

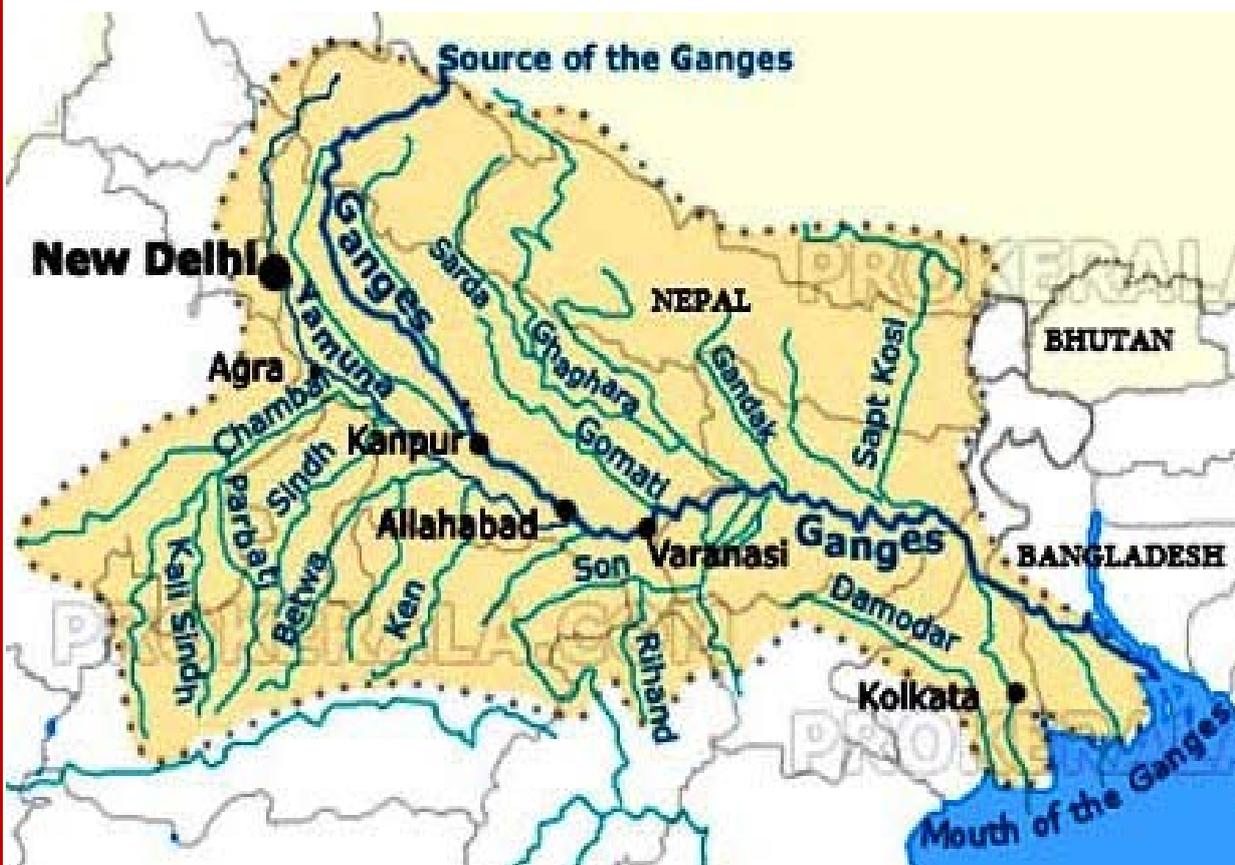


Government of India
Ministry of Water Resources, River
Development & Ganga Rejuvenation
Ganga Flood Control Commission

FOR OFFICIAL USE

Summary Recommendations of Comprehensive Master Plans

May 2015



GANGA BASIN

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PREFACE

Two holy rivers originating from the glacial peaks of the Himalayas at an altitude of about 7000 meter, the Alaknanda and the Bhagirathi unite near Devprayag and form river Ganga which traverses its course of 2525 Km (1450 Km in Uttarakhand and Uttar Pradesh, 110 Km along Uttar Pradesh-Bihar border, 445 km in Bihar and Jharkhand and 520 km in West Bengal) before its outfall into the Bay of Bengal.

Ganga basin is spread over 11 States namely, (i) Uttarakhand, (ii) Himachal Pradesh, (iii) Haryana, (iv) Delhi, (v) Uttar Pradesh, (vi) Rajasthan, (vii) Madhya Pradesh, (viii) Chhattisgarh, (ix) Bihar, (x) Jharkhand and (xi) West Bengal.

The Ganga sub-basin in India is the worst flood affected river basin in the country. In the Ganga basin floods in some part or the other are an annual feature. On account of the inadequacy of the protection works carried out so far, the large scale damage due to floods often occurs every year. Also, the flood management issues of an inter-state river call for a comprehensive approach. Piecemeal approach in tackling these issues by States in isolation is likely to do more harm than good. It was therefore felt necessary to prepare an integrated plan to tackle floods, erosion and drainage problems in the basin and implement it in a phased and coordinated manner. It was with this in view that GFCC was set up to prepare Comprehensive Plans for flood management for the Ganga basin.

The Ganga basin has been divided into 23 river systems. The river systems of the basin are (i) Gomati, (ii) Adhwara Group, (iii) Ghaghra, (iv) Mahananda, (v) Kamla Balan, (vi) Burhi Gandak, (vii) Bagmati, (viii) Punpun, (ix) Kosi, (x) Gandak, (xi) Ajoy, (xii) Kiul-Harohar, (xiii) Damodar, (xiv) Mayurakshi, (xv) Yamuna, (xvi) Ramganga, (xvii) Tons, (xviii) Badhua-Chandan, (xix) Rupnarain-Haldi-Rasulpur, (xx) Jalangi, (xxi) Sone, (xxii) Tidal rivers and (xiii) Main Ganga Stem. Most of these rivers are inter-state though a few are within one state.

Comprehensive plans for flood management of these twenty three river systems were prepared by GFCC between 1975 and 1990. Due to changes in the behaviour of the rivers in the Ganga basin over a period of time and for other associated changes, it was considered necessary to update the Comprehensive Plans for flood management of all the river systems periodically. So far, twenty two plans have been updated once and five plans have been updated twice. Both updated and original comprehensive plans were circulated to the State Governments concerned for preparing specific schemes for implementation as per recommendations given therein.

As the preparations of all twenty three comprehensive plans have already been completed, it is considered desirable that their implementations are also taken up in phases attaching due priorities to each recommended measure. Keeping mainly this in view, this compilation of the summary of recommendations made in the comprehensive master plans is published with the purpose of making it as a handy reference booklet for all the stakeholders.

It is sincerely hoped that concerned States will look into all the measures, attach due priority and seriousness towards their implementation and discuss unresolved issues in subsequent meetings of GFCC/GFCB. I am sure the booklet will prove its utility in all such endeavours.



(G.S. Jha)
Chairman

Ganga Flood Control Commission

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Ministry of Water Resources, River Development & Ganga Rejuvenation

Summary Recommendations of Comprehensive Master Plans Prepared By Ganga Flood Control Commission (GFCC)

Main Ganga Stem River System (2004)[#]

- (i) All the on-going flood control and drainage scheme in the states of Uttaranchal (if any), Uttar Pradesh, Bihar, Jharkhand (if any) and West Bengal should be completed expeditiously by the concerned State authorities to achieve immediate benefits rather than taking up a large number of additional new schemes with outlay thinly distributed during the plan period. Hence, it is suggested that no new schemes be taken up in the X-Plan till the ongoing schemes have been fully funded and completed.
- (ii) The dams in the upper reaches of the main Ganga will not, in all probability, play any important role in respect of flood control in overall reach of the main Ganga stem and no flood cushion is therefore suggested in any proposed multi-purpose reservoirs on the main Ganga portion.
- (iii) Any further construction of new embankments on the main Ganga river will need detailed study of the contours of the flood plain, the cross-section of the river etc. to avoid drainage congestion of the protected area in the post-embanked condition as a large number of tributaries join the Ganga at various points. These studies need to be taken up by the concerned states.
- (iv) It will be desirable to have some detention basins at suitable places to partly moderate the peak floods of 25 years frequency and above. The natural detention basin in Mokamah Tal, can be used as a major flood detention basin. Similar detention basins could also be considered for other similar areas on both banks of the Ganga viz. the Hardia Chaur in Bihar and several beels in West Bengal by the side of the Bhagirathi. The possibility of attenuating the flood peaks in the main Ganga by utilizing the natural detention basins need to be studied in depth and proposal framed by the concerned State Government.
- (v) The flood congestion in the Bhagirathi in West Bengal can be mitigated by partial diversion of flood waters through some of its old spill channels. Detailed investigations in this connection need to be taken up by the Government of West Bengal and proposal should be framed found feasible.
- (vi) The channel improvement of the Ganga through strengthening of loops and deepening of its bed by dredging is not feasible on economic and technical considerations and the same is not recommended. The Union Ministry of Water Resources desired that the problem be studied by the Central Water and Power Research Station, Pune (CWPRS) before taking up the appropriate remedial measures forecasting bank erosion.
- (vii) Extensive watershed management particularly in upper reaches of the river system needs to be taken up with a view to mitigating the problem of soil erosion brought about by ruthless exploitation of forests, over grazing and improper management of agricultural land over many years.
- (viii) The soil conservation works will have to be done in the upper reaches of the Ganga river because most of the soil is brought down into the main Ganga stem from this portion i.e. the lower Himalayas.

year of preparation or revision

- (ix) Non- structural measures like flood plain zoning should be given serious consideration. Preparation of flood risk maps after necessary surveys and flood plain zoning through appropriate legislation and follow up regulations may be taken up by the concerned states in their respective regions.
- (x) Adequate infra-structure for disaster preparedness should be created besides providing proper training in the disaster management from different angles .
- (xi) The village raising work as a flood proofing measure should continue to be adopted in the flood prone areas, which cannot be protected from structural measures, during the five year plan, in spite of its limitations, as it protects the human lives, movable property and other possessions and buildings.
- (xii) The existing flood control and drainage works should be look after adequately and maintained properly.
- (xiii) Necessary stocks of flood fighting materials should be readily available at vulnerable points along the embankments well before the onset of flood season. The surface communication should be improved wherever required.

Adhwara River System (1988)

- (i) The Adhwara flood control schemes proposed in three phases may be completed expeditiously by the State Govt. of Bihar. The proposals are summarised below :

S. No.	Description of works	Length Km	Estimated cost (Rs. in lakh)
	Phase I		
(a)	Embankments on right bank of river Darbhanga-Bagmati from Ekmighat to Hirauli(Pupri)	66	1616.09
(b)	Embankment on left bank of river Darbhanga-Bagmati from Mabbi to Saulighat	32	
(c)	Gap closure in Khiroi left Embankment at Agropatti	0.36	
(d)	Raising of left Khiroi embankment at Pupri	7	
(e)	Straightening of river loop	3.05	
	Phase-II		
(a)	Embankment on right bank from Bhithamore to Nihsa on river Rato	16.5	592.93
(b)	Embankment on right bank Of Dhaus river from Brahmapuri to Trimohanghat	21.5	
(c)	Embankment on left bank of river Dhaus from Basharia to Saulighat	23.0	
(d)	Embankment on left bank of River Rato and Sursari from Bhithamore to Trimohanghat	27.0	
	Phase-III		
(a)	Embankment on right bank of river Jamura from Sitamarhi-Sone barsa road to Sonebarsa village.	5.18	
(b)	Embankment on right bank of river Jhim from Sonebarsa Bazar to Sonebarsa village	20.88	
(c)	Embankment on left bank of river Jhim from Sonebarsa Bazar to Sonebarsa village	21.6	
(c)	Embankment on left bank of river Jamura from Saitamarhi-Sonebarsa Road to Sonebarsa village	4.11	

- (ii) All the choked drains may be de-silted to the proper section and gradient. Additional drains may be provided in the uncovered areas. The waterways under the road and rail bridges should be enlarged, if required after detailed investigation. Human interference & growth of vegetation in the channels should also be curbed.
- (iii) Concerted efforts for integrated watershed management in the upper catchment of the Adhwara river system should be sustained. In this task active cooperation & participation of Govt. of Bihar and Govt. of Nepal may be ensured.
- (iv) Flood plain zoning law may be enacted in the Adhwara river system and Flood zones may be delineated with the help of flood management maps under preparation by Survey of India.
- (v) Adequate infrastructure for disaster preparedness may be created besides providing proper training for an efficient disaster management system.
- (vi) Existing embankments in the Kareh(Bagmati) river may be raised by 1.22 m to cope up with the additional discharge brought down by Darbhanga-Bagmati after its jacketing.
- (vii) The efficiency of the existing flood forecasting system in the lower Adhwara basin may be assessed and Central Water Commission may be approached for extending the network to additional needy areas. Alternatively the State Government may set up their own flood forecasting unit in the uncovered area in close co-ordination with CWC.
- (viii) The existing embankments, anti-erosion works should be looked after adequately and maintained properly. Necessary stocks of flood fighting materials such as boulders, Salballah, empty sand bags etc. should be built and maintained at vulnerable points.

Ajoy River System (2002)

- (i) Application of Remote Sensing Technology to have better appreciation of morphological parameters like drainage density, erosion of bank etc.
- (ii) Raising strengthening and realigning of the existing embankments should be carried out as necessary at present to withstand the 25 years and 100 years return period floods for protection of the agricultural areas and urban areas respectively
- (iii) The approved Kunur embankment scheme may be implemented.
- (iv) Possibility of extending the embankments on the river Ajoy in the lower reaches below Nutanhat may be examined in depth as prima facie study of the index plan indicates favourable scope for the same.
- (v) Possibility of providing additional flood cushion in the proposed irrigation dams, namely, Sarkunda Burhai and Dhakwa may be examined, besides the provision kept in the proposed dam at Putulia by West Bengal.
- (vi) Attempt should be made to utilize some part of the flood cushion for irrigation as well as for suitable reservoir operation schedule
- (vii) Watershed management works should be continued with priority to check soil erosion and land deterioration.
- (viii) The inter-state problems may be taken upto different State Govt. for amicable settlement of the issue.
- (ix) Channelization in different reaches of the river may be taken up to improve the carrying capacities.

- (x) Forecasting tools i.e. travel time curve, correlation graphs etc., may be updated.
- (xi) Issue of inflow forecast at Sikatia barrage may be taken up.

Badua-Chandan River System (2003)

- (i) Soil conservation measure need to be taken extensively particularly in upper reaches of the basin.
- (ii) Flood forecasting need to be extended to this basin. At least seasonal G/D observation along with silt observation site need to be established on rivers Badua & Chandan.
- (iii) Non-structural measures like flood plain zoning may be give serious consideration.
- (iv) Old schemes of flood management in hand/under construction may be completed before taking up large number of new schemes by State Governments.
- (v) The existing flood control and drainage works should be improved wherever required.
- (vi) Drains and other flood management works should be properly maintained. Waterways under road and rail bridges, if required, should be increased after proper investigations and adequacy studies.
- (vii) Wherever required flood proofing may be provided for protection of towns/villages not protected by embankments.

Bagmati River System (1991)

- (i) It is extremely urgent that the remaining portions of the river, which are yet to be embanked should be provided with embankments without any delay. The ongoing Bagmati flood control scheme should be completed on priority basis by allocating adequate funds for this works.
- (ii) Detailed investigations to study the feasibility of a reservoir with adequate flood cushion at Noonthore in Nepal should be taken up with the cooperation of the HMG Nepal.
- (iii) Extensive watershed management works should be launched in the catchment of the Bagmati and its tributaries originating from Nepal. Needless to say that for this also cooperation of the HMG Nepal will be essential.
- (iv) Feasibility of re-sectioning the main Bagmati river its tributaries and spill channels should be studied in depth and appropriate measures taken.
- (v) Requirements of extra waterway in the road and rail bridges should be determined after detailed investigation of each case and appropriate measures to be taken to relieve the problem.
- (vi) The problem of inundation and drainage congestion at the tri-junction of Kamla, Kosi and Karih river should be studied in depth.
- (vii) Flood Plain Zoning Bill should be enacted in the Bagmati river system and flood plain zones should be delineated with the help of flood management maps, under preparation by the Survey of India, to regulate the developmental activities in the river system.
- (viii) Adequate infrastructure for disaster preparedness should be created, besides providing proper training in the disaster management from different angles.

- (ix) The feasibility of opening a couple of flood forecasting sites in the Nepal territory should be explored so that longer time lag is available for taking required measures to face the oncoming floods.
- (x) A properly equipped and well orchestrated flood warning system should be developed and kept ready to meet any contingency.
- (xi) The existing embankment should be looked after adequately and maintained properly . Necessary arrangements for flood fighting should also be taken in advance.
- (xii) Collection of data as per comprehensive list furnished by the GFCC should be continued so that refinement and updating of this Plan for flood control may be possible.

Burhi Gandak River (2008)

A. Short Term Measures

- (i) The remaining portion of unembanked reach of the river in the upper reaches should be provided with embankment to check floods in this region. The on-going flood embankments should be completed by allocating adequate funds and the normal gaps existing in the completed embankments should also be closed.
- (ii) The existing embankments should be maintained adequately.
- (iii) Various anti erosion measures should be continued to safeguard the embankments from bank erosion. On-going drainage schemes should be completed and proposed schemes should be taken up at the earliest.
- (iv) The river system is almost provided with adequate hydrological and hydro-meteorological stations. However, the different sites need a review so as to assess space time variations of different hydrological parameters in an economical way.

B. Long Term Measures

- (i) A hydraulic model to study (i) the flood management measures to be undertaken in the upper reaches (ii) the efficacy and appropriateness of the alignment of the existing embankments and if necessary the need to retire the embankments at some cordinal points to economise on annual expenditure on anti erosion measures, raising and strengthening of embankments and general maintenance and (iii) diversion of a part of peak flood discharge through abandoned spill channels to relieve pressure on the embankment.
- (ii) The gap of 10.5 km length in the existing embankment near Muzaffarpur should be closed after its thorough examination and finding ways to remove the adverse effects on the Bagmati floods, if any.
- (iii) Detailed investigations for assessing the feasibility of diverting the discharge of the lower None directly to the main Ganga should be taken up.
- (iv) Requirement of additional waterways in the road & rail bridges should be determined after detailed investigations & study and appropriate measures taken to mitigate the drainage/ flood problem.
- (v) Soil conservation works should be taken up in the catchment of the main river and its tributaries, especially in its upper reaches.
- (vi) A suitable legislation for flood plain zoning should be enacted in the State and flood

plain zones, if any, should be delineated with the help of flood management maps, under preparation by the Survey of India. This will facilitate regulation of a land use for various development activities in the river system.

- (vii) Adequate infrastructure for disaster preparedness at a few important sites should be created, besides providing proper training in the disaster management, from different angles.

Damodar River System (1996)

- (i) Existing embankments in the lower reaches of the Damodar river system may be raised and strengthened adequately as envisaged in the lower Damodar Drainage Scheme - 1985.
- (ii) Remodelling of existing channels of the Damodar and deepening of the Rupnarayan may be taken up for execution.
- (iii) The flood absorption capacities of the existing reservoirs are inadequate in comparison to the volume of flood, they are expected to moderate. Possibilities of construction of additional storage reservoir on Barakar near at Balpahari may be investigated.
- (iv) Feasibility of increasing the efficacy of the existing depressions in the vicinity of Khanakul area of the lower Damodar river system as detention basin maybe explored.
- (v) Towns such as Pursura, Khanakul etc. frequented by flood devastation and other marooned villages may be provided with ring bunds wherever feasible.
- (vi) In the affected reaches of the Damodar river on the left bank between Silna and Champadanga anti-erosion and bank stabilization measures may be executed so that the embankment does not come under attack.
- (vii) All the choked drains may be de-silted to the proper section and gradient. Additional drains may be provided in the uncovered areas. The waterways under the road and rail bridges should be enlarged, if required, after detailed investigation. Human interferences & growth of vegetation in the channels should also be curbed.
- (viii) Concerted efforts for integrated watershed management in the upper catchment of the Damodar river should be sustained. In this task active co-operation & participation of Govt. of Bihar, Govt. Of West Bengal and DVC may be ensured.
- (ix) Flood Plain Zoning law may be enacted in the Damodar river system and Flood Zones may be delineated with the help of flood management maps prepared by Survey of India.
- (x) Adequate infrastructure for disaster preparedness may be created besides providing proper training for an efficient disaster management system.

Gandak River System (2004)

- (i) Discussion may be held with HMG Nepal so that the proposed 3 dams on the Gandak are constructed. Studies may be carried out to estimate the flood moderation due to the dams. Analysis may also be carried out for providing flood cushion in these dams.
- (ii) To reduce the amount of silt coming into the Gandak river system watershed management in the upper catchment lying in Nepal should be carried out.
- (iii) Bank erosion appears to be the most serious problem in this river system. A multi-

pronged strategy needs to be adopted to mitigate this problem. This could consist of

- Construction of a physical model of the reach which is inspected by GHLC every year.
 - Development of mathematical model for the river and problematic reaches.
 - Morphological studies of the river. Some work is being done in this area by Morphology Directorate, Central Water Commission.
 - Obtain and analyse satellite imagery for studies on bank line shifting
- (iv) Soil tests are needed for grain size analysis and determination of other engineering properties of the bed and bank materials for proper planning and design of flood and anti – erosion works.
 - (v) Use of geo-synthetics may be encouraged wherever found economical or better in terms of performance. Geo-synthetics, Gabions of nylon ropes etc. should be tried in trial reaches to study their efficacy.
 - (vi) In a number of situation sufficient space may not be there to construct the slope of the embankment. In such situation use of reinforced earth technique, geo-grids should be considered.
 - (vii) Raising and strengthening of embankment may be done as per requirement so that frequent breaches/overtopping does not take place.
 - (viii) Close contour survey should be made for preparation of inundation maps and this can be used for disaster management activities.
 - (ix) Dam break analysis should be carried out at sensitive location where breaches have taken place in the past and which are assessed as vulnerable presently.
 - (x) A large population is inhabiting the area between the embankment and the river. All out efforts need to be made to curb further increase in population in this area. Govt. buildings etc. should not be constructed in this area. Flood Plain Zoning may be done in such area.
 - (xi) It is essential that the remaining portion of the river which are not embanked should be provided with embankment on priority basis. The entire ongoing flood control schemes in this basin should be completed without delay. Adequate allocation of funds should be made for this purpose. Arrangement should also be made for in depth study of the Morphology of the Gandak river so that behaviour of the river could be predicted well in advance. For this satellite imagery of the entire river length should be observed pre and post flood every year.
 - (xii) The benefits accruing from the completed drainage schemes should be assessed and if satisfied other drainage schemes should be executed on large scale. Additional waterways in the tight rail road bridges and C/D work should be provided after detail investigation.
 - (xiii) Flood Plain Zoning law should be enacted . Flood zones should be delineated with the help of flood management maps under preparation by Survey of India.
 - (xiv) Adequate infrastructure for disaster preparedness should be created besides providing proper training in the disaster management from different angles.
 - (xv) The State may assess the efficacy of the existing flood forecasting arrangement in the Gandak river system and approach CWC to extend the network if necessary. Alternatively the State Government may set up their own flood forecasting unit in the uncovered areas in close co-ordination with CWC.
 - (xvi) The existing embankment, anti-erosion works should be looked after adequately and

maintained properly. Necessary stocks of flood fighting materials should be made at vulnerable points.

Ghaghra River System (2001)

- (i) Construction of three multi-purpose reservoirs viz. Sikta across Rapti, Chisapani across Karnali (Ghaghra) and Puniagiri across Sarda in Nepal territory.
- (ii) Construction of embankments of about 166 km. length as under
 - Puranpur-Kheri embankment on the right bank of Sarda.
 - Embankment on right and left banks of Sarju upto Rly. Bridge.
 - Embankments along Daha, Sondhi, Tel and Jharahi.
- (iii) Raising and strengthening of existing embankments for total length of 253 km. as under
 - Raising and strengthening of Bansura-Ramnagar Baragaon road on the right of Ghaghra.
 - Raising and strengthening of Highway from Ikauna Bansi along the right of Rapti.
 - Raising and strengthening of roadway between Tajpur and Chapra and Chapra and Chapra-Dighwara on the left of the river Ghaghra
- (iv) Diversion of waters of Rapti into Ghaghra by constructing diversion structure with lead channel of 41 km. length
- (v) Channel improvement in the lower reaches of Ghaghra from Turtipar bridge to some distance downstream of its confluence with Ganga
- (vi) Construction of new drainage channels and improvements to the existing ones in order to give quick relief in drainage congestion to the countryside and to the areas lying outside the embankments
- (vii) Town protection works for Gorakhpur, Naugarh, Ballia, Barhaj and Pithoragarh
- (viii) Soil conservation works for reducing the silt load
- (ix) Remodeling and providing adequate spillway capacities in old tanks specially in Rapti catchment with inadequate surpassing arrangements
- (x) Raising of habitations above high flood level, flood proofing and flood forecasting measures
- (xi) Morphological studies for identified critical reaches of Rapti and Ghaghra river to be carried out on priority basis with the help of satellite imagery from NRSA.

Gomati River (1996)

- (i) Marginal embankments 586.0 km long (313 km on the left bank and 273 km on the right bank) have been proposed under different reaches of the Gomati and Sai rivers to prevent inundation of the adjoining areas.
- (ii) Construction of town protection works in Jaunpur, Lucknow, Sitapur, Sultanpur, Raibareilly and Pratapgarh.
- (iii) Survey and investigations for formulating detailed schemes on drainage improvement in

the Gomati river system by regrading and re-sectioning of the tributaries of the Gomati including provision of artificial drains for drainage of Sarada canal command area.

- (iv) Improving drainage capacity of Gomati and Sai by loop cutting in selected reaches.
- (v) Remodeling/Replacement of 12 rail/road bridge on Gomati and 26 nos. in Sai.
- (vi) The possibility of using the Jheels for flood moderation may be explored and detailed schemes for the same may be formulated and processed.
- (vii) Watershed management in the Gomati river system should be launched to prevent soil erosion.
- (viii) Anti-erosion measures may be undertaken as and when necessary.
- (ix) Raising of villages above HFL.
- (x) The State may assess the efficacy of the existing flood forecasting arrangements in the Gomati river system and approach the Central Water Commission to extend the net work if necessary. Alternatively, the State Govt. may set up their own flood forecasting unit in the uncovered arrears.
- (xi) Flood plain zoning bill on the line of model bill circulated by the Govt. of India in the year 1975 should be enacted and enforced.
- (xii) Adequate measures for flood fighting and disaster preparedness like evacuation of population, provision of relief etc. should be kept ready to meet any eventuality.
- (xiii) The existing flood control and drainage measures should be maintained meticulously and adequate funds should be provided for the purposes.

Jalangi River System (1999)

(a) Short Term Structural measures

- (i) The 'Beel' should be linked with the corresponding outfalling Khals/drains in the area to ensure drainage of area before the commencement of the Rabi season as also the existing Khals/drains should be re-sectioned wherever required to ensure proper passage of design discharge through it to the trunk drain.
- (ii) River section of the Jalangi and Bhairab which are the trunk drainage routes alongwith its tributaries (251 km.) should be suitably re-sectioned wherever required.
- (iii) The horse-shoe loops in the river course of Jalangi should be straightened (13 km.) to improve the gradient of flow in this trunk drain.

(b) Long Term Structural Measures.

- (i) Diversion of part of flood water of the Jalangi (approx. 400 cumecs i.e. one fourth of the maximum discharge) into the Churni(12 kms.) with necessary re-sectioning of the river Churni from the diversion site to its confluence with Bhagirathi (32 kms.).
- (ii) Regulator at the offtake of the Bhairab from the Padma after making detailed studies for the same.
- (iii) Short embankments in about 50 km. in long lower reach of the river Jalangi may be provided to prevent spills from back water flow of the Bhagirathi.
- (iv) The embankments along left bank of the Bhagirathi and right bank of Padma which enclose the Jalangi river are stated to be Zamindari embankments. These may not be of

the required specification. Suitable raising and strengthening (155 kms.) wherever needed may be planned and also its regular maintenance should be done to avoid any catastrophe.

- (v) Adequacy of waterways in rail and road bridges particularly in the large number of roads that have come up in the recent past in this area should be examined and waterways extended wherever required and found feasible.

Non-Structural Measures

- (i) Flood Plain Zoning in the flood plain of the river system should be done. Pending enactment and legislation of flood plain zoning, suitable administrative action should be taken for preventing new encroachment and regulating development activity in the flood plain. The flood plain should be identified and flood risk maps prepared demonstrating the information in the field and educate all concerned. Growth of towns and development activity well within the flood/plain zone should be discouraged.
- (ii) Disaster preparedness should be developed suitable to this particular area and propagated extensively for use at the time of need.
- (c) **Future studies to be carried out**
 - (i) Depth and duration of flooding in individual 'Beel' areas in conjunction with the gauge readings at outfall points should be collected and studied to provide a clear idea of the gravity of the problem being faced.
 - (ii) Flood damage data should be compiled river system-wise rather than only district-wise as being done at present.
 - (iii) A large number of 'Beel' drainage schemes already executed should be evaluated to provide a feedback for the future planners.

Kamla-Balan River System (2005)

(A) Short Term Measures

- (i) Extention of Right Kamla-Balan Eebankment from Kothram to Badlaghat (length 48 km.)
- (ii) Construction of the Jainagar-Mirchaiya embankment scheme in Nepal (length 22 km)
- (iii) Jacketting of the tributaries to prevent back water spills
- (iv) Drainage Improvement Works (as envisaged in the "Drainage Schemes In the Irrigation Commands of Gangak and Kosi Projects, 1987", of Govt. of Bihar etc.
- (v) Maintenance of existing embankments (Particularly raising & strengthening)

(B) Long Term Measures

- (i) Construction of multipurpose reservoir at Chisapani on the river Kamla in Nepal
- (ii) Determination of adequacy of waterways in rail and road bridges & provision of requisite waterways
- (iii) Watershed management works in the Upper catchment
- (iv) Setting up of a network of rain-gauge stations in Nepal having at least one self Recording station
- (v) Determination of rise in water table in the catchment if any, following flood

management works carried out in the area.

- (vi) Provision of adequate cross Drainage works in the Western Kosi Canal System under construction
- (vii) Examination of possibility of pumping Water from isolated pockets to improve drainage by the Govt. of Bihar
- (viii) Development of disaster preparedness
- (ix) Flood Plain Zoning

Kiul-Harohar River System (1993)

A. Short Term Measures

- (i) Completion of Punpun right bank embankment which will prevent its spill into the Tal.
- (ii) Closure of road culverts from where the Ganga water enters as back flow into the Tal.
- (iii) Raising of Patna Munger road wherever it is being over topped by Ganga Flood spill.
- (iv) Construction of outlet channels to Ganga wherever levels permit to ensure timely drainage of the Tal area.
- (v) Construction of regulators across the river Harohar and also at new outlet channels so that Ganga water may not enter into the Tal area.
- (vi) Construction of some flood proofing schemes in the Tal area and assessing their utility.
- (vii) Construction of embankment in the upper reaches of the rivers from where frequent spills take place inundating vast areas. The existing Zamindar embankments which are still seems to be useful may be renovated to conform with the prevailing standards.
- (viii) Installation of flood forecasting sites on the Sakri, Kiul and Falgu rivers.
- (ix) Upgrading of Jamui, Son and Garhi gauge site in Gauge-Discharge site.

B. Long Term Measures

- (i) Construction of storage reservoirs in the upper reaches across the major rivers. These reservoirs should preferably have some flood cushion. However, the effect of these reservoirs on the channels downstream by flood moderation, needs to be made before taking up these reservoirs from flood moderation/management view.
- (ii) Re-excavation of small channels which have got silted up leaving no depth available for containing the river flow.
- (iii) The flood proofing schemes, if found utilizable may be taken up in large numbers.
- (iv) Soil conservation works should be taken up in the catchment of the main river and its tributaries, specially in its upper reaches.
- (v) A suitable legislation for flood plain zoning could be enacted in the state and flood plain zones should be delineated with the help of flood maps under preparation by the survey of India.
- (vi) Detailed investigation and studies for exploring the possibility of diverting the accumulated surface water of the Tal area to underground storage (aquifers) by puncturing the bed of Tal at suitable locations.
- (vii) Taking up topographical survey of the entire Tal area in order to prepare maps having contours at an interval of 0.5 or 1m. and setting up of a network of hydrological observation sites in the entire Tal area to collect data on continuing basis.

- (viii) Adequate infrastructure for disaster preparedness at a few important sluice should be created, and proper training in the disaster management should also be provided to the personnel in-charge of flood management.
- (ix) The existing works of flood management should be properly maintained and arrangement for thorough movement of personnel in-charge of flood management should be created to facilitate their movement during flood seasons.

Kosi River System (1986)

- (i) Construction of dam on Kosi at Barahkshetra as well as on the tributaries
- (ii) Water shed management by intensive soil conservation measures in the upper catchment
- (iii) Extension of embankment on the left bank from Koparia to Kursela
- (iv) Construction of a detention basin by constructing forward embankments on both sides of the river. This is also expected to help in preventing the braiding of the river courses
- (v) Protection of river banks and the flood banks particularly on eastern bank from erosion
- (vi) Planning and execution of an efficient network of drainage channels in the eastern side, to rid the area of water logging and drainage problems
- (vii) Raising of flood prone village above the highest flood level to provide protection of life and property
- (viii) Hydrological data observations at some more sites in the upper reaches of the river in Nepal to improve the warning time for flood forecasts

Mahananda River System (1992)

- (i) Topmost priority may be accorded for preparation and finalization of joint Comprehensive Master Plan with Govt. of Nepal for this system and taking up works accordingly, which may include extension of embankments in Nepal as well.
- (ii) Embankments on both banks of the main river and its tributaries particularly in the lower reaches with complementary sluices and regulators may be completed on priority. Detailed investigation should be carried out by the State Govt. on proposed embankments in the plan and project proposals framed.
- (iii) Detailed investigations should be taken up for the Multipurpose storage reservoir project having provision for flood storage specially across the western Kankai river in the Nepal territory.
- (iv) Various barrages across the tributaries and the main Mahananda river near Indo-Nepal border and downstream proposed should be further examined by the Govt. of Bihar.
- (v) Extensive watershed management works should be taken up in the upper catchment of the Mahananda basin with co-operation of the Govt. of Nepal.
- (vi) The waterways of the existing railway and road bridges may suitably be increased.
- (vii) A suitable legislation for flood plain zoning should be enacted in the States and flood plain zones should be delineated with the help of flood management maps of the Survey of India. This will facilitate regulation of land use for various development activities in the river system.
- (viii) Adequate infrastructures for disaster preparedness should be created, besides providing proper training in the disaster management from different angles.
- (ix) A properly equipped and well connected flood forecasting and warning network should

be installed in the flood sensitive areas in order to have warning well in advance to the administration and the people in the flood prone areas for taking required measures to face the floods.

- (x) The maintenance of the flood control structures may be given priority.
- (xi) The flushing of the river is a must particularly in the lower reaches having the mild slopes. If flushing is not possible in the big river, dredging may be resorted to maintain the required cross-section capable of carrying the maximum discharge.
- (xii) Apart from the proposals/schemes proposed in the Comprehensive Plan, the State concerned have been proposing various flood control schemes every year as per local requirements. While doing so the overall situation in the entire river length alongwith the provision in the Comprehensive plan of flood management of the river system should be kept in view.

Mayurakshi River System (1999)

- (i) Strengthening/Raising of embankments
- (ii) Soil conservation measures in the upper catchment
- (iii) Flood control reservoir in the Ajoy
- (iv) Thorough examination of the embankments for the purpose of deciding which of them are to be retained.
- (v) Improving the existing outfall channels.
- (vi) Provision of additional drainage outlets.
- (vii) Provision of additional waterways in different sections as mentioned in the comprehensive report.
- (viii) Removing or retiring some of the Gher bunds and constructing escapes or sluices in all the Gher bunds decided to be retained.
- (ix) Resuscitation of existing outfall system of Uttarasan and Babla with provision of a regulator over river Uttarasan of capacity 850 cumecs and increasing the waterway at the existing road/railway bridges including the proposed spill bridge on river Babla for a design discharge of 2,124cumecs.
- (x) Jacketting the Dwarka for a length of 4.8 km. D/s of Sankoghat and tagging the left embankment with spill checking embankment of Beel area detention basin.
- (xi) Raising & Strengthening the existing embankments on both banks of river Mayurakshi below Sainthia and upto Babsahi road alongwith Jacketting the river Kuya upto Badshahi road with existing left embankments tagged with right embankment of river Mayurakshi and right embankment tagged with Badsahi road.
- (xii) Provision of detention basin of 106.0 sqkm. with pond level at 18.30 m. mainly Hijol Beel area with a demarcating embankment of length 154 km. all around to hold the flood volume of Mayurakshi river system.
- (xiii) Provision of a flushing regulator and cross dam over Thum-Thumi channel bridge over river Banki, sluices over river Kanamor and other ancillary structures etc.
- (xiv) Provision of bank protection works at vulnerable reaches.
- (xv) Provision of retired embankments where considered necessary.
- (xvi) Provision of other ancillary structures like sluices at select location, repairing and remodeling of existing sluices etc. as per requirement.

- (xvii) Separation of Dwaraka Brahamni Kanamor system from the Mayurakshi system and provision of an independent outfall channel into the Bhagirathi may also be considered.
- (xviii) The number of G/D sites and Raingauge stations should be expanded to SRRS.

Punpun River System (1997)

- (i) Review of the design of existing dams in the Punpun river systems viz. Batans Reservoir Scheme, Jagannath dam and Ankhar Dam should be done to study the possibility of providing flood cushion in these dams alongwith adequate flood forecasting network.
- (ii) Embankment on the Punpun, Morhar and Dardha should be constructed as detailed below:-
 - a) Embankment on right bank of Punpun from Fatwah to Jahanabad-Kinjar road, out of which work on 12.33 km. long embankment is already under progress.
 - b) Extension of existing left Punpun Embankment from Akbarpur to Jahanabad Kinjer road.
 - c) Construction of embankments on both banks of Morhar from confluence with Punpun to Taregana Bharatpur road or further upstream as found necessary after detailed investigation.
 - d) Construction of embankments on both banks of Dardha from the confluence with Punpun to Taregana Dumra road, or further upstream as found necessary after detailed investigation.
- (iii) Additional waterway under road and rail bridges should be provided to reduce drainage congestion, if any, for which detailed studies may be carried out. Particularly, the discharge basis, (which has been tentatively accepted to be of the order of 2,20,000 cusecs) on which basis the quantum of discharge for which spill structures will be required to be provided in the National Highway between Deedarganj and Fatwah can be decided. Total jacketing of the river should not be done until adequate provision of waterway in rail and road bridges is made.
- (iv) The feasibility of improving the channel capacities of the Punpun, Morhar and Dardha by taking suitable measures should be explored but with due caution, as pointed out by the RBA in its report.
- (v) The possibility of construction of Flood sluices on proposed right Morhar embankment which will facilitate diversion of water to Dardha thereby keeping the flood in Morhar to be desired level. Similar possibility in case of Ganghar river also be examined.
- (vi) The feasibility of diversion of some of the flood water of Punpun river to the Sone river should be explored.
- (vii) A few discharge silt sites should be established in the non spilling portion of the river upstream of Kinjer and regular observations should be done. Simultaneously, rainfall observations with the help of a couple of self recording rain gauges should be started with the help of data so collected discharge of the Punpun rivers should be determined on a rational basis. Similar observations should also be done at suitable sites of Morhar and Dardha.
- (viii) A suitable model for forecasting the flood on the basis of actually observed rainfall and discharge data should be developed. The forecasting services should also be extended to Morhar and Dardha.

- (ix) Soil conservation measures should be executed to prevent soil erosion in the catchment. Priority areas for soil conservation measures should be delineated on the basis of
 - a. reconnaissance survey and also with the help of remote sensing technique.
- (x) The likely a diverse effects on the countryside drainage when Punpun, Dardha and Morhar are fully jacketed, should be studied in depth.
- (xi) To control high flood possibilities of construction of a few small reservoirs may be explored. Also the possibility of use of depression in the lower reach of river to act as natural detention basis may be examined. Also bank stabilization and anti-erosion works may be executed as and where required.
- (xii) It is observed that some town and village area are frequently effected by floods. These areas may be provided with ringer bund.
- (xiii) It is seen that when river bank/bed are silted discharge are not passing through these areas in normal flow and people of the surrounding area start living in these places. But all these places effected by high floods causing loss of property/lives of the please settled in the area. So necessary flood plain zoning law should be enacted so that people cannot settled in vulnerable area. Flood Plain Zoning Map should also be prepared to assess the flood prone area.
- (xiv) Adequate infrastructure should be made disaster preparedness.
- (xv) Proposed/ongoing irrigation schemes should be completed on priority basis.

Ramganga River System (1999)

- (i) All existing works like embankments, Anti-erosion works, drainage etc. should be adequately maintained.
- (ii) The State authorities should not allow the villagers, people living in towns etc. to encroach upon the natural bed of the river. Steps should be taken to implement flood plain zoning effectively for proper flood plain management in this river system.
- (iii) Soil Conservation measures particularly in the upper reaches of the river system need to be taken with a view to control the problem of soil erosion brought about by ruthless exploitation of forests over grazing and improper management of agricultural land over the years.
- (iv) Raised platforms should be constructed in the flood affected areas so that people can stay safely on that platforms during occurrence of floods.
- (v) Appropriate flood forecasting system may be introduced for the inflow forecast of reservoir at Kalagarh.
- (vi) Use of modern technologies of Remote Sensing etc. should be resorted for better understanding of river morphology, and for effective measures of anti-erosion works and flood fighting.

Rupnarayan-Haldi-Rasulpur Rivers System (2003)

- (i) The existing Khals/drains etc. should be re-sectioned wherever required to ensure passage of discharge through it to the trunk drain.
- (ii) On-going drainage schemes should be completed at the earliest to get relief of drainage congestions.

- (iii) The Horse shoe loops of river course at near Madpur on river Kasai and below the confluences of Kalaichand with Kangsabati should be straightened to improve gradient of flow.
- (iv) Bank protection work should be taken up in the lower reaches of Rupnarayan-haldi-Rasulpur river system specially from Gopalnagar (R. Rupnarayan), Sillalpur (R. Haldi), & Danpurulia (R. Rasulpur) to the confluence of river Hooghly.
- (v) The river Kangsabati bifurcates into two channels near Kapastikri, one outfalls into the river Dwarkeshwar, forming the river Rupnarayan while the other outfalls into the river Kaliaghai, forming the river Haldi. To control the flow of the river Kangsabati into the river Rupnarayan and the river Haldi a control structure at Kapastikri is needed on the river Kangsabati for flood moderation purpose.
- (vi) Embankment may be constructed in the lower reaches after adequate survey & investigation to check the bank spilling of flood water.
- (vii) Existing embankments may be suitably raised & strengthened after proper investigation and survey.
- (viii) Construction of storage reservoirs in the upper reaches of Rupnarayan-Haldi and its tributaries may be planned. Construction of anti tide sluice at the outfall of different khals/channels with Rupnarayan-Haldi may be considered to check inflow of tidal water into khals/channels which will subsequently improve drainage congestion in country side areas due to improvement of outfall condition. Site for construction of Upper Kangsabati Dam selected at Bansla-Dalong in P.S. Pucha Purulia district, site for construction of Gandeswari dam located at Chamkara in Bankura district and site for construction of Dwarkeshwar dam selected at Suknibasa in the district of Bankura. A barrage will also be constructed below the confluence of Gandeswar-Dearkeshwar river at Pratapur, district-Bankura.
- (ix) Flood Forecasting and Warning system should be introduced below Mohanpur in Rupnarayan and Haldi river system.
- (x) Water shed management in the upper catchment should be taken up immediately.
- (xi) Flood plain zoning maps and regulation of law should be made.
- (xii) Disaster preparedness cell should be made.
- (xiii) Stoppage of fly ash flow from Kolaghat thermal plant into Rupnarayan is urgently required.
- (xiv) Self recording Raingauge stations needs to be increased.
- (xv) Nos. of gauge and discharge sites is to be increased.
- (xvi) Morphology studies in the river basin need to be carried out by remote sensing application.
- (xvii) Flood damage data to be collected basin wise.

Sone River System (2004)

(A) Short Term Measures

- (i) Gaps in the existing embankments should be plugged at the earliest.
- (ii) Drainage scheme as recommended by Tripathi Committee should be taken up at the earliest.
- (iii) All weather road should be constructed on top of the embankments wherever there is no

Pucca road running parallel to it.

- (iv) Detail system study should be taken up to assess the flood moderation impact of various individual reservoirs existing/proposed as well as due to the integrated operation of these keeping in mind the overall scarcity situation in the Sone basin as whole.

(B) Long Term Measures

- (i) Arrangement for inflow forecast and measurement of out flow at major reservoir sides be made.
- (ii) Remaining works of soil conservation should be made .
- (iii) Disaster preparedness should be developed suitably for this particular area and propagated extensively for use the time of need.
- (iv) Flood plain zoning in flood plain should be done. Pending enactment and legislation of flood plain zoning suitable administrative steps should be formally taken for preventing new encroachment and regulating developmental activity in the flood plain.
- (v) All encroachment should be provided for early completion of various reservoirs.

Tons River System (2000)

- (i) This river system has inadequate number of hydrological observation sites. Additional hydrological observation sites are required to be installed to supplement flood forecasting activity in the basin.
- (ii) Silt observation may be started at any gauge and discharge site to have a watch on river behavior.
- (iii) Recommendations of Rastriya Barh Ayog with regard to collection of flood damage data and methodology of flood damage assessment need to be followed in true sense for better planning of flood control measures.
- (iv) Back water study based upon long term data is prerequisite before taking up construction of afflux bunds /embankment on river Tons and Belan.
- (v) Improvement of channel conditions of Bihar nadi and its tributaries is required to be done to increase its carrying capacity.
- (vi) Straightening of long crops of Tons upstream of Meza road site.
- (vii) Internal linking of the low-lying areas to respective drainage channels and on to the rivers or any of its tributary may be taken up to reduce drainage congestion. These low lying areas may also be developed as detention basins.
- (viii) Watershed management works in upper catchment may be taken up.
- (ix) Concerned state govt. may chalk out detailed disaster management plan to effectively reduce the impact of floods/natural disasters.
- (x) Flood plan zonation map of the basin may be prepared.
- (xi) Inflow/gauge forecast sites needs to be established in the basin to improve integrated reservoir operation and also to issue flood bulletin on real time basis to appraise the administrative/people of the areas.
- (xii) Inter-state dispute may be resolved amicably in consultation with GFCC.

Yamuna River System (2002)

- (i) Soil conservation measures particularly in the upper reaches of the river system need to be taken with a view to mitigate the problem of soil erosion brought about by ruthless exploitation of forests over grazing and improper management of agricultural land over many years.
- (ii) Flood forecasting technique may continue to be modernised/updated and its programme expanded to include additional areas where necessary. The State Governments concerned may also set up their own flood forecasting units in the uncovered areas in close coronation with Central Water Commission.
- (iii) The State authorities may look into the feasibility of providing/augmenting flood storage in all on-going/proposed multipurpose projects viz. Lakhwar Vyasi and Kishau Dams in Uttar Pradesh and Reunka Dam in Himachal Pradesh and explore the possibility of construction of flood detention reservoirs, particularly upstream of Tajewala.
- (iv) Non-structural measures like flood plain zoning be given serious consideration. Preparation of flood risk map after necessary surveys and flood plain zoning through appropriate legislation and follow-up regulations may be taken up/pursued by the concerned States/U.T in the respective regions from Tajewala to Allahabad.
- (v) All the schemes on flood control and drainage in hand/under construction may be completed expeditiously by the concerned States/U.T. authorities to achieve immediate benefits rather than taking up a large number of new schemes with outlay thinly distributed during the plan period.
- (vi) To retain the flood detention capacity of the flood plains which has been and is likely to be cut off by the existing/proposed embankments, provision of fuse plugs/breaching sections in the rural embankments may be considered. These fuse plugs/breaching sections should be operative only during floods with a return period of more than 25 years. These sections shall not require any physical breaching and the overflows would be semi-control. They shall be provided with energy dissipation devices on the land side to reduce sand deposits and damage to agricultural land due to high velocity of flow. Full and speedy compensation may be paid to the rural population whose land/properly would get affected on this account. The extent of inundation being known before hand, the damage which is likely to occur can be approximately assessed in advance and compensation paid without less of time. The issues pertaining to fuse plugs/breaching sections would need to be sorted out at higher political level among the States of Uttar Pradesh and Haryana and Delhi.
- (vii) All the remaining schemes contained in the Master Plan of Sahibi Nadi-Najatgarh Nala Drainage Basin which had been prepared in Central Water Commission in 1978 and agreed to by the concerned States/U.T. may be completed expeditiously with suitable modification, wherever required due to changes that might have taken during the intervening period.
- (viii) The existing flood control and drainage works should be looked after adequately and maintained properly. Necessary stocks of flood fighting materials should be readily available at vulnerable points along the embankments well before the on-set of flood season. The communication should be improved wherever required.
- (ix) The choked drains may be de-silted to proper sections and gradient after proper study and evaluation of the benefit accruing from the scheme. Additional drains may be provided in the uncovered areas which may be designed as per I.S. codes or guidelines given by the CWC. The waterways under the roads, railways and irrigation channels should be increased if required after proper investigating.

- (x) Additional towns and villages may be provided flood protection wherever required. Villages may be protected against floods preferably by flood proofing/raising them or otherwise by construction of ring bunds which should be so aligned as to avoid obstruction to the free flow of flood water in the river.
- (xi) It is necessary to identify the chronically affected sensitive flood prone and erosion prone reaches on river Yamuna and its tributaries and morphological studies should be conducted for these reaches and accordingly protection measures should be taken so that these protective works prove to be more efficient long lasting and have no adverse effect on river regime either upstream or downstream of the protected section.

Tidal River System (2003)

(A) Short Term Structural Measure

- (i) The existing Khals /Drains etc. should be re-sectioned after proper survey and investigation to ensure passage of discharge through it to trunk drain.
- (ii) On-going drainage scheme should be completed at the earliest to get relief of drainage congestions.
- (iii) Bank protection work should be should be taken up in the lower reaches of Tidal rivers to avoid further erosion.

(B) Long Term Structural Measures

- (i) Embankment may be constructed after proper survey and investigation especially in Nadia & 24–Pargana (N) district to check the bank spilling of flood water.
- (ii) Existing embankment may be strengthen and raised as per requirements specially for Sunderban area.
- (iii) Construction for anti-tide sluice at the outfall of different khals / channel which will subsequently cause drainage congestion in country side areas improvement of outfall condition.
- (iv) Modelling of Flood Flows in the Tidal Catchment

(C) Non Structural Measures

- (i) Flood plain zoning maps and regulation of law should be made.
- (ii) Disaster preparedness cell should be made.

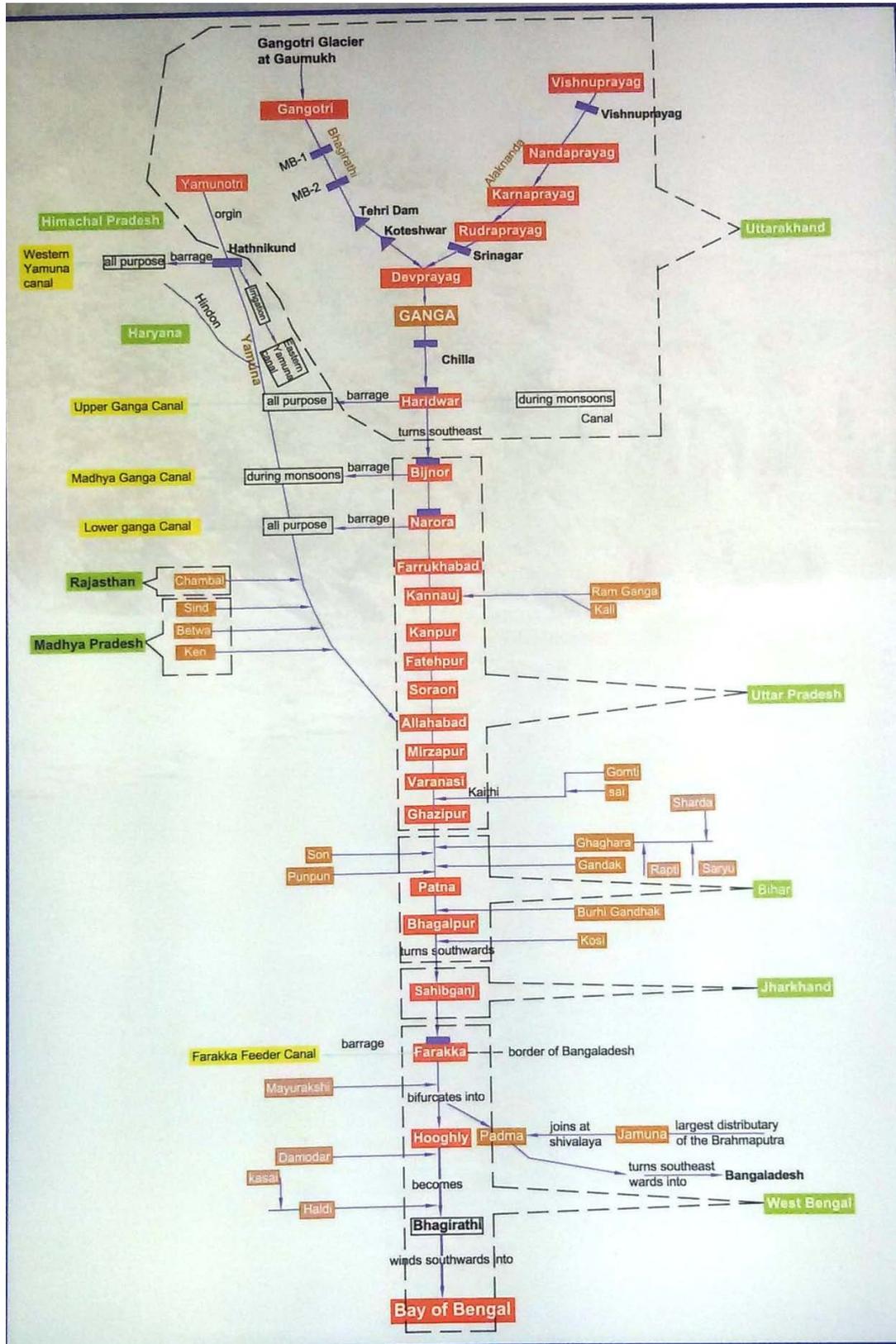


Plate I: Line diagram of river Ganga