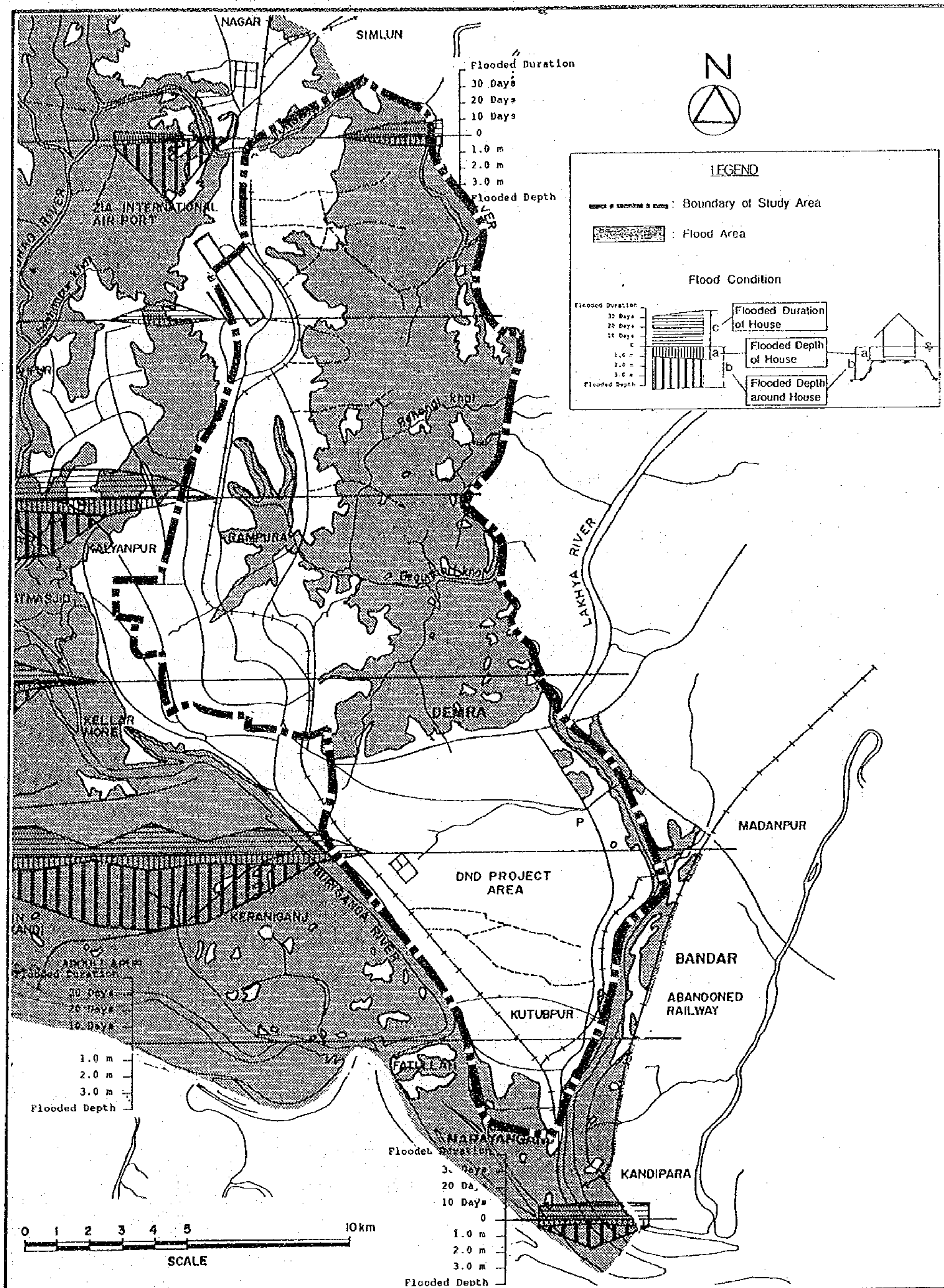


FIG. B.4 EXTERNAL FLOOD MAP : 1987 FLOOD

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

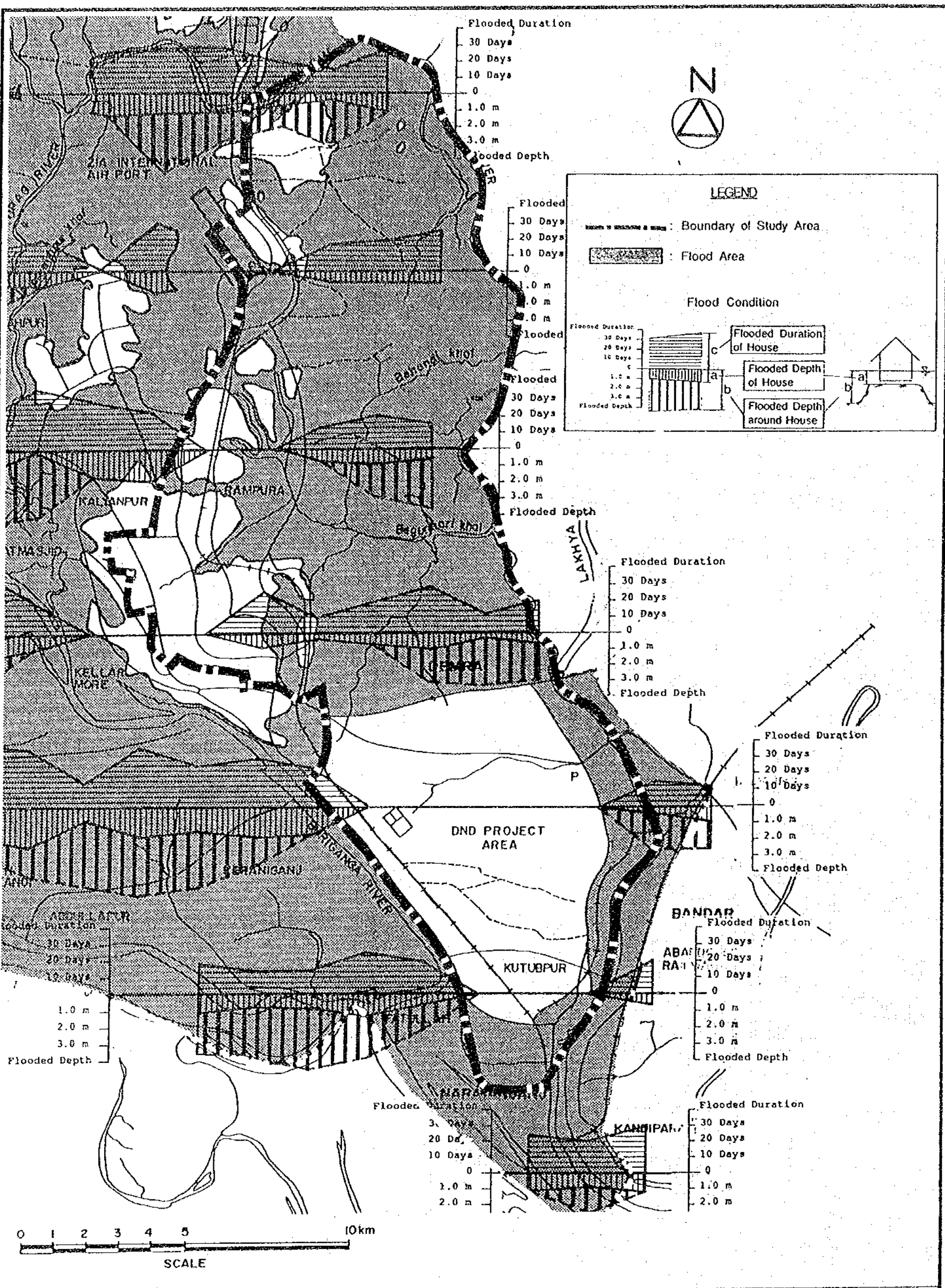


FIG. B.5 EXTERNAL FLOOD MAP : 1988 FLOOD

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

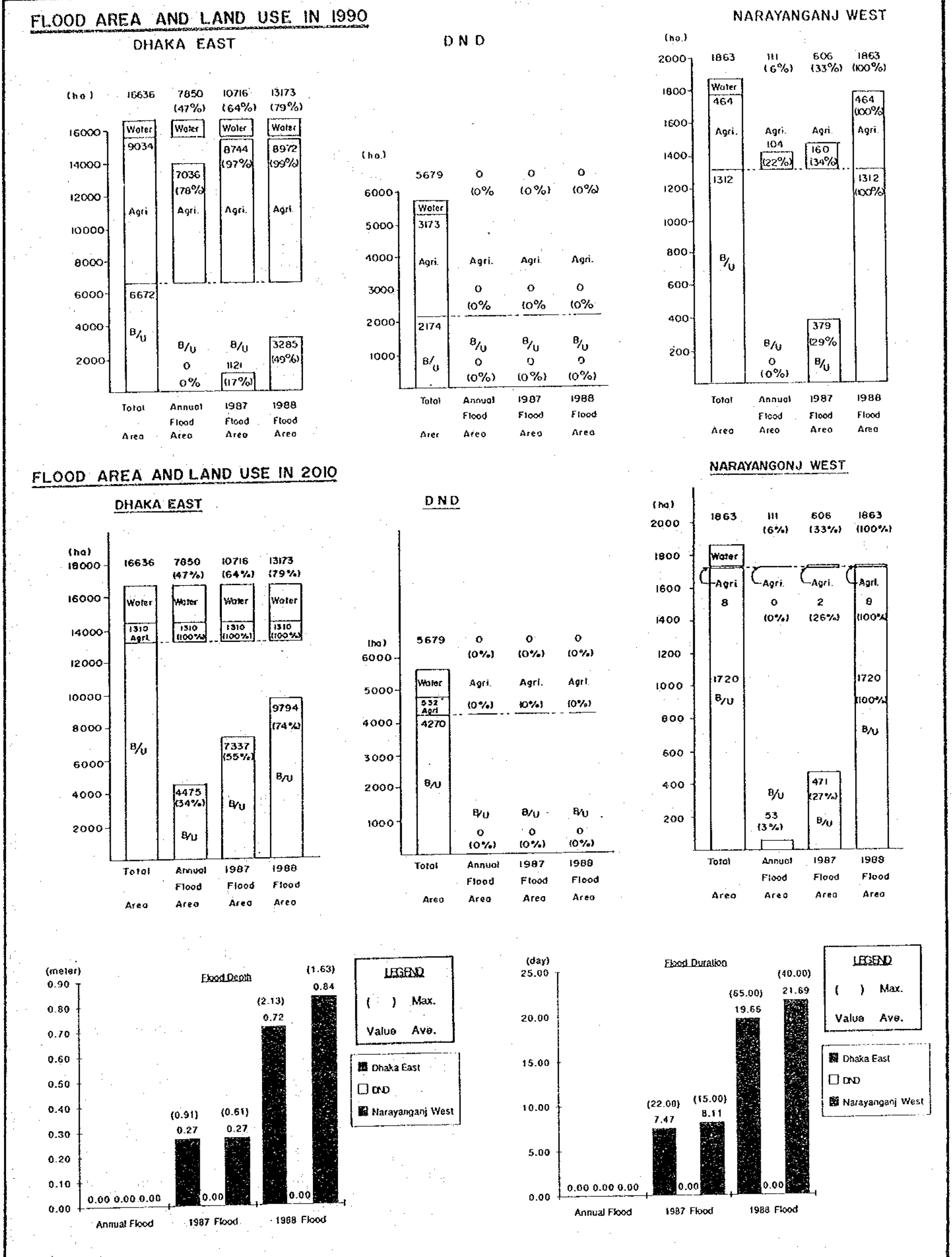


FIG. B.6 EXTERNAL FLOOD CONDITIONS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

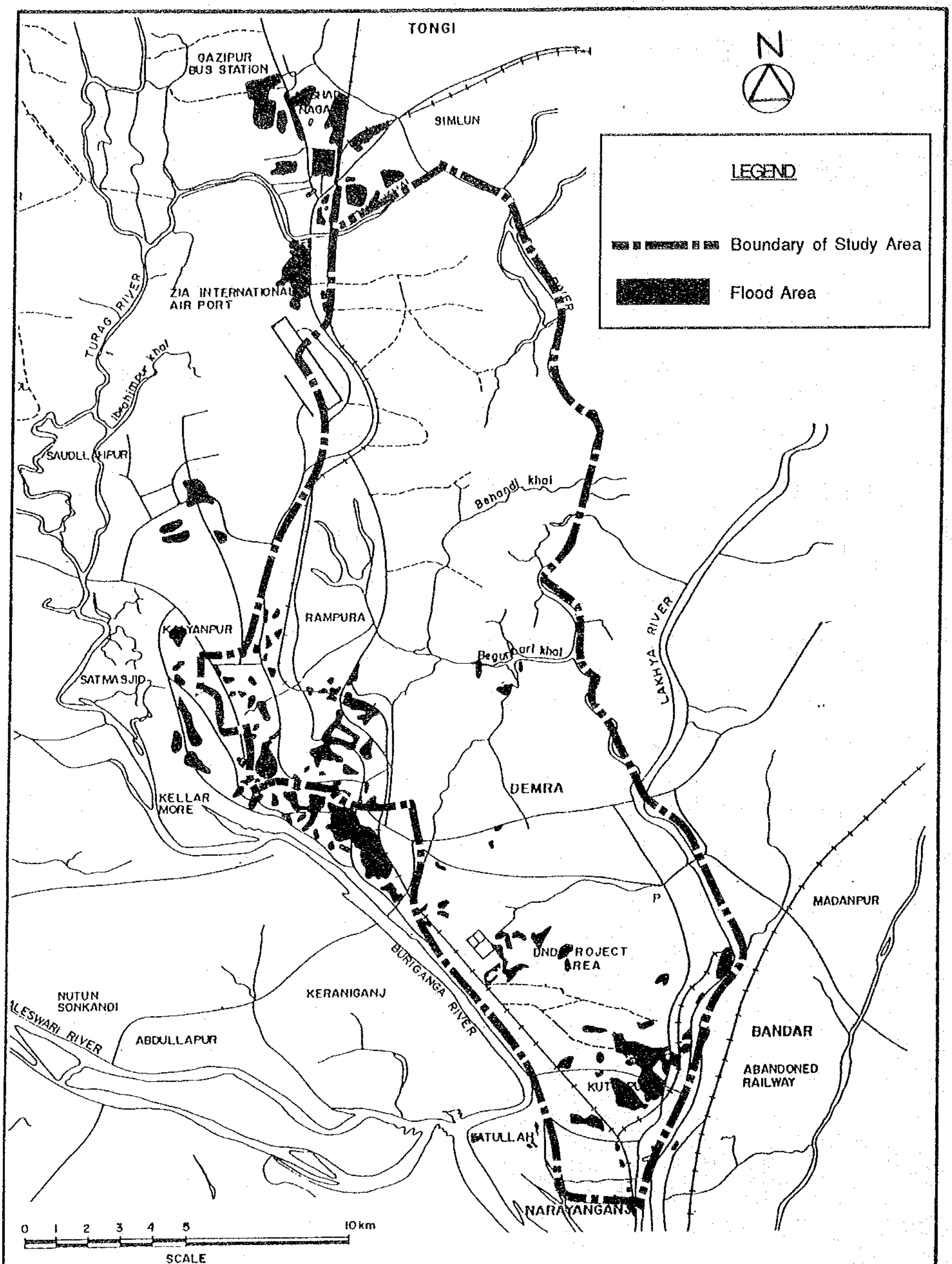
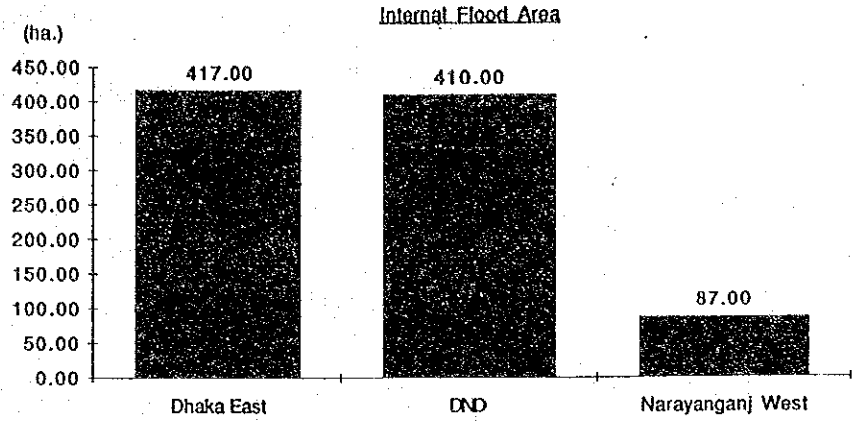
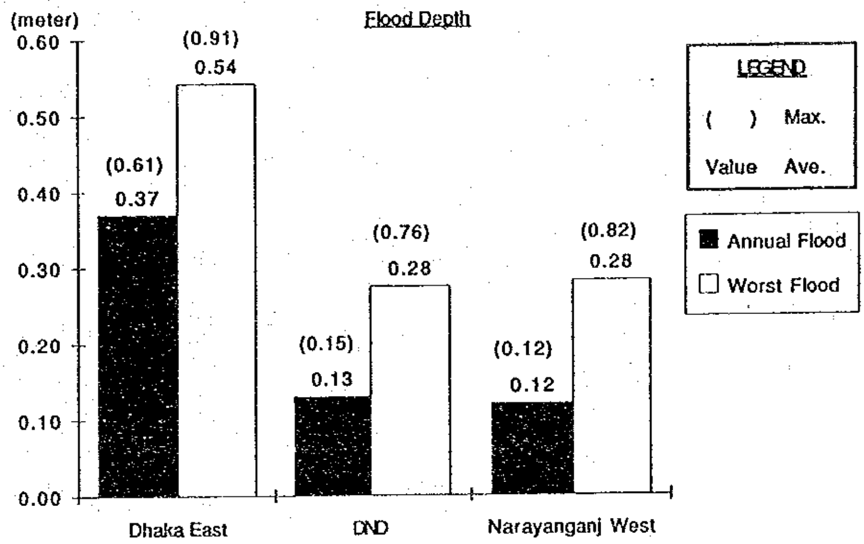


