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Environmental Hazards of Flooding —An Overview of Sapporo and Madras Experience— (Environmental Hazards of Flooding)

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Abstract

Flooding of low lying areas due to heavy rains, flash floods inundation and consequent heavy damages to properties and lives are the common features in many of the urban areas of the world. Apparently the pace of urban growth is at a faster rate when compared to the protective measures undertaken. The increasing demand for land utilization, the cost and opportunity factors etc more often outbeat the effectiveness of the development control stipulations of the local Govts for these areas. Though the environmental hazards are common in both the developed and developing world yet the dimension and magnitude of the problem varies in relation to the geographical location, socio-economic texture of the urban society and the function of the urban areas. More often the frequent occurrence of flooding poses a host of urban planning and development issues for deeper understanding of the problems involved and the efforts needed to be undertaken by the Govts concerned.

Several earlier studies and efforts either proved to be inadequate or not in tune with the dimensions of the problem as they lacked a comprehensive approach and concrete solution. In this paper an attempt has been made to bring out the various facets of flooding hazards, the environmental and planning issues involved and measures undertaken and needed to be undertaken to mitigate the problems in the city of Sapporo of Japan and Madras of India.

Key Words: Flood prone areas, Drainage basin, Plains, Inundation, Conventional land use pattern, Non-renewable resource, Combined sewer system, Design period, Green wedges, Tropical maritime monsoon, Flood moderator, Sand bar effect.

1. Introduction :

In the history of location and development of cities, nearness of water sources was of primary concern, while all other factors were also given due importance. Human settlement planning was attempted on a land normally not subject to major natural calamities. However at the advent of industrialization, concentration of major activities and abundance of employment opportunities caused a greater impact on the physical and economic development of urban areas. As the cities grew the land economics started playing a vital role in making the land available at affordable cost for various activities. While the higher order activities forced their way to

occupy centralized locations due to high accessibility factor, the lower order activities like residential use were pushed to the periphery creating an enormous impact on individuals accessibility to the employment centre and other essential facilities and services. Complex urban economic systems and the individuals affordability factors often resulted in occupation of low lying areas closer to the city center along the river margins and other water sheds which primarily serve as a drainage basin for the whole city during monsoon seasons. These areas are often not well protected against flash floods and heavy rainfall and the people encounter a host of environmental problems besides heavy damages to properties. Under average rainfall conditions every year the impact of floods and inundation on the settlement are innumerable. The effects though of short duration, more often have longer impact.

The city of Sapporo has an unique short history of development and the settlement is often subject to inundation in the low lying areas although flash floods during heavy rainfall are not uncommon. The geographical location of Sapporo has special features in terms of, the river, the terrain conditions, weather conditions and the drainage pattern. On the contrary the city of Madras in India which has a long history of growth also faces similar hazards with different geographical conditions in terms of rivers and lakes, flatness of the terrain and host of cyclones and heavy rains.

Both the cities, Sapporo and Madras though fall in the Asian region, the socio-economic conditions, the magnitude of the problem and the approach to the problem are vastly different. In this paper therefore an attempt has been made to bring out the salient features of the flooding causes, the hazards and impact, the Urban planning and development issues involved and a comparative analysis of the efforts made in these cities towards flood prevention and protection and the future policy needs.

2. Sapporo City Experience :

Sapporo city is the fifth largest city in Japan in terms of population (1.5 million) and third largest in terms of area (1118 sq kms), is located on the western plains of Hokkaido (Figure. 1), the northern most island of Japan. The fan shaped city of Sapporo is the capital of Hokkaido and the hub of commercial and administrative activities. In the short history of Sapporo which dates back to 1867, an enormous impetus was given for its development by the National Govt. Greater efforts were made to induce people to settle in the new island by providing basic infrastructure facilities and development of land and public facilities. Sapporo city experienced a greater influx of people till recently and the number of immigrants has almost levelled off. However Sapporo city has been experiencing a 2% annual growth of population. During winter Olympics in 1972 the Sapporo city again got a face lift and huge amount was spent on development of infrastructure facilities. Though Sapporo city does not have greater industrial activities, interms of commerce, science and information it plays a vital role and is also a fast growing city

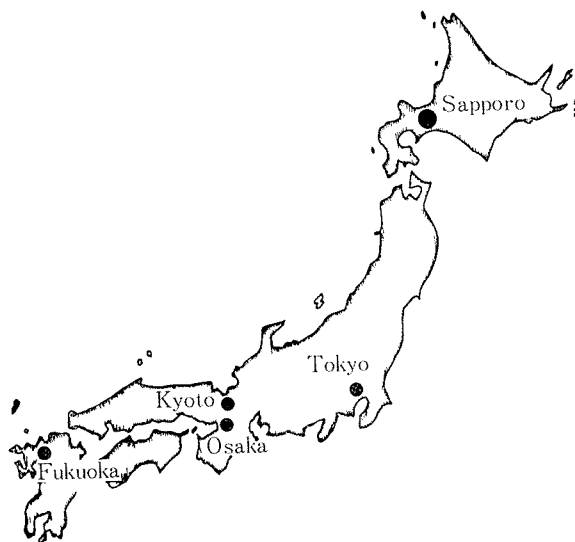


Figure 1. Location of Sapporo City.

