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FLOOD DAMAGE COMPUTATION IN URBAN AREA—A CASE STUDY

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SYNOPSIS

Flood damage computations in case of rare events in urban areas is an important step in Flood Management. In this paper the difficulties, limitations of the current approaches for evaluating the flood-frequency-damage relationships has been broughtout clearly by using the field data collected in Madras city.

1.0 INTRODUCTION

1.1 Losses due to flood has been increasing every year and as well the investment by the governments. This increase in loss is due to the increasing interference by man within the nature's right of way. The different types of damages caused by the flood requires analysis and it should throw light on the trend of area affected and of damages inflicted, composition of damages, distribution, causal factors and their impact on economy. The flood plain management is to mitigate the flood using the integrated approach of structural damages and non-structural measures. This requires a detailed flood risk mapping. However, flood risk maps provide only a static view of flood problems, is troublesome where dynamic change occurs as in rapidly urbanising catchments. Generally areas are flooded with water due to rainfall and/or river spill, is not able to drain off quickly. In case of natural drains, insufficient capacity could be the result of weed growth and obstructions like bridges etc.

1.2 Standard data requirement in flood management are flood frequency, stage discharge and stage damage relationships (Fig.1). It is always presumed that there is a method available for obtaining the flood frequency. However, the existing methods are inadequate. Further, is the assumption of single valued stage discharge relationship. Many a time a stage discharge relationship is obtained using slope area method. The derived information depends on the estimated value of Manning's roughness of steady uniform flow. If in a reach the lateral flow is dominant the storage effect comes into picture. The control reaches required for slope area method may not be available as in the case of stream of shorter length and winding through the urban area (Fig. 2). Such a stage discharge relationship is affected by the backwater effect.

1.3 Floods in urban areas become more distructive as the rate of growth of urban area increases. Urbanisation results in modification of hydrologic and hydraulic characteristics. Further it may increases the peak flow and decreases the time to peak. The runoff volume for a storm (that would have resulted in less volume) increases. The variation of inflow, storage volume , obstructions (levees, encroachmments) influences the water levels affecting the estimated discharge. In otherwards for a given stage the river can discharge less flow

compared to pre-urbanisation condition. Further, if an event of large magnitude is added to a small set of data upsets the frequency distribution. Hence, the frequency-discharge, the stage discharge relationships are getting modified continuously in a region of low urban area under transition to high urban area.

1.4 It is common practice to divide a river into reaches. Quite often a single stage (flow) frequency relationship is considered as representative of many reaches eventhough stage-flow frequency damage relationships would be different along a river.

