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Coastal City Resilience — A Case Study of Chennai, India

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Abstract: In the past two decades, India has been on a growth path economically. This growth also saw major developments in real estate with almost all the cities ever expanding and exponentially growing beyond the limits which caused unexpected physical changes to the natural topography. During the first ten days of December itself, the city received 539mm of rainfall as against the monthly average of 191mm. On 1st December, Chennai received 272mm of rainfall in a span of 12 hours. The floods of 2015 in a few days caused havoc to the environment, ecology and to the citizens of the city. The government agencies were unprepared to handle the problem and the citizens themselves tackled the situation saving lives and properties. The cities like Chennai are just a tip of an iceberg. Many cities in India have faced similar situations of flooding, the country has a particularly bigger challenge as most of the major cities are on the coastline of India which is 5700Kms long. The city of Chennai especially is significant as it was one of the most affected cities during 2004 Tsunami that hit the state of Tamil Nadu. Hence the dangers are from both internal and external sides, from within due to floods and from outside due to the Tsunamis. There is also a fear of climate change and the rise in sea levels which may affect the city in future. This paper will look at Chennai from both scenarios and discuss the way the resilient community responded in the absence or the ineffectiveness of the government machinery. It will further, deliberate the need for a change in the attitude of the people towards these recurring disasters and the way to mitigate them through urban design that responds to the very life of the people who would build their resilience in facing these disasters.

Keywords: Floods, tsunamis, the coastal community, urban design, rainfall, topography.

1. History of Tsunami in Chennai

The state of Tamil Nadu on the western coast of the south Indian peninsula is an area of low-to moderate seismicity thus not having experienced any strong earthquakes. On 8th February 1900, the city of Coimbatore once recorded an earthquake of M = 6.0 which was the strongest known. The earliest recorded tsunami in Chennai was on 31st December 1881 due to an earthquake of M = 7.9 at Car Nicobar Island, when the recorded height of the tsunami wave was 1m. The second recorded tsunami of 2m high waves was in August 1883 when a volcano erupted in Krakatau, Indonesia. Another recorded earthquake of M = 8.1 in the Andaman Islands caused a tsunami of 1m in Chennai on 26th June 1941 [1].

2. Tsunami of 2004 — External Danger to the City

A massive undersea earthquake with its epicenter located near Sumatra, Indonesia occurred on 26th December, 2004. This triggered massive seismic waves killing thousands of people in South-East Asia, Sri Lanka and India. In Tamil Nadu, the critically affected districts were Kanyakumari, Nagapattinam, Cuddalore, Kancheepuram and Chennai. The table below shows the effects of the Tsunami in Tamil Nadu.

In Chennai, the massive waves swept across the Marina Beach killing a number of fishermen and early morning walkers. It also cost lives and irreparable damage to the houses and the families of the fishermen

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who lived close to the beach. Several of the fishermen died in their sleep when water entered their homes in the Santhome and Mylapore in the early hours of the morning. A vast number of the deceased population were the children of the suburbs. The massive tide of water swept away houses and huts, a number of vehicles that were parked on the beach by the people who had come to walk.

Table 1 Tsunami effects in Tamil Nadu [1].

State	Coastal length affected (km)	Water penetration into mainland (km)	Average height of tsunami wave (m)	Human lives lost, per district	
Tamil Nadu (West Coast)	100	0.2-2.0	3-10	824	Kanyakumari
				6051	Nagapattinam
				612	Cuddalore
Tamil Nadu (East Coast)	800	0.4-1.5	2-10	128	Kancheepuram
				206	Chennai
				144	Others

Fig. 1 Aerial view of Marina Beach showing the water level rising and swamping the region [2].

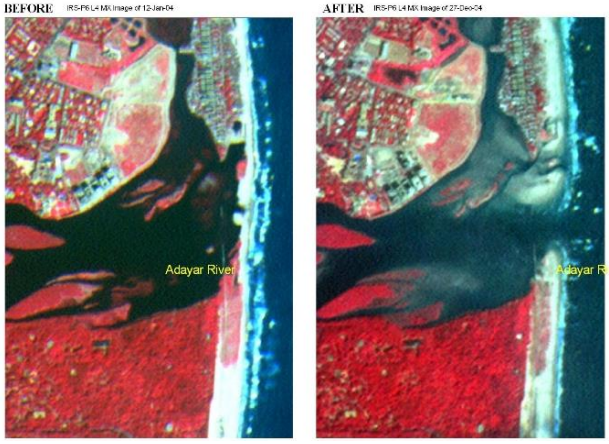

Fig. 2 Before and after satellite images of 2004 Tsunami at Chennai [3].