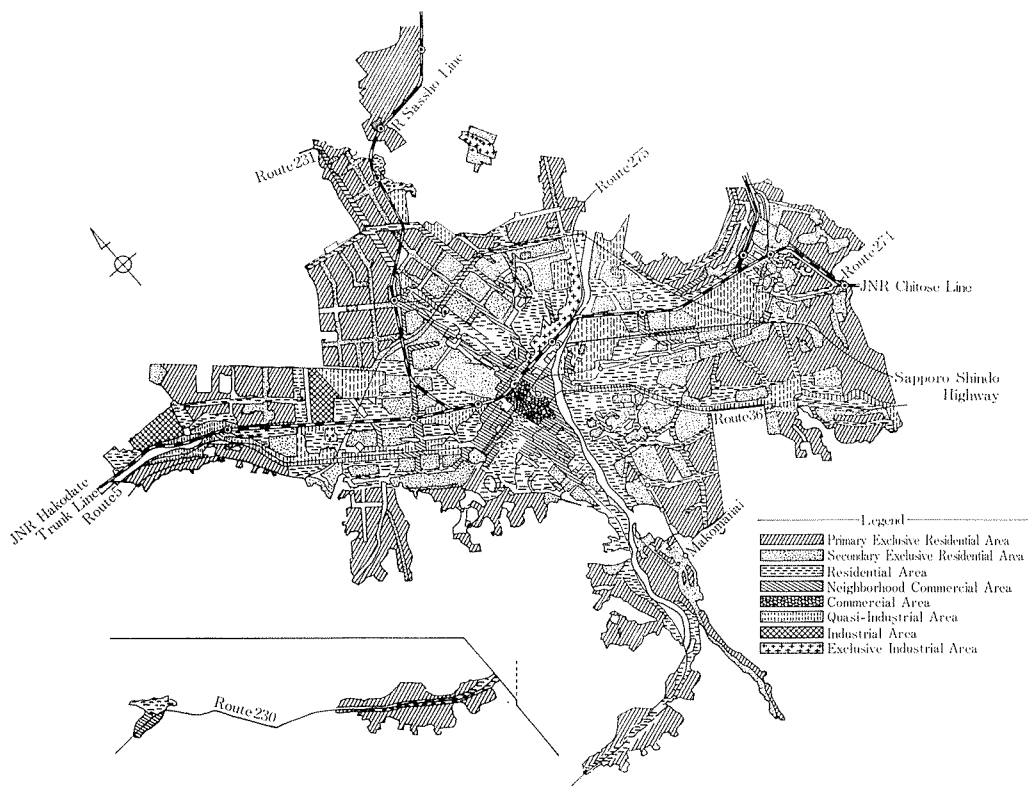


Figure 2. City Land Use.

in the northern part of Japan.

(1) *Development and Land Use Pattern of Sapporo :*

The Figure. 2 shows the land use pattern of the city of Sapporo. The pattern of developments is one that of Gird iron pattern with moderately wide roads. Akin to the grid pattern, though the city is served with mass transport facilities like Tube railway, buses and tram cars, the effectiveness of the transport facilities are not to the optimum level of service in terms of percentage population served. The city basically depends on private mode of transport to a greater extent. The core of the city being the Odori area, encompasses all the major business and administrative establishments with all the major transport corridors converging towards the city center. The central area in general and the public transport facilities in particular experience a tidal flow conditions during the peak hours. Surrounding the central business district second order activities like commercial and mixed residential activities are located. The Sapporo city does not have major heavy and pollution causing industries, however all the minor and light industries are located along the thorough fares away from the central area. The third order use viz the residential use is predominantly located along the periphery of the city. The conventional land use development pattern of the city has brought in a host of problems to the city center.

(2) *Rainfall in Sapporo :*

Sapporo city experiences a widely varied rainfall pattern due to typhoon activities. The average annual rainfall varies from 120 to 130 cms (including snow fall) with heavy showers in the month of August and September at an average rate of 13 to 15 cms. Snow fall starts in mid november and continues till March with an average annual accumulation of about 500 cms depth of snow. The minimum temperature during winter goes down to as low as -15°C and maximum temperature during summer reaches a level of 33°C . For a major period of the year Sapporo experiences a cooler climate.

(3) *Topography of Sapporo :*

Sapporo is located in the south western part of the Ishikari plain (Figure. 3). Green mountainous regions cover more than half of the entire city area. Urban activities center principally on the fan shaped area formed by the Toyohira River which runs bifurcating the city of Sapporo towards the Ishikari low land. The Toyohira river which originates in the mountains on the west has a very small plain which is the central core of the city and runs in the East over a very large delta region. The city on the southern direction of Toyohira river is comparatively on a higher level than the northern part of the city. Besides the main stream of the river there are many drainage channels running through the city area and ultimately joining with the main at many locations. River Toyohira is the tributary of the bigger river called the Ishikari river. The region where the Toyohira river merges with Ishikari river the land is at a very low level and the soil is of very poor character. The Sapporo city being sandwiched between the high moun-