1.5 There are several interplaying variables that influence the damage. (Fig.3).

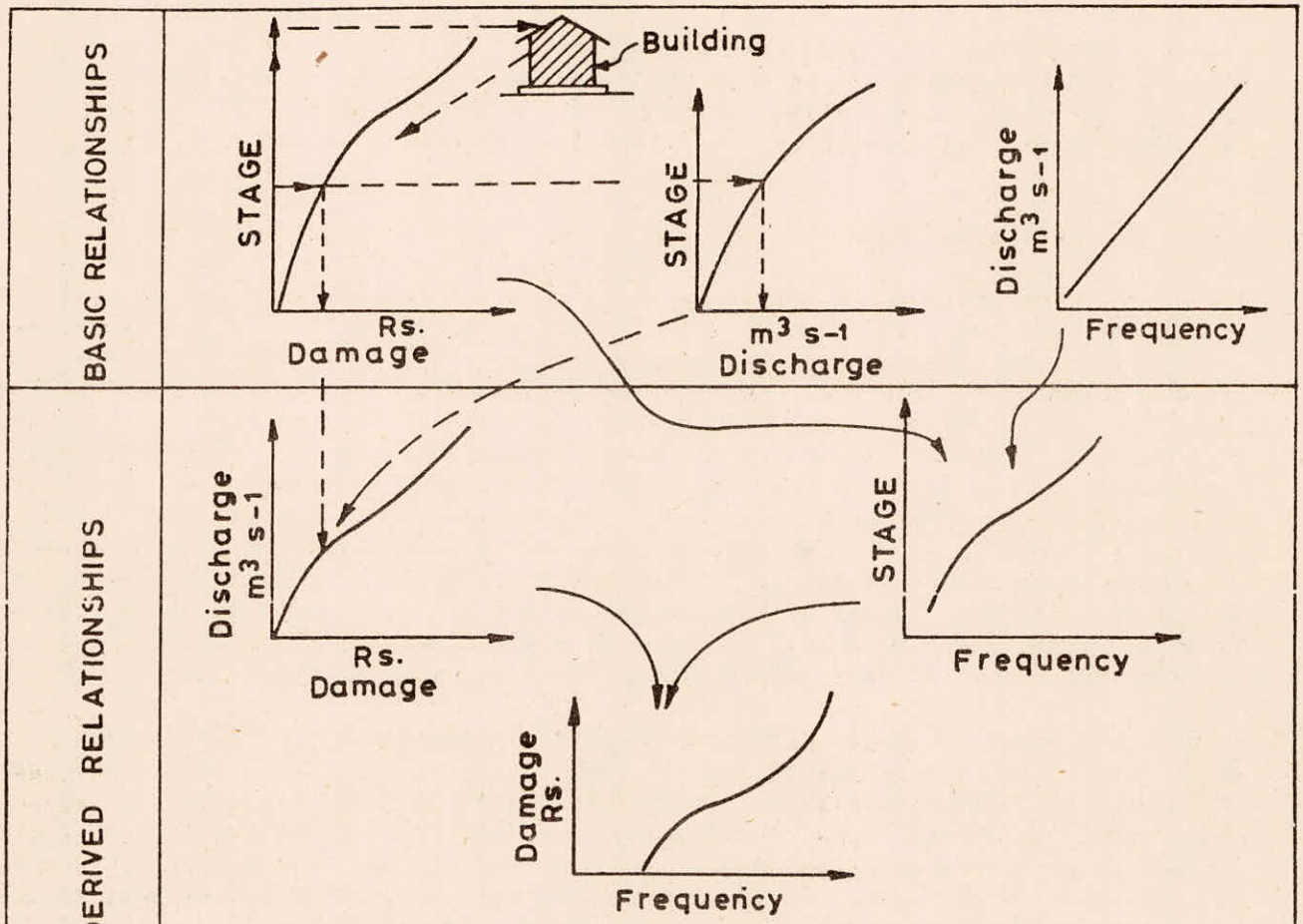

FIG. 1 - INFORMATION TRANSFORMATION FOR OBTAINING DAMAGE - FREQUENCY RELATIONSHIPS.