FIG. B.7 INTERNAL FLOOD MAP

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH





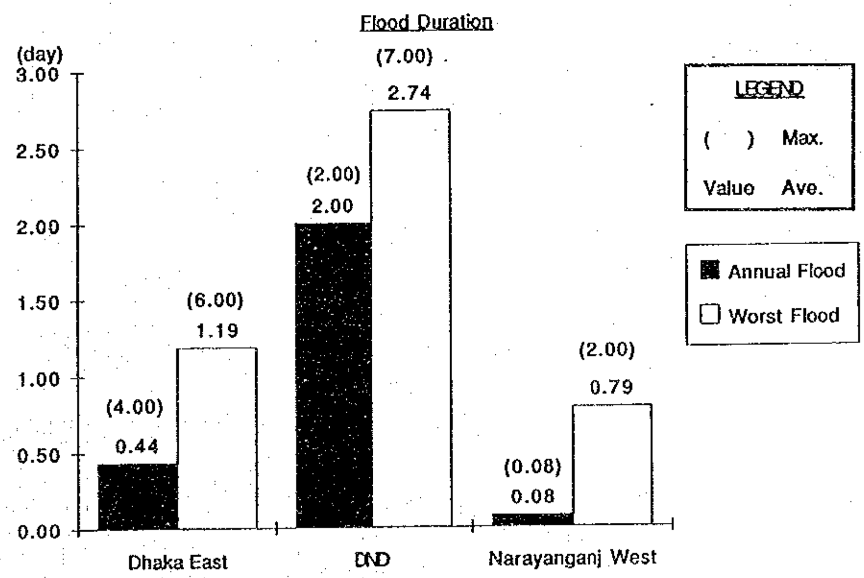


FIG. B.8	INTERNAL FLOOD CONDITIONS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

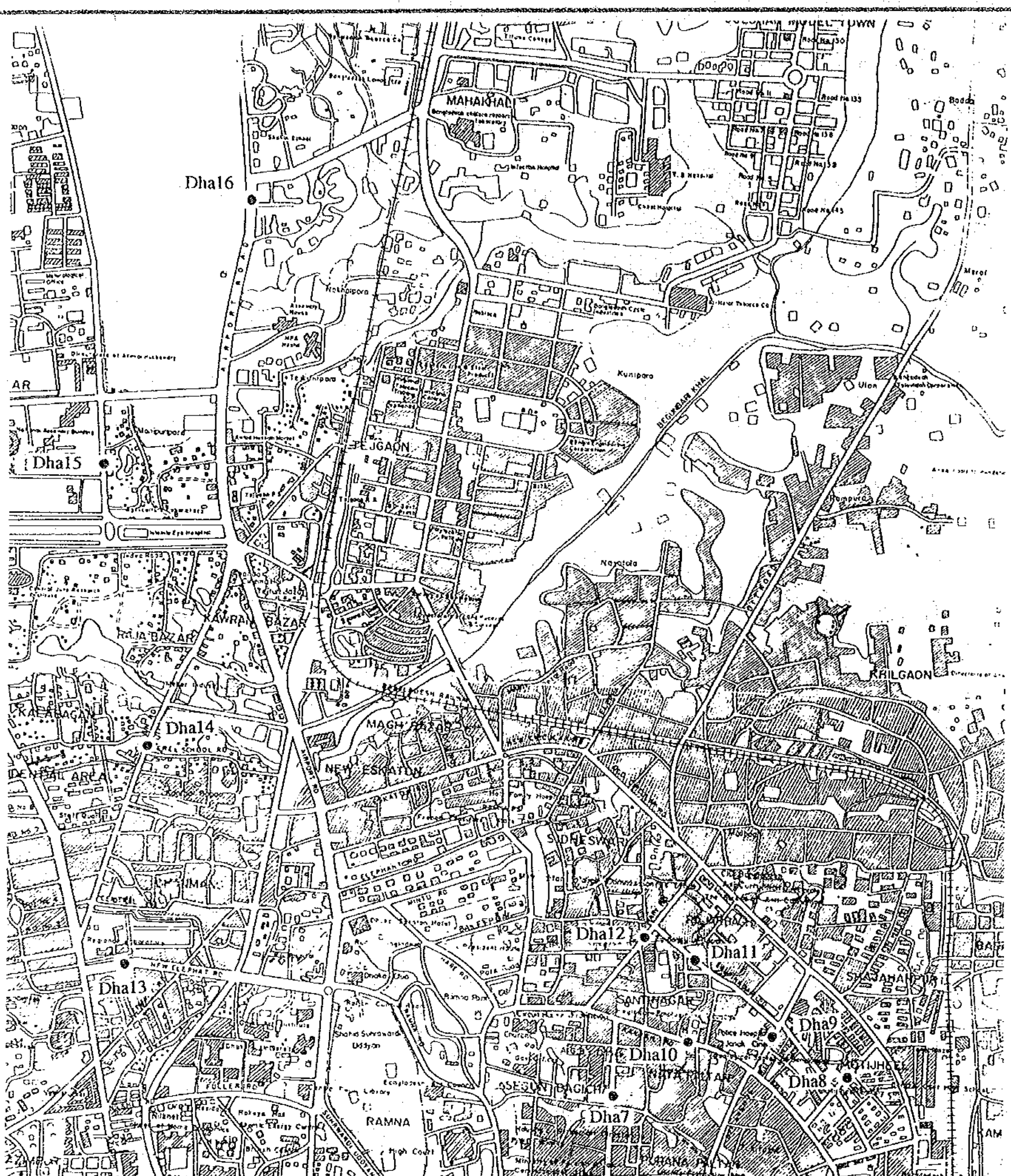


FIG. B.9 TRAFFIC SURVEY POINTS FOR INTERNAL FLOOD : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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FIG. B.10 TRAFFIC SURVEY POINTS FOR INTERNAL FLOOD : NARAYANGANJ

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

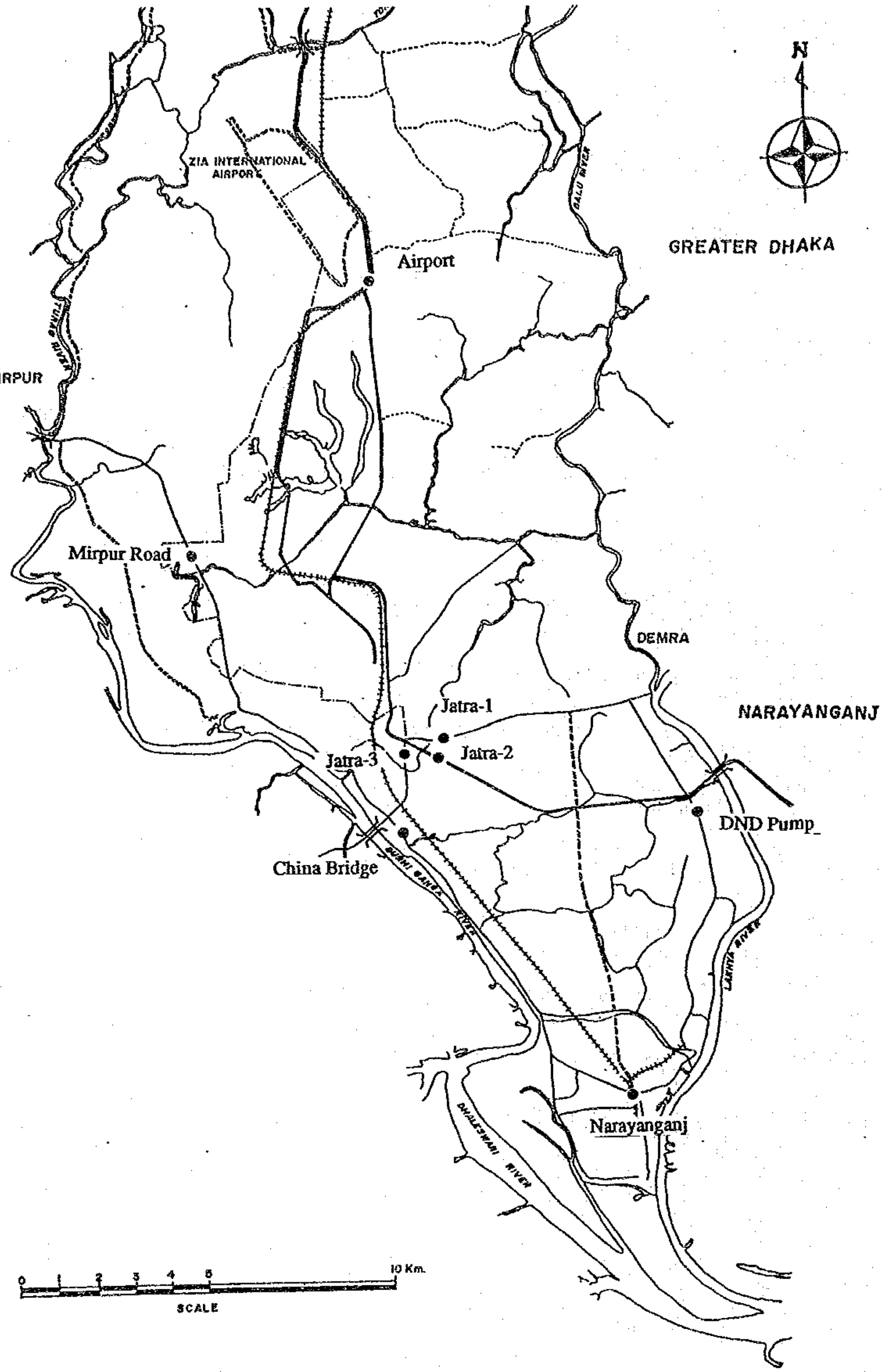


FIG. B.11 TRAFFIC SURVEY POINTS FOR EXTERNAL FLOOD

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

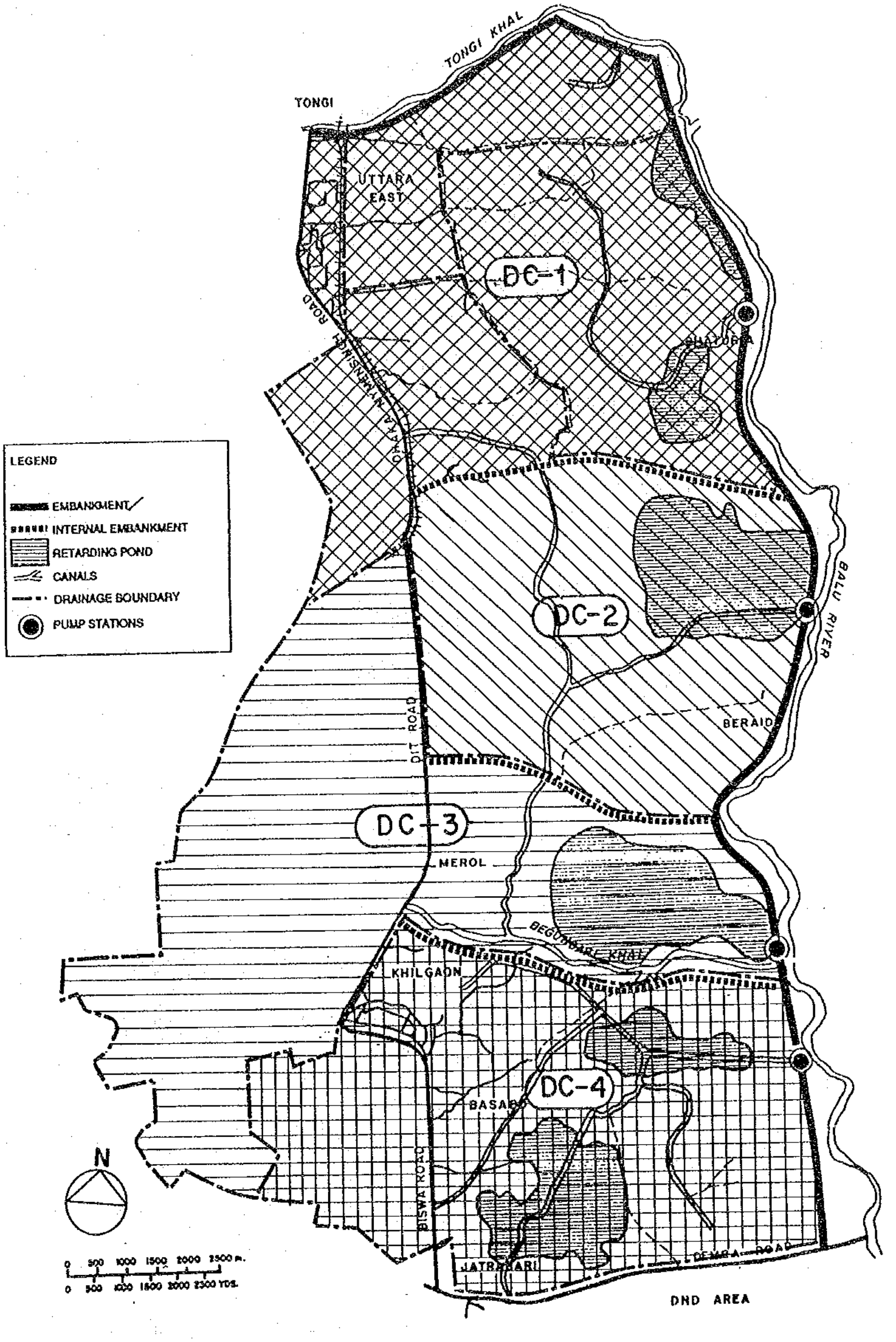


FIG. B.12	COMPARTMENTALIZATION OF GREATER DHAKA EAST FOR ECONOMIC EVALUATION

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

ANNEXES

ANNEX 1. CALCULATIVE STEPS LEADING TO ESTIMATION OF NUMBER OF INUNDATED PROPERTIES AND RESIDENTIAL DAMAGES BY A 1987-SCALE FLOOD IN GREATER DHAKA EAST

1. Estimation of Number of Inundated Properties

1) The number of houses, businesses, industries and institutions in Greater Dhaka East for 1990 was estimated by Zone based on Population Census 1981. The number for 2010 was estimated based on Zone-wise population growth forecasts from 1990 to 2010. (Refer to Tables A1.1, A1.2 and A1.3.)