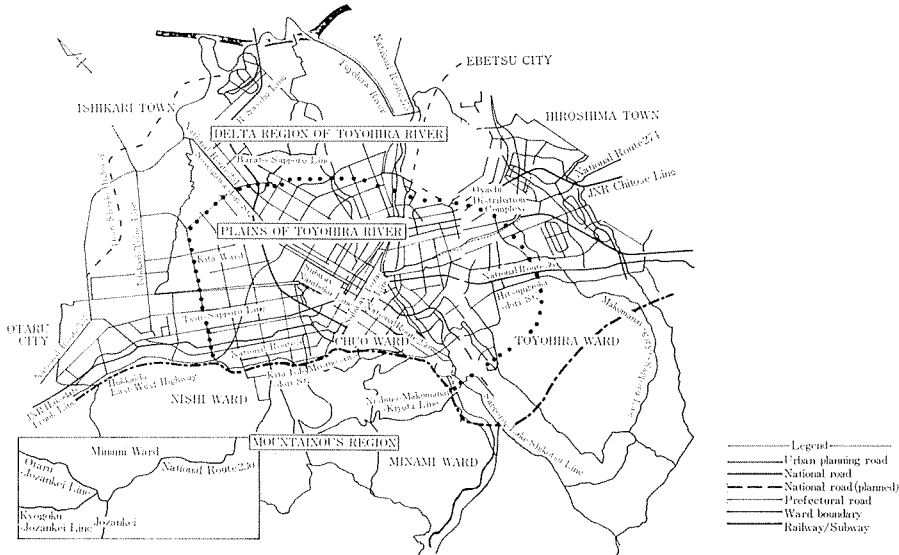


Figure 3. Sapporo City and its General Topography.

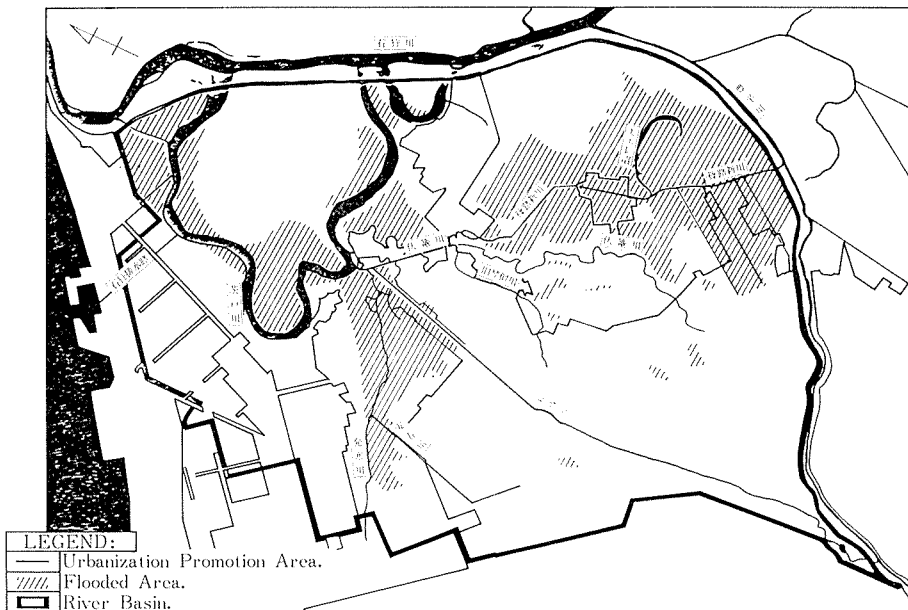


Figure 4. Sapporo City Flood Affected Areas in 1980.

tains on the west and the low lying land on the East has greater possibilities for periodic flooding during heavy downpour seasons as the catchment area is a very large mountainous area with a very small plain which can hardly neutralize the fury of flood. Sapporo city experienced severe flooding during (Figures 4. & 5) the years 1980 and 1981 and the damages were also considerable.

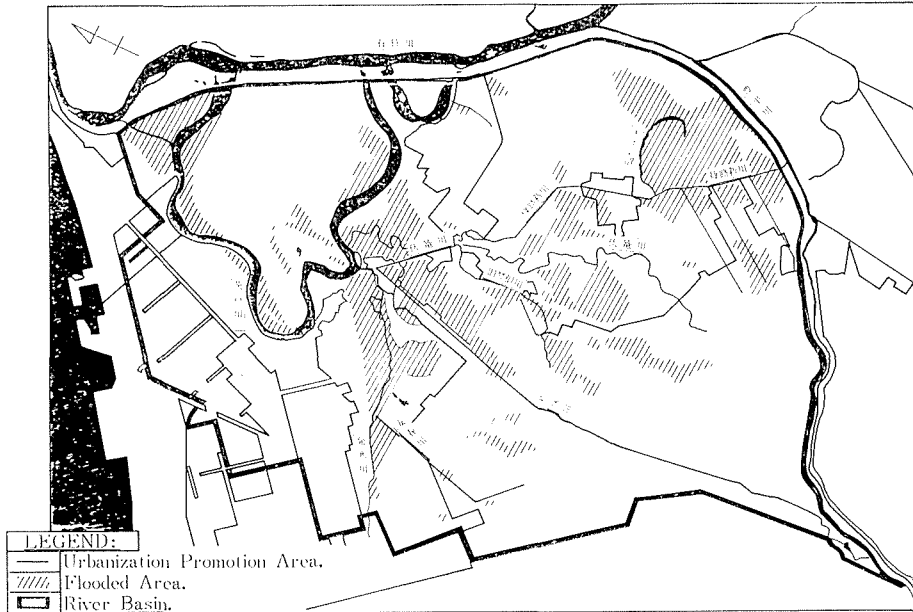


Figure 5. Sapporo City Flood Affected Areas in 1981.