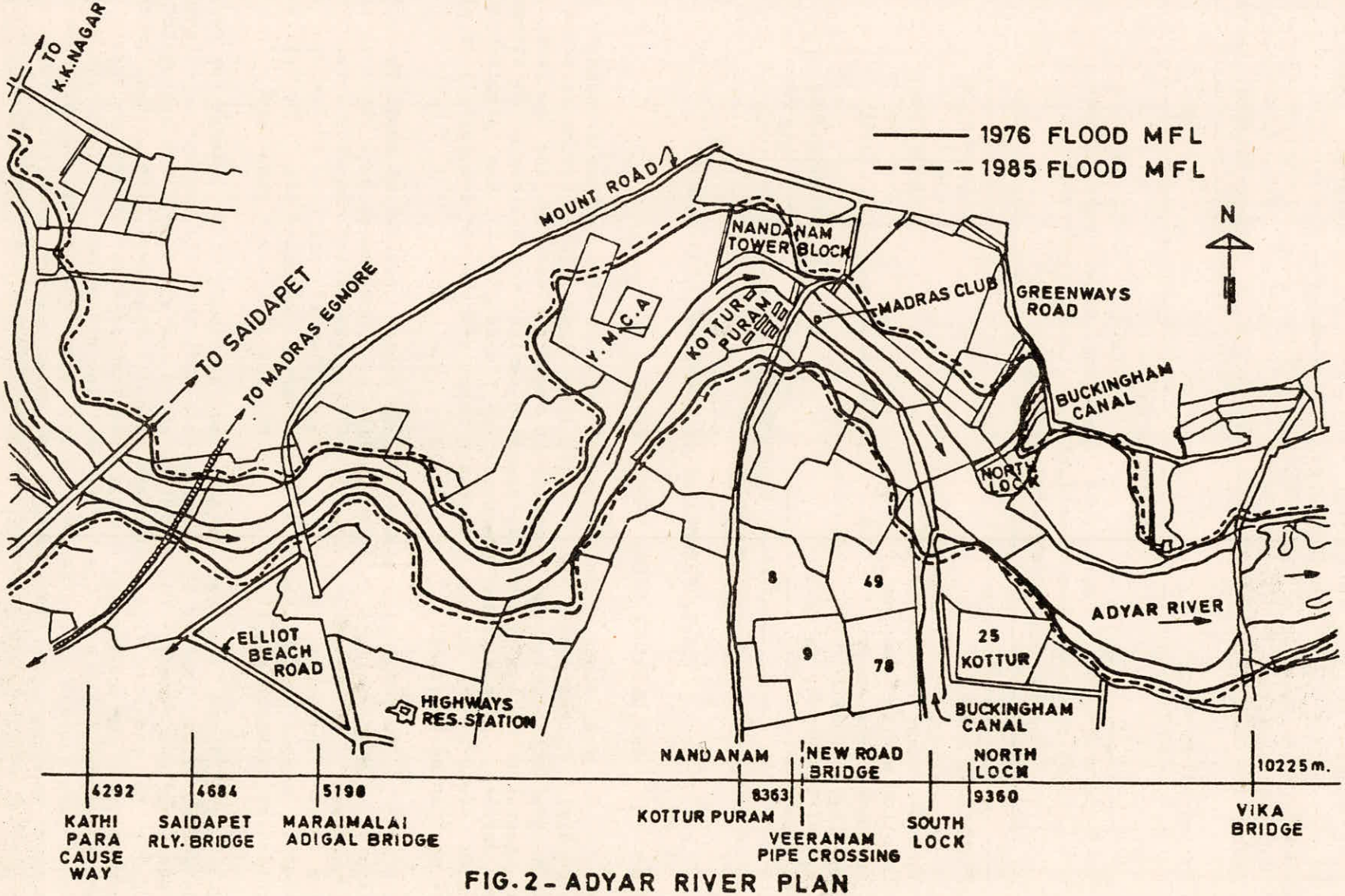

FIG. 2 - ADYAR RIVER PLAN

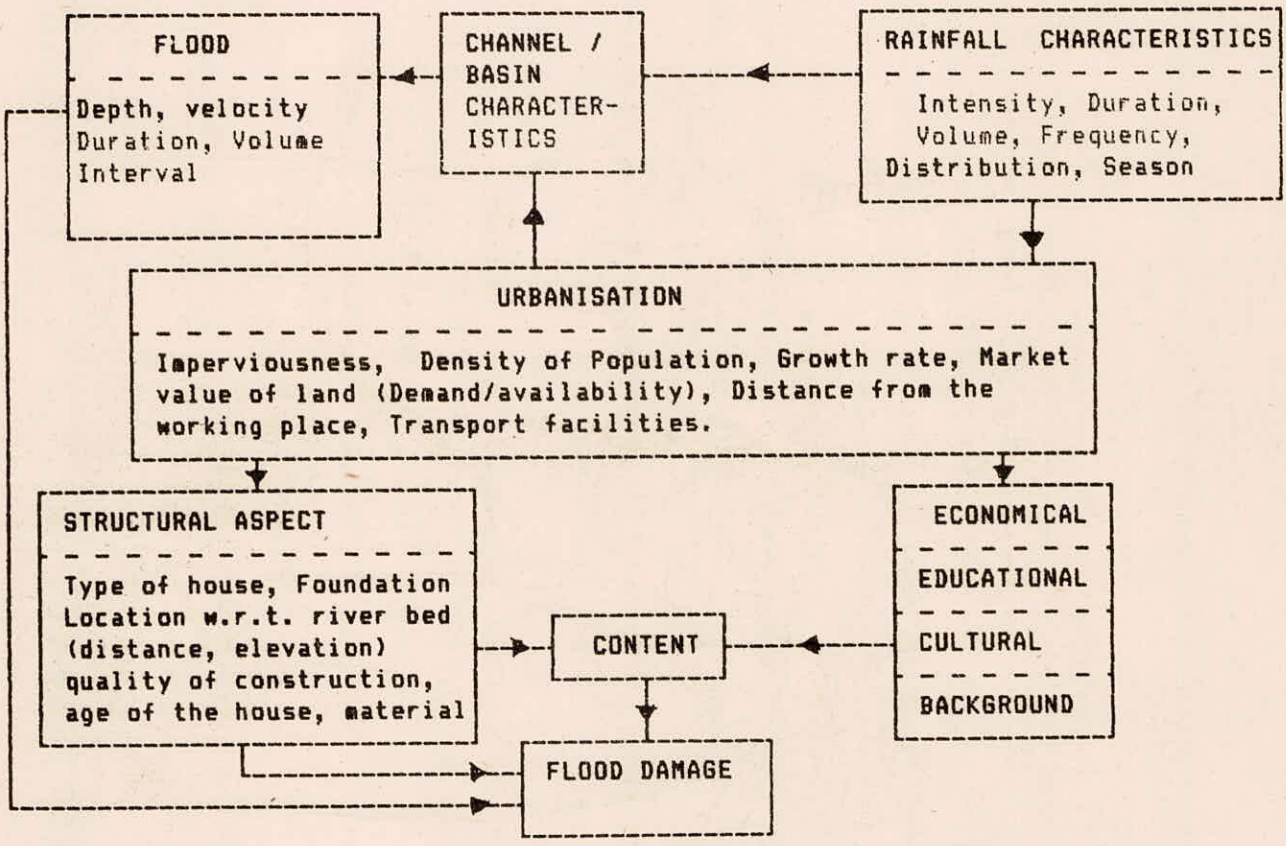

Fig.3. PARAMETERS INFLUENCING FLOOD DAMAGE

2.0 WHY DETAILED FLOOD DAMAGE DATA?

2.1 The flood plain management programs require that a boundary be drawn separately "flood prone" from "flood free" land. Since nature does not provide such distinct boundary, a yardstick to measure flood risk and the levels of risk as measured by that yardstick regarding various constraints on development must be defined. The National Commission of Floods [NCF,2], has established the 100 years flood as the maximum acceptable level of risk for the main floor elevation of most urban buildings.

2.2 The ideal data base for flood damage estimation would be on the spot records. NCF mentions that the quality of flood damage data needs considerable improvement and there are several deficiencies in the reported data. Presently the major components of these data collected relate to the area affected by floods, number of villages and population affected etc. The data should be collected based on pre-flood, Inter-flood and post-flood enquiries.

2.3 There are two methods of assessing the damage for residential property viz.; the use of standaru data and, the site surveying. Standard data regarding the damage to building could be adopted if the houses constructed adhere to standard sizes, standard plans, but however, the content in the house depends on the income and the taste of individuals. In Indian context in urban areas several factors influence the building of houses. For security reasons the walls are normally constructed using good quality bricks with cement / lime mortor and surface plastered. The warm weather conditions require broader

openings. The minimum requirement in a dwellings place is a kitchen, a common hall, bath and toilet and if possible additional bed rooms. The citizens who depend on salary have an upper limit on the rent that they can afford to pay and usually depends on basic salary and the house rent allowance. Hence, economic status of the individuals, number of members in a family, their cultural, religious and educational background influences the type of dwelling one occupies. Further, the contents in the house is directly influenced by income.

