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Full Length Research Paper

Flood risk and context of land-uses: Chennai city case

Anil K. Gupta* and Sreeja S. Nair

National Institute of Disaster Management (Ministry of Home Affairs, Govt of India), New Delhi- 110 002, India.

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India witnessed increased flooding incidences during recent past especially in urban areas reportedly since Mumbai (2005) as a mega disaster. Other South Asian cities like Dhaka, Islamabad, Rawalpindi, besides many other cities in India, are also reportedly been affected by frequent floods. Flood risk in urban areas are attributed to hazards accelerated by growth in terms of population, housing, paved-up areas, waste disposal, vehicles, water use, etc. all contributing to high intensity – high load of runoff. Reduced carrying capacity of drainage channels is also a key concern. Haphazard growth of low-income habitations and un-organised trade added to challenge. Spatial dimensions of all these flood factors are often characterised by land-use and changes. Chennai, a coastal mega-city is fourth largest metropolis in India, has a history of over 350 years of growth. Meteorologically there is no major upward or downward trend of rainfall during 200 years, and a decrease in last 20 years with a contrast record of increasing floods have been experienced. Analysis of land-use changes over the temporal and spatial scale has been undertaken for Chennai city in order to understand the patterns on green-cover, built-up area and consequences on hydrological settings. Land-use issues like decreased natural areas, loss of water bodies, encroachment of river/streams and other drainage channels, uncontrolled multiplication of built-up areas, have been identified as contributory factor to flood risk in Chennai. The paper discusses flood risk reduction and management strategies in urban context with example of the Chennai city and draws attention of land-use planners and disaster management experts to integrate their efforts for better and sustainable results.

Key words: Chennai city, floods, land-use changes, national guidelines.

INTRODUCTION

India witnessed increased flooding incidences during recent past, especially in urban areas reportedly since Mumbai (2005) as mega disaster. Other South Asian cities like Dhaka, Islamabad and Rawalpindi are also reported for frequent floods. Floods result from the overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions, deposition of materials in stream channels during flood recession, rise of ground water coincident with increased stream flow, and other geo-environmental influences. Hazards of flood could be from heavy rains, dam failures, tides or cyclonic surges.

There are four interrelated but separable effects of land-use changes on the hydrology of an area: changes in peak flow characteristics, changes in total runoff, changes in quality of water, and changes in the hydro-logic amenities (Leopold, 1968). Of all land-use changes affecting the hydrology of an area, urbanization is by far the most forceful. Census 2001 figured 285 million people in 35 metro cities of India, and is estimated to cross 600 million with 100 metro cities in 2021. Climatic variability and regional environmental challenges are known to aggravate flood risks. Urban flood, being significantly different from those of flooding natural or rural areas, has drawn attention of disaster risk managers. Causes of floods in urban areas are given in Figure 1.

*Corresponding author. E-mail: envirosafe2007@gmail.com, sreejanair22@gmail.com. Tel: +91-11-23724311, 23702432, 9868207006. Fax: 23702442 / 46.