3. Environmental Hazards of Flooding and Urban Planning

Issues in Sapporo :

- (1). The development thrust and the population influx in to the city induced a greater demand for land utilization in the plains of Toyohira river and the consequent exorbitant land cost forced the lower order uses (predominantly residential use) to spread to the delta region of the river which are mostly low lying areas subject to frequent flooding and inundation. The urban planning and development issue has been, how and where safe land could be provided for development purposes as the non renewable source (the land) is very less when compared to the population in Japan.
- (2). While the Toyohira river has constantly been improved for flood protection, the pace of construction and the level of construction have not been commensurate with the need and severity of the situation. Though high flood risk areas have been banned for any urban development purposes in the delta region, the areas where developments are permitted are not devoid of flooding or inundation, however the risk of flooding is less frequent. Here the major planning and development consensus has been that the frequency of high flood risk is very less and the possible damage to the properties will be very less.
- (3). At the time when there was a heavy demand for land utilization, developments were initiated along the valleys in the mountainous region of west and southern parts of the city. However flash floods in the streams and intermitent landslides proved the venture to be more dangerous compared to the development in the low lying areas of the delta regions and thus the delta region attained greater

significance.

(4). One of the many studies conducted in these areas indicates that most of the settlers of the flood prone areas were not aware of the problems before settling there. The major criteria for the settlers was that land was available at an affordable cost. Lack of adequate and proper information on the flood prone areas seemed to have been the greatest handicap.

(5). In the city of Sapporo there is no separate system of rain, snow water drainage and sewage. What has been planned and constructed is a combined form of sewerage system. While the combined system has its own advantages, for the terrain and weather conditions of Sapporo it proves to be inadequate and inefficient during the heavy rains. Taking in to consideration the need for protecting a vast area of the city from the devastating effects of flooding of Toyohira river the National Govt has conceived a Toyohira river improvement scheme for a design period of hundred years and the civil works are being constructed accordingly. On the other hand the combined system of sewerage has been planned by the Local Govt for a design period of thirty years which has left a great gap in the effectiveness of the sewerage system to drain into the Toyohira river.

(6). Frequency of heavy floods in Toyohira river and consequent breaching of the bunds and flooding of the city is very less, however the water which gets collected due to rains in the low lying city area (Delta region) itself is very large in quantity and causes inundation for several days. This is further aggravated by the flow of water from high lands (Plains) of the city which has a very high coefficient of runoff due to intense developments. The pumping stations which have been located along the river sides are more often inadequate to meet the demand and relieving the area of the rain water in the shortest time possible.

(7). More serious environmental hazard is caused by the combined sewer system itself. The sewage getting mixed with the rain water while running towards the treatment plants chokes the sewer system. This is due to the large and sudden influx of rain water. This in turn over flows through the manholes located along the streets of low lying areas, not only inundating the whole area with the sewage but also creates an unhygienic environment.

(8). The enormous quantity of water collected during the flooding seasons at the sewage treatment plant more often increases the load on the treatment plant. As a result it becomes impossible to treat the entire inflow and therefore almost half of the sewage is led into the rivers untreated, thereby polluting them.

(9). Residential buildings located in the delta region with adequate protection against inundation get affected less than other buildings. It is a common feature that a high degree of dampness is mostly caused to the buildings constructed with thermally insulated walls due to inundation. In many cases the dampness has led to the total destruction of buildings.

(10). Considering the physical constraints for further developments, the Sapporo Development plan for 1995 stipulates for restriction of population to 1.85 million from the present level of 1.5 million. While there is still the problem of flooding

persisting for the existing population adequate planning and development efforts are needed to be taken care of for the anticipated population.

(11). Developments in low lying flood prone areas are the manifestation of sky rocketing land prices in the central and surrounding area and greater danger of living in mountainous areas. While the landuse or Zonal plans have been effective in controlling the land uses, they are not effective in controlling the land cost and therefore the landuse plans in use do not seem to be functional in their existence.

(12). So far the major thrust was on improving the Toyohira river alone against flood. The Ishikari river of which the Toyohira river is a tributary has not been given adequate importance. Though there have been many studies relating to the flood hazards in the flood plains of the river a comprehensive hydrological model, characteristics of flooding and its impacts do not seem to exist. In the absence of such a study document it may not be possible to take major investment decisions.

4. Madras City Experience :

1). *Genaral* :

Madras is the fourth largest city in India with a population of 4.5 million in an area of 1761 sq.km, is located on the eastern sea board of the sub continent (Figure. 6) with a harbour that caters for a fifth of the country's imports and exports. It is well located in relation to rail routes to the rest of India and has a firm but relatively static base of large scale formal industry and commerce including insurance, shipping and banking. It is relatively uncongested city by Indian standards and is expanding outwards rather than upwards because of the ready availability of Land (Figure. 7).