2.4 The poor are really socially and economically backward and number of dependents are also more. Hence, per capita money available is far less than the middle income salaried class. The urban population could be divided into different categories as unemployed and homeless, poor who live in huts, lower middle class who can afford to have a rented single room accomodation, upper middle class who can afford to have a reasonably good house (and in addition can afford for basic amenities and comforts), the rich (can afford to luxuries, bungalows, individual houses). Average number of members per family would be around 8, 6, and 4 respectively for huts, houses and bungalows. A typical hut in a city has a plinth area of 20 to 60 sq.m, whereas the average house it is 50 to 80 sq.m. However for bigger house it is between 150 to 200 sq.m. The daily wages can be Rs. 10 to Rs.50 a day depending on whether one is unskilled or skilled. Professionals like auto /taxi drivers earn Rs. 50 to Rs.150 a day. An employee of state / central government depending on the class, earns Rs.500 to Rs.5000 a month and a counterpart in private sector earns higher wages.

2.5 Flood damage may be computed for a single flood event or for all possible flood events. A high return period data added to preceeding 5 or 10 years data will introduce bias. However longer the period of data better it would be but it suffers from the influence due to changes in price and landuses, development activities etc. Floods of simliar magnitude can produce a different order of damage today, as compared to what they would have damaged earlier. ; Use of a universal incipient flood frequency for flood plain regulation falsely implies to the public uniform risk at the water surface elevation of a given flood frequency. Different types of structures sustain different amount of damages from a given depth of flooding. The maximum depth is probably the best single index of flood severity as higher depth means, greater velocity, longer durations, more sediment content, and higher damage.