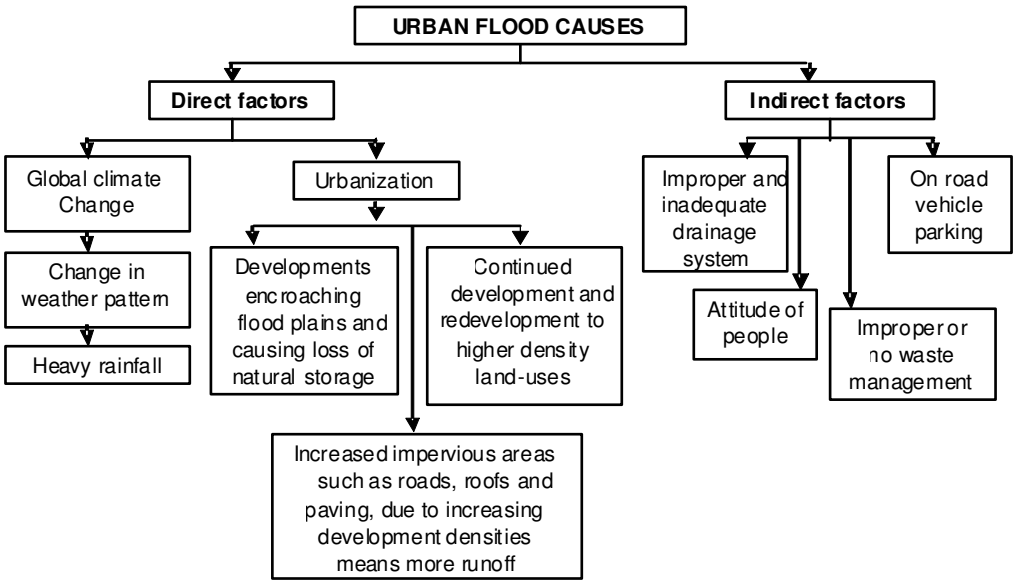

Figure 1. Causes of floods in urban areas (Gupta and Nair, 2009).

APPROACH AND METHODOLOGY

This paper is drawn from the technical report of a national level study accomplished in India covering 8 important cities – Bangalore, Bhopal, Chennai, Kolkata, Hyderabad and Mumbai, Bhopal and Surat by National Institute of Disaster Management, through city-wise teams for capturing city's experience on floods. Case studies were undertaken looking into the aspects of geo-environmental, hydrological and socio-economic profiles. Prevailing and proposed city infrastructure with reference to drainage and flood control including structural and non-structural measures have been evaluated in the context of flooding in the past and present. Master plan provisions and their failures, administrative and technical enquiries, good practices and lessons, and the suggested strategies have been covered. Urban flood challenges and implications of land-use changes that aggravate disasters have been discussed in this paper. Information and data used were mostly secondary in nature were reports and publications of different departments/agencies were put into use.

Chennai city profile and growth

Madras (now Chennai) in 1600 was formed of scattered settlements separated by long distances. Each settlement grew around a nucleus of a temple and has its own history. Regional setting of Chennai, the capital City of Tamil Nadu is the fourth largest Metropolitan City in India. The CMA falls in three Districts of the Tamil Nadu State viz. Chennai District, part of Thiruvallur District, and part of Kancheepuram District. The extent of the Chennai District (covered in Chennai Municipal Corporation area) is 176 sq.km and comprises 55 revenue villages in five Taluks [viz. (i) Fort-Tondiarpet Taluk, (ii) Perambur-Purasawalkam Taluk, (iii) Egmore-Nungambakkam Taluk, (iv) Mambalam-Guindy Taluk and (v) Mylapore-Triplicane Taluk]. In Thiruvallur District out of total district area of 3427 sq.km, 637 sq.km in Ambattur, Thiruvallur, Ponneri and Poonamallee taluks fall in CMA. In Kancheepuram District out of 4433 sq.km, 376 sq.km in Tambaram, Sriperumbudur and Chengalpattu Taluks fall in the Metropolitan area.

Chennai is shown in Figure 2. Topographically plain terrain with few isolated hillocks in the south-west, city is bounded on the east by the Bay of Bengal and on the remaining three sides by Kanchipuram and Thiruvallur district. Average annual rainfall is about 1,300 mm. The city of Chennai, one among the four major metropolitan cities of India, located in the southern India lies between 12° 09', 80°12 NE and 13° 09', 80° 19'NE. It is having population of 6.04 million in an area of 170.47 Sq. km. It is growing at an average of 25% per decade. Chennai city does not have much of green space, except the Guindy National Park with an area of 270.57 hectares, which is under reserve forest category. Chennai has two administrative boundary, the outer boundary is Chennai metropolitan boundary – encompass the suburban areas; the inner one is the corporation boundary, which include only the urban area.

Chennai lacks natural gradient for free run-off. This necessitates an effective storm water drainage system. Sewage system in Chennai was originally designed for the population of 0.65 million at 114 L per capita per day of water supply, and was further modified during 1989 - 1991, and is now much below the required capacity

