CHAPTER - I

INTRODUCTION

1.0 Background

Ministry of Water Resources, Government of India in the year 2004 decided to undertake comprehensive assessment of feasibility of linking of the rivers of the country starting with southern rivers in a fully consultative manner and to explore the feasibility of intrastate river links of the country.

Accordingly, proposal for inclusion of prefeasibility / feasibility studies of intrastate links aspect in NWDA's mandate was put up for consideration in Special General Meeting of NWDA Society held on June 28, 2006 and it was decided to incorporate this function in NWDA's mandate. Finally, MoWR vide Resolution dated November 30, 2006 modified the functions of NWDA Society to include preparation of prefeasibility/feasibility studies of intrastate links.

The functions of NWDA were further modified vide MoWR Resolution dated May 19, 2011 to undertake the work of preparation of Detailed Project Reports (DPRs) of intrastate links also by NWDA. Further, the Gazette notification of the enhanced mandate was issued on June 11, 2011.

In the meantime, on the basis of approval conveyed by MoWR in June, 2005, NWDA requested all the State Governments to identify the intrastate link proposals in their States and send details to NWDA for their prefeasibility / feasibility studies. Bihar responded to NWDA's request vide letter No. PMC-5(IS)-01/2006-427, Patna dated May 15, 2008 and submitted their proposals. Subsequently, a meeting was held between the officers of Water Resource Department (WRD), Government of Bihar and NWDA on June 16, 2008 in Patna. In the said meeting, Government of Bihar requested NWDA to prepare the prefeasibility reports of six intrastate links out of which two were irrigation schemes. The Kosi-Mechi Link is one of them.

Accordingly, NWDA directly took up the work of preparation of the DPR of the above link canal project. Further, in 27th Annual General Meeting (AGM) of NWDA held on March 31, 2012, Water Resources Minister, Government of Bihar requested NWDA to prepare the Preliminary

Project Report (PPR) of Kosi-Mechi link project on priority. After carrying out detailed topographical surveys and firming up the techno-economic viability of the project, NWDA has prepared PPR of Kosi-Mechi link project as per the CWC guidelines for submission, appraisal and clearance of irrigation and multipurpose projects-2010 and submitted to Government of Bihar and Central Water Commission (CWC) during October, 2012 for examination. The PPR of the project was duly examined by CWC and comments thereon received from CWC were discussed with the officers of WRD, Government of Bihar during meeting taken by Principal Secretary, Government of Bihar on January 16, 2013.

1.1 Proposal received from WRD, Government of Bihar

The Government of Bihar vide letter dated 28.07.2008 proposed to extend existing EKMC beyond its tail end RD 41.30 km so that rivers Kosi and Mechi which flow through Bihar itself after crossing Indo-Nepal border, can be linked within Bihar State by taking off the link canal from existing Hanuman Nagar barrage and outfalling in river Mechi at suitable point while running the canal adjacent to Indo-Nepal border. It will provide irrigation in Araria and Kishanganj districts depending upon pondage available in Hanuman Nagar barrage. Though this intrastate link canal will not have any back-up storage scheme presently, it can be later supported by and linked with proposed Kosi High Dam which is likely to take concrete shape after joint surveys and investigations by Government of Nepal and India.

Out of the total command area 4,45,000 ha of Mahananda river basin, the Kosi-Mechi link canal will irrigate the areas excluding CCA covered by other schemes falling under this river basin with irrigation of 75%, 95% and 80% of CCA for kharif, rabi and hot weather crops respectively.

To augment flow in the link canal, barrage at its crossing points with rivers like Parman, Bakra, West Kankai, East Kankai and Mechi may also be considered as an integrated approach. This intrastate link scheme will thus transfer part of surplus water of Kosi basin to Mahananda basin.

This link will have advantage of complete independent control of Bihar.

1.1.1 Aim and justification of the project

The river Kosi is an international river originating from Tibet flowing through Tibet, Nepal in Himalayan Mountains and the lower portion through plains of North Bihar. To overcome the acute problem of shifting of course of Kosi river, heavy sediment load, flooding etc. and to alleviate the severe suffering of the people of Bihar, the then His Majesty's Government of Nepal and The Government of India signed an agreement on 25th April 1954 for implementation of Kosi project. The Kosi project includes a barrage namely Hanuman Nagar across river Kosi located near Hanuman Nagar town close to Indo-Nepal border, canal headworks, Western Kosi Main Canal (WKMC) system in Nepal, Eastern Kosi Main Canal (EKMC) system in India. The present proposal is an extension of EKMC upto river Mechi, a tributary of river Mahananda.