3. CASE STUDY

3.1 Madras had developed sparsely during 1943-63 along Adyar river, but now it has developed into thickly builtup region. The population density was low (<10000 / sq.km.) in 1951 and has increased to 10 to 20 * 1000/sq.km. in 1971. However, the population density has reached as high as 40 to 50 * 1000/sq.km. in reaches which are within a km. distance from river bank. Gradually the open space has been occupied and developed into urban area of high urbanisation. The existing landuse pattern in and around Madras can be classified into primary residential, mixed residential, commercial, light industry, heavy industry, Industrial, open surface and recreational and non-urban area.

3.2 The city has been visited by two significant floods in 1976 and 1985 in Adyar river (Fig.2). The discharge in the river during most part of the year is either zero or negligible. Earlier agriculture was practiced intensly and now

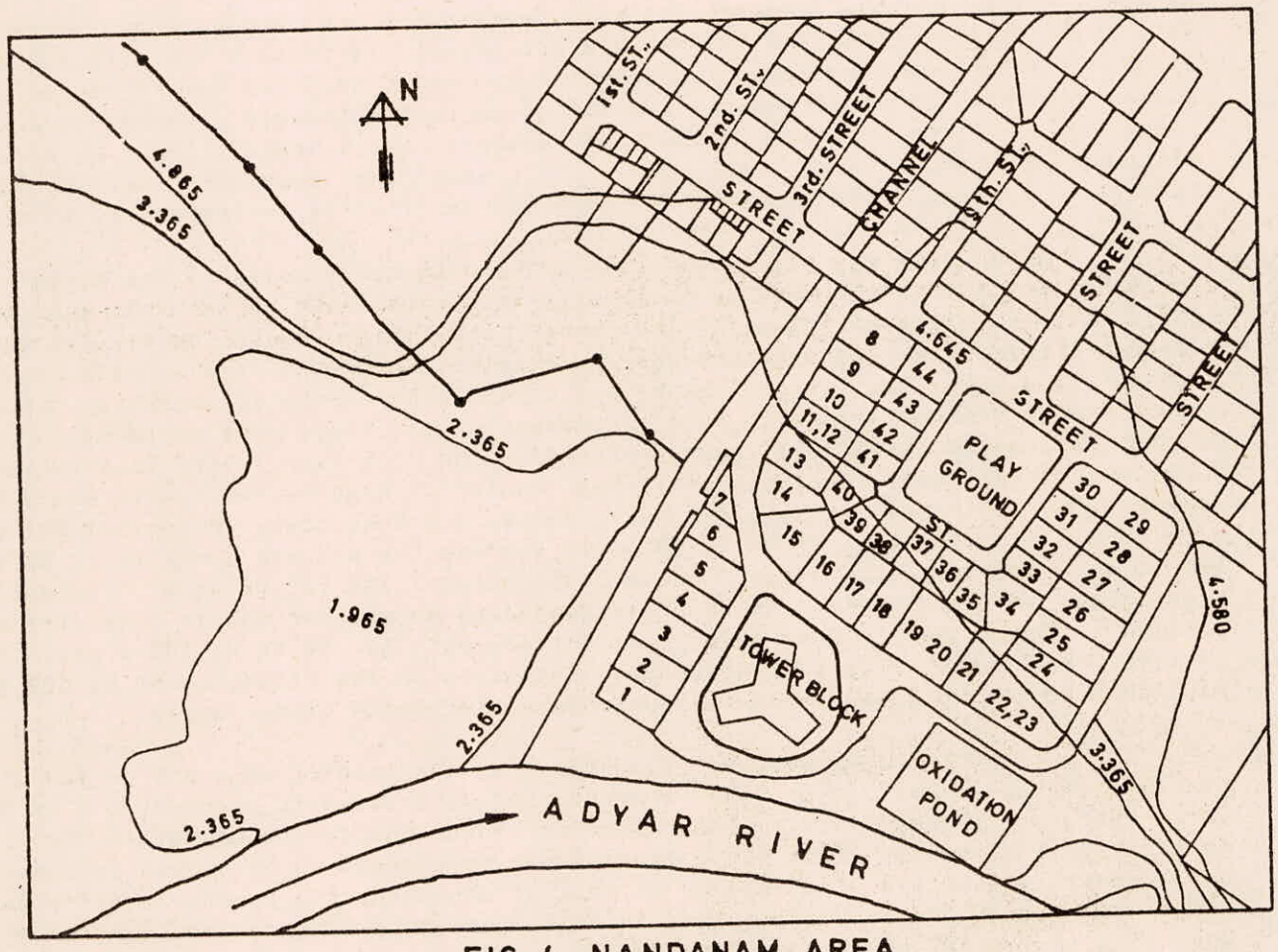

FIG.4 - NANDANAM AREA

the people are induced to occupy the flood plain and also government has encouraged the development. There are 3 highway bridges, 2 causeways, 1 pipe line crossing. Recently after 1985, one more road bridge has been constructed. The poor have occupied the lower reaches (Mallipur, Radhakrishna Puram) and a posh locality has developed in Nandanam area (Fig. 4.& Appendix I).