3. History of Floods in Chennai

Tamil Nadu with its coastline of about 1076 km is one of the longest of the country. The capital city of Tamil Nadu, Chennai is elevated about 6.7 m above the sea level. The two main rivers that provide water to Chennai are the Cooum river and the Adyar river and the Buckingham Canal serves as the primary canal water drainage.

Chennai has been a victim of disastrous flooding a number of times in the past. The years 1903, 1918, 1943, 1976, 1978, 1985 and 2002 witnessed cyclones that caused heavy flooding. Failure in maintaining the two main rivers and improper drainage systems resulted in irreparable damage during the floods [5]. The years 1976 when the Army had to step in to keep the Manali oil refinery from shutting down is remarkable. Another year 1985, when M.G. Ramachandran, the then Chief Minister of Tamil Nadu, had to evacuate his residence due to the floods is worth mentioning. The Cooum and the Adyar rivers were damaged in the years 1943 and 1978 respectively [6].

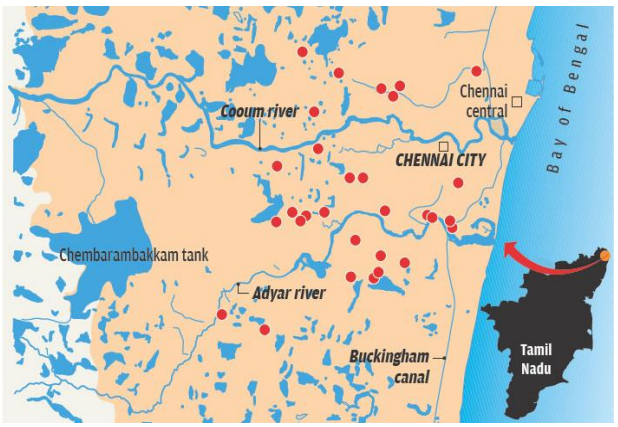

Fig. 3 Map showing the key rivers and Canal of Chennai [4].

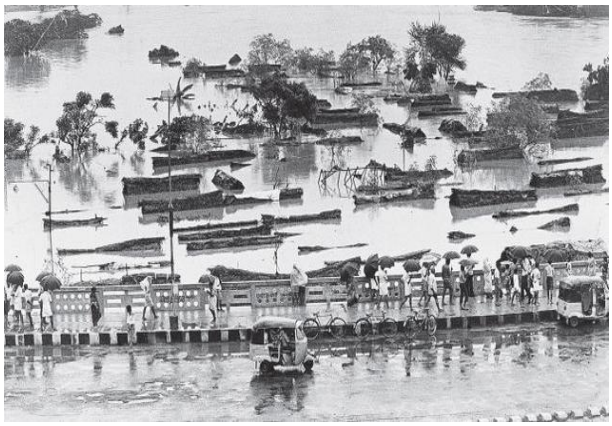

Fig. 4 Marmalong Bridge in Saidapet, Chennai damaged by the 1985 floods [5].

Fig. 5 Former Chief Minister, M.G. Ramachandran in knee-deep water during the 1985 floods [6].

4. Floods of 2015 — Internal Danger to the City

The two rivers are highly polluted today due to various reasons like excessive groundwater pumping, dumping of untreated industrial effluents and sewage and encroachments along the banks of the rivers.

Tamil Nadu gets its annual rainfall from the northeast monsoon during the winter months. It was once such period of increased rainfall due to the northeast monsoon during the months of November and December that caused the Floods of 2015. The flooding in particular was started by three bouts of excessive rainfall (two being in November and one in December) that the city had not witnessed before. The first spell of excessive rainfall was on the 8th and 9th of November and the second heavy spell of continuous rainfall of three days on 15th, 16th and 17th November. With the average rainfall in the month of November being one of the highest in the last century, the rains had caused a lot of havoc in the city of Chennai. However, the most gravely affected was Cuddalore district with unprecedented damage to their livelihood.