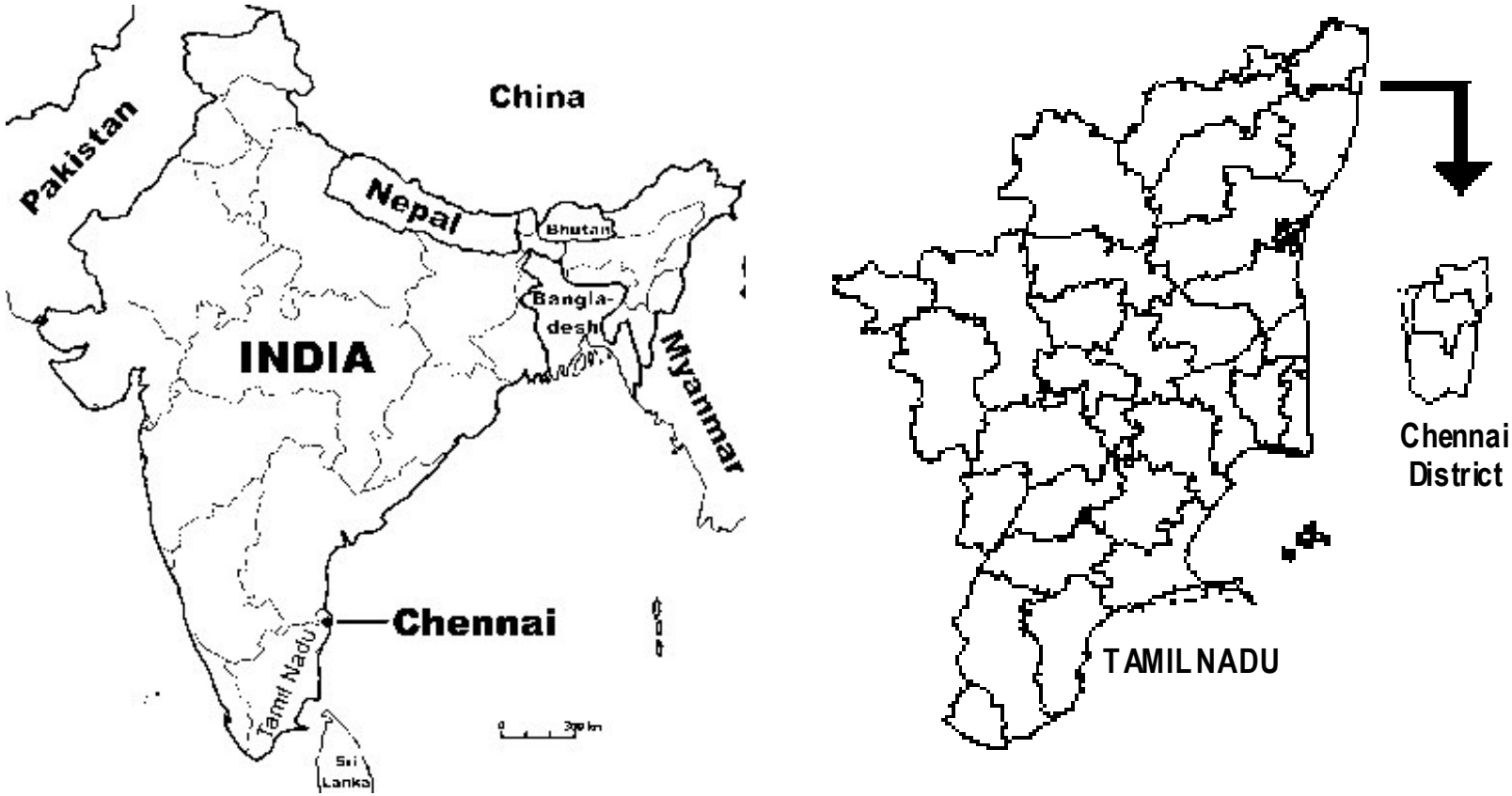

Figure 2. Location map of Chennai.

(CPREEC, 2008). Cooum and Adyer rivers in Chennai city are almost stagnant and do not carry enough water except during rains. These rivers are play a major role during floods, collects surplus water from about 75 and 450 tanks, in their respective catchments. Chennai municipal area has a network of canals and channels within its boundary. Buckingham, originally a navigation channel and waterway till 1954, now serves only as drainage channel. City with plain terrain lacks natural gradient for free runoff and necessitates an effective storm-water drainage system. Since the beginning of the 20th Century, Chennai has witnessed a steady deterioration of and decrease in water bodies and open spaces.