4. DATA COLLECTION SURVEY

4.1 The information on various aspects were collected by designing questionaire (Appendix II). The people were also interviewed. The people living in huts were not inclined to provide much information about their experience of the flood or they were afraid to express their opinion regarding their experiences and help provided to them. However by cajoling the people the information could be obtained. The response to enquiry ranged from 50 to 75% in the economically weaker section. In addition to the economnic background the educational background was also poor and it was mostly limited to primary level. Data from 80 families were collected. The photographic survey was also conducted to record the information. But on the other hand, the Nandanam area contained well educated, well informed people who were enthusiastic to give the correct picture and filled the questionaires with full details.

5. ASSESSMENT REGARDING DAMAGE TO CONTENTS

5.1 Structural information were noted as in Table 1. The information regarding topographic elevation reference flood elevation, damage reach (distance) deliniation, coding, and the content were collected (Table. 2). The assessment of damage to content was carried out with certain assumptions. The details are as follows:

When the ground floor is provided with the plinth, the water has opportunity to enter / leak through the gaps in the door openings. The gap depends on the type of door and the quality of joints with the door frame. The ordinary tin sheet doors provided in the huts were of poor quality. The water can penetrate as the junction yields under hydrodynamic forces. The water as it rises gradually seeps through the mud wall in case of huts and wets the mud plaster and due to differential pressure on the walls of huts, the hut can get crumbled. When

TABLE 1 The materials used in Building Houses / and other information

Flooring:	Mud, stone, plain cement, concrete, mosaic
Wall:	Mud, mud with bamboos, brick(plastered, concrete(rare)
Foundation:	Stone, concrete footing, pile, raft, brick
Roof:	Bamboo, coconut thatched, tile(country), machined tiles, flat roof with RCC.
Compound:	brick, fence (barbared wire) with concrete posts
Doors/windows:	Wood, tin, panelled doors, glass panels, flush doors steel frame, sash bars.
Opening sizes:	60 cm x 120 cm (huts): 90 cm to 120 cm x 200 to 250 cm.
Type:	Individual house, flat, hut, bunglaws
Floors:	Ground Floor, first floor, high rise
Plinth area:	(5 sq.m.)

water level rises upto window sill level it has more opportunity to enter through openings, from all sides of the houses exposed to flood waters. Mostly the materials such as beds, linens, openings in shelf, books in table drawers, chairs are located between floor level and window sill level. Hence, the damage to the content increases. The further increase in water level attacks the materials meant for decoration (eg: flower vases, photographs, delicate art items, paintings, drawings) and also affects the electrical connections. The dining table, chairs are all now subjected to damage at this level. When the laminated dining table is submerged, the binding material used may come loose and may yield thus deterioration would set in. The kitcken is assumed to have a platform at 75 cm from the floor level. The mixies, grinder, powdering machine, hot plate, gas stove, heaters are located at this elevation of platform and the rate of damage is high for these items at this level. The washing machine, refregerator can also be damaged due to short circuiting of electric connections and water may enter into the sealed portion, motors, compressors, insulation, can deposit in sediments. Thus damage is assumed to be increasing at higher rates as the water level increases. The television could be saved. otherwise when once the water enters the damage that can be caused cannot be estimated. Picture tube is the most sensitive component and the damage of this means the sharp rise in damage value. The musical instruments such as Harmonium, Veena, Guitar could be damaged fully if the wood, wax etc used for fixing is deteriorated under water. Thus there is not any functional relationships for

Table 2: The Elevations of Different Blocks in Nandanam.
(Basement /plinth = 0.5 m above ground level. Water depth 1.65 m above ground level)