Nevertheless the Madras Metropolitan area is experiencing acute problems of rapid urban growth. Its population is increasing rapidly at the rate of 3.2% per

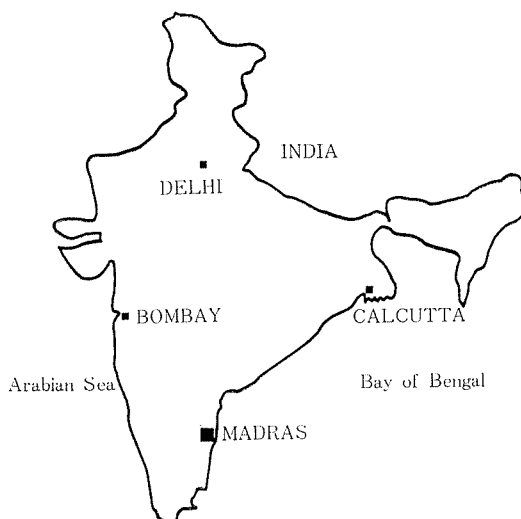


Figure 6. Location of Madras.

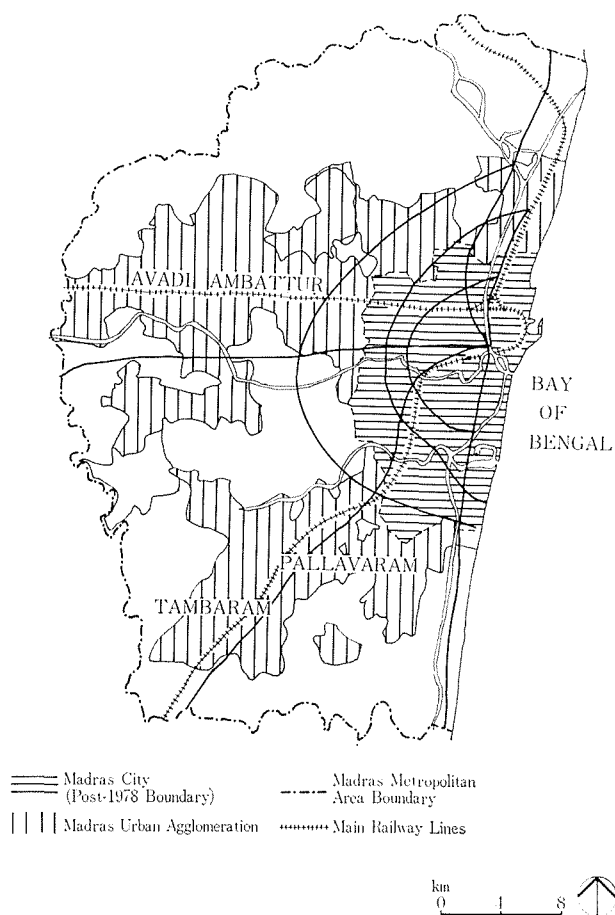


Figure 7. Boundaries of the City of Madras, the Madras Urban Agglomeration and the MMA.

annum. its economy is not expanding at an equivalent rate and there is growing pressure on the limited utility services that exist. It is becoming more difficult to find work except in the informal sector and real incomes are declining. About one third of the population lives in squatter settlements called slums mostly located on river margins, low lying areas and public lands normally subject to flooding and inundation.

2). *Development and Land use Pattern of Madras :*

The thirty years between 1941 and 1971 saw tremendous growth in population and economic activity in and around the city. The population first passed the million mark around 1943 and then doubled itself in a short span of twenty years to cross the two million mark. This period also saw intensification of development and the growth of new residential and industrial suburbs, particularly on the west and south, the trend of which is continuing. The growth of Madras did not take place in a regulated manner except in a few areas developed through Town planning

Schemes. The expansion of the city was not however accompanied by the provision of infrastructure facilities.

The main reasons for this fast growth can be attributed to the forces of economic activity realised after the country obtained independence. Early Five Year Plan schemes gave impetus to industrial activity in the public sector and this broadened the city's function from that of a predominantly administrative and commercial center. The major developments in the industrial field during the post independence era have been the establishment of a number of industries, both private and public. Many of them are located at the outskirts in the north, west and south west directions. The industrial areas within the city (Figure. 8) are mainly in the north and west where they are closely tied to residential developments. Government, quasi-government and private commercial firms are dispersed but those which were established earlier are concentrated in the older parts of the city. In