2) The number of the above four types of properties to have been inundated due to a 1987-scale flood in 1990 was estimated by multiplying the number of houses in each Zone in 1990 by the inundation ratio in the built-up areas in each Zone in 1990 due to the 1987-scale flood. (Refer to Table A1.2, Table B.1(1) and Table A1.4.)

   The number of properties to be inundated in 2010 due to a 1987-scale flood was estimated in the same way. (Refer to Table A1.3, Table B.1(1) and Table A1.5.)

2. Estimation of Residential Damages

1) Flood damage ratios for residential building(s) and household effects per household and income loss ratio per household in a 1987-scale flood were estimated by using multiple regression equations determining the relationships between the depth/duration of inundation and flood damage ratios or income loss ratio in a 1987-scale flood, and the depth/duration of inundation in each Zone in a 1987-scale flood. (Refer to Table E.10(1) of the Master Plan Supporting Report I and Table B.2.)

2) The average values of residential building(s) and household effects per household and the average annual income per household for 1990 were estimated as a result of the sampling questionnaire survey. (Refer to Table B.4(1) 3. and Table E.12(1) of the Master Plan Supporting Report I.)

   The average values of residential building(s) and household effects per household and the average annual income per household for 2010 were estimated on the assumption that the above values and income will increase in parallel with the growth of per capita GDP in the Study Area.

   In the Fourth Five Year Plan 1990 to 1995 the government of Bangladesh worked out the 5% annual economic growth for the whole country. According to the Statistical

Yearbook of Bangladesh 1990 the annual population growth in Bangladesh during the same period is estimated at 2.26% (refer to Table B.1(1) of the Master Plan Supporting Report I). It follows from the above that the annual per capita economic growth of 2.68% is planned for the country during 1990 to 1995.

Against this background, the average annual economic growth of 7% and 6.5% against the average annual Study Area population growth of 3.99% was assumed from 1990 to 2010 for the two northern compartments (DC-1 and DC-2) and the two southern compartments (DC-3 and DC-4), respectively. That is to say, the annual per capita economic growth of 2.89% and 2.41% was assumed for the northern and southern compartments, respectively.

The reason the per capita economic growth is higher in the two northern compartments than in the two southern compartments is that the people who will move and settle in the newly developed areas in the northern compartments were assumed to be richer on average.

3) Multiplying 1) by 2), and then multiplying the results by the number of inundated houses we get flood damages to residential buildings and household effects and household income losses in Greater Dhaka East due to a 1987-scale flood in 1990 and 2010. (Refer to Tables A1.6, A1.7, A1.8 and A1.9.)

Table A1.1 Population by Zone in Greater Dhaka East in 1990 and 2010

No.	Name of Zones	1990	2010
1	4	49,956	71,741
2	7	55,084	141,718
3	8	44,959	77,131
4	9	45,481	50,421
5	11	27,216	23,427
6	13	33,750	51,302
7	27	54,566	21,775
8	28	47,311	34,540
9	29	42,051	52,269
10	34	103,587	156,361
11	35	60,656	94,928
12	36	74,394	125,507
13	37	45,280	65,717
14	38	58,125	85,494
15	39	109,560	134,871
16	40	81,722	214,717
17	41	59,402	87,403
18	42	62,963	62,565
19	43	48,913	73,851
20	44	64,399	111,226
21	45	52,698	94,231
22	46	64,258	94,038
23	47	93,935	109,208
24	48	114,062	171,764
25	49	34,857	71,863
26	50	65,956	48,061
27	51	66,843	160,066
28	52	70,388	105,367
29	53	56,766	84,665
30	Gulshan 57	57,177	331,265
31	Cantonment Ward-1	79,283	115,296
32	Cantonment Ward-3	29,655	234,795
33	Dakshin Khan Cantt.	40,515	97,025
34	Uttar Khan	23,111	292,073
35	Dakshin Khan Gulshan	48,824	302,466
36	Beraid Gulshan	15,627	93,927
37	Beraid Demra	8,121	15,197
38	Demra	50,131	114,438
39	Matuail Dhaka	8,304	197,390
	Greater Dhaka East	2,149,886	4,470,099

Table A1.2 No. of Properties by Zone by Type of Properties in Greater Dhaka East in 1990

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	8,370	355	5	272
2	7	7,822	198	0	751
3	8	7,204	196	8	403
4	9	6,524	511	0	545
5	11	4,271	130	0	51
6	13	4,932	220	0	185
7	27	8,208	862	4	257
8	28	7,218	364	33	241
9	29	6,812	301	30	293
10	34	20,511	521	13	1,933
11	35	9,940	635	0	539
12	36	13,071	387	0	193
13	37	5,345	157	0	85
14	38	10,523	528	0	133
15	39	19,676	447	0	447
16	40	7,055	224	0	182
17	41	9,149	155	0	147
18	42	9,580	637	0	810
19	43	7,066	534	0	499
20	44	7,998	490	142	1,098
21	45	6,698	166	0	1,757
22	46	9,827	232	147	372
23	47	14,746	667	0	565
24	48	18,878	154	1,111	1,951
25	49	4,764	875	0	62
26	50	9,594	779	0	430
27	51	11,862	449	0	1,007
28	52	12,754	328	0	300
29	53	9,847	501	4	715
30	Gulshan 57	9,382	18	0	53
31	Cantonment Ward-1	14,092	797	0	1,654
32	Cantonment Ward-3	5,133	168	0	110
33	Dakshin Khan Cantt.	7,240	411	0	851
34	Uttar Khan	3,823	1	0	6
35	Dakshin Khan Gulshan	8,117	226	0	29
36	Beraid Gulshan	2,665	2	0	5
37	Beraid Demra	1,193	13	0	5
38	Demra	8,301	165	0	396
39	Matuail Dhaka	1,485	48	1	164
	Greater Dhaka East	341,673	13,851	1,499	19,497

Table A1.3 No. of Properties by Zone by Type of Properties in Greater Dhaka East in 2010

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	12,020	509	8	390
2	7	20,124	509	0	1,932
3	8	12,360	336	13	691
4	9	7,233	566	0	604
5	11	3,676	112	0	44
6	13	7,496	334	0	282
7	27	3,276	344	2	102
8	28	5,270	266	24	176
9	29	8,468	374	37	364
10	34	30,961	787	19	2,918
11	35	15,556	993	0	843
12	36	22,052	653	0	325
13	37	7,758	228	0	124
14	38	15,478	777	0	196
15	39	24,221	550	0	550
16	40	18,536	588	0	478
17	41	13,461	228	0	217
18	42	9,519	633	0	805
19	43	10,668	807	0	754
20	44	13,813	846	245	1,897
21	45	11,976	297	0	3,141
22	46	14,381	340	216	545
23	47	17,143	775	0	657
24	48	28,428	232	1,673	2,938
25	49	9,821	1,805	0	127
26	50	6,991	568	0	313
27	51	28,405	1,075	0	2,410
28	52	19,092	491	0	450
29	53	14,686	747	6	1,066
30	Gulshan 57	54,358	103	0	308
31	Cantonment Ward-1	20,493	1,159	0	2,406
32	Cantonment Ward-3	40,638	1,327	0	871
33	Dakshin Khan Cantt.	17,337	985	0	2,038
34	Uttar Khan	48,315	16	0	81
35	Dakshin Khan Gulshan	50,286	1,398	0	182
36	Beraid Gulshan	16,021	11	0	32
37	Beraid Demra	2,232	25	0	9
38	Demra	18,949	377	0	904
39	Matuail Dhaka	35,288	1,136	26	3,909
	Greater Dhaka East	716,785	23,306	2,269	36,079

Table A1.4 No. of Properties in Inundation Areas by Zone by Type of Properties in 1990 (1987-Scale Flood)

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	0	0	0	0
2	7	0	0	0	0
3	8	0	0	0	0
4	9	0	0	0	0
5	11	0	0	0	0
6	13	0	0	0	0
7	27	0	0	0	0
8	28	0	0	0	0
9	29	0	0	0	0
10	34	10,051	255	6	947
11	35	0	0	0	0
12	36	1,176	35	0	17
13	37	0	0	0	0
14	38	947	48	0	12
15	39	12,592	286	0	286
16	40	2,046	65	0	53
17	41	0	0	0	0
18	42	0	0	0	0
19	43	0	0	0	0
20	44	0	0	0	0
21	45	0	0	0	0
22	46	0	0	0	0
23	47	1,180	53	0	45
24	48	5,286	43	311	546
25	49	333	61	0	4
26	50	192	16	0	9
27	51	3,321	126	0	282
28	52	7,780	200	0	183
29	53	4,136	210	2	300
30	Gulshan 57	0	0	0	0
31	Cantonment Ward-1	705	40	0	83
32	Cantonment Ward-3	0	0	0	0
33	Dakshin Khan Cantt.	0	0	0	0
34	Uttar Khan	0	0	0	0
35	Dakshin Khan Gulshan	3,328	93	0	12
36	Beraid Gulshan	1,466	1	0	3
37	Beraid Demra	1,193	13	0	5
38	Demra	5,644	112	0	269
39	Matuail Dhaka	0	0	0	0
	Greater Dhaka East	61,376	1,657	319	3,057

Table A1.5 No. of Properties in Inundation Areas by Zone by Type of Properties in 2010 (1987-Scale Flood)

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	0	0	0	0
2	7	0	0	0	0
3	8	0	0	0	0
4	9	0	0	0	0
5	11	0	0	0	0
6	13	0	0	0	0
7	27	0	0	0	0
8	28	0	0	0	0
9	29	0	0	0	0
10	34	18,886	480	12	1,780
11	35	0	0	0	0
12	36	4,852	144	0	71
13	37	0	0	0	0
14	38	2,322	117	0	29
15	39	16,955	385	0	385
16	40	9,639	306	0	248
17	41	0	0	0	0
18	42	0	0	0	0
19	43	0	0	0	0
20	44	0	0	0	0
21	45	0	0	0	0
22	46	0	0	0	0
23	47	2,571	116	0	98
24	48	7,960	65	468	823
25	49	491	90	0	6
26	50	140	11	0	6
27	51	8,237	312	0	699
28	52	12,983	334	0	306
29	53	7,049	359	3	512
30	Gulshan 57	47,835	90	0	271
31	Cantonment Ward-1	1,639	93	0	192
32	Cantonment Ward-3	20,319	663	0	436
33	Dakshin Khan Cantt.	1,734	99	0	204
34	Uttar Khan	36,236	12	0	61
35	Dakshin Khan Gulshan	43,246	1,202	0	156
36	Beraid Gulshan	15,059	10	0	30
37	Beraid Demra	2,232	25	0	9
38	Demra	17,812	354	0	850
39	Matuail Dhaka	25,760	829	19	2,853
	Greater Dhaka East	303,957	6,096	502	10,027

Table A1.6 Formulas for Estimation of Flood Damages to Houses by 1987-Scale Flood in 1990

1. H19BDDM(i)=H19P(2,i)*(HAV(1,1)*RT1+HAV(1,2)*RT2+HAV(1,3)*RT3)*(H87A(1)+H87B1(1)*DP(2,i)+H87B2(1)*DR(2,i))/100/1000000

where,

H19BDDM(i): Direct flood damages to house building(s) (Tk. million) by 1987-scale flood for Zone No. i in 1990

H19P(2,i): No. of houses in inundation areas by 1987-scale flood for Zone No. i in 1990

HAV(1,1)(=33216), HAV(1,2)(=167767), HAV(1,3)(=377182): Value (Tk.) of house building(s) for Low, Middle and High Classes

RT1(=.6), RT2 (=.37), RT3 (=.03): Composition of No. of households for Low, Middle and High Classes

H87A(1)(=-6.482), H87B1(1)(=2.093), H87B2(1)(=1.182): Coefficients of regression equation for house building

DP(2,i): Depth of inundation (m) for Zone No.i by 1987-scale flood
DR(2,i): Duration of inundation (days) for Zone No.i by 1987-scale flood

2. H19HEDM(i)=H19P(2,i)*(HAV(2,1)*RT1+HAV(2,2)*RT2+HAV(2,3)*RT3)*(H87A(2)+H87B1(2)*DP(2,i)+H87B2(2)*DR(2,i))/100/1000000

where,

H19HEDM(i): Direct flood damages to household effects (Tk. million) by 1987-scale flood for Zone No. i in 1990

HAV(2,1)(=9429), HAV(2,2)(=37802), HAV(2,3)(=158998): Value (Tk.) of household effects for Low, Middle and High Classes

H87A(2)(=-4.638), H87B1(2)(=5.521), H87B2(2)(=.312): Coefficients of regression equation for household effects

3. H19ICDM(i)=H19P(2,i)*(HAV(3,1)*RT1+HAV(3,2)*RT2+HAV(3,3)*RT3)*(H87A(3)+H87B1(3)*DP(2,i)+H87B2(3)*DR(2,i))/100/1000000

where,

H19ICDM(i): Income losses (Tk. million) by 1987-scale flood for Zone No. i in 1990

HAV(3,1)(=21754), HAV(3,2)(=56703), HAV(3,3)(=217810): Annual household income (Tk.) for Low, Middle and High Classes

H87A(3)(=1.383), H87B1(3)(=.157), H87B2(3)(=.185): Coefficients of regression equation for household income

Table A1.7 Formulas for Estimation of Flood Damages to Houses by 1987-Scale Flood in 2010

1. H20BDDM(i)=H20P(2,i)*(HAV(1,1)*RT1+HAV(1,2)*RT2+HAV(1,3)*RT3)*(H87A(1)+H87B1(1)*DP(2,i)+H87B2(1)*DR(2,i))/100/1000000*GRT

   where,

   H20BDDM(i): Direct flood damages to house building(s) (Tk. million) by 1987-scale flood for Zone No. i in 2010

   H20P(2,i): No. of houses in inundation areas by 1987-scale flood for Zone No. i in 2010

   HAV(1,1)(=33216), HAV(1,2)(=167767), HAV(1,3)(=377182): Value (Tk.) of house building(s) for Low, Middle and High Classes

   RT1(=.6), RT2 (=.37), RT3 (=.03): Composition of No. of households for Low, Middle and High Classes

   H87A(1)(=-6.482), H87B1(1)(=2.093), H87B2(1)(=1.182): Coefficients of regression equation for house building