However, as intensive as the first two bouts of rainfall were, it was the third spell on the 1st of December that caused a lot of destruction to the city of Chennai and other parts of the state like Kanchipuram, Thiruvallur, Cuddalore and Villupuam. The rainfall of the city of Chennai was estimated to be about 272mm in a span of 12 hours of incessant rains. This is extremely high considering the average rainfall for the month of December in Chennai is only 191mm.

Even though the flood was a natural disaster, the damage to lives and livelihood of the people were amplified by a number of decisions and errors that were man-made. The month of November had already made the reservoirs to reach its full capacity in Chennai. The incessant rains on December 1st made the Chembarambakkam reservoir to reach its maximum volume. This reservoir is one of the most imperative water sources and central reservoirs of Chennai. The Adyar River, one of the two main rivers of Chennai, starts from this Chembarambakkam Lake. In fear of breaching the limit of the reservoir, the water was released from the Chembarambakkam reservoir by the government without proper warning to the public. There was also increase in the water discharge to more than 3 times its regular limit. Vast areas of land were left swamped as the Adyar channels were no more capable of carrying the excess water. This, combined with the inadequate drainage system and no hydrological planning were one of the primary reasons of flooding in Chennai [7].

Other factors contributing to the disaster include climate change, rapid and unplanned urban development, illegal constructions, projects built without conducting Environmental Impact Assessments and various other reasons all triggering environmental damage. Several of the existing ways and channels of the rivers are

encroached by shelters thereby contributing to silting. Many of the tanks and lakes have disappeared and developed as housing units across the city [5].

5. Citizens Resilience

Even though warning systems were in place, they were not efficient enough at the face of the crisis. Evacuation systems were not in place before the flooding. The Armed Forces and the Indian Coast Guard carried out rescue operation and airdropped food supplies. However, a vast majority of the affected population had to evacuate on their own.

It was during this time that the city and its people came to the rescue of the ones in distress. With a large number of people volunteering and distributing food and clothing to the ones stranded in distressed and waterlogged areas, the spirit of the city and its people was alive and kicking. A number of people who were living in secure places, opened their homes to people in need. Public places like malls, theatres, restaurants, etc. were open for people to take shelter. Many families cooked meals and distributed to the people in stranded areas. Some resourceful citizens with internet access recharged phones for people as most of the city did not have power supply. There were hospitals which provided free medical care and restaurants which offered free food to the local population. The fishermen

Fig. 6 National disaster response force rescue operation [9].

Fig. 7 Citizens of Chennai helping the ones in need [8].

of the city were also of immense help to the people as fishing boats, catamarans and kayaks were the only mode of transportation that was possible in the water-logged streets. They rescued a stream of stranded people in the low-lying areas providing with best evacuation options and rescue operations possible [8].

6. Andaman Islands and Learning From the Sentinelese

The tsunami of 24th December 2004 with its epicenter near Sumatra, Indonesia is only about 60 nautical miles from the Andaman and Nicobar Islands. About 500 group of islands constitute these islands of the Indian Ocean. Out of this, about 38 islands are inhabited by human population. Most of these settlements are situated in the north of the islands and around Port Blair.

The four Andaman tribes — the Great Andamanese, Onge, Jarawa, and Sentinelese — are known as the Negrito tribes and are of African descent. Among these tribes, the Sentinelese are a tribe of people who live on the North Sentinel Island. These people choose to live in isolation and reject all kinds of contact with the rest of the world. After the 2004 Tsunami, it was noted from a distance that they were doing well and remained healthy [10].