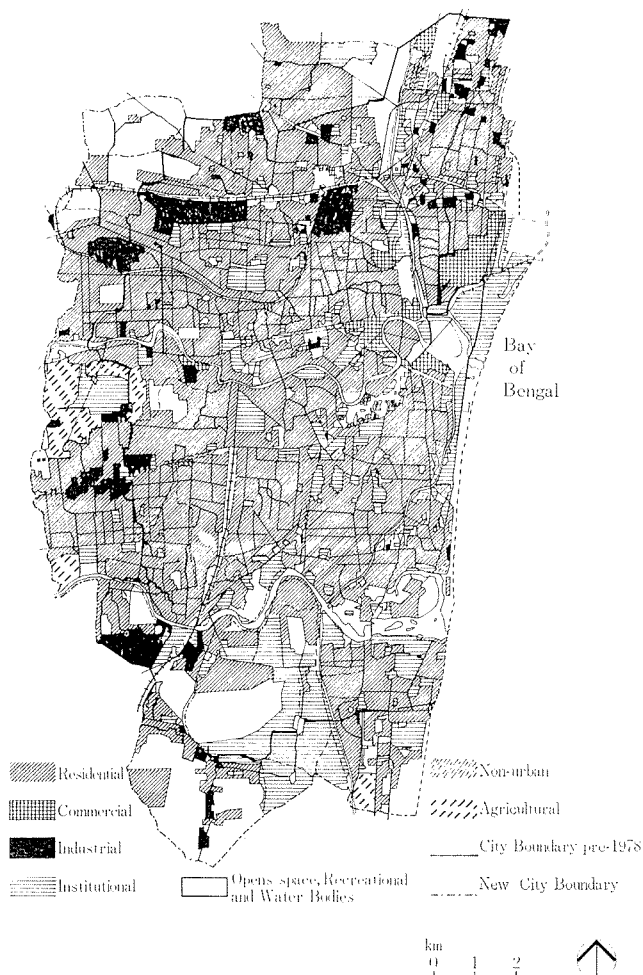


Figure 8. City Land Use.

the C.B.D which is the core are of the city, most of the whole sale trade, specialised retail trade and banking and financial institutions are located. It is here the commercial activity is intense. Shopping facilities of local importance have developed along almost all major roads.

The rural areas surrounding the city generally remain agriculture in use. The present structure of the city approximates to a semi circle with extensions in five main directions, the north, north-west, west, south- west and south. Early in the development of the city, the area surrounding the Harbour had become the commercial center of the city. Naturally all communication lines led to this centre and these in turn were linked with each other producing a ring and radial pattern of development. The ring and radial type of development has created green wedges, the edges of which in some cases touch the city. The main communication routes outside the city are linked with industrial establishments and shopping, but the development is diffused.

Madras is the only urban agglomeration with over two million population in South India. The gross density of population over the entire city is of the order of 20900 persons per sq. km.

3). *Topography of Madras :*

The site of Madras city and its environs is very flat, the contours ranging from 2.0 to 10.0 metres above M.S.L. There are three rivers running through the Madras Metropolitan Area from west to east. All the rivers run in a radial direction in the north, central and southern sector. All three rivers are non per-

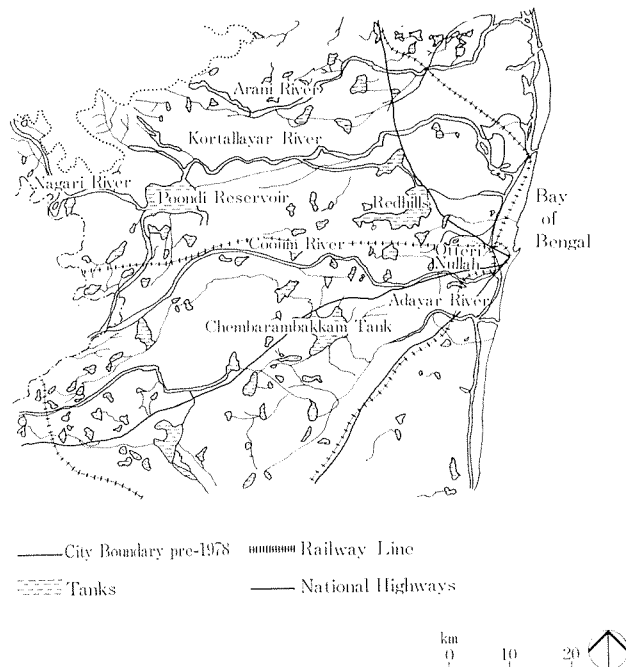


Figure 9. Topography showing Streams and Waterbodies.

ennial, but have a substantial flow during the monsoon. There is another artificial canal running in the North-South direction, originally used for navigational purposes. Figure. 9 shows the rivers, lakes and canals existing in the Metropolitan area. All these water courses basically serve as drainage courses during rainy seasons, and have obstruction at the mouths by sand bars.

4). *Rainfall in Madras :*

The climate of Madras is a 'tropical maritime monsoon type'. The intensity of rainfall, particularly during the North-East Monsoon can result in serious inundation. The South-East Monsoon is between June and September and does not bring such precipitation. During the North East Monsoon period "Every year... cyclonic storms of varying intensity, some very severe cross the coast. The cyclone which hit the coast in 1977 generated a tidal wave about 6 M high which travelled several kilometres inland. The storms and cyclones mainly originate in the Bay of Bengal and are experienced more severely during the period of October to December of an year. The mean annual rainfall is 120 cms. During the monsoon period the maximum rainfall experienced is 66 cm over a period of one month

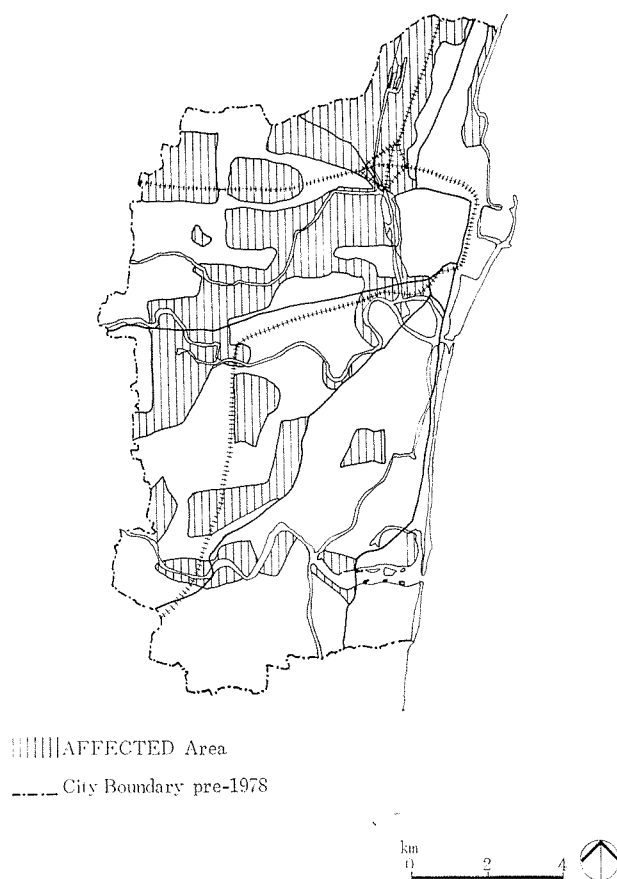


Figure 10. Area affected by Floods in the City 1976.

only.

5). *Inundation in Madras :*

The periods of heavy rain cause local floods for several days even after the rain has ceased. Stagnation in certain low lying areas lasts for several months. Drainage of this storm water is made more difficult for a number of reasons :

- a. Large areas of open fields which used to absorb water have been progressively built up.
- b. The rivers and channels draining in to the sea do not possess adequate capacity. They have become constricted over time by silting and by having their margins encroached upon by development (mainly squatter settlements).
- c. A number of irrigation tanks which formerly also acted as flood moderators have been taken over for urban development.
- d. The upkeep of streams and the construction of proper drainage channels leading to the streams have not kept pace with the growth of urban area.

The floods particularly those in 1976 which were of unprecedented severity causing damage running into crores of rupees and inflicting great human suffering to the poorer section of the community. This has re-emphasised the seriousness of the flood hazard and the urgent need to implement a programme to prevent physical damage and suffering resulting from floods. Figure. 10 and Figure. 11

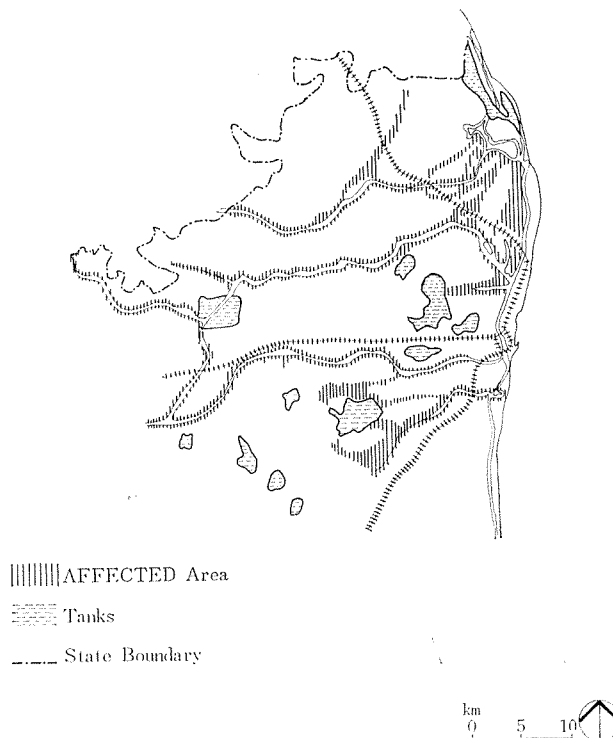


Figure 11. Flooded Areas around the City November 1976.

show the areas which were inundated during the November 1976 floods. Recurring damage to property particularly of slum dwellers is usually great. In the recent 1978 and 1985 rains more than 70000 families had to be shifted and provided with temporary shelter and food, costing the Government millions of rupees.

5. Environmental Hazards of Flooding and Urban Planning Issues in Madras:

- (1). Flooding and washing away of the temporary shelters are the common features wherein the Economically weaker section (EWS) of the society is uprooted from their localities temporarily forcing the local Govt to provide them shelter and food. Sizeable number of EWS people who migrated from the rural areas normally try to settle down along the river margins and low lying areas closer to work centres as the land belongs to Govt. Besides relief operations, the Govt is saddled with the burden of planning for the economic upliftment of the people as well as arrest migration by creating better economic opportunities at the regional level.
- (2). Poor sanitary conditions prevailing in the slum areas are aggravated during the monsoon period exposing the EWS people to greater health hazards. Considering the gravity of the situation the Govt created an exclusive department for the improvement and clearance of slum areas. Under different programmes and with the aid of International development organisations, many slum areas have been improved, however many slums along the river margins and low lying areas continue to be exposed to the dangers of flooding and inundation.
- (3). The city of Madras has separate sewerage and storm water facilities. However the non availability of such facilities in the low lying areas and along the river margins, make the people let the waste and sullage in to the city water courses running along the densely developed areas of the city. Plugging all such unauthorised inlets and planning for a comprehensive waste water collection and disposal system along these areas has posed great many physical and economic problems to the authorities concerned.
- (4). The city of Madras was bestowed with many lakes and ponds to act as natural flood moderators. However with the onset of rapid urban growth most of the lakes were filled up and developed. The non availability of flood moderators coupled with increased runoff due to denser developments has increased the potential for frequent flooding and inundation in many low lying areas. The city planning challenge has been one that of finding alternate locations for development purposes which could form an integral part of the city.
- (5). Madras city is supplied with treated drinking water drawn from a net work of lakes which in turn depend on monsoon. The city has an intermittent supply at a maximum rate of 90 lpcd which is far below an acceptable standard of an urban area. To augment the water needs people draw water from wells. Gradual depletion of lakes, steady pavement of surfaces in developing areas have greatly increased the risk of less ground water recharge resulting in steady lowering down of the ground water table. Lowering of the ground water table often resulted in

building settlement and crack formation due to soil settlement.