Block No	Ground level m	Water Surface level above river bed m	Ground floor ceiling level m	Distance from left bank m	Plinth area sq.m.	Constant for content values damage(Rs)
1.	1.10	2.350	4.100	38	148.6	24400
2	2.40	3.650	5.400	50	148.6	15680
3	2.475	3.725	5.475	65	183.5	6950
6	2.625	3.875	5.625	110	148.6	13420
11&12	2.900	4.150	5.900	170/165	83.6	17120
16	2.625	3.875	5.625	110	60.4	8320
17	2.600	8.850	5.600	100	88.30	9940
18	2.575	3.825	5.575	96	185.80	59500
19/20	2.550	3.800	5.550	88/88	83.60	11360
27	2.750	4.000	5.750	140	83.60	25100
9	3.050	4.300	6.050	195	92.90	53420
32	2.775	4.025	5.775	145	83.60	251.00
37	2.675	3.925	5.675	122	139.40	7440
42	2.850	4.100	5.850	158	68.10	6020

damage and it is only a guestimation. The damage to the kitchen utensils depends on the type of material. The ceramic dishes (dining plates, cups), china, glass could be damaged 100% if they fall or hit by the debris brought by the sediment laiden water or by the fall or other heavy materials on them. If the vessels are made of mud damage is assumed as 100%. The damage to other type (steel, brass, bronze) vessels is negligible except for loosing the material itself. The carpets could be totally destroyed when submerged.

5.2 While evaluating the prices of material certain difficulties arise. If an item is being used and was already depreciated and now if damaged 100%, the 100% cost of replacement cannot be assumed. Its resale value has to be estimated accounting for repairs. Then it is this difference in cost i.e. pre-flood sale value and post-flood sale value has to be taken into account. However, the market price changes in a great manner. The unit cost of repair depends on the demand and supply of labour, material, time and money available for repair. Thus increase in unit repair cost influences the average annual damage cost. Further,

the resale value of material afterflood is always underquoted. Even if the material is totally damaged, it may have the scrap value and it would be impossible to estimate this scrap value. The damage to the books cannot be estimated by any means. If the damage is only external such as for binding the loss is negligible but if not easily available rare book is damaged, it would be an irrepairable loss and no depreciation can be accounted. Thus to evaluate the cost of the content it is advisable to physically inspect the items immediately after the flood has receded, but not later. The post-flood survey is done usually after a lapse of time. However as the situation would be changing a general software could be used by adopting the matrix showing the percentage of total cost for depths for individual material as given in Table. 3.

6. CONCLUSIONS

6.1 Damage evaluation in urban area requires updating and is dynamic. A general purpose program to evaluate such information is required. There is a need for research in obtaining stage-discharge frequency relationships.

Table. 3. Matrix for the percentage of total cost for depth - typical values

Item	DURATION	Depth from ground level (m)								
		0	0.4	0.6	0.8	1.0	1.4	2.0	2.4	3.0
		percentage of total cost								
Refrigerator	S	0	0	40	40	70	70	70	75	
	L	0	0	15	60	60	80	100	100	100
Bed and	S	0	0	0	0	0	35	40	40	40
Linen	L	0	0	0	10	10	60	100	100	100
Clothes	S	0	0	0	20	40	90	100	100	100
	L	0	0	0	25	50	100	100	100	100
Kitchen	S	0	0	0	0	5.0	20	90	90	90
Electrical	L	0	0	0	0	10	20	90	100	100
Gas Stove	S	0	0	10	20	30	50	80	80	80
	L	0	0	10	20	30	50	80	100	100
Food	S	0	0	10	25	50	60	75	90	100
Stock	L	0	0	15	30	60	80	90	100	100
Linolieum	S	0	0	25	50	75	100	100	100	100
	L	0	0	100	100	100	100	100	100	100

S = short < 12 hrs., L = long > 12 hrs.

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2. Rashtriya Barh Ayog (NCF), (1980), 'A Report', Govt. of India, New Delhi.

3. Thandaveswara B.S. et al., (1986), ' Regional Variation of Flood Damage - A case study', Fifth Cong. Asia & Pacefic Regional Dn. IAHR. Seoul, pp. 201 - 226.

4. Thomas N, Yanchy et al. (1976), 'Disaster Caused Increases in Unit Repair Cost', Jl. of Wat. Reso. Plan & Man. ASCE. V 102, WR 2, pp. 265 - 282.

5. William K. Johnson, (1985), 'Significance of Location in Computing Flood Damage', ibid, V. 111, WR1, pp. 65 - 81.

Appendix I

Some salient features of selected reaches in Adyar.

1. Nandanam Reach: Tower Block : 8 floors (Tall structure), at ground floor level 6 garages, four elevators and six flats in each floor. Well planned RCC, G.L. 2.375 m. basement level 2.875 m. water surface level 3.625 m. distance from river 50 m. Rental value Rs. 800 pm. (Govt. quarters allottment), average income of the family members Rs. 3000 pm. Content values average Rs. 30 000 per house, High level education.