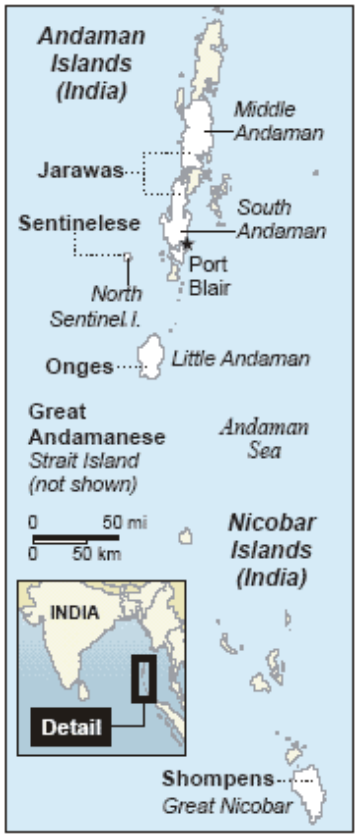

Fig. 8 The Andaman and Nicobar Islands [18].

It was reported after a week of the disaster that a vast majority of the population was missing from the islands. The investigations that were carried out by the Coast Guards revealed that the missing aboriginal people of the Great Andamanese, Onge and the Jarawa tribes had relocated to a higher level amidst a forest a while before the disaster. These indigenous people, having lived in close proximity to the nature for many generations, had a very good understanding of the flora and fauna around them and how they function. They understood the movement of the birds, the designs and routines of the animals, the swimming pattern of the aquatic creatures and the water currents. When changes were noticeable in the functions of the plants, animals and birds around them, they were able to predict the onslaught of a natural disaster [11]. This was not only an instinctive response but also a result of a deep knowledge of the environment in which they lived in and an awareness and consciousness that was developed for centuries.

7. Tackling External Threats

The intensity of the damage caused by the tsunami varied from one place to another based on a number of factors like the physical, geographical and topographical conditions. Other factors like the number of waves that hit the area, distance travelled by the wave, population density of the region also played a main role in the amount of destruction that was created. Most of the houses were vulnerable because they were not constructed by complying with the coastal regulations. Poor construction techniques and materials resulted in damage to the structures. It is possible to avoid these damages due to disasters only if the people learn from their mistakes and cooperate with the government by strictly following the coastal regulations which necessitates the structures to be at least 500 m from the shoreline [1].

With regards to mitigation measures, places like Japan and Hawaiian Islands that has had a number of devastating tsunamis in the past can give a cue. Two key areas are immediate warning system that reaches the people and physical mitigation of people to low risk areas. Construction of seawalls along the coasts, tsunami gates at the entrances to bays and harbors and design of evacuation routes are some of the things that can save lives during a disaster. Another challenge for architects and structural engineers could be to provide design solutions and develop construction methodology by implementing vertical evacuation routes which will provide shelter on the building's upper floors.

An efficient tsunami warning system in combination with other risk assessment and mitigation strategies like creating awareness, safety drills, vulnerability mapping and urban planning is the way forward [12].

8. Tackling Internal Threats

The floods of 2015 baffled the population as to why a state with over 41,127 tanks and its incredible connection of smaller water bodies and marshlands fail to save the city in times of the disaster. Unfortunately,

only a portion of these waterbodies remain today as encroachments has taken over most of the city. Like most of the other metropolitan cities in India, in Chennai too most of the tanks and ponds even as recent as 10 years ago have given way to buildings. It is to be noted that besides private property developers, the government projects also show this kind of appalling negligence. The Chennai airport sitting on the floodplains of the Adyar river and the MRTS (Mass Rapid Transit System) having its elevated line on the expanse of the Buckingham Canal is just the tip of the iceberg.

9. Water Channels and Lakes of Chennai

The area of rivers of Adyar, Coum and lakes of Velachery, Vyasarpadi, Mogappair, Villivakkam and Ambattur have visibly reduced in the course of the past few years of urbanization [13].