   DP(2,i): Depth of inundation (m) for Zone No.i by 1987-scale flood
   DR(2,i): Duration of inundation (days) for Zone No.i by 1987-scale flood

   GRT (=1.070^20/(6710661/3068927) for DC-1 & DC-2,
   1.065^20/(6710661/3068927) for DC-3 & DC-4):
   Per capita GDP growth rate from 1990 to 2010

2. H20HEDM(i)=H20P(2,i)*(HAV(2,1)*RT1+HAV(2,2)*RT2+HAV(2,3)*RT3)*(H87A(2)+H87B1(2)*DP(2,i)+H87B2(2)*DR(2,i))/100/1000000*GRT

   where,

   H20HEDM(i): Direct flood damages to household effects (Tk. million) by 1987-scale flood for Zone No. i in 2010

   HAV(2,1)(=9429), HAV(2,2)(=37802), HAV(2,3)(=158998): Value (Tk.) of household effects for Low, Middle and High Classes

   H87A(2)(=-4.638), H87B1(2)(=5.521), H87B2(2)(=.312): Coefficients of regression equation for household effects

3. H20ICDM(i)=H20P(2,i)*(HAV(3,1)*RT1+HAV(3,2)*RT2+HAV(3,3)*RT3)*(H87A(3)+H87B1(3)*DP(2,i)+H87B2(3)*DR(2,i))/100/1000000*GRT

   where,

   H20ICDM(i): Income losses (Tk. million) by 1987-scale flood for Zone No. i in 2010

   HAV(3,1)(=21754), HAV(3,2)(=56703), HAV(3,3)(=217810): Annual household income (Tk.) for Low, Middle and High Classes

   H87A(3)(=1.383), H87B1(3)(=.157), H87B2(3)(=.185): Coefficients of regression equation for household income

Table A1.8 Flood Damages to Houses by Zone in Greater Dhaka East in 1990 - (1987-Scale Flood)

(Unit: Tk. Million)

No.	Name of Zones	Buildings	Household Effects	Household Income
1	4	0.0	0.0	0.0
2	7	0.0	0.0	0.0
3	8	0.0	0.0	0.0
4	9	0.0	0.0	0.0
5	11	0.0	0.0	0.0
6	13	0.0	0.0	0.0
7	27	0.0	0.0	0.0
8	28	0.0	0.0	0.0
9	29	0.0	0.0	0.0
10	34	77.3	4.7	14.7
11	35	0.0	0.0	0.0
12	36	0.0	0.0	0.8
13	37	0.0	0.0	0.0
14	38	0.9	0.0	1.0
15	39	0.0	0.0	11.9
16	40	0.0	0.0	1.9
17	41	0.0	0.0	0.0
18	42	0.0	0.0	0.0
19	43	0.0	0.0	0.0
20	44	0.0	0.0	0.0
21	45	0.0	0.0	0.0
22	46	0.0	0.0	0.0
23	47	0.0	0.0	0.8
24	48	38.7	2.4	7.6
25	49	0.0	0.0	0.2
26	50	0.0	0.0	0.1
27	51	19.5	0.8	4.5
28	52	0.0	0.0	6.8
29	53	0.0	0.0	3.9
30	Gulshan 57	0.0	0.0	0.0
31	Cantonment Ward-1	2.3	0.0	0.8
32	Cantonment Ward-3	0.0	0.0	0.0
33	Dakshin Khan Cantt.	0.0	0.0	0.0
34	Uttar Khan	0.0	0.0	0.0
35	Dakshin Khan Gulshan	18.4	0.3	4.4
36	Beraid Gulshan	3.0	0.0	1.6
37	Beraid Demra	2.6	0.0	1.3
38	Demra	29.8	0.0	7.4
39	Matuail Dhaka	0.0	0.0	0.0
	Greater Dhaka East	192.4	8.2	69.7

Table A1.9 Flood Damages to Houses by Zone in Greater Dhaka East in 2010 - (1987-Scale Flood)

(Unit: Tk. Million)

No.	Name of Zones	Buildings	Household Effects	Household Income
1	4	0.0	0.0	0.0
2	7	0.0	0.0	0.0
3	8	0.0	0.0	0.0
4	9	0.0	0.0	0.0
5	11	0.0	0.0	0.0
6	13	0.0	0.0	0.0
7	27	0.0	0.0	0.0
8	28	0.0	0.0	0.0
9	29	0.0	0.0	0.0
10	34	234.1	14.4	44.4
11	35	0.0	0.0	0.0
12	36	0.0	0.0	5.6
13	37	0.0	0.0	0.0
14	38	3.4	0.0	3.8
15	39	0.0	0.0	25.8
16	40	0.0	0.0	14.7
17	41	0.0	0.0	0.0
18	42	0.0	0.0	0.0
19	43	0.0	0.0	0.0
20	44	0.0	0.0	0.0
21	45	0.0	0.0	0.0
22	46	0.0	0.0	0.0
23	47	0.0	0.0	3.0
24	48	94.0	5.7	18.4
25	49	0.0	0.0	0.4
26	50	0.0	0.0	0.1
27	51	78.0	3.3	17.8
28	52	0.0	0.0	18.2
29	53	0.0	0.0	10.7
30	Gulshan 57	238.7	0.0	92.6
31	Cantonment Ward-1	8.5	0.0	3.1
32	Cantonment Ward-3	152.6	0.0	43.3
33	Dakshin Khan Cantt.	0.0	0.0	1.7
34	Uttar Khan	508.0	21.1	95.1
35	Dakshin Khan Gulshan	423.5	6.1	101.5
36	Beraid Gulshan	55.0	0.0	29.3
37	Beraid Demra	7.7	0.0	4.0
38	Demra	151.3	0.0	37.6
39	Matuail Dhaka	224.9	6.5	54.5
	Greater Dhaka East	2,179.7	57.1	625.7

ANNEX 2. EXPLANATION/SUBSTANTIATION OF 10% ADDITION TO ANALYTICALLY WORKED OUT FLOOD DAMAGES

The 10% addition was made at the final stage to the summation of flood damages (that is, benefits) analytically worked out. The reasons/background are explained under in qualitative as well as quantitative terms.

1. On page 11-5 to 11-9 of the F/S Main Report socio-economic impact assessment of the project is done. As negative impacts displacement of people, adverse effects on boating and fishing people, and loss of farm land and occupation as farmers are taken up. Out of them, displacement of people was taken into consideration in economic analysis in the form of resettlement cost. The other two are negative impacts from the standpoint of the parties directly concerned, but will bring positive impacts on the economy in the long run.

2. As positive impacts population to be saved from inundation, area to be saved from inundation, creation of employment, reduction of water-borne diseases, removal of psychological burden and elevation of land use are listed. The first two are related to flood damages to be saved and can be considered to have been incorporated in economic analysis as benefits. Economic theories are divided over whether the creation of employment should be treated as a benefit. The latter three are obviously important benefits, but were not taken into account in economic analysis due to difficulty in expressing them in quantitative terms in a sufficient manner.

3. The quantitative information on the reduction of water-borne diseases is not sufficient enough to incorporate it in economic analysis. But, trial estimation of the benefits of water-borne disease reduction in 1990 was done below.

   1) 1987-Scale Flood

      Tk. 45.0 million * 1.0399 ^ 3 = Tk. 50.6 million

      where 1.0399 is the estimated average annual growth rate of population in the Study Area

   2) 1988-Scale Flood

      (Estimation of incremental water-borne disease cases using the information from both the Yearbook of Bangladesh and the results of the field survey)

      178,984 * 0.2969 * Tk. 3,178 = Tk. 168.9 million
      Tk. 168.9 million + Tk. 45.0 million
      = Tk. 213.9 million
      Tk. 213.9 million * 1.0399 ^ 2
      = Tk. 231.3 million

where,

178,984 : the difference in the number of cases of water-borne diseases in the Region of Dhaka between 1988 and 1987
0.2969 : population ratio of the Study Area to the Region of Dhaka in 1990
Tk. 3,178: average medical cost per case in 1990

In the above cost the cost for the mortal cases is not included.

4. The removal of psychological burden is very hard to be expressed in monetary terms. But, its far-reaching effects and importance in socio-economic context cannot be overemphasized.

5. Elevation of land use is reflected in the value, that is, price of land. The benefits related to it can be expressed as the difference in the value of urban land between the W and WO cases. The price of urban land in the W case can be surmised from the price of the existing urban land which was not inundated in 1987 and 1988 external floods as well as in internal floods on one hand. On the other the price of urban land in the WO case can be derived from the price of the existing urban land which was affected in the two external floods as well as in internal floods.

Supposing the said net difference is Tk.300 per sq. m, which is a conservative estimate the ultimate benefits of the increase of land value in the W case are calculated at Tk. 57,705 million (= 19,235 ha * @ Tk. 3 million). It is 2.60 times greater than the project costs.

Note) 19,235 ha: Estimated built-up area in the Study Area in 2010

Although such benefits as the reduction of flood damages are considered to be reflected in the incremental land value, the amount is quite massive.

6. The JICA Study Team visited the government offices and NGO concerned to gather the data and information on the extent of relief the affected people received in the form of commodities (food, clothes, etc.) and money in the 1987 and 1988 floods. The survey results reveal that people in the Study Area received the relief amounting to Tk. 12.5 million and Tk. 137.6 million in 1987 and 1988, respectively. This is the foreign aid provided through the government and NGO. It can be counted in as a benefit. In 1990 the benefit will grow to Tk. 15.1 million (= Tk. 12.5 million * 1.0399 ^ 3 * 1.0249 ^ 3) in a 1987-scale flood and Tk. 156.3 million (= Tk. 137.6 million * 1.0399 ^ 2 * 1.0249 ^ 2) in a 1988-scale

flood.

Note) 1.0249: the estimated average annual growth rate of the per capita GDP in the Study Area

7. The reduction of water-borne diseases and flood relief add up to Tk. 65.7 million in a 1987-scale flood in 1990. Similarly, they add up to Tk 387.6 million in a 1988-scale flood in the same year. On the other hand, the 10% addition is calculated at Tk. 93.9 million and Tk. 731.3 million in 1987- and 1988-scale floods respectively in 1990. That is to say, the two benefits have already explained away 70.0% and 53.0% of the 10% addition in the two floods. If the benefit of land value increase is further added to the above two benefits (which is methodologically not immediately possible), the resultant size of benefits may be by far greater than the 10% addition.

8. Flood damages (that is, project benefits) are almost always underestimated in the same way that project costs are apt to be underestimated according to the experience of JICA. It is because there are innumerable factors related to flood damages. In our case, for instance, we have not taken into account the dead people directly due to flood, mortal water-borne disease cases due to flood, the cost of temporary/permanent flood protection measures individual households/establishments are forced to take in the WO situation, direct flood damages to vehicle equipment, loss of livestock, the stoppage/slowing down of human traffic (vis-a-vis vehicular traffic), damages to water life (including fish) by flood, general health hazards in time of flood, loss of amenity due to inaccessibility to piped water, electricity, etc. and so on.

   The above flood damages are expected in the WO case. That is to say, They are considered benefits in the W case.

   It is to be emphasized, moreover, that those flood damages that have been taken into account are in themselves probably an underestimate because of the limitations and constraints surrounding the data and information on which analyses are based.

9. Because of the reasons as expounded above it is considered necessary to make a 10% addition at least. It resembles the practice in the cost estimate in which 10% to 30% additions are made to the base cost at the last stage as contingencies.

ANNEX 3. CALCULATIVE STEPS LEADING TO ESTIMATION OF AVERAGE ANNUAL FLOOD DAMAGES FOR GREATER DHAKA EAST

1. Formulation of the Relationships between the Return Period and Flood Damages, and between Frequency and Flood Damages

1) External Flood

It is assumed that if the return period is equal to or less than 10 years, then the relationships between the return period and flood damages will be expressed as the convex logarithmic curve satisfying the coordinates (1, D(m,1)) and (10, D(m,2)). Likewise, if the return period is equal to or greater than 10 years, then the above relationships will be expressed as the equation of the first degree satisfying the coordinates (10, D(m,2)) and (70, D(m,3)).

Note) D(m,n): External flood damages
m : 1 = 1990, 2 = 2010
n : 1 = Annual flood, 2 = 1987-scale flood
3 = 1988-scale flood

The relationships between frequency and the return period is formulated as follows:

RP = 1/(1-FQ) ....Formula 1

where, RP: Return period
FQ: Frequency (non-exceedance)

The relationships between frequency and flood damages derive from the relationships between the return period and flood damages, and Formula 1.

Table A3.1 shows damage - return period and damage - frequency formulas for Greater Dhaka East in the external flood. Table A3.3 derives from and visualizes Table A3.1. Fig. A3.1 graphically shows the relationships between frequency and external flood damages for Greater Dhaka East.

2) Internal Flood

It is assumed that the relationships between the return period and flood damages will be expressed as the convex logarithmic curve satisfying the coordinates (1, D(m,1)) and (10, D(m,2)).

Note) D(m,n): Internal flood damages
m : 1 = 1990, 2 = 2010
n : 1 = Annual flood, 2 = Worst flood

This way of formulation is based on the similar relationships proved to exist between the return period and rainfall intensity.

The relationships between frequency and the return period is formulated as follows:

RP = 1/(1-FQ) ....Formula 1

where, RP: Return period
FQ: Frequency (non-exceedance)

The relationships between frequency and flood damages derive from the relationships between the return period and flood damages, and Formula 1.

Table A3.2 shows damage - return period and damage - frequency formulas for Greater Dhaka East in the internal flood. Table A3.3 derives from and visualizes Table A3.2. Fig. A3.1 graphically shows the relationships between frequency and internal flood damages for Greater Dhaka East.

2. Formulation of Functions for Calculation of Average Annual Flood Damages

One can employ either damage - return period formulas or damage - frequency formulas to calculate average annual flood damages.

1) Adoption of Damage - Return Period Formulas

Let us first suppose that one adopts the former formulas.

External Flood

If the return period is equal to or less than ten years, then one divides the function concerned by RP^2 and integrates the resultant function by RP with respect to the section (1, 10). Likewise, if the return period is equal to or greater than 10 years, then one divides the function concerned by RP^2 and integrates the resultant function by RP with respect to the section (10, 100). (The facilities concerned will be designed so that damages and losses may not occur under the external floods of the 100 year or less than 100 year return period.) The two values worked out in this way are added together.

Internal Flood

One divides the function concerned by RP^2 and integrates the resultant function by RP with respect to the section (1, 5). (The facilities concerned will be designed so that damages and losses will not occur under the internal floods of the 5 year or less than 5 year return period.)

(Refer to Table A3.4(1).)

2) Adoption of Damage - Frequency Formulas

Then, let us suppose that one adopts the former formulas.

External Flood

If frequency is equal to or less than 0.90, then one integrates the function concerned by FQ with respect to the section (0.00, 0.90). Likewise, if frequency is equal to or greater than 0.90, then one integrates the function concerned by FQ with respect to the section (0.90, 0.99). (The facilities concerned will be designed so that damages and losses may not occur under the external floods of the 0.99 or less than 0.99 frequency.) The two values worked out in this way are added together.

Internal Flood

One integrates the function concerned by FQ with respect to the section (0.00, 0.80). (The facilities concerned will be designed so that damages and losses will not occur under the internal floods of the 0.80 or less than 0.80 frequency.)

(Refer to Table A3.4(2).)