2. South Kesavapuram: No. of houses/ huts 214 (10 tiled roof with brick walls and 3 houses with first floor), 152 owners (140 huts + 10 tiled houses + 2 pucca houses), rented tenents 72, rental value Rs. 30, 40, 50 and 100 pm, No. of shops 3, temples 2, church 1. Total no. of people 2000 (800 males, 700 females and 500 children), profession / occupation: coolies, drivers, factory labourers, clerks, business. Plinth area of huts range from 6 x 9 m. to 3 x 12.2 m. Structural aspects: huts have no specific foundation, mudchani flooring, pucca houses have mosaic/ cement flooring. Cost of construction Rs. 2000 to 3000 per hut (thatched roof, brick dwarf wall, fence) Rs. 10 to 15 000 per 10 square m. for tiled gabled roof, Rs. 25 000 per RCC house. During 1976 floods 10 to 15 huts were washed out. 400 people have studied upto a maximum of SSLC. 30 to 35 years old establishments. 3 days for the flood to rise and one week for receding including returing to normalcy. Flood was upto 1.22 m. above ground level. Authorised by MMDA. Earlier (1959-60) this was revenue land.
Compensation: Rs. 100 if hut is damaged, 50 Kos of rice one saree and one Lungi per family.

3. Mallipur: Total no. of houses 400 (390 huts + 10 RCC buildings) plinth area 55 sq.m., 300 houses have labourers, 100 houses have salaried people, the ranges of income Rs. 300 to 400, Rs. 400 to 700 a month respectively. Two tailoring shops and two provision shops. Average size of the family 5 persons, average no.of earning members 1.3 per family. Estimated damage by owners; 6 responders respectively.
Rs. 4000, Rs. 1000, Rs. 700, Rs. 5000, Rs. 1500$, Rs. 500$.
($ = repair cost in shops + Rs. 1000, Rs. 500 respectively).

Appendix II

Questionaire on socio economic aspects of urban areas for houses.

1. Name (Head of the family) 2. Address 3. Occupation
4. No. of persons in the family.
5. No. of earning members:

	Age	Qualification
Male Female Children		

Income of each earning member (i) daily, (ii) monthly, (iii) Annual in Rs.
Total income of the family.

6. Range of income:

Code	a	b	c	d	e	f	g	h	i
Income(Rs)	0.5	5-10	10-50	50-100	100-250	250-500	500-1000	1000-2000	2000-5000

Code	j	k
Income (Rs)	5 000 - 10 000	> 10 000

7. Has this building ben affected during flood: Yes/No.
   If Yes; How? Why? and When?
   Due to (a) physical handicap (b) delay in flood warning
   (c) self negligence (d) other reasons (specify)

8. Do you have flood Risks Cover, if Yes,
   Insurance coverage of life, property against risk and extent of the same.
   period, premium, risks, amount, under/over insurance.

9. Period of stay in the same locality.

10.a) Why are you staying in the region even though you encounter flood?
   b) Were you staying elsewhere earlier and reasons for moving into this region.
   C) Number of floods experienced by you during your stay and the extent of damage in terms of Rs. (include year of flood).

11. Type of house: Rented / owned.
   Plinth area: Single or multistorey house; Rental Value pm.
   Classification:
   Hut/house/commerciasl/industrial/public

List of material content: (Type/cost)

(i) Chairs, (ii) Tables, (iii) Cots, (iv) Radio/Transistor (Portable or fixed), (v) TV, (vi) cycle (brand), (vii) Moped/Scooter/Car/Van; Model , (viii) Vessels, (Steel, Copper, Bronze, Brass, Aluminium, mud, pots) total value, (ix) cloth, (x) steel cupboards etc.

12. Any particular measures were taken during construction. If so, measures taken regarding
(i) foundation, (ii) basement (iii) flooring (iv) windowsills, (v) construction materials of (a) foundation, (b) walls/windows, doors, (c) roof.

13. Whether the stay in the locality has been authorised?

14.Flood details:
(i) Year of flood
(ii) Details of damages
(a) People: Death/Health/affected(physical)handicap.
(b) Cattles/animals: death/lost
(c) contents: cars/cycles/house/contents
(d) period of dislocation
(iii) Government actions
(a) Compensation paid by Govt. if any.
(b) Warning: was it given? If so, time of warning.
Authority who informed.
Was there any electricity failure?
(iv) Any other details?