Chennai population has grown 8 times in 1901 – 2001 period and per hectare population density has increased from 80 to 247. Chennai has large migrant population came from other parts of Tamil Nadu or other parts of the country, accounting a figure of 21.57% of Chennai population in 2001. There are three major watercourses (Cooum, Buckngham Canal and Adyar) in the Chennai city and the banks of all the areas are highly

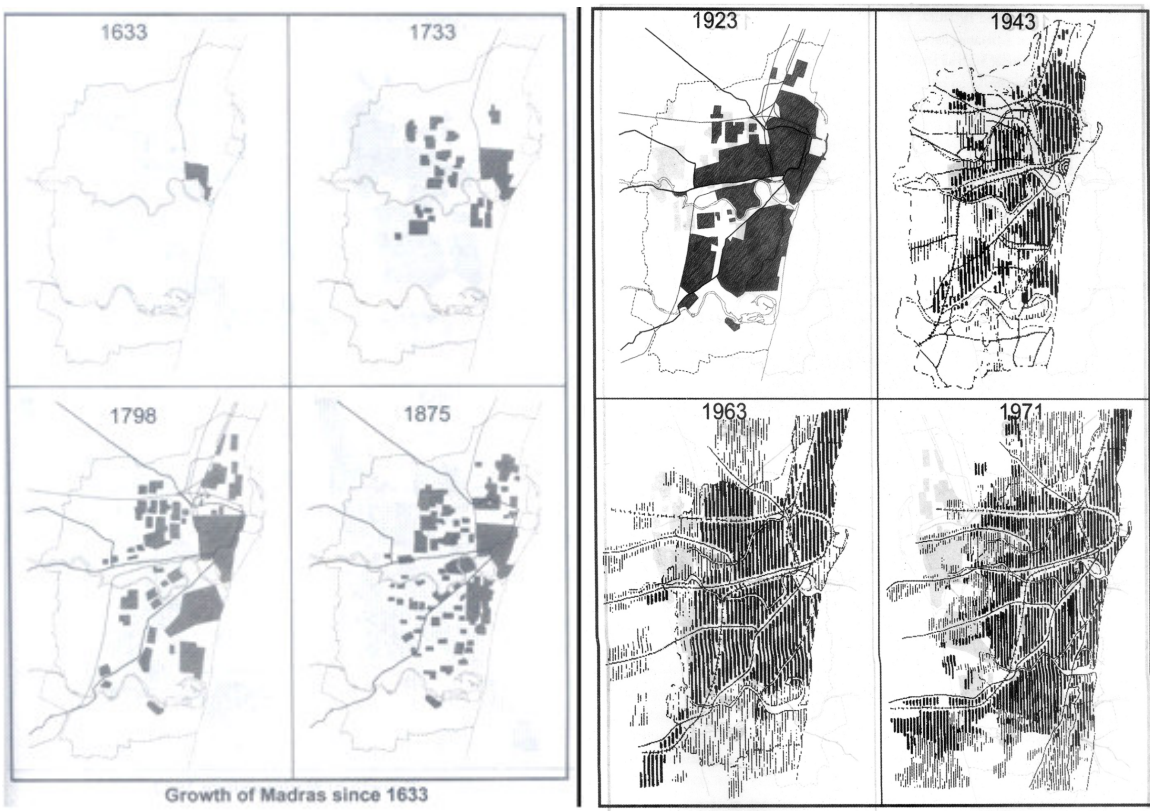

Figure 3. Growth of Chennai city (Source: Chennai Municipal area corporation).

encroached. The slums (number recorded to be 30,922) have developed there without basic amenities and are subjected to flood every year. They often pollute the water courses making health situations worse (CPREEC, 2008) (Figure 3).

The green covers reduced rapidly across the city between the year 1997 to 2001, at some ward almost 99% of the green covers replaced by the non vegetative developments (www.hindu.com). As a result, the water holding capacity of the city's surface gone down drastically. The reduced city's surface water holding capacity combine with the augmented impermeable surface increased the peak flow, up to 89% from the year 1997 to 2001 at some of the wards. Increased surface runoff and reduced retention capacity of the land cover almost stopped the ground water recharging processes in the city. The ground water level came down up to 10 m from the year 1997 to 2001 (Source: CMWSSB). The analysis shows that the green cover reduction and the increased impermeable surfaces lowered the ground water level to the extent of 33% at some part of the city between the year 1997 - 2001. This eventually reduced the ground water quality (The Hindu, 2004).