Table A3.1 Damage - Return Period and Damage - Frequency Formulas for Greater Dhaka East (External Flood)

1. Flood Damages

1) 1990

```
D(1,1)=46.2, D(1,2)=720.1, D(1,3)=4,151.9

where, D(1,1): Annual flood damages in 1990
       D(1,2): 1987-scale flood damages in 1990
       D(1,3): 1988-scale flood damages in 1990
```

2) 2010

```
D(2,1)=322.1, D(2,2)=3,720.8, D(2,3)=16,676.4

where, D(2,1): Annual flood damages in 2010
       D(2,2): 1987-scale flood damages in 2010
       D(2,3): 1988-scale flood damages in 2010
```

2. Damage - Return Period Formulas

1) Return Period =< 10 Years

```
D(m,n) = D(m,1)+(D(m,2)-D(m,1))/log10*logRP

where, D(m,n): Flood damages
       m      : 1 = 1990, 2 = 2010
       n      : 1 = Annual flood, 2 = 1987-scale flood
                3 = 1988-scale flood
       RP     : Return period
```

2) 10 Years =< Return Period

```
D(m,n) = (10*D(m,3)-70*D(m,2))/(10-70)+
         (D(m,2)-D(m,3))/(10-70)*RP
```

3. Damage - Frequency Formulas

1) Frequency =< .9

```
D(m,n) = D(m,1)+(D(m,2)-D(m,1))/log10*log(1/(1-FQ))

where, FQ     : Frequency (non-exceedance)
```

2) .9 =< Frequency

```
D(m,n) = (10*D(m,3)-70*D(m,2))/(10-70)+
         (D(m,2)-D(m,3))/(10-70)*(1/(1-FQ))
```

Table A3.2 Damage - Return Period and Damage - Frequency Formulas for Greater Dhaka East (Internal Flood)

1. Flood Damages

1) 1990

D(1,1)=158.4, D(1,2)=391.1

where, D(1,1): Annual flood damages in 1990
D(1,2): Worst flood damages in 1990

2) 2010

D(2,1)=285.8, D(2,2)=768.2

where, D(2,1): Annual flood damages in 2010
D(2,2): Worst flood damages in 2010

2. Damage - Return Period Formula

D(m,n)=D(m,1)+(D(m,2)-D(m,1))/log10*logRP

where, D(m,n): Flood damages
m : 1 = 1990, 2 = 2010
n : 1 = Annual flood, 2 = Worst flood
RP : Return period

3. Damage - Frequency Formula

D(m,n)=D(m,1)+(D(m,2)-D(m,1))/log10*log(1/(1-FQ))

where, FQ : Frequency (non-exceedance)

Table A3.3 Damage - Return Period and Damage - Frequency Tables for Greater Dhaka East

1. External Flood

Frequency (Non-exceedance)	Return Period (Years)	Estimated Damages (Tk. Million) 1990 WO	1990 W	2010 WO	2010 W
0.00	1.00	46.2	0.0	322.1	0.0
0.10	1.11	77.0	0.0	477.6	0.0
0.20	1.25	111.5	0.0	651.5	0.0
0.30	1.43	150.6	0.0	848.6	0.0
0.40	1.67	195.7	0.0	1,076.1	0.0
0.50	2.00	249.1	0.0	1,345.2	0.0
0.60	2.50	314.4	0.0	1,674.6	0.0
0.70	3.33	398.6	0.0	2,099.2	0.0
0.80	5.00	517.2	0.0	2,697.7	0.0
0.90	10.00	720.1	0.0	3,720.8	0.0
0.95	20.00	1,292.1	0.0	5,880.1	0.0
0.98571	70.00	4,151.9	0.0	16,676.4	0.0
0.99	100.00	5,867.8	0.0	23,154.2	0.0

2. Internal Flood

Frequency (Non-exceedance)	Return Period (Years)	Estimated Damages (Tk. Million) 1990 WO	1990 W	2010 WO	2010 W
0.00	1.00	158.4	0.0	285.8	0.0
0.10	1.11	169.0	0.0	307.9	0.0
0.20	1.25	181.0	0.0	332.5	0.0
0.30	1.43	194.4	0.0	360.5	0.0
0.40	1.67	210.0	0.0	392.8	0.0
0.50	2.00	228.4	0.0	431.0	0.0
0.60	2.50	251.0	0.0	477.8	0.0
0.70	3.33	280.1	0.0	538.0	0.0
0.80	5.00	321.1	0.0	623.0	0.0
0.90	10.00	391.1	70.0	768.2	145.2
0.95	20.00	461.1	140.0	913.4	290.4
0.98571	70.00	587.8	266.7	1,175.9	552.9
0.99	100.00	623.8	302.7	1,250.6	627.6

Note: WO = Without Case, W = With Case

Table A3.4(1) Calculation of Average Annual Flood Damages

Either Method I or Method II can be employed.

1. Method I

1) External Flood

(1) 1990

$$\int_{1}^{10}(D(1,1)+(D(1,2)-D(1,1))/log10*logRP)/RP\char94 2dRP+\int_{10}^{100}(10*D(1,3)$$

$$-70*D(1,2))/(10-70)+(D(1,2)-D(1,3))/(10-70)*RP)/RP\char94 2dRP$$

= Tk. 382.6 Million

(2) 2010

$$\int_{1}^{10}(D(2,1)+(D(2,2)-D(2,1))/log10*logRP)/RP\char94 2dRP+\int_{10}^{100}((10*D(2,3)$$

$$-70*D(2,2))/(10-70)+(D(2,2)-D(2,3))/(10-70)*RP)/RP\char94 2dRP$$

= Tk. 1,916.1 Million

Note: Regarding D(1,1), D(1,2), D(1,3), D(2,1), D(2,2), D(2,3) and RP refer to Table A3.1.

2) Internal Flood

(1) 1990

$$\int_{1}^{5}(D(1,1)+(D(1,2)-D(1,1))/log10*logRP)/RP\char94 2dRP$$

= Tk. 175.1 Million

(2) 2010

$$\int_{1}^{5}(D(2,1)+(D(2,2)-D(2,1))/log10*logRP)/RP\char94 2dRP$$

= Tk. 328.8 Million

Note: Regarding D(1,1), D(1,2), D(2,1), D(2,2) and RP refer to Table A3.2.

Table A3.4(2) Calculation of Average Annual Flood Damages

2. Method II

1) External Flood

(1) 1990

$$\int_{0.00}^{0.90}(D(1,1)+(D(1,2)-D(1,1))/\log 10*\log(1/(1-FQ)))dFQ+$$

$$\int_{0.90}^{0.99}((10*D(1,3)-70*D(1,2))/(10-70)+(D(1,2)-D(1,3))/(10-70)*$$

$$(1/(1-FQ)))dFQ = Tk.\ 382.6\ Million$$

(2) 2010

$$\int_{0.00}^{0.90}(D(2,1)+(D(2,2)-D(2,1))/\log 10*\log(1/(1-FQ)))dFQ+$$

$$\int_{0.90}^{0.99}((10*D(2,3)-70*D(2,2))/(10-70)+(D(2,2)-D(2,3))/(10-70)*$$

$$(1/(1-FQ)))dFQ = Tk.\ 1,916.1\ Million$$

Note: Regarding D(1,1), D(1,2), D(1,3), D(2,1), D(2,2), D(2,3) and FQ refer to Table A3.1.

2) Internal Flood

(1) 1990

$$\int_{0.00}^{0.80}(D(1,1)+(D(1,2)-D(1,1))/\log 10*\log(1/(1-FQ)))dFQ$$

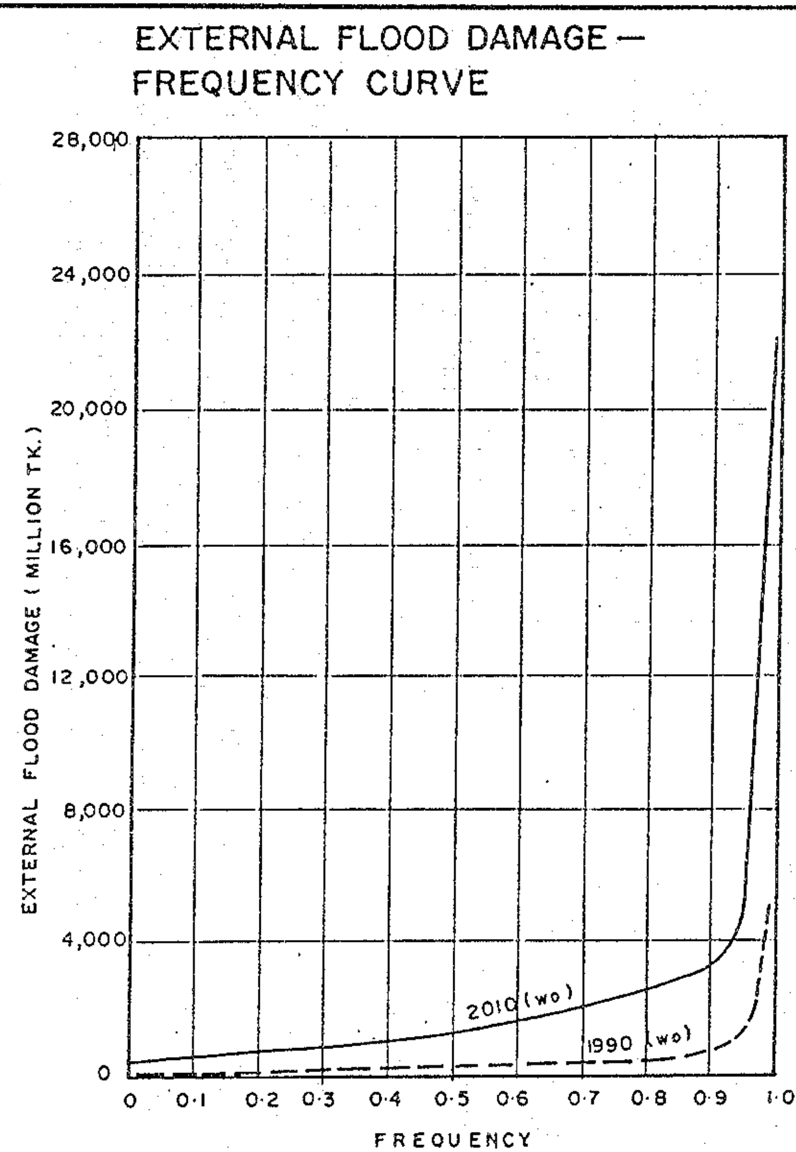
$$= Tk.\ 175.1\ Million$$

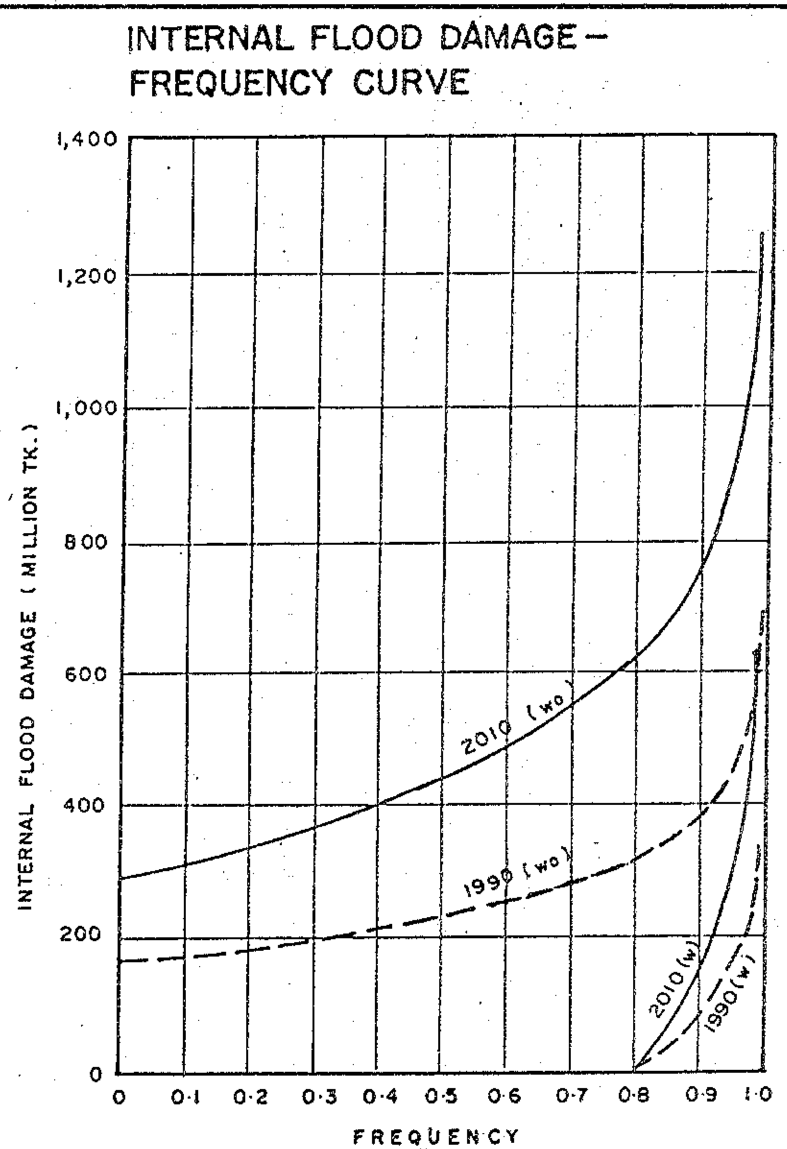
(2) 2010

$$\int_{0.00}^{0.80}(D(2,1)+(D(2,2)-D(2,1))/\log 10*\log(1/(1-FQ)))dFQ$$

$$= Tk.\ 328.8\ Million$$

Note: Regarding D(1,1), D(1,2), D(2,1), D(2,2) and FQ refer to Table A3.2.





Note: WO = Without Case
W = With Case

FIG. A3.1 DAMAGE - FREQUENCY CURVES FOR GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

ANNEX 4. NOTE ON THE TWO ESTIMATIONS OF 1987 AND 1988 FLOOD DAMAGES IN MASTER PLAN STUDY AREA

1. Abbreviated Naming of the Two Estimations

For the sake of convenience the estimation of 1987 and 1988 flood damages in the master plan study area based on data collected from agencies concerned will from now on be called Estimation I, while the estimation of 1987-scale and 1988-scale flood damages in 1990 in the master plan study area as a result of analysis using data collected through sampling questionnaire surveys will be called Estimation II.

2. Request for Explanation

In the Record of Discussion dated 28 May, 1992 prepared by FPCO it is asked that the wide difference in flood damages as shown below be explained in detail.

(Unit: Tk. Million)

Item	1987 Flood	1988 Flood
Estimation I	347	781
Estimation II	3,884.4	13,655.8

This annex is prepared to meet the above request.

3. Reason for Reporting Estimation I in Master Plan Study Report

The JICA Study Team sent men to the Deputy Commissioner, Dhaka Region and Upazila Offices of Narayanganj, Keraniganj, Savar and Tongi to collect data concerning 1987 and 1988 flood damages in the early part of the M/P study period.

All the officials concerned were reportedly very cooperative and helpful. It was felt that the data collected should be reported in some way or another.

The Team was to start the sampling questionnaire surveys over the entire master plan study area with the number of samples reaching 5,200. The samples consisted of houses, farm houses shops and factories. The surveys aimed at obtaining the information on the inundation depths/durations, damage ratios and income/profit loss ratios of various types of inundated properties, etc. in time of 1987, 1988 and other floods for each of the 116 wards or unions over the master plan study area. This information along with the information on the number and value of various types of properties was used to arrive at the damage estimates of 1987, 1988 and other floods in 1990 and 2010. Those damage estimates were ultimately converted into benefits and utilized in the economic analysis.

