in 50m of the river, so it becomes easy to make required modifications in the channel and also there will be less waste thrown into the upstream.

3. Avoiding further reclamation:

As the city has been there for a long time and has adapted a natural process, but if any further reclamation work is done near the cost of Bandra, Worli, Bandra Kurla Complex, Airport Runway Extension can be hazardous to the city drainage and sewage system.

4. Connecting Mithi River to the Mahul Creek (**Major Recommendation**):

This is one of our own recommendations where if we see the Mithi river being connected to the Mahul Creek, the storm water drained to the Mithi river can be divided into two flows and thus reducing the load of flow. This will also reduce the overflowing of the water and affect the city working.

The government should see the change in the other part of the nation and also various Techniques at the international level to be adopted here. The Mithi river can be brought into live similar to the Sabarmati River which once was the polluted river which now has a river front and other water activities.

By just connecting the Mithi to the Mahul creek canal we can see the change in discharge and outflow discharge.

References

PDF: Increasing Storm Water Drainage Capacity of Mithi River and Mumbai City drains

Down To Earth:
[https://www.downtoearth.org.in/news/haphazard-land-reclamation-fuelled-mumbais-maximum--dreams-40745](https://www.downtoearth.org.in/news/haphazard-land-reclamation-fuelled-mumbais-maximum-dreams-40745)

Spring Link:
<https://link.springer.com/article/10.1007/BF02990923>

The Quint Article:
<https://www.thequint.com/explainers/mumbai-mithi-river-pollution-problem-explained>

Wikipedia Mithi Nadi:
https://en.wikipedia.org/wiki/Mithi_River

Science Direct:
<https://www.sciencedirect.com/science/article/pii/S0305748816301529>