Meteorological and hydrological aspects

There were several past instances of catastrophic floods in Chennai (1943, 1976, 1985) caused by heavy rain associated with depressions and cyclonic storms, led to floods in major rivers and failure of and drainage systems. Chennai was severally flooded due to heavy rains (16 - 20 cm, attributed to a trough of low pressure from the Gulf of Mannar to the South-west bay off the Tamil Nadu coast) during October 30 to November 2 during 2002. Residential areas became 'islands' and cut-off, paralysing life, services and trade including transport, communication, etc. On November 5, 2004, a heavy rainfall (6 cm within 24 h or less) caused flooding and water-logging in many areas, inundating most of the slums. A deep depression over Bay of Bengal brought 42 cm rainfall in around 40 h during North-east monsoon of 2005. Several such incidences were reported during 2006, 2007 and 2008. Closing of schools due to flooding every year is a usual case for many areas of Chennai (Figure 4). Chennai Municipal Corporation has identified 36 localities as flood risk hotspots. Meteorologically there is no major upward or downward trend of rainfall during

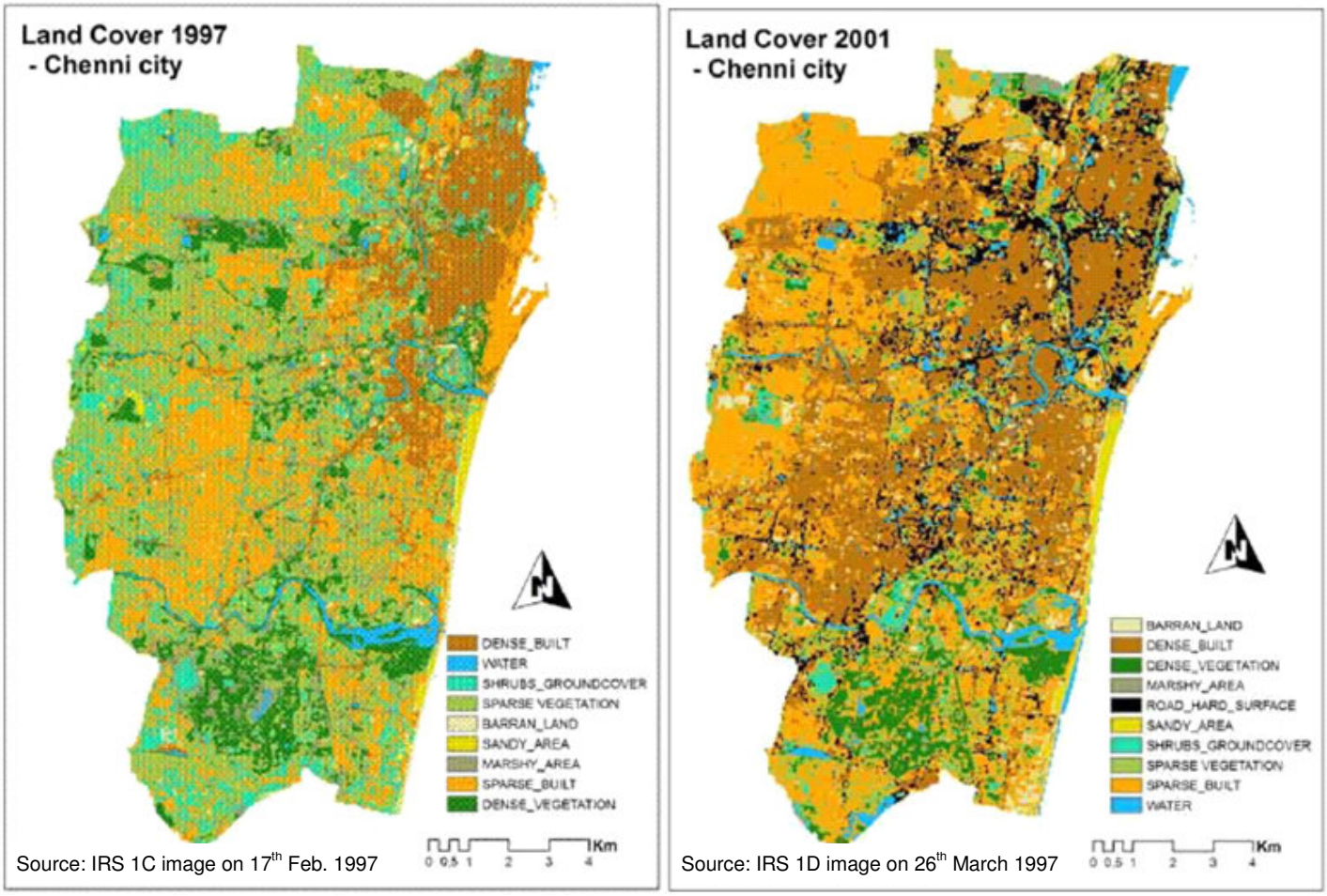

Figure 4. Chennai city's land-cover (Source: Sundaram, map India, 2009).