Estimation I is made up of three steps, i.e. (1) the estimation of the quantities (number, area, length, etc.) of properties/farms/infrastructures damaged by 1987 and 1988 floods, (2) the estimation of flood damages per unit quantity and (3) multiplication of (1) by (2). Also, damage items are limited in this estimation.

It was thought that some information in Estimation I would be helpful and meaningful in the course of preparation/formulation of Estimation II. However, from the beginning Estimation I was not intended for use in the flood damage estimation, benefit calculation and economic analysis.

Just in order to pay respect to the officials who cooperated with the JICA Study Team Estimation I was shown in the Master Plan Study Report.

4. Basic Differences in the Two Estimations

1) There is methodological difference in the two estimations. The difference is already mentioned in the above section. Detailed methodology for Estimation II is described in Table A4.1.

   The methodology for Estimation I is very simple, while the methodology for Estimation II is structural as well as analytical.

2) The sources of data and information are different. In Estimation I they are several offices concerned, while in Estimation II they are 5,200 houses, shops and factories which directly experienced 1987 and 1988 floods distributed over the master plan study area.

3) The number of damage items is different. In Estimation I they are 6, while in Estimation II they are 11. (Refer to Tables A4.2 and A4.3.)

5. Resultant Major Derivative Differences in the Two Estimations

As a result of methodological and other basic differences the following crucial differences are derived. (Refer to Tables A4.2, A4.3 and Fig. A4.1.)

1) Quantities (number, etc.) of the affected properties and other objects are different. For instance in the 1987 flood the number of affected houses in Estimations I and II is 95,009 and 414,304, respectively and in the 1988 flood the number of affected houses in Estimations I and II is 268,042 and 642,939, respectively.

2) Damages per unit quantity of affected properties and other objects are different. For instance in the 1987 flood damages per house are Tk. 1,426 and Tk. 5,775 in Estimations I and II, respectively and in the 1988 flood damages per house in Estimations I and II are Tk. 1,439 and Tk 10,632, respectively.

3) Because of the above two differences in the 1987 flood house damages in Estimation II (which account for 61.6% of the total flood damages) are 17.7 times greater than in Estimation I and in the 1988 flood house damages in Estimation II (which account for 50.0% of the total flood damages) are 17.2 times greater than in Estimation I.

4) Damageable items such as household effects, commercial buildings, commercial equipment & inventories, industrial buildings, industrial equipment & inventories, institutional buildings, income losses for households, profit losses for businesses and profit losses for industries (which account for 17.4% and 42.9% of the total flood damages in Estimation II in 1987 and 1988 floods, respectively) are almost lacking in Estimation I.

5) In the 1987 flood damages to crops in Estimation II are 6.5 times greater than in Estimation I and in the 1988 flood damages to crops in Estimation II are 5.4 times greater than in Estimation I.

6. Conclusions

Estimation I and Estimation II are schematically compared in Fig. A4.1. By viewing it one can grasp the background leading to the wide gap in the two estimates.

That is to say, it is:

1) Wide difference in house damage estimates. This explains away the majority of difference in the two estimates.

2) Damages to other properties and income/profit losses which occupy important positions in Estimation II are little considered in Estimation I.

3) Difference in crop damage estimates.

Table A4.1(1) Methodological Comparison of Two Estimations of 1987 and 1988 Flood Damages in the Master Plan Study Area

1. Estimation of 1987 and 1988 flood damages based on data collected from agencies concerned

   A Estimation of the quantities (number, area, length, etc.) of properties/farms/infrastructures damaged by 1987 and 1988 floods.

   B Estimation of flood damages per unit quantity.

   C (= A * B). Calculation of flood damages.

2. Estimation of 1987-scale and 1988-scale flood damages in 1990 as a result of analysis using data collected through sampling questionnaire surveys

   A Estimation of the number of properties by Zone (based on ward or union) by type of properties (i.e. houses, businesses, industries and institutions) in 1990.

   B Estimation of ratios of inundation area to total area by Zone in 1987 and 1988 floods.

   C (= A * B). Calculation of the number of properties to have been inundated by 1987-scale and 1988-scale floods by Zone by type of properties in 1990.

   D1 Estimation of unit value of properties by type and detailed breakdown of properties (i.e. residential buildings, household effects, commercial buildings, commercial equipment & inventories, industrial buildings, industrial equipment & inventories and institutional buildings).

   D2 Estimation of annual income per household, annual profit per commercial establishment and annual profit per industrial establishment.

   E1 (= C * D1). Calculation of the value of properties to have been inundated by 1987-scale and 1988-scale floods by Zone by type and detailed breakdown of properties in 1990.

   E2 (= C * D2). Calculation of income/profit of properties to have been inundated by 1987-scale and 1988-scale floods by Zone by type of properties in 1990.

   F Estimation of average depths/durations of inundation by Zone in 1987 and 1988 floods.

Table A4.1(2) Methodological Comparison of Two Estimations of 1987 and 1988 Flood Damages in the Master Plan Study Area

G1 Formulation of regressional equations determining the relationships between depths/durations of inundation and ratios of flood damages to properties by type and detailed breakdown of properties in 1987 and 1988 floods.

G2 Formulation of regressional equations determining the relationships between depths/durations of inundation and ratios of income/profit losses to properties by type of properties in 1987 and 1988 floods.

H1 (from E1, F and G1). Calculation of property damages due to 1987-scale and 1988-scale floods by Zone by type and detailed breakdown of properties in 1990.

H2 (from E2, F and G2). Calculation of income/profit losses due to 1987-scale and 1988-scale floods by Zone by type of properties in 1990.

I Estimation of the number of farmers by Zone in 1990.

J Estimation of inundation ratios in agricultural areas in 1987 and 1988 floods.

K (= I * J). Calculation of the number of farmers to have been affected by 1987-scale and 1988-scale floods by Zone in 1990.

L Estimation of average economic value of agricultural crops in the flood season per farmer.

M (= K * L). Calculation of economic value of agricultural crops to have been affected by 1987-scale and 1988-scale floods by Zone in 1990.

N Estimation of average depths/durations of inundation in agricultural areas by Zone in 1987 and 1988 floods.

O Formulation of regressional equations determining the relationships between depths/durations of inundation in agricultural areas and ratios of flood damages to agricultural crops in 1987 and 1988 floods.

P (from M, N and O). Calculation of crop damages due to 1987-scale and 1988-scale floods by Zone in 1990.

Table A4.2 Breakdowns of 1987 Flood Damages in the Master Plan Study Area for Comparison

1. 1987 Flood Damages (based on data collected from agencies concerned)

Item	Houses	Crops	Schools	Roads	Live-stock	Rehabili-tation	Total
Quantity (A)	95,009 (No.)	19,729 (ha)	690 (No.)	1,333 (km)	2,968 (No.)	-	-
Amount (B) (Tk Mln.)	135.5	124.9	16.2	58.2	12.3	-	347.1
B/A (C) (Tk)	1,426	6,331	23,478	43,661	4,144	-	-

Note: Rehabilitation = Rehabilitation costs of power, water-supply, gas, telecommunications and transportation facilities

2. 1987-Scale Flood Damages in 1990 (results of analysis using data collected through sampling questionnaire surveys)

Item	Residential			Commercial		
	Bd	H.E	Ic	Bd	E&I	Pf
Quantity (A) (No.)		414,304			12,051	
Amount (B) (Tk Mln.)	2,392.5	137.3	531.1	0.0	0.0	6.7
B/A (C) (Tk)	5,775	332	1,282	0.0	0.0	556

Item	Industrial			Institu-tional	Agricul-tural	Total
	Bd	E&I	Ic	Bd	Cp	
Quantity (A) (No.)		2,316		10,507	160,006	-
Amount (B) (Tk Mln.)	0.0	0.0	0.0	0.0	816.8	3,884.4
B/A (C) (Tk)	0.0	0.0	0.0	0.0	5,105	-

Note: Bd = Building(s), H.E = Household Effects, Ic = Income, E&I = Equipment & Inventories, Pf = Profit, Cp = Crops

Table A4.3 Breakdowns of 1988 Flood Damages in the Master Plan Study Area for Comparison

1. 1988 Flood Damages (based on data collected from agencies concerned)

Item	Houses	Crops	Schools	Roads	Live-stock	Rehabili-tation	Total
Quantity (A)	268,042 (No.)	29,377 (ha)	878 (No.)	2,106 (km)	2,356 (No.)	-	-
Amount (B) (Tk Mln.)	385.7	178.3	20.7	97.1	9.8	89.5	781.1
B/A (C) (Tk)	1,439	6,069	23,576	46,106	4,160	-	-

Note: Rehabilitation = Rehabilitation costs of power, water-supply, gas, telecommunications and transportation facilities

2. 1988-Scale Flood Damages in 1990 (results of analysis using data collected through sampling questionnaire surveys)

Item	Residential			Commercial		
	Bd	H.E	Ic	Bd	E&I	Pf
Quantity (A) (No.)		642,939			20,683	
Amount (B) (Tk Mln.)	6,836.0	2,928.7	868.2	150.7	352.1	31.4
B/A (C) (Tk)	10,632	4,555	1,350	7,286	17,024	1,518

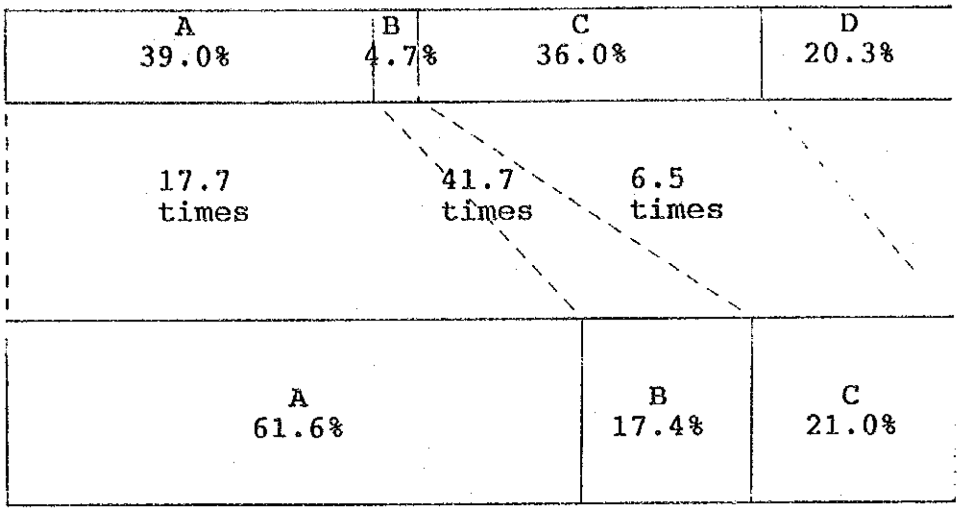
Item	Industrial			Institu-tional	Agricul-tural	Total
	Bd	E&I	Ic	Bd	Cp	
Quantity (A) (No.)		4,595		19,834	160,006	-
Amount (B) (Tk Mln.)	189.5	629.6	99.8	603.4	966.4	13,655.8
B/A (C) (Tk)	41,240	137,018	21,719	30,423	6,040	-

Note: Bd = Building(s), H.E = Household Effects, Ic = Income, E&I = Equipment & Inventories, Pf = Profit, Cp = Crops

1. 1987 Flood

Estimation I

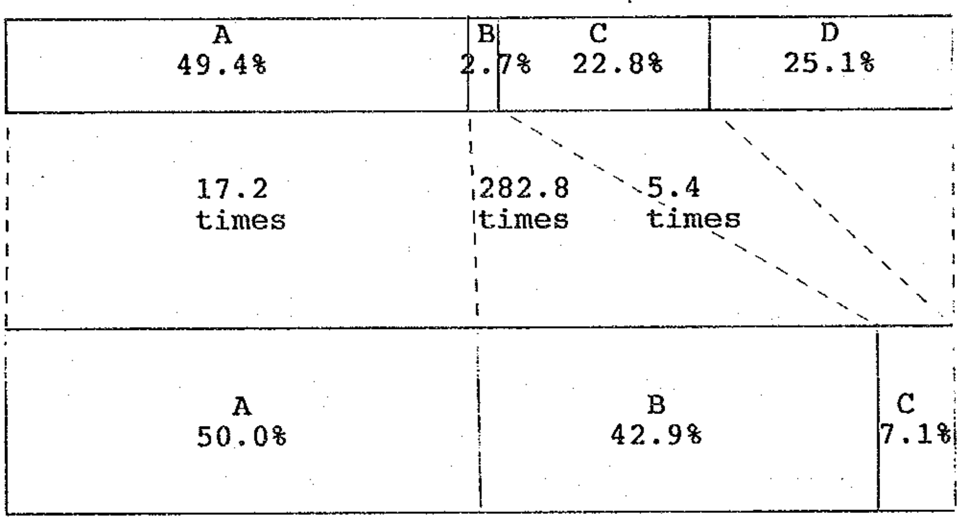
Estimation II



2. 1988 Flood

Estimation I

Estimation II



Legend: Estimation I = Estimation of 1987 and 1988 flood damages based on data collected from agencies concerned
Estimation II = Estimation of 1987-scale and 1988-scale flood damages in 1990 as a result of analysis using data collected through sampling questionnaire surveys

A = Damages to houses, B = Damages to other properties and income/profit losses, C = Damages to crops, D = Damages to infrastructures, etc.

FIG. A4.1 SCHEMATIC COMPARISON OF TWO ESTIMATIONS OF 1987 AND 1988 FLOOD DAMAGES IN M/P STUDY AREA

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

SUPPORTING REPORT C
LIVING ENVIRONMENT AND ECOLOGY

DRAFT FINAL REPORT

SUPPORTING REPORT C : LIVING ENVIRONMENT AND ECOLOGY

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SUPPORTING REPORT C : LIVING ENVIRONMENT AND ECOLOGY

1. Introduction

1.1 General

The environmental study in the feasibility study (FS) stage is principally targeted at the anticipated major environmental consequences, both of direct and indirect nature, by the implementation of the proposed flood control and drainage works. The predominant indirect consequence will be due to subsequent urbanization of the project area as emphasized in the master plan report (ref. Supporting Report F, Master Plan Study, FAP 8A, November 1991). Though urbanization itself would lead to much direct environmental impacts, living environmental issue with specific concern to sanitation is only selected as the priority element for detailed consideration in this flood control and drainage project. The other major direct environmental issues of urbanization shall be addressed by future studies of direct concern. Nevertheless, major environmental effects, both of direct and indirect, are still identified along with their degree of significance. Possible mitigatory measures are also recommended.

1.2 Environmental Study Area

Based on the previous master plan study of FAP-8A, conducted covering an area of about 850 sq.km. of Greater Dhaka and its vicinity, namely Narayanganj, Keraniganj, Tongi and Savar, an area of about 340 sq.km. covering Greater Dhaka and Narayanganj was delineated as the priority area of project implementation. The environmental study area covers this whole priority area, in general (ref. Fig. C.1).

This priority area is subdivided into four (4) areas as per the master plan study. They are :

(1) Greater Dhaka
- Dhaka West
- Dhaka East

(2) Narayanganj
- DND
- Narayanganj West

The existing population, and flooding conditions along with that of future population land use and the retarding areas proposed to be reserved for planned internal flooding as envisaged by this FAP-8A master plan and feasibility study, in the priority area until the year 2010, is summarized in Table C.1.

From the above table it is evident that built up area would account for 80% of land use in 2010, against its present share of 45.5% in the priority area. While, the agricultural land use would decrease to 7% from the existing share of 43.5%. The population will double to about 10.8 million from 5.4 million.

The feasibility study of the highest priority area, Dhaka West, was conducted by ADB under FAP-8B project. Accordingly, the detailed environmental considerations of this area by the project are dealt with in FAP-8B study reports and the progress EIA for DFPP report by DOE of July 1990, hence are not duplicated in this study.

2. Ecology

A comprehensive ecological survey, based on available secondary data in combination with judicious field verification, was carried out for establishing the base line conditions of existing ecological resources in the priority area of Greater Dhaka and Narayanganj (ref. Fig. C.1), and hence to identify significant impacts, if any, on such resources by the project implementation, on a preliminary basis. The ecological resources targeted by the survey are flora and fauna, termed as general ecological resources, and agriculture and aquaculture, termed as productive ecological resources in consideration to their direct economic value.

The survey was conducted during the six (6) month period from October 1991 to February 1992, to encompass as far as possible both the flood season and dry season conditions. This is in due consideration to the distinct environmental conditions in the flood plains that predominates East Dhaka (Balu River flood plain).

The ecological survey results incorporating a comprehensive ecological evaluation by the project is presented in the subsequent sections.

The impacts by the project on ecology, both due to the direct dry up effect of embankments and the subsequent change in land use due to urbanization, is evaluated to be insignificant when assessed from a broad perspective on a national basis.

2.1 General Ecology

Flora and fauna are the defined general ecological elements. Faunal elements of an ecosystem could be grouped into four (4) categories. They are, in the sequential order of their evolutionary status, amphibia, reptiles, birds and mammals. Such a simple classification is impossible for flora due to their complex evolutionary status and varieties.

Nevertheless, floral elements in the priority area falls into two (2) broad categories of aquatic and terrestrial species. The aquatic species are classified into four (4) groups based on their degree of submergence in water. They are, species of floating, completely submerged, partly submerged and marsh plants with very little submergence. While, the terrestrial plant species are also grouped to for (4) categories, namely, trees, shrubs, climbers and herbaceous weeds.

2.1.1 Flora

A total of 112 floral species are identified in the objective area, of which 81 being terrestrial belonging predominantly to the high lands, and 31 being aquatic of low lands and flood plains. Terrestrial plants are generally not seasonal and present for years, while the aquatic ones dominate mostly during the flood season from July to October.

The terrestrial plant species belonging to trees, shrubs and climbers are prominent in homesteads and village thickets, most being planted. The herbaceous weeds grow mostly in waste areas and agricultural lands.

In case of the aquatic plant species, some floating types are very dominant in flooded low lands and flood plains during rainy/flood season, from July to October. In particular, water hyacinth/kachuri pana (Eichhornia crassipes) is the most invasive in most shallow water bodies/areas of Dhaka East and DND in association with topa pana (Pistia stratiotes), duckweed/khudi pana (Lemna spp.) and indurkani pana (Salvinia cucullata).

The number of these floral species, classified according to their groups, along with the respective important species, is summarized below ;

Floral Class	Species in Objective Area		Important Species
	Types	Number	
Terrestrial Species	Trees	32	10
	Shrubs	11	2
	Climbers	7	2
	Herbeceous Weeds	31	2
Aquatic Species	Floating	10	3
	Completely submerged	4	1
	Partly submerged	11	6
	Marsh plant	6	4
Total :		112	30

Floral species of significant economic value are considered as important species. It is noted that irrespective of importance of a species, all the species that are found in the priority area also found elsewhere in the country. Moreover, most of the important terrestrial species are planted trees in homestead like jackfruit, coconut, mango trees and others. While most important aquatics have relatively indirect economic value, like water hyacinth being protective to fish nursery development, a cattle feed and also an organic manure, and duck weed (Wolffia arrhiza) being a favorite food for fish.

Consequent to the embankment and dry-up of flood plains followed with progressing urban development, Dhaka East area in particular, terrestrial plant species would become dominant replacing the aquatic plants, other than in the lowland retarding areas and other water bodies. Even among the terrestrial species, planted homestead ones of direct economic importance will predominate with increasing residential development. The existing already protected DND triangle area depicts the evolution of above mentioned state, in reality.

Nevertheless, in consideration to the fact that most of Bangladesh is a delta with vast flood plains, such a dominance by terrestrial species in place of aquatics in the priority area is assessed to be insignificant. Moreover, of the master plan area of 850 km^2, still an area of 328 km^2 is proposed to remain as flood plains with no significant change in land use, where aquatics will continue to dominate (ref. Chapter 10 of Main Report, Master Plan).

2.1.2 Fauna

Most faunal elements, other than amphibia, in the objective area are either aquatic or terrestrial of origin. The total number of identified faunal species are 177. Their breakdown according to the four (4) categories are, seven (7) species of amphibia, 22 species of reptiles, 127 species of wild birds and 21 species of wild mammals. Of the bird species 90 are resident, hence considered to be present throughout the year. While 37 are migratory bird species and mostly reside during the dry winter season, from November to February. The 21 wild mammal species has one (1) semi-aquatic species, the otter.

The number of the existing species, separated according to their faunal classification, along with the respective important species, is summarized below;

Fauna	Number of Species in Objective Area				Important Species
	Aquatic	Terrestrial	Aquatic & Terrestrial	Total	
Amphibia *	-	-	7	7	1
Reptiles	6	16	-	22	7
Birds : Resident	17	73	-	90	9
: Migratory	24	13	-	37	2
Mammals (Wild)	-	20	1	21	7
Total	47	122	8	177	26

* Amphibia by its nature is both aquatic and terrestrial

The important faunal species are considered as those of economic importance as well as those of which population are somewhat affected or threatened as per the baseline conditions.

Irrespective of importance, all the species are expected also in elsewhere of the country. No species is identified to be peculiar to the priority area.

The important species identified in the priority area includes the following endangered species cited in the CITIES convention. Those species are also supposed to be present on a country wide basis. Hence the required protective measures are recommended to be undertaken on a national basis based on the causative elements of their demise. In most cases, human pressure like hunting and others is the major cause. Such species endangered due to human pressure are best protected in wild-life sanctuaries and in other areas away from urban environment.

The endangered species, listed in CITIES convention, identified in the priority area are confined to reptiles (2 species) and birds (3 species). They are as follows:

Endangered reptiles

Peacock soft shell turtle (Trionyx hurum) : Aquatic reptile
Grey land monitor (Varanus bengalensis) : Terrestrial reptile

Endangered birds

Comb duck/Nukhta (Sarcodiornis melanotus) : Aquatic bird
Great eared nightjar (Eurostopodus macrotis) : Terrestrial bird
Slork billed kingfisher (Pellargepsis capensis) : Terrestrial bird

All the above three (3) are resident bird species. Moreover, the nation-wide status of Comb duck and Great eared nightjar are uncertain. Hence an intensive study on wild life ecology remain to be undertaken on a national basis to determine the base line condition and to formulate a rational wild life conservation strategy.

It is noted that the faunal survey does not take into consideration of the domestic species reared by man for their economic and other usefulness, among which the mammals predominate. There are six (6) such domestic mammal species widely distributed in the whole country, namely, cow, buffalos, horse, goat, dog and cat. These domestic species would thrive and their population would not be in danger in consideration for their direct importance to human welfare, hence are not covered in this comprehensive survey.

With the embankment and subsequent dry-up and urban development, similar to the floral species dealt with in the foregone section, terrestrial species will become dominant in place of aquatic species, other than in the low land retarding areas and other water bodies. Amphibian species, as it is both aquatic and terrestrial is highly versatile in adapting to this environmental change. While those highly mobile aquatic species of birds and reptiles would find alternative areas that will prevail around the priority area. In this regard, the flood plain management area of 328 km^2 of the master plan area is of significance as alternative aquatic habitat, though a vast flood plain still surrounds even the master plan area of 850 km^2. Even those aquatic reptiles with low mobility like turtle species would find adequate habitat in the remaining low lands, canals and other water areas.

The following urban development and the subsequent reduction of wood lands would still affect the terrestrial species of wild origin due to inherent loss of their habitat. Moreover, with increasing residential development terrestrial domestic species with direct economic and other importance to human welfare, like dog, cat, cow etc., would become dominant at the expense of terrestrial species of wild origin.

A wild life sanctuary like the botanical garden and zoo in Mirpur of West Dhaka, is recommended to be established in Dhaka East area as well. This could also serve as recreational area of urban population. Kaskara area in the northern most compartment of the proposed flood control and drainage plan (DC-1) along with northern most retarding area is recommended for further studies as a potential terrestrial and aquatic wild life sanctuary. Land use of this area surrounding the northern most retarding area of Dhaka East is proposed to be agriculture, as per the indicative land use plan in 2010 (ref. Fig. A.9 of Supporting Report A). A portion of this proposed agricultural area and retarding area could still be reserved for wild life conservation.

Moreover the high land rural area in Savar (about 43 km^2) and the low land flood plain management areas (about 328 km^2), the land use of which are proposed to remain unchanged according to the previous master plan study encompassing an area of 850 km^2, are potential areas of natural wild life conservation. Development of portions of these areas as natural wild life conservation areas is recommended for detailed investigation as further studies (ref. Table C.12, Fig. C.17 and Fig. C.18 of Supporting Report C, Master Plan).

As long as the land use of these proposed rural master plan areas are ensured to remain unaffected natural protection of both the general and productive ecological elements of flora, fauna, agriculture and aquaculture can be reasonably expected.

2.2 Productive Ecology

The representative productive ecological elements are the agricultural crops and the aquacultural species of both natural (generally known as fishery) and artificially cultured (generally known as aquaculture), in the priority area.

During flood season, the lowland areas, that account for about 33% (11,200 ha) of the priority area of 34,000 ha, are encompassed by open water bodies due to overflow from surrounding rivers. Such open water bodies are vast in East Dhaka Balu river flood plains. While closed water bodies and marsh lands cover an area of about 3,600 ha.

These open water bodies of potential aquaculture during flood season becomes single cropped agricultural lands during dry season. This is a very typical phenomenon in most lowland flood plains of the whole country.

2.2.1 Agriculture

1) Existing Condition

The environmental study area, priority area, covers about 34,000 ha (ref. Fig. C.1). Under the existing conditions of land use, agriculture accounts for 44% of the total land use covering about 14,800 ha, which is very significant (ref. Table C.1).

The land use distinguished between agriculture and others in Greater Dhaka (Dhaka West and Dhaka East) and Narayanganj (DND and Narayanganj West) is summarized below.

Agricultural Land Use in 1990

Land Use	Greater Dhaka		Narayanganj		Priority Area (Total)	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agriculture	11,181	42.5	3,637	48.2	14,818	44
Others	15,126	57.5	3,905	51.8	19,031	56
Total	26,307	100	7,542	100	33,849	100

The farming practice comprises three annual seasons, namely Karif - I (March - June), Karif - II (July - October) and Rabi (November - February).

(1) <u>Karif - I (pre monsoon) season</u>

This is a very good crop production season though not a prominent crop planting season. The climatic condition is marked with high temperature and low humidity resulting in high evaporation. Rain fall is very low while solar radiation is high.

(2) Karif - II (monsoon) season

This season is marked with high rainfall and high humidity. This is also the flood season in which the low-lying agricultural lands, predominantly in East Dhaka, and the crops if not harvested get inundated by external and/or internal flood water. Hence no cropping is possible in low lands with no flood protection and drainage measures during this season.

(3) Rabi (post monsoon - winter) season

This season is characterized with low temperature, high solar radiation, low evaporation and little or no rain fall. This season also marks the receding of external flood water form the surrounding rivers in flood pains, like that of Balu River flood pains in East Dhaka, making them suitable for single crop cultivation. This is the predominant crop planting season.

(4) Farming Practice

The existing farming practice is to suit the above climatic and the related land and flood water area changes. Rice and wheat are the major crops cultivated. Their varieties are itemized below. Rice cultivation predominates in Karif I and Karif II seasons, though Rabi is its major planting season. While wheat and other products like oil seeds, potatoes, vegetables and pulses are cultivated in Rabi season.

Rice (Boro)

HYV	:	Br-3, Br-8, Br-9, Br-12, IR-8.
Local	:	Amboro, Khaiyaboro, Chiniboro.
Improved	:	Pyzam.

Rice (Aman)

HYV	:	Br-3, Br-4, Br-10, Br-11, IR-20.
Improved	:	Pyzam.

Rice (Aus)

HYV	:	Br-12, Br-15, Br-16, IR-8.

Wheat

Recommended variety	:	Sonalika, Balaka, Ananda, Barkat, Akbar, Kanchan.

(5) Annual Cropping Intensity

Single cropping, which is mainly confined to Rabi and Karif-I season, is predominant that covers about 58% of the total agricultural lands which are mostly flood plains. While double cropping encompassing two seasons accounts for about 33% and triple cropping covering all three (3) seasons accounts for the remaining 9% of agricultural lands, being confined mostly to flood protected DND area.

Accordingly, the average cropping intensity in the whole objective area (priority area) becomes 152%, which is much less than the cropping intensity of Dhaka district with 171%. Hence, it could be concluded that this priority area that encompasses both the existing and the potential future urban area is more suited for urban land use than that of agriculture, based on the existing conditions. Nevertheless, it is to be admitted that flood mitigation and drainage would increase the potential cropping intensity of the protected agricultural land as well. This aspect is hypothetically analyzed in the subsequent section on future condition. Breakdown of cropping pattern along with the respective crops is tabulated below.

Existing Cropping Pattern in Priority Area

Pattern	Cultivated Crops	Cultivated Area		Cropped Area	Cropping Intensity
		ha	%	ha	%
Single Cropping	Boro (Local) or Boro (Improved) or Boro (HYV) or Fruits	8,523	57.5	8,523	57.5
Double Cropping	Boro (HYV) followed with T. Aman (HYV) or Rabi crops followed with T. Aus (HYV) or Rabi Crops followed with T. Aman (HYV)	4,945	33.4	9,890	66.8
Triple Cropping	Rabi crops followed with Boro (HYV) and T. Aman (Improved)	1,350	9.1	4,050	27.3
Total :		14,818	100	22,463	151.6

Note : Rabi crops include all, other than rice and fruits, in general.

The total annual production of major agricultural crops of rice, wheat, potatoes, oil seeds, pulses vegetables and fruits in the above agricultural lands of the priority area along with their respective yields, cost of production and market price and other related information is given in Table C.2.

The total annual net value added of agricultural production, under existing condition, is about 389 million Tk., as evident from Table C.2. Total annual net value added is defined as the difference between total annual market price and that of production cost of the whole agricultural production in a year.

2) Future Condition

The future agricultural condition is assessed under two(2) scenario. First, it is hypothetically assumed that no change in existing agricultural land use, though such a change to urban use is inevitable, would occur even under with project conditions of flood control and drainage facilities. Then the change in land use is superimposed in accordance with the land use and urban planning study results as summarized in Table C.1, the major indirect effect of the project.

Under the hypothetical scenario of with project, the cropping intensity is estimated to increase to 160%, with a cropped area of 23,733 ha, which is still less than the existing level for Dhaka district with 171%.

The projected cropping pattern under this hypothetical scenario is summarized below.

Future hypothetical Cropping Pattern

Pattern	Cultivated Crops	Cultivated Area		Cropped Area	Cropping Intensity
		ha	%	ha	%
Single Cropping	Boro (Local) or Boro (Improved) or Boro (HYV) or Fruits	7,273	49.1	7,273	49.1
Double Cropping	Boro (HYV) followed with T. Aman (HYV) or Rabi crops followed with T. Aus or Rabi Crops followed with T. Aman (HYV)	6,175	41.7	12,350	83.4
Triple Cropping	Rabi crops followed with Boro (HYV) and T. Aman (Improved)	1,370	9.2	4,110	27.6
Total :		14,818	100	23,733	160.1

The total annual production of major crops and other related information similar to that of Table C.2, for this hypothetical case is given in Table C.3. The cost estimation is made assuming that both the cost and price of per ton product will remain unchanged even in future.

As per Table C.3, the total net value added of this hypothetical agricultural production becomes about 485 million Tk. This amounts to a net gain of 96 million Tk., if land use remain unchanged, the hypothetical agricultural benefit of the project.

Nevertheless, the project is aimed at protecting both the existing and potential future urban area of Dhaka from flood damage. The potential future urban areas were identified based on the "pull area" concept developed in the Master Plan (ref. Supporting Report C on Landuse and Urban Planning).

Hence even with no project conditions, change in land use from agricultural to urban would proceed, as the major factor inducing such a change is the existing urban area of Dhaka.

As per Table C.1, the future agricultural land use in 2010 will occupy 2,452 ha against the existing area of 14,818 ha. Nevertheless, atleast a portion of retarding areas (about 70%) could also be used for agriculture, during dry season. These retarding areas have multiple potential use as illustrated in Supporting Report A. Accordingly, assuming the most critical condition with future agricultural land area of 2,452 ha, the total annual net value added of future agricultural production that will remain in 2010 is estimated at 80 million Tk.

Hence, the overall maximum annual agricultural production loss including the indirect effect of urbanization becomes 309 million Tk., in terms of total net value added agricultural production.

2.2.2 Aquaculture

In this section, fish species that occurs naturally in open water bodies is referred to as capture fishery or simply "fishery" while that is cultured artificially in ponds as culture fishery or aquaculture.

Most low lands and flood plains of single cropped agriculture are the potential open water capture fishery areas of non cropping period. The Balu river flood plain of East Dhaka is the predominant spawning grounds of open water capture fishery. The low lands of DND area also possesses considerable fishing potential.

1) Fishing system

There exist four major fishery/aquaculture systems in the objective area. They are ;

(1) River/Khal fishery

This is a year round activity carried out by professional fishermen which will not be significantly affected by the project, as the project does not interfere with river, khal networks, other than their development.

(2) Flood plain fishery

This is the fishery activity confined predominantly to the flood season and the beginning of dry season prior to crop planting in flood plains. This will be affected by the embankment as flooding itself will be prevented. This fishing activity is also conducted by professional fishermen.

(3) Beel and reservoir fishery

This is both a professional and subsistence fishing activity confined to those beels in flood plains, derelict ponds and other permanent water bodies, carried out predominantly in the dry season. This will also be affected as disappearance of flood plains and their subsequent change in land use to urban and others also means the disappearance of beels, in principle, other than those retarding areas.

(4) Culture fishery or aquaculture

This is artificial culturing of fish in fish ponds. Flood control and drainage facilities will enhance the potential of culture fishery, provided land is allocated for such purpose. At present, culture fishery is widely prevalent in DND area, which is protected from external flooding. The proposed retarding areas are potential grounds for aquaculture, an important component of their multipurpose use.

2) Fish species

A total of 86 open water general capture fish species comprising 74 fish species, 10 freshwater prawn species, and 2 crab species is identified in the priority area. In addition, five (5) exotic fish species are also found to exist. All cultured species are also found naturally in open waters. Of the 86 general species 25 species are identified to be commercially important. They are grouped into eight (8) categories as given below.

Commercially Important Species	
Group Name	No. of Species
Clupeoid	1
Feather back	1
Major carp	3
Minor carp	4
Cat fish	6
Snake head	3
Perches	5
Prawn	2
Total	25

3) Fish harvest

The harvest of both the capture and culture fisheries in the priority area, under existing conditions, was preliminary estimated for the survey period of six (6) months from October 1991 to March 1992. This half year period, which predominantly comprised the dry season, represents higher fish harvest but lower fish production in comparison to the other half year period that was not surveyed.

(1) Capture fishery

The total capture (harvest) of open water fishery in flood plains, beels and other internal rivers for this half year is estimated to be about 17,120 ton, with a total current market price of 742 million Tk.

Of this, the share of flood plains and beels fishery, that would predominantly be affected directly be the construction of embankment and the subsequent dry-up of fish spawning grounds, is determined to be about 11, 910 ton having a current market price of 424 million Tk. Accordingly the potential loss of capture fishery with respect to total capture by the project, within the priority area, is anticipated to be a 70% based on total quantity of harvest, but only a 57% based on current market price, for the six (6) months survey period.

However additional production loss, though indirectly due to change in land use and potential increased pollution load discharge by urban and other developments, to internal khal and irrigation canal fishery also may result in future.

The water quality aspect on aquaculture/fishery is illustrated in details, based on the baseline water quality in the proposed retarding areas, in Chapter 4 on Environmental Monitoring.

(2) Culture fishery

The survey period encompassed both the flood season and dry season harvest, which is practised twice times in a year, of cultured fishery in the priority area. The annual harvest is estimated to be about 2,500 ton, with a current market price of about 148 million Tk.

The project will enhance the potential of aquaculture in the flood protected land as in case of agriculture. However, reservation of lands for such purpose is necessary. The retarding areas are potential grounds to enhance culture fishery (aquaculture) production, as a component of multiple beneficial use.

4) Fishery Development

It is to be noted that as per Table C.1, the area of potential future water body is expected to increase to 13% (4,361 ha) from the existing ratio of 11% (3,631 ha). Hence the potential for culture fishery development is very significant, provided the water quality deterioration is controlled. Moreover, there is much room to improve the fish culturing and management technology, which is at a rather primitive stage in comparison to agriculture, in order to increase the harvest biomass.

Highly profitable species of culturing (aquaculture) are identified as follows:

(1) Freshwater fish species

(i) Family-Cyprinidae (carp)
- Labeo rohita (ruhu)
- Cirrhina mrigala (mrigal)
- Catla catla (catla)

(ii) Family-Claridae (cat fish)
  - Clarias batrachus (cat fish)

(2) Freshwater prawn species

Family-Palaemonidae
- Microbrachium rosenbergii

(3) Exotic fish species

Family-Cyprinidae
- Cyprinus carpio ver specularis (mirror carp)
- Hypopthilmichthys molitrix (silver carp)
- Ctenopharyngodon (grass carp)

Development of aquaculture/fishery technology, along with culturing the above identified and other profitable species, is recommended as a rational means to compensate the inevitable loss of open water capture fishery in the existing flood plains and low lands.

The loss of open water capture fishery can be grossly visualized from Table C.1. The projected increase in future builtup area to 80% (27,036 ha) from the existing ratio of 45% (15,400 ha) is mainly achieved by subsequent reduction in the existing flood plain area with a ratio of 35% (11,914 ha). This flood plain area (noted as annual external flood area) is not only the major spawning grounds of capture fishery but also single cropped agriculture land.

Nevertheless, this loss of flood plain area, and the accompanied fishery and agriculture resources, is insignificant from a national view point in consideration to the availability of vast flood plains around the priority area.

In fact of the master plan area of 850 km^2, the flood plains to be lost by the embankments and the subsequent change in land use are concentrated principally in the Dhaka East area only. Bulk of the flood plains, with an area of 328 km^2, of the master plan are is planned to remain intact with no significant change in land use (ref. Table C.12 of Supporting Report C, Master Plan). Guidelines of flood plain management are proposed for this area in Chapter 10 of Main Report, Master Plan.

This flood plain management area has the potential for the development of open water capture fishery, as well as agriculture. Further studies and research are recommended to enhance the productivity and harvest of fishery and agricultural resources in this area. A combined development both fishery and agriculture, simultaneously, is a field of study worth for detailed investigation.

3. Living Environment

3.1 General

An inventory study covering the whole study area of master plan of 850 sq. km, which incorporated this priority area of 340 sq. km, concerning water supply, sewerage and sanitation and solid waste management, the prime living environment aspects, has already been presented in Supporting Report F of the Master Plan study (FAP-8A).

Most of the existing piped water service area, sewered area and solid waste service area (ref. Fig. F. 1 ~ Fig. F. 3 of Supporting Report F, Master Plan), other than the Bandar area in Narayanganj East of Narayanganj Municipality and Tongi Municipality, is encompassed within the priority area of this study. Hence, a supplemental living environment study targeting the on-site sanitation aspects in the priority area of Greater Dhaka and Narayanganj (DND area and Narayanganj West) was carried out, in order to elucidate the existing sanitation condition and hence to identify its short commings and the possible means of sanitation improvement.

3.2 Sanitation in Priority Area

3.2.1 Sewerage

The existing sewered area of DWASA, that covers about 33% of Dhaka City Corporation (DCC) area of 226 sq.km, is entirely encompassed by the Greater Dhaka area portion of the priority area of this study. This sewerage system is dealt with in details in Chapter 3 of Supporting Report F, Master Plan (ref. also Fig. F. 2).

The sewerage system is estimated to serve only a 15% of the population even within its service area. Hence the whole objective area is dependent on some form of on-site sanitation system for human waste disposal.

3.2.2 Sanitation System

The population in the objective area are presently using various alternative methods or ways of human waste disposal such as septic tank, pit latrine/leaching pit, bucket latrine, katcha latrines (make-shift latrine) and public toilets and open defecation. There are no exact data available about latrines. Most of the households with permanent housing structures are either connected to the existing sewer system (if available) or have septic tank arrangements. House holds with semi-permanent housing mostly have single pit on-set latrines or twin pit off-set latrines and katcha housing have katcha latrine or no latrine. Hence both the type of housing and sanitation system is dependent on house hold income class distribution. This socio-economic aspects of sanitation is dealt with in the subsequent section.

The various alternative on-site systems that exist in the priority area are classified into five (5) main categories principally based on their technical features. They are septic tank, pit latrine or leaching pit, bucket latrine, surface latrine and other practice. Their salient features are briefed below.

1) Septic Tank

The most complete fluid on-site system and treatment plant is the septic tank, in which the night soil from water closets (generally having piped water supply) is collected from one or more (clusters of) houses through small diameter underground pipes. In the septic tank a partial removal of wastes through anaerobic digestion processes under fluid conditions is achieved for settled solids while the effluent is drained through a soak-way or drain/infiltration field. The total annual costs of septic tanks are, generally speaking for urban core of Dhaka and Narayanganj, higher than those of a sewer system-cum-treatment plant. However, considering that the costs for the building of septic tanks is a part of the initial investment costs for the construction of a house, while constructing a sewer system as mainly an undertaking to be financed from public funds, and when such public funds are not available, septic tanks would be the practical option by those people who can afford its high cost of investment.

2) Pit Latrine

Pit latrine is widely known as leaching pit, which is essentially a covered pit dug at the compound. This pit is used to retain solid contents of night soil while the fluids infiltrate into the surrounding subsoil as the pit wall is unsealed. Solids that remain in the pit are decomposed through anaerobic digestion processes under dry conditions, in general. Mostly a pit with a volume of about 1.5 m^3 will suffice for one household for one year (Source : Bangladesh Water Supply and Sanitation Sector Study, Hasconing, 1986). Various designs for the pit latrine/leaching pit have been developed in the course of time with or without water seal, with different types of lining for the pit, with on to or set a side pit, single or twin pit arrangements and various types of superstructures, with each design having its own costs and performance advantages and disadvantages.

3) Bucket Latrine

One of the oldest methods for the collection of the nightsoil is with a bucket latrine, either situated inside the house or in the compound. Although it is not costly in construction, the emptying of the bucket has to be regular and hence very demanding and is very often accomplished in an insanitary manner. It imposes great health risks to the sweepers as it is extremely difficult to avoid direct contact with nightsoil. Although bucket latrines can be applied every where and in itself do not require any specific water supply facilities and is therefore cost widely acceptable by the users, as long as they do not do the emptying job by themselves, it is essentially an insanitary latrine.

4) Surface Latrine

Surface latrines are insanitary latrines where excreta is simply flushed to drains in immediate vicinity, though the latrine superstructure itself may be a permanent structure.

5) Other Practice

There are some other practices which are insanitary. Along ponds, streams and rivers, hang-latrines may be found, constructed above the water level and consisting of a superstructure and a floor with a hole in it. It is obvious that only flowing water courses with an adequate self-purification capacity are capable of absorbing the pollution load thus discharged / disposed.

A majority of the population still uses open areas as a place to relieve themselves. It is very clear that these "open latrines" are a serious public health hazard not to mention the pollution effects. The same goes for the hang-latrines over ponds and stagnant water courses, in this regard. However, as long as no safe low-cost sanitary alternatives are provided these practices will unfortunately continue.

One system worth mentioning is the communal sanitation facility or public latrine. There are only a few in operation in the priority area. Experience has shown that more attention to be paid to the maintenance by an appointed care taker who is to charge for the service and to keep the facility clean. Local community participation in organizing a maintenance system would be very helpful.

3.2.3 Socio-Economic Aspects of Sanitation

No specific recent studies on sanitation condition of Dhaka or Narayanganj was conducted. As a result, no detailed information is available. However, a sanitation survey was conducted in Manikganj, a district town adjacent to Dhaka during August, 1989. The survey was carried out as a component of 18 District water supply and sanitation project by Netherlands-Bangladesh Co-operation Programme, the findings of which could be considered quite representative to both the unsewered areas of Dhaka and Narayanganj as well. Nevertheless, the data of the Manikganj town were modified to suit the local conditions to the extent possible based on the information obtained from DCC and Narayanganj Municipality.

1) Distribution of Sanitary Facility

The existing sanitary facilities and their types are related to the type of housing and hence household income levels.

The income class separation as low (poor), mid and high (rich) income levels and their respective incomes and percent of population in the priority area is given below :

Income Group According to Real Income in Priority Area

Income Class	Income (in Tk.) per month	Percentage of population
Low income (Poor)	Tk. 2,000	40%
Medium income (Middle class)	Tk. 2,000 - 8,000	30%
High income (Rich)	Tk. 8,000 to above	30%

Source : Social Formation in Dhaka City, University Press Ltd. 1990

Type of sanitary facilities used by each income group, which is also related to type of housing, along with the percentage of population in Greater Dhaka is given below:

Sanitary Facilities According to Income Group - Greater Dhaka

Income Group	House Type	Facility	Percent Population
High & Medium	Pucca	Sewerage	15%
High & Medium	Pucca	Septic Tank	40%
Low & Medium	Semi-pucca	Pit Latrine	15%
Low	Katcha	Bucket Latrine and Others	30%

Source : Based on Water Supply and Sanitation Sector in Bangladesh. UNDP, 1991 (a proposal for future strategies)

Information to an extent to that of the above table could not be determined for Narayanganj Area. However, a distribution of sanitation facility according to housing type is estimated as given below.

Facility	Percent(%) user according to housing
Septic tank	Pucca Housing - 20% Semi-pucca housing - 15% Katcha housing - 0%
Pit latrine	Pucca housing - 80% Semi-pucca housing - 60% Katcha housing - 24%
Bucket latrine and others	Pucca housing - 0% Semi-pucca housing - 25% Katcha housing - 76%

From the above tables it could be concluded that in general high and medium income people have access to acceptable sanitary facilities like septic tank and pit latrine/leaching pit.

A general definition of Pucca, Semi-pucca and Katcha housing is as follows:

Pucca house : House having R.C.C. roof with brick wall and cement floor.

Semi-pucca house : House having brick wall and cement floor with tined roof.

Katcha house : A house made of bamboo or wood having earthen floor with tined roof or thached roof.