The aim of extension of EKMC upto Mechi river is mainly to provide irrigation benefits to the water scarce Mahananda basin command in the districts of Araria, Kishanganj, Purnea and Katihar during kharif season depending upon the pondage available in Hanuman Nagar barrage. Though this intrastate link canal will not have any back-up storage scheme at present, later it can be supported by and linked with proposed Kosi High Dam which is likely to take concrete shape after joint surveys and investigations of Kosi High Dam project by Government of Nepal and India. Out of the total command area 4.40 lakh ha of Mahananda river basin, the proposed Kosi-Mechi link canal will irrigate 2.15 lakh ha areas excluding CCA covered by other schemes falling under this river basin. This intrastate link scheme will thus transfer part of surplus water of Kosi basin to Mahananda basin. In view of irrigation benefit from the link canal, the project is fully justified.

1.2 Earlier studies

1.2.1 Prefeasibility Report (PFR)

NWDA has prepared the prefeasibility study report (PFR) of Kosi-Mechi intrastate link project in 2009. It was proposed to utilize the existing EKMC upto its tail end RD 41.30 km after remodelling and its extension upto river Mechi for providing irrigation in new command areas lying between rivers Parman and Mechi in Mahanadi basin and further diversion of balance

surplus Kosi water into river Mechi for future utilization by Government of Bihar. The total length of the link canal including the length of the existing EKMC was 120.15 km.

As per the PFR, the Kosi-Mechi Intrastate link project envisaged diversion of 12,582 MCM of Kosi water from existing Hanuman Nagar barrage to Mechi river. After meeting the requirements of existing EKMC, the link canal was proposed to provide 2265 MCM of water for irrigation in the new command areas. Provision of 14 MCM of water for domestic and industrial water needs for enroute village/towns were also made. Transmission losses in the canal were computed @ 0.6 cumec per square km wetted perimeter and estimated to be 73 MCM. After meeting all the enroute requirements 4148 MCM of water was proposed to be diverted into river Mechi for further utilization by Government of Bihar to supplement irrigation demand of Mahananda basin. The total cost of the link project was estimated as Rs. 4441.82 crore. The B.C ratio and IRR of the link canal project were assessed as 1.51 and 15.99% respectively.

1.3 Present studies at DPR stage

To expedite the preparation of DPRs of intrastate river linking projects of Bihar, a meeting was held on January 18, 2010 between officers of WRD, Government of Bihar and NWDA. In the meeting, the Government of Bihar requested NWDA to prepare DPR of Kosi- Mechi link project as this scheme was found viable at the PFR stage. It was also decided that NWDA can go ahead with the preparation of DPR directly to save time instead of first preparing the feasibility report and then DPR. Accordingly, after carrying out detailed topographical surveys and firming up the techno-economic viability of the project NWDA directly took up the work of preparation of DPR of this link project. The observations of Government of Bihar on PFR of Kosi-Mechi link are given in Annexure 1.1.

In 27th Annual General Meeting of NWDA held on March 31, 2012 Water Resources Minister, Government of Bihar requested NWDA to prepare the Preliminary Project Report (PPR) of Kosi-Mechi intrastate link project on

priority. Accordingly, after carrying out detailed topographical surveys and firming the techno-economic viability of the project up NWDA has prepared PPR following the CWC guidelines for submission, appraisal and clearance of irrigation and multipurpose projects, 2010 and submitted the same to Water Resources Department, Government of Bihar and CWC in October, 2012. The study was duly examined and comments of CWC were discussed with Government of Bihar and CWC officials during meeting convened by Principal Secretary, Water Resources Department, Government of Bihar held on January 16, 2013 at Patna. The replies of NWDA on comments of CWC on PPR are given in Annexure 1.2. Further comments of CWC on hydrology were also received and appended as Annexure 1.3.

Some changes in the proposal of pre-feasibility stage have been made at Detailed Project Report stage due to following reasons:

(i) There is an existing canal power house at RD 3.66 km of existing EKMC utilizing a fall of 3.96 m and having an installed capacity of 19.2 MW. The Maximum tail water level of this power house is 70.104 m. The salient features of canal power house are given in Annexure 1.4. This fall was not accounted at PFR stage. Due to consideration of this fall, the canal alignment has been shifted to lower levels.