200 years, and a decrease in last 30 years with a contrast record of increasing floods have been experienced for Chennai (Glaser et al., 2008).

Urban land use changes, governance and floods

Causes of increased flooding in Chennai are identified as (a) uncontrolled urban sprawl and loss of natural drainage. Drainage channels have been blocked and urban lakes filled and encroached, canals degraded and polluted, heavily silted and narrowed. A 1994 survey revealed waterways contamination and anaerobic digestion led to sludge accumulation causing hydraulic hindrances, (b) Inadequacy of storm water drainage system and lack of maintenance (Drescher et al., 2007). City has only 855 km of storm drains against 2,847 km of urban roads. Plastic and polythene constituents to the storm water stream along poor or no maintenance aggravates floods, (c) Increase in impervious surfaces. Paving of roadsides, park and open areas causing flood severity and condition for following droughts, (d) Lack of coordination between agencies. Lack of unified flood control implementing agency that could integrates the functions of Corporation, Development Authority, Public Works Department, Slum Clearance Board, Housing Board, etc., adds to weak points.

Many of the water bodies including man-made wetlands/lakes and natural depressions and have disappeared due to human induced succession, filled with waste and development or slum encroachments (Sundersingh, 1990). This is the common observation in most of the Indian cities and is guesstimate that urban wetlands have reduced to 30% during last 50 years (Gupta and Nair, 2009). Wetlands are among the most valuable ecosystems in the world and are useful for improving water quality and storing floodwaters and releasing it slowly as they travel downstream (Melesse et

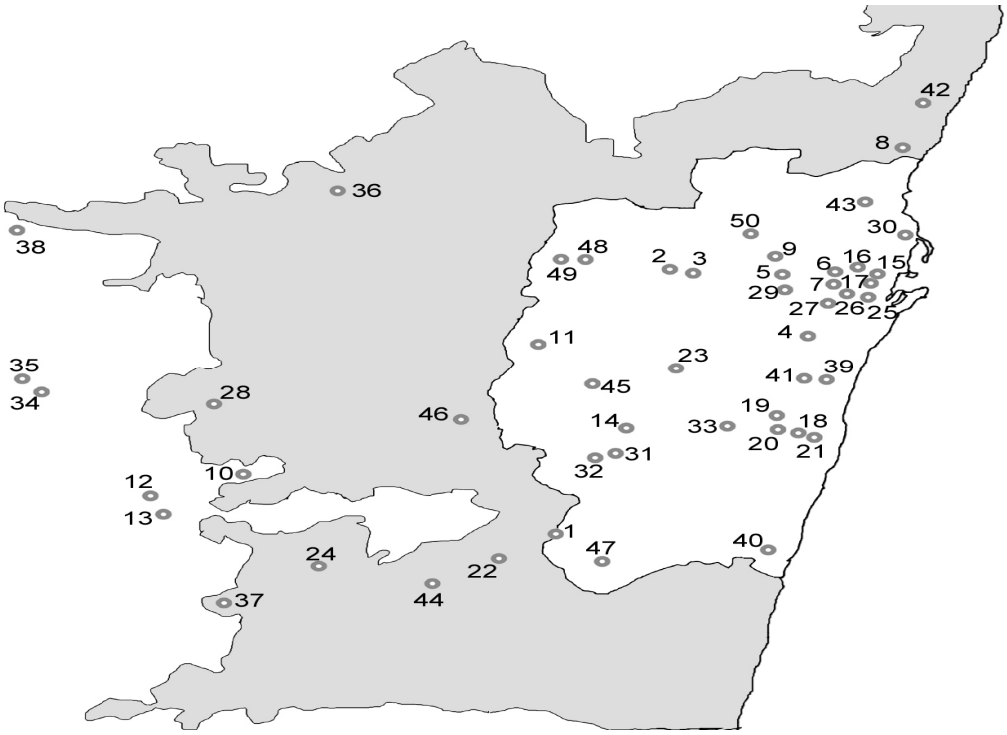

Figure 5. Temples tanks in Chennai (Source: CPREEC, 2008).

al., 2006). A significant phenomenon which has increased during recent years is that of local flooding attributable to impervious surface and high density development. Switching over to efficient drainage designs is the need. Chennai witnesses 425 new vehicles put on road every day causing pressure for motorable and parking space. Increase in road space accounts for only 3 - 4% as compared to 11% in Bangkok and 20 - 25% in developed cities like London, Paris or New York (Gupta and Nair, 2009).

Decline in area under water bodies has been remarkable, owing to eutrophication, their use as waste dumping sites, later encroaches by slums or poor colonies, then converted to land for housing complex, playgrounds or garden/parks but significantly loosing natural flood control sites. Figure 5 reveals spread of temple tanks in the entire Chennai most of which are degraded now and inefficient in controlling floods or storing water. Figure 6 shows degradation of wetlands or other water bodies. Degeneration and loss of temple tanks are another attribute of land-use modifications leading to reduced flood control systems (Figure 7).

Master plan and flood mitigation in Chennai

Master plan 1992 - 1993 incorporated Madras Metro Flood Relief (MMFR)/Storm Water Drainage (SWD) study outcomes in form of structural and non-structural measures. Land-use being most significant aspect that governs environmental and hydrological regimes along drainage and waste management issues, must be taken into consideration in any planning for urban risk mitigation. Vision 2026 of Chennai Municipal Authority (CMA) developed in 2007, aims to make Chennai a prime metropolis which will be more livable, economically vibrant and environmentally sustainable and with better assets for the future generations. Provision of rainwater structures in all types of developments, irrespective of size or use was made mandatory by amending DCR and building byelaws in the year 2001, not only for the buildings proposed to be constructed but also for all the existing buildings. After implementation of this scheme widely in CMA, a significant increase in the ground water levels and also quality of ground water was noted (CPREEC, 2008). Chennai City River conservation project was launched in year 2000 in order to improve waterways, with estimated outlay of Rs. 17,000 million. The projects proposed included sludge removal and disposal from waterway banks, improvement of macro drainage network in the catchments, improvements of micro drainage network in the city, improving the water quality of rivers and waterway, strengthening urban drainage network in the city, construction of sewage flow

Figure 6. Degradation of lake Madhuravayal.

Figure 7. Loss of temple tanks.

interceptors and treatment facilities.

Flood resistance in cities must address three contributory aspects, viz. flood avoidance, flood tolerance and flood resilience, in an integrated mode. This is the core of disaster risk reduction and directly addresses climate resilience in cities context. A Government funded

flood alleviation scheme was launched in 1998, with a cost Rs. 3000 million, focussed mainly on structural measures. Adequacy of flow in the arterial drainage system, removing impediments, safeguard against tidal and fluvial flooding, relocation and rehabilitation of encroachers were main objective components in the package. Cleaning of certain waterways and lakes was also undertaken under the scheme.

Conclusion

Planning and regulatory controls to prevent development in old tank beds unless adequate flood defence measures are in place enforced by the local government of Chennai. However, the implementation is a bigger challenge. Developments/construction taken cannot be brought back to the original landscape. The lakes / water bodies should be protected from encroachments and existing encroachments should be evicted by the departments/agency concerned bringing the water bodies to its original state. Vulnerability to hydro-meteorological disasters especially in urban context stems from large concentration of people, infrastructure and financial assets (Olavi et al., 1996). Disaster risks and impacts are aggravated due to environmental impacts of migration, slum habitations, poor waste management and local atmospheric phenomenon over the dramatic changes in land-uses and landscapes not only are macro level but more importantly at micro level – village/wards level. Ability to withstand a disaster is another important dimension in flood disaster management in cities. Land-uses issues especially water-relief regime, natural flood controls in form of wetlands, raised housing, better plinth in building and sanitary, maintaining open areas are examples of concern. Risk sensitive land-use planning has two fold implications – (a) managing environments and landscapes to avoid or reduce flooding, and (b) managing developments and human settlements from exposure/impact of floods (Goeghegan, 2002; Srinivasan, 2008). Land-use influences in terms of drainage and debris, flow gradient, rainwater amount and intensity over sewerage, urban forestry, pose serious challenges in flood disaster risk assessment, environmental planning in cities and disaster mitigation. Chennai's growth during fifty years with increased flood challenges and changing perceptions in master plan and land-uses now sets excellent example for further studies and research.

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