PRACTICES AND CURRENT STATUS OF FLOOD FORECASTING AND MANAGEMENT IN INDIA

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ABSTRACT

Man has experienced flood since time immemorial and he has learnt to live with the floods. However, there was ample space always at higher elevation for evacuation. Population pressure on the flood plains has deprived this advantage in various parts of the country. In fact drought and flood syndromes have been a yearly feature in India affecting one or the other region.

In the Five Decades since independence, India has overcome drought-famine syndrome completely and also the rain floods syndrome considerably. We claim to have provided reasonable protection to a third of flood prone area, but the annual loss due to floods has not shown a distinct downward trend. In view of the above, early warnings and proper forecasting on floods, has become the prime necessity to mitigate the loss of life and property. The paper deals with brief review on the established practices and the present status of management and forecasting on the floods, so that the advancement in the technology may be suitably used, to mitigate the recurring loss of the life and property.

1.0 INTRODUCTION

1.1. India is endowed with vast water and land resources. Renewable water resources in the country is about 4 percent of global availability. Arable land is 184 million hectares (m.ha) which is second highest in the world. During 1951, nearly 70 percent of the population comprised of cultivators and agricultural labourers; even in 1991, the figure stands at 65 percent, which amply indicates our continued dependence on agriculture.

The geographical area of India is about 320 m.ha with a wide range of physiographical and climatic variation. The climatic variation ranges from continental to oceanic, from extreme heat to extreme cold, from extreme aridity to excessive humidity and rainfall. The average annual precipitation, including snowfall, is estimated to be of the order of 4,000 billion cubic metre (b.cu.m) of which monsoon rainfall during June to September itself is around 3000 b.cu.m. The average annual runoff as per the estimate of Central Water Commission is 1869 b.cu.m. The aerial distribution of the water resources in the country is highly uneven. Though the present national per capita annual availability is assessed to be about 2,200 cu.m, the average availability in Brahmaputra basin is as high as 18,400 cu.m while it is as low as 380 cu.m in some of the east flowing rivers of Tamil Nadu. In fact, one-third of the country is always under threat of drought, not necessarily due to deficient rainfall, but many times due to its uneven occurrence. This is the peculiar phenomenon of scarcity amidst plenty , manifesting often in the form of droughts and floods.

1.2 In a monsoon climate and an agrarian economy like India, irrigation has played a major role in the production process. There is evidence of the practice of irrigation since the establishment of settled agriculture during the Indus Valley civilization (2500 BC). In the medieval India rapid advances took place in the construction of inundation canals.

Irrigation development under British rule began with the renovation, improvement and extension of existing works. When enough experience and confidence has been gained, the Government ventured on new major works, like Grand Ganges canal (upper Ganga Canal), the Upper Bari Doab canal and the Krishna and Godavari Delta systems (1830s to 1850s). Upper Ganga Canal (1838-54) was the first largest perennial canal in India, with some of the major hydraulic structures being unprecedented on the earth, by mid of 19th century. These canal systems followed by other large irrigation systems, specially in Northern India, taken off from large Himalayan Rivers. Recording and regulation of floods

at the headworks of major canals initiated the practice of gauging of the rivers and issuing flood warning, to the areas along the lower reaches of the rivers. Dependable daily water availability and flood intensity records and high flood marks are available at Raiwala, gauge 10 km upstream of headworks of Upper Ganga Canal, since 1880 onwards. In view of projection of Upper Ganga Canal (1854) from river Ganga, the history of floods in the Ganga river at Hardwar (off-take point of canal) has been very well documented since 1854.

2.0 EVOLUTION OF POLICIES ON FLOOD MANAGEMENT

2.1 It is often stated that the flood plains are the play grounds of the river and should be left as such, without any human interference . Wise as it may seem, this philosophy can not be practical basis for flood management in the over populated developing countries like South Asian and South East Asian countries; firstly the limits of the play grounds cannot be defined in specific way and also a very large part of the Gangetic alluvium including much of the land occupied by territory of Bangladesh, would have to be left alone, without human settlements.

2.2 After the unprecedented floods of 1954, the Govt. of India took several initiatives and constituted a number of committees to study the problems of floods in the country. The important steps are,

- Policy statement 1954
- High level committee on floods — 1957
- Policy statement of 1958
- Ministerial committee on flood control — 1964
- Minister s committee on floods and flood relief — 1972
- Working group on flood control for Five Year Plans
- Rashtriya Barh Ayog (RBA) — 1980
- National Water Policy (1987)
- National Commission for integrated Water Resource Development Plan — 1996.

2.3 During the monsoons of 1996, a large number of states including Rajasthan and Haryana; which were generally not flood prone, experienced floods of severe intensity, causing extensive damage to life and property. It was, therefore, been considered essential to examine the problem of floods and flood management in the country afresh. Consequent upon this, Govt. of India had constituted five regional task forces viz.

(i) Eastern Region Task Force
(ii) Northern Eastern region Task Force
(iii) Northern region Task Force
(iv) North-Western Region Task Force
(v) South Region Task Force

Many thrust areas were identified for actions by these Task Forces. The Task Forces have submitted their report to Ministry of Water Resources.

2.4 Organizations in the field of flood management

- State Flood Control Departments
- Central Water Commission
- Ganga Flood Control Commission
- Brahmaputra Board.

3.0 FLOOD MANAGEMENT STRATEGY

3.1 General

Providing absolute protection to all flood prone areas for all magnitude of floods of different probabilities of occurrence is neither practically possible nor economically viable. Hence, a practical approach in flood management is to provide a reasonable degree of protection, against flood damage at economic costs through a combination of structural and non-structural measures.

3.2 STRUCTURAL MEASURES

The main thrust of flood protection programme undertaken in India so far has been in the nature of structural measures like:

(i) Embankment, flood walls

(ii) Dams and reservoirs

(iii) Natural detention basin

(iv) Channel improvement

(v) Drainage improvement

(vi) Diversion of flood waters.

3.3 Non-structural Measures

- Flood plain zoning
- Flood proofing

Flood plain zoning aims at disseminating information on a wider basis so as to regulate indiscriminate and unplanned development in flood plains and is relevant both for unprotected as well as protected area. At present the watershed development and management programmes are being implemented under centrally sponsored schemes of Ministry of Agriculture, Ministry of Rural Areas and Employment & Ministry of Forests. Flood proofing measures help greatly in mitigation of distress and provide immediate relief to the population.

4.0 REVIEW OF PROGRESS OF FLOOD MANAGEMENT WORKS

4.1 During the last 40 years, different methods of flood protection, both long term and short term, have been adopted in different states depending upon the nature of problems and local conditions.

The flood management works carried out, so far, has provided reasonable degree of protection to an area of 14.374 m. ha upto March 1993. The works consists of 16,199 km of new embankments, 32,003 km of drainage channels, 906 town protection works and raising of 4,721 villages above flood levels.

Reservoirs constructed on the Damadar river, across Mahanadi (at Hirakund), Sutlej (at Bhakra), Brahmam (at Rengali) and Tapi, (at Ukai), as also on a

number of other major and medium reservoirs, have helped greatly in reducing the intensity of flood in the flood plains.

4.2 Another important non-structural measure for mitigating damages from floods is Flood Plain Zoning , out of 1,06,000 sq.km. programmed for surveys in the country, about 55,000 sq.km of flood prone area was surveyed upto March 1991, by the Survey of India, for preparation of large scale maps of 1:15000 with contour intervals of 0.3 to 0.5 m. The maps to be used by the State Governments to demarcate flood plains and to prepare Flood Risk Maps for introducing suitable regulatory measures in the flood plains.

Similarly, flood proofing considered as one of the important non-structural measures for mitigating damages, has been initiated in North Bihar area.

4.3 All the works have resulted in providing reasonable degree of protection to total area of about 14 m ha against the total flood prone area of 40 m. ha in the country. Total investment on flood control during the last four decades has been of the order of about Rs. 40 billion.

5.0 FLOOD FORECASTING AND WARNING

5.1 Of all the non-structural measures for flood management which rely on the modification of susceptibility to flood damages, the one which is gaining increased/sustained attention of the planners and acceptance of the public, is the flood forecasting and warning. Flood forecasting enables forewarning as to where the river is going to use its flood plain, to what extent and for how long.

As per strategy of laying more emphasis on non-structures, a Nationwide Flood forecasting and warning system has been established by Central Water Commission. The system under CWC is largely on major interstate rivers and states often supplement these by their own efforts at other stations. With reliable advance information / warning about impending floods, loss of human lives and moveable properties and human miseries can be reduced to a considerable

extent. People and cattle can be shifted to safer places. Similarly, valuable moveable properties can be removed to safer places beyond area to be inundated.

5.2 The flood forecasting system of CWC in India function under Member (River Management). Seven field offices of Chief Engineers, ten offices of Superintending Engineers and nineteen Divisional Offices are incharge of management of the forecasting work. These offices are responsible for hydrological and hydro meteorological data collections such as gauge, discharge and rainfall data, their transmission from field stations to Central control room, formulation of forecasts and dissemination to various concerned officers every day in the morning. The forecasts are also transmitted to CWC headquarters at New Delhi, where bulletins lives are prepared for the country as a whole and sent to all concerned departments of the governments. The flood forecasting network of the Central Water Commission covers most of the flood prone inter-state river basins in the country. The Commission is responsible for issuing flood forecast at 157 stations, 132 being river-stage forecasting and 25 inflow forecasting for operations of reservoirs.

5.3 Early warning are specially extremely valuable in cases of flashy floods which are quite frequent on Himalayan Rivers and their tributaries due to heavy land slides. Likewise such warnings are also of extremely useful in cases of flooding by cyclones and storms surges in coastal areas parts of country, mainly coastal areas of A.P. Assam, Orissa, Tamil Nadu and West Bengal experience such cyclones, leading to extensive flooding. The flood due to super cyclone combined with heavy rainfall during October 1999 in the coastal belt of Orissa is an example.

Similarly, flashy floods in River Ganga 1894, 1970, and 1978 have been the results of large hill slides in upper reaches of the river. Flash flood in Sutlej, Aug. 2000, caused sharp rise of discharge at Rampur in Himachal Pradesh from 54000 cusec to 1,80,000 cusecs, during time interval of 0300 hrs to 0530 hrs. The flash flood caused wide spread damages to life and property in Kinnour

districts washing away almost all bridges and villages. The well known calamitous flashy flood in Ganga at Hardwar in 1970 has caused unprecedented complete choking of 12 km length of head reach of upper Ganga canal, the prestigious and most durable and important canal of the country.

6.0 DISASTER PREPAREDNESS AND RESPONSE PLANNING

6.1 The suddenness of disaster as well as its destructive potential render preventive action on a matching scale difficult, by a normal administrative set up. An effective way to meet such a situation is preparedness to face the disaster with anticipatory approach and to mitigate its impact by timely rescue, relief and rehabilitation operations.

The management of disaster in India is primarily a Government responsibility. At the central level Ministry of Agriculture, the Govt. of India has prepared a contingency action plan for natural calamities including floods. In this the duties and responsibilities of each Govt. Department and Non Govt. organizations are clearly defined in case of disasters including flood.

6.2 There is a National Crisis Management Committee (NCMC) with Cabinet Secretary as Chairman and a Crisis Management Group (CMG) with relief Commissioner as Chairman.

Ministry of Agriculture during Aug. 1999 constituted a High Powered Committee for preparation of Disaster Management Plan for the whole country, for all types of disasters.

6.3 FLOOD DISASTER RELIEF

Flood Disaster Relief does not aim at managing the flood but at reducing its economic impact through relief, after occurrence of the flood.

7.0 BASIN WISE FLOOD MANAGEMENT ACTION PLAN

The National Water Policy (1987) adopted by Govt. of India emphasizes a master plan for flood control and management for each flood prone river basin.

Although, development of water resources is a state subject, political and social issues relating to sharing of resources comes in the way of durable measures for solving flood problems of the basin.

8.0 LEGISLATION FOR FLOOD PLAIN ZONING

The need for flood plain zoning had received recognition in the Seventies and a model draft bill for flood plain zoning legislation was circulated by the Union Govt. in 1975 to all the states. In fact the progress achieved in enactment and enforcement of legislation for flood plain zoning is tardy. A task force for the purpose is required to be considered.

9.0 COMMUNITY PARTICIPATION

Flood being a common concern for all sections of society living in the affected area, flood management needs active involvement and participation of all to fulfill its objective. The national Water Policy also provides for involvement of beneficiaries in various aspects of management of Irrigation & Flood Control Schemes.

If people, living in the flood plains, are fully conversant with the system of warning signals, issued from time to time in different situations, messages are disseminated to the people living in affected areas quickly and they are fully involved, the loss of life and property can be minimised to a considerable extent.

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Analysis of Annual Rainfall (mm) in India

(1871 to 1990)

Sl. No.	Decade	Average	Maximum	Minimum
1.	1871-1880	1059	1230	914
2.	1881-1890	903	1158	1060
3.	1891-1900	1094	1336	811
4.	1901-1910	1040	1156	920
5.	1911-1920	1077	1349	858
6.	1921-1930	1074	1125	858
7.	1931-1940	1123	1280	998
8.	1941-1950	1140	1216	957
9.	1951-1960	1123	1334	972
10.	1961-1970	1069	1314	872
11.	1971-1980	1091	1199	848
12.	1981-1990	1070	1244	965

Source : Theoretical and Applied Climatology, 1994.

IMPORTANT MAXIMUM HISTORIC FLOODS IN THE WORLD

Country	River (Gauge station)	Date	Flood discharge m^3/s	Drainage area Km^2
Australia	Budekin (Clare)	17.02.1968	27,043	
Bangladesh	Brahmaputra (Jamuna)	01.08.1955	93,500	530,000
	Ganga (Hardinge bridge)	Not available	70,790	1,073,070
Brazil	Amazon (Obidos)	22.05.1944	227,000	4,688,000
Burma	Irrawaddy	1877	63,700	360,000
China	Yangtzekiang	Not available	84,950	Not available
Egypt	Nile (Aswan)	Not available	13,500	30,00,000
Ghana	Volta (Senchi)	1963	14,272	394095
India	- Godavari (Dowleswaram)	17.09.1959	88,350	314,684
	- Brahmaputra (Pandu)	Not available	73,620	934,990
	Narmada	Sept. 1970	70,790	98,420
Khmer (Cambodia)	Mekong (Kratie)	1939	75,700	646,000
Madagascar	Mangoky (Banian)	09.01.1956	14,800	Not available
USA	Missisippi (Columbus)	27.02.1937	70,792	2,387,950
	Ohio (Caro)	04.02.1937	55,218	528,300
USSR	Yenisey (Igarka)	03.06.1937	132,000	2,440,000
	Volga (Volgograd)	29.05.1926	51,900	1,350,000
	Amur (Kombomolsk)	1876	50,000	1,700,000
	Lena (Kusur)	11.06.1944	194,000	2,430,000
Zambia	Zambezi (Kariba)	05.03.1958	16,990	633,040

Source : Flood control in the World by Shri Framji & Garg (1978)

WATER RESOURCES POTENTIAL IN THE RIVER BASINS OF INDIA

Sl. No	Name of the River Basin	Average annual surface water potential km^3	Estimated utilisable flow excluding groundwater km^3	Total replenishable groundwater resources km^3	Population in 1991 Millions	Per capita available surface water m^3	Per capita surface and groundwater m^3
1.	Indus (upto Border)	73.31	46.00	26.49	41.90	1750	2382
2.	a) Ganga	525.02	250.00	170.99	356.80	1471	1951
	b) Brahmaputra, Barak & others	585.60	24.00	53.91	35.24	16617	18147
3.	Godavari	110.54	76.30	40.65	53.98	2048	2801
4.	Krishna	78.12	58.00	26.41	60.78	1285	1720
5.	Cauvery	21.36	19.00	12.30	29.33	728	1148
6.	Pennar	6.32	6.86	4.93	23.60	652	1160
7.	East flowing rivers						
	Between Mahanadi	22.52	13.11		23.60	954	
	Pennar						831
8.	East flowing rivers between Pennar and Kanyakumari	16.46	16.73	18.22	45.20	364	
9.	Mahanadi	66.88	49.99	16.46	26.60	2514	3133
10.	Brahamani & Baitarni	28.48	18.30	4.05	9.77	2915	3329
11.	Subernarekha	12.37	6.81	1.82	9.46	1308	1500
12.	Subarmati	3.81	1.93		10.58	360	
13.	Mahi	11.02	3.10		10.48	1052	
14.	West flowing rivers of Kutch, Saurashtra including Luni	15.10	14.98	18.42	22.10	683	1120
15.	Narmada	45.64	34.50	10.83	14.70	3105	3842
16.	Tapi	14.88	14.50	8.27	14.80	1005	1564
17.	West flowing rivers from Tapi to Tadri	87.41	11.94		25.80	3388	
18.	West flowing rivers from Tadri to Kanyakumari	113.53	24.27	17.69	32.60	3483	37.44
19.	Area of Inland drainage	NEG.			7.10		
20.	Minor river basins	31.00			2.10	14762	14762
	Draining into Bangladesh & Burma						
	Total	1869.35	690.31	431.44	842.62	2218	2731

AREA LIABLE TO FLOODS (AS PER REPORT OF RASHTRIYA BARH AYOG)

Sl. No.	State	Geographical area (m.ha.)	Area liable to flood (m.ha.)	% of area liable to flood	Area protected (m.ha.) as considered by RBA
1.	Andhra Pradesh	27.51	1.39	5.05	0.700
2.	Assam	7.84	3.15	40.18	1.305
3.	Gujarat	17.39	4.26	24.50	1.566
4.	Gujarat	19.60	1.39	7.09	0.362
5.	Haryana	4.42	2.35	53.17	1.095
6.	Himachal Pradesh	5.57	0.23	4.13	-
7.	Jammu & Kashmir	22.22	0.08	0.36	0.012
8.	Karnataka	19.18	0.02	0.10	0.001
9.	Kerala	3.89	0.87	22.37	0.011
10.	Madhya Pradesh	44.34	0.26	0.59	-
11.	Maharashtra	30.77	0.23	0.75	0.001
12.	Manipur	2.23	0.08	3.59	0.073
13.	Meghalaya	2.24	0.02	0.89	0.075
14.	Orissa	15.57	1.40	8.99	0.351
15.	Punjab	5.04	3.70	73.41	2.407
16.	Rajasthan	34.22	3.26	9.53	0.016
17.	Tamil Nadu	13.01	0.45	3.46	0.029
18.	Tripura	1.05	0.33	31.43	0.009
19.	Uttar Pradesh	29.44	7.34	24.93	0.739
20.	West Bengal	8.88	2.65	29.84	1.001
21.	Delhi	0.15	0.05	33.33	0.023
22.	Pondicherry	0.05	0.01	20.00	Neg.
	Total	-	33.52	-	9.776
	Say	-	34 m.ha.	-	10.00 m.ha

From the above table, the total flood prone area in the country is as below:

a) Flood prone area in states 34.0 m.ha
b) Area protected in states till then 10.0 m.ha.

Area flooded due to failure of protection works which might have been included in reported flooded areas (asusmed) (-) 4.00 m.ha.
Total flood prone area in the country **40.0 million ha.**

DAMAGE DUE TO FLOODS / HEAVY RAINS DURING 1953 TO 2000

Sl. No.	Year	Area affected in Tha.ha	Population affected in Thousands	Damage to Crops Area in		Damages to Houses		Cattle lost nos. in Thousands	Human live lost nos.	Damage to public utilities in Rs. crore	Total damages crops, houses, public utilities in Rs. crores (Col. 6+8+11)	Total damage value as per constant price Rs. crore
				Area In Th ha	Value in Rs. crore	Nos. In Thou-sands	Value in Rs. crores					
1	2	3	4	5	6	7	8	9	10	11	12	13
1	1953	2290	24280	930	42	265	7	47	37	3	52	316
2	1954	7490	12920	2610	41	200	7	23	279	10	57	367
3	1955	9440	25270	5310	78	1667	21	72	865	4	103	713
4	1956	9240	14570	1110	44	726	8	16	462	1	54	333
5	1957	4860	6760	450	14	318	5	7	352	4	23	137
6	1958	6260	10980	1400	38	382	4	18	389	2	44	253
7	1959	5770	14520	1540	57	649	9	73	619	20	86	476
8	1960	7530	8350	2270	43	610	14	14	510	6	63	327
9	1961	6560	9260	1970	24	533	1	16	1374	6	31	159
10	1962	6120	15460	3390	83	514	11	38	348	1	95	465
11	1963	3490	10930	2050	30	421	4	5	432	3	37	173
12	1964	4900	13780	2490	57	256	5	5	690	5	67	285
13	1965	1460	3610	270	6	113	0	7	79	1	7	28
14	1966	4740	14400	2160	80	217	3	9	180	6	88	312
15	1967	7120	20460	3270	133	568	14	6	355	8	155	477
16	1968	7150	21170	2620	145	683	41	130	3497	25	211	650
17	1969	6200	33220	2910	282	1269	54	270	1408	68	404	1222
18	1970	8460	31830	4910	163	1434	49	19	1076	76	288	818
19	1971	13250	59740	6240	423	2428	80	13	994	129	632	1696
20	1972	4100	26690	2450	99	897	12	58	544	47	158	394
21	1973	11790	64080	3730	428	870	52	261	1349	88	569	1216
22	1974	6700	29450	3330	418	747	72	17	387	85	569	947
23	1975	6170	31360	3850	271	804	34	17	686	166	472	755
24	1976	11910	50460	6040	595	1746	92	80	1373	201	889	1450
25	1977	11460	49430	6840	721	1662	152	556	11316	329	1202	1824
26	1978	17500	70450	9960	911	3508	168	239	3396	376	1455	2211
27	1979	3990	19520	2170	170	1329	211	618	3637	234	614	837
28	1980	11460	54120	5550	366	2533	171	59	1913	303	841	953
29	1981	6120	32490	3270	525	913	160	82	1376	512	1197	1209
30	1982	8870	56010	5000	589	2397	384	247	1573	672	1645	1622
31	1983	9020	61030	3290	1286	2394	332	153	2378	873	2492	2271
32	1984	10710	54550	5190	906	1764	181	141	1661	818	1906	1605
33	1985	8380	59590	4650	1425	2450	584	43	1804	2050	4059	3232
34	1986	8810	55500	4580	1232	2049	534	60	1200	1983	3749	2833
35	1987	8890	48340	4940	1155	2919	464	129	1835	951	2570	1826
36	1988	16290	59550	10150	2511	2277	742	151	4252	1378	4630	3038
37	1989	8060	34150	3010	957	782	150	75	1718	1299	2405	1480
38	1990	9303	40259	3179	696	1020	214	134	1855	455	1709	964
39	1991	6357	33889	2698	579	1134	180	41	1187	729	1488	739
40	1992	2645	19256	1748	1028	687	306	79	1533	2011	3345	1488
41	1993	11439	30409	3206	1309	1926	528	211	2864	1446	3282	1356
42	1994	4805	27548	3963	889	915	165	52	2078	741	1795	671
43	1995	5245	35932	3245	1715	2002	1308	1	1814	680	3702	1266
44	1996	8049	44729	3827	1124	727	177	73	1803	861	3006	973
45	1997	4569	29663	2250	693	505	153	28	1402	1986	2831	870
46	1998*	9133	68718	5872	2373	1119	302	106	2758	3171	5846	1679
47	1999*	3978	25659	1762	1663	696	174	9	576	269	2108	572@
48	2000*	4940	40063	2880	273	2295	285	19	2345	858	1416	365@
	Total	363023	1604405	170538	28684	58320	8624	4527	76559	25950	64447	49853
	AVG	7563	33425	3553	598	1215	180	94	1595	541	1343	1039

Note : Figures rounded to nearest 1000/1000 ha/Rs.Crores in respects of columns 4,7,9/3,5/6,8,11, & 13 respectively.
@ Anticipated Figures are tentative

FLOOD FORECASTING STATIONS

A : River System Wise

Sl. No.	River System	No .of FF Stations
1.	Ganga – Brhamaputra – Meghna System	109
2.	West flowing rivers	15
3.	The Krishna Basin	8
4.	Mahanadi basin	3
5.	Eastern rivers	9
6.	The godavari basin	13
	Total	157

B : Statewise

Sl. No.	States	No. of FF Stations
1.	Andhra Pradesh	11
2.	Assam	23
3.	Bihar	36
4.	Gujarat	10
5.	Haryana	1
6.	Karnataka	4
7.	Madhya Pradesh	3
8.	Maharashtra	7
9.	Orissa	11
10.	Uttar Pradesh	33
11.	West Bengal	14
12.	Dadra & Nagar Haveli	2
13.	NCT of Delhi	2
	Total	157

PERFORMANCE OF FLOOD FORECASTS BY CWC (1991-2000)

Year	No. of Forecasts issued	Accuracy of forecast	
		No. of forecasts within ± 15 cm, ± 20%	% of accurate forecast
1991	6603	6225	94.3
1992	4764	4567	95.9
1993	6643	6438	96.9
1994	7476	7087	94.8
1995	6417	6189	96.4
1996	6467	6266	96.9
1997	5465	5263	96.3
1998	7943	7775	97.9
1999	7055	6826	96.8
2000	6510	6315	97.1

BROAD FEATURES OF THE FLOOD FORECASTING PEROFRMANCE BETWEEN 01.05.94 AND 31.10.94

1. Total No. of Flood Forecasting Stations operated.	157
2. No. of Flood Forecasting Station where no forecast was issued	19 (12.1%)
3. No. of Flood Forecasting stations where forecasts were actually issued	138 (87.9%)

4. a) Flood Forecasting Stations mentioned below crossed the previous Highest Flood Level during the flood season.
[Numbers refer o stations No. in Table 11A /Table – 11B]

Sl. No.	Name of Station	Name of River	Name of State
1.	Patna (Gandhighat)	GANGA	BIHAR
2.	Bhandara	WAINGANGA	MAHARASHTRA
3.	Pauni	WAINGANGA	MAHARASHTRA
4.	Deongaon	BHIMA	KARNATAKA

4 b) Flood Forecasting Stations which approached within 0.5 meter of previous H. F. L. during the flood seasons

1.	Ballia	GANGA	UTTAR PRADESH
2.	Hathidah	GANGA	BIHAR
3.	Bhagalpur	GANGA	BIHAR
4.	Colgong	GANGA	BIHAR
5.	Farakka	GANGA	WEST BENGAL
6.	Rajghat	SUBERNAREKHA	ORISSA
7.	Nimapara	MAHANADI	ORISSA
8.	Damman	DAMANGANGA	DADRA & NAGAR HAVELI

5.	Total No. of forcasts issued .	7476
6.	Total No. of forecasts which were correct within (+/-15 cm)/(+/-20% cumecs).	7087 (94.8%)
7.	Total no. of flood forecasting stations above the %age of item 6 above	90 (65.2%)
8.	Average no. of flood forecasts per forecaste station	54
9.	No. of stations where 100% correct forecasts were issued	65 (47.1%)
10.	No. of stations where 100% incorrect forecasts were issued	1 (0.7%)

Source : Central Water Commission (Hydrological Observation Circle, NOIDA).

DAMMING OF BIRHI GANGA – HEAVY LAND SLIDE FORECAST OF FLOOD DUE TO BREACH OF DAM GOHNA FLOOD (1894), U.P. INDIA

1.	Heavy land slide	: End of Sept. 1893
2.	Dam	: 900 ft high
		2000 ft across at top
		600 ft across at bottom
		3000 ft at top, 11000 ft bottom along valley
3.	Lake formed	: 13-14 Dec. 93 – 450 high
4.	Forecast of breach	: Mid of August to end of August 1994
5.	Dam breached	: 26th August 1999
6.	Rise in River level (forecast)	: 180 ft to 40 ft
7.	Actual rise of level in River	: 160 ft to 35 ft.