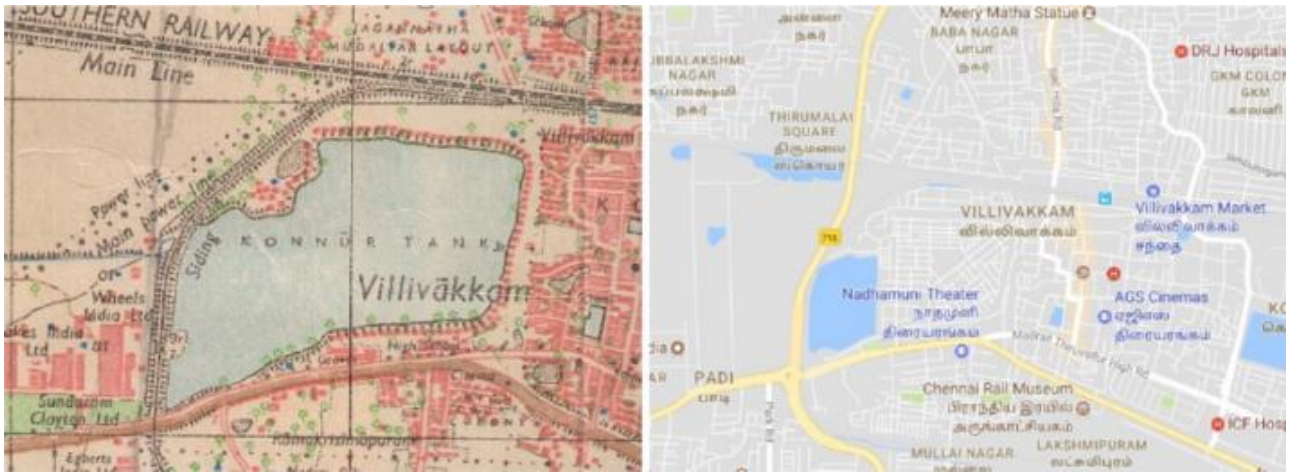

Fig. 9 Konnur Tank, Villivakkam — Survey of India Map, 1970 (Left) and Google map, 2017 (Right) [14].

Fig. 10 Pallikaranai marshlands in 2001 [15].

Fig. 11 Pallikaranai marshlands in 2017 [15].

10. Marshlands of Pallikaranai

Another serious problem is the poor quality of groundwater as a result of using marshlands as dumping yards for construction debris and household garbage. The Pallikaranai marshlands is a striking example of this problem. The marshland which was home to a variety of flora and fauna is dwindling at a rapid rate. Over 60 hectares of land and 112 hectares of marsh have turned into dump yards in the course of few years. With the city is expanding ever-so rapidly, this situation is only becoming worse. Besides this and the air, soil and water pollution, these marshlands are not able to soak and trap the flood water and supply it to the floodplain slowly [15].

11. Adyar Park — A Case of Eco-restoration

With a concern about the depleting state of the natural rivers and lakes, the Tamil Nadu Government set up a Trust called the AdyarPoonga (Park) Trust in the year 2006 to restore the water bodies and to provide a healthy environment. This was later renamed as the Chennai Rivers Restoration trust. The first project of the trust was to develop an Eco Park in 58 acres of the Adyar creek. The restoration activities which commenced in January 2008 and completed in January 2010 included the following: Excavation to increase in Water Spread Area, Arresting of Sewage discharge from outfalls, land development, recreating vegetation and animal diversity. The area has been completely transformed into an impressive park with interactive learning spaces where the people of Chennai learn about the ecology and environment and are able to interact with nature [16].

Fig. 12 Ecological master plan for Adyar Park, Creek and Estuary (Phase 1) [17].

12. Conclusion

The city of Chennai and its people have shown their solidarity and resilience in remarkable ways at the wake of any disaster. However, the greatest problem when it comes to coping up with any disaster in the future is not the wrath of the nature but the forgetfulness of the people. The November 2017 floods of Chennai are proof that no important lessons were learnt from the 2015 floods. Even though the impact was not as much as the 2015 floods, the waterlogged streets were a sad remainder of the past. The Government, with the cooperation of the public has a lot of important and immediate duties to perform. Desilting of rivers and other water bodies of the city should be undertaken periodically. Repairing, renovating and restoring water bodies has to be taken up on a much larger scale. Strict laws and building regulations are needed and action against bodies, both private and government, that encroach the natural resources are the need of the hour. Any kind of infrastructure development should be strictly monitored and reviewed by Government authorities at regular intervals. Restoring the marshlands and giving it a new life is very imperative to restore the ecological balance. Water collection ponds that would get filled up when there is excess water is another scheme that the city can incorporate. These can become interactive community spaces. A well planned alert system and monitoring of the same is essential to save lives in times of peril. Education of the public and community drills can also go a long way during disasters.

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