(6). Besides modern sewage treatment plants, three large sewage farms are used for the purpose of sewage treatment. The collected sewage is spread over large extent of land which is used for cultivation of cattle feed is flooded during rainy seasons. Since the city has grown to a larger extent very often the sewage mixed water finds its way in to the living area, not only causing health nuisance, but also pollutes the ground water sources. This problem has not only created the need for abandoning of the sewage farms, but also construction of new treatment plants with improved, collection and disposal system.

(7). The Madras urban area is flat with hardly five metres above the MSL and has two heavy monsoon seasons bringing in a host of environmental problems. Besides planning for adequate drainage system, construction of drainage channels with adequate fall to be effective is another major planning and engineering challenge.

(8). The three major rivers which serve as drainage channels discharge the flooding water in to the sea at different locations. At the mouth of these rivers, formation of sand bars due to high tides is another major impedence for the smooth flow of drainage water. During cyclonic seasons the high tides at sea not only impedes the inflow, more often causes back flow making the situation worse.

(9). Flooding and inundation cause enormous damage to the road surface during the rainy season. Observations have revealed that traffic accidents during the rainy season is very high due to very bad road conditions and the annual maintenance cost of roads has also been running in to millions.

(10). Given the topography and the climatical conditions of Madras the problem of flooding and inundation needs deeper investigation interms of their hydraulics and characteristics. A Governmental Hydrological research institute established in Madras has been studying the problems only to a limited extent. A comprehensive model study may lead to clarification of many problems before investment decisions are taken.

(11). The Master plan for Madras stipulates a wide range of regulations to curb developments along flood plains and inundation prone areas. Any developments likely to be located closer to flood prone areas are carefully scrutinised before permitting such activities. However more often unauthorised low level activities spring up in such areas, because of low land price.

(12). Lack of concrete plans and programmes for the low lying areas to develop them as recreational centers or for any other ventures is another handicap in deterring such unauthorised developments.

(13). Construction of main and feeder drains have been done in many parts of the city under different schemes. However lack of comprehensive system of drainage schemes with adequate arrangements for the removal of sandbars at the mouth of the rivers have not been forthcoming and the problems continue to persist.

6. Future Efforts and Policy Needs:

In any urban situation where new land must be found for expansion, there

are bound to be constraints and opportunities and Sapporo and Madras are no exceptions. Without planning control of any kind, market forces are likely to determine a pattern of 'desirable' land use based on such factors as convenience, location in relation to services, jobs or in the case of industry, in relation to transportation terminals, materials or a pool of labour. Thus many of the criteria which may be formally studied by planners are used (perhaps even sub-consciously) by individuals or companies wishing to locate a home or a business. Therefore it is absolutely vital to recognise that an effective flood control programme has four elements.

- a. Land use control of flood prone areas.
- b. Land use management (particularly soil conservation) in the catchment area
- c. Flood protection measures, and
- d. Urban development thrust.

The Environmental hazards arising out of flooding and inundation in both the cities reveal that the problems are basically manifestations of rapid growth of cities and lack of timely action to combat the situation. Though both the cities face almost similar problems, in view of the socio-economic conditions of the city and peculiarity of the terrain conditions, the following are the suggestions relating to the future efforts and policy needs.

7. *Relating to Sapporo's situation*: —

- (1). Redensification of low density areas of the existing city for an optimum utilization of the facilities already created without foregoing the overall living environment by revising or redrafting the Zonal or land use plans to be more functional and effective.
- (2). Plan for increased accessibility to public transport systems and reduce the dependance on private transport, thereby reducing wide roads construction and maintenance cost.
- (3). Plan for exclusive drainage system atleast in elevated areas of the city to avoid choking of the sewerage system in the low lying areas.
- (4). Develop low lying or flood prone areas for recreational purposes during lean seasons and as flood moderators during rainy seasons.
- (5). Undertake a comprehensive hydrological study for the Toyohira and Ishikari river basins in view of the future developmental needs and investment decisions.

8. *Relating to Madras's situation*: —

- (1). Study and develop appropriate plans to remove all the unauthorised constructions and slums from the river margins and low lying areas and resettle them at locations which are easily accessible to employment centers.
- (2). Improve the public transport system to be more efficient and sufficient to provide for better accessibility.
- (3). Construct adequate number of sewage treatment plants and plug all the unauthorised drainage inlets in the river courses.

- (4). Develop a plan for improvement of all water courses for recreational or water transport purposes.
- (5). Allocate adequate funds towards carrying out the various identified civil works on a systematic basis.

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