(ii) The Government of Bihar is constructing a silt settling tank in the initial reach at RD 1.06 km of existing EKMC for silt control in the canal. The same has been considered in the DPR with slight remodelling of the canal as design discharge of existing EKMC at RD 4.57 km is 382 cumec where as the combined discharge of Kosi-Mechi link canal at head is 573 cumec.

(iii) The Bihar State Hydro Electric Power Corporation has proposed a hydro electric power station located about 31 km downstream of Hanuman Nagar barrage near village Dagmara having a installed capacity of 26X5 MW. The impact of this hydroelectric power station has also has been considered in the study.

(iv) The irrigation potential of Hanuman Nagar barrage is still not fully developed. The Central Water Commission has reassessed the existing as well as proposed water requirements for full development of irrigation potential of barrage.

1.4 Variation in present studies from PFR stage

Keeping in view the changes in the proposals of PFR stage have been made at DPR stage.

(i) Water diversion through link canal

Considering the new assessed water requirement of Hanuman Nagar Barrage and downstream requirements due to Dagmara Hydropower project, the augmentation to river Mechi as proposed in earlier studies has now been dropped at DPR stage. The link canal will now provide irrigation during kharif season from June to October only. Due to non-availability of water in non monsoon period, the proposal of drinking water supply has also been dropped. However, further irrigation and domestic and industrial water supply may be considered, if the Kosi High Dam comes up in future.

(ii) Remodelling of existing Eastern Kosi Main Canal

Keeping in view the technical and economic viability, the parameters of remodelled section of existing canal are planned in such a way so that maximum numbers of existing structures can be utilized. The comparison between existing EKMC and remodelled Kosi-Mechi link canal from RD 0.0 km to 41.3 km is furnished in Table 1.1.

Table-1.1

Parameters of the existing EKMC and proposed remodeled canal

Sl. No.	RD	Particulars	FPS unit	MKS unit	FPS unit	MKS units
1	0.0	Design discharge	15000 cusec	425 cumec	20247 cusec	573 cumec
		Bed width	360'	110 m	431.43 '	131.50 m
		Canal depth	11'6"	3.5 m	11'6"	3.50 m
		Bed slope	1:11000		1:11000	
		Canal section	Unlined		Lined	
2	4.57	Design discharge	10589 cusec	300 cumec	17288 cusec	490 cumec
		Bed width	260'	79.24 m	260.83’	79.50 m
		Canal depth	11'	3.35	13.9’	4.25 m
		Bed slope	1:10000		1:11000	
		Canal section	Unlined		Lined	
3	13.35	Design discharge	8266 cusec	234 cumec	15677 cusec	444 cumec
		Bed width	220'	67.06 m	236.22’	72.00 m
		Canal depth	11'	3.35 m	13.9’	4.25 m
		Bed slope	1:10000		1:11000	
		Canal section	Unlined		Lined	
4	23.9	Design discharge	4870 cusec	138 cumec	11695 cusec	331 cumec
		Bed width	145'	44.20	193.57’	59.00 m
		Canal depth	9'6"	2.9 m	13.1’	4.00 m
		Bed slope	1:9000		1:11000	
		Canal section	Unlined		Lined	
5	30.93	Design discharge	4610 cusec	131 cumec	11695 cusec	331 cumec
		Bed width (m)	145'	44.20	193.57’	59.00 m
		Canal depth	9'	2.75 m	13.1’	4.00 m
		Bed slope	1:9000		1:12000	
		Canal section	Unlined		Lined	
6	39.99	Design discharge	1437 cusec	41 cumec	8301 cusec	235 cumec
		Bed width	66'	20.11m	172.24’	52.50 m
		Canal depth	7'	2.13 m	11’6”	3.50 m
		Bed slope	1:7500		1:12000	
		Canal section	Unlined		Lined	

To maintain the functioning of the canal power house located at RD 3.66 km as it is the existing full supply level, FSD and bed slope of canal upto RD 4.57 km has been kept intact. The full supply depth of canal is considered as varying from 4.25 m to 3.5 m with a bed slope of 1 in 11000 in entire length of EKMC up to RD 41.30 km.

(iii) New extended Kosi-Mechi link canal (RD 41.30 km to RD 117.50 km)

Beyond tail end of existing EKMC, a new canal alignment is proposed. The full supply depth of canal is varying from 4.0 m to 3.5 m with a uniform bed slope of 1:12000. The canal will out fall in river Mechi at RD 117.50 Km.

The Kosi-Mechi Intrastate Link (existing canal) offtakes from the left bank head regulator of the Hanuman Nagar barrage at FSL 74.371 m and outfalls into river Mechi at FSL 54.239 m. The total length of the link canal is 117.50 km, out of which alignment in the initial reach, i.e. from RD 0.00 km to 41.30 km has been kept the same as that of existing Eastern Kosi Main Canal whereas alignment in the remaining reach i.e. from RD 41.30 km to 117.50 km will be new one. The index map of Kosi-Mechi link project is appended as Plate 1.1 in Drawing Volume of the report. The layout plan of existing Hanuman Nagar barrage, plan and section of eastern Kosi canal head regulator at Hanuman Nagar barrage and outfall point of the Kosi-Mechi link canal are shown as Plate 1.2, 1.3 and 1.4 respectively in Drawing Volume of the report.

The design discharge of canal at its offtake point is 573 cumec. The full supply depth from RD 0.00 km to RD 41.30 km is proposed varying from 4.25 m to 3.5 m with 0.75 m free board. While full supply depth from RD 41.30 km to RD 117.50 km is varying from 3.5 m to 2.00 m. The bed slope is kept as 1:11000 between RD 0.00 km to RD 41.30 Km and 1:12000 between RD 41.30 km to RD 117.50 km. The comparison between the link proposal at PFR stage and DPR stage is given in Table 1.2.

Table-1.2

Comparison between proposals of PFR /PPR stage and DPR stage

Sl. No.	Particulars	As per PFR/PPR	At DPR stage
1	Design discharge at head	537 cumec	573 cumec
2	Full supply depth of canal		
i	Existing canal (RD 0.00to 41.30 km)	6 m	4.25m to 3.5 m
ii	New canal (RD 41.30 to 117.50km)	6 m	3.5 m to 2.0 m
3	Bed width		
i	At head	55 m	131.5 m
ii	At tail	32 m	15.00 m
4	Length of canal	120.15 km	117.50 km
5	Bed slope		
(i)	RD 0.00 - 41.30 km	As per table 1.1	1:11000
(ii)	RD 41.- 117.50 km	1:15000	1:12000
6	Canal power house	Not considered	Considered
7	Location of outfall at Mechi river	15 km u/s of its confluence of river Mechi andMahanand	1.50 km u/s of its confluence of river Mechi andMahanand
8	New command area	2.43 lakh ha	2.15 lakh ha
9	Water utilisation (MCM) for		
i	Irrigation	2265	1718
ii	D and I requirements	14	0
iii	Augmentation to Mechi river	4148	0
iv	Total diversion including existing utilisation of EKMC of 6082 MCM	12582 MCM	7896 MCM
10	B. C. Ratio	1.51	3.66
11	IRR	15.99%	27%

The details of link alignment surveys and other related aspects are described in respective chapters.

1.5 Lessons learned from previous interlinking projects

No river linking project has been implemented in Bihar so far. However, brief details of a few river linking projects of past and recent past in India are given below.

Periyar-Vaigai Link System

The project is the most notable endeavor of the 19th century in transbasin diversion. The project involves transfer of water from Periyar basin to Vaigai basin. A masonry gravity dam of 47.28 m high has been constructed across a gorge on the west flowing Periyar river. A 1,740 m long tunnel with a discharging capacity of 40.75 cumecs has been driven across the mountain barrier to convey the water eastwards to Vaigai basin. The project was commissioned in 1895 and provided irrigation to 57,923 ha initially, which has since been extended to 81,069 ha. There is also a power station of 140 MW capacity.

Parambikulam-Aliyar Project

The project was built during 1960s after the finalisation/signing of an agreement between Kerala and Tamil Nadu. It is a multi-purpose project consisting of five west and two east flowing rivers. Dams were constructed on these 5 rivers and inter-connected to divert water eastward from Parambikulam (Chalakudy) catchment in Kerala to Aliyar in Bharathapuzha and Cauvery catchments in Tamil Nadu. Water is ultimately supplied to drought prone areas of Coimbatore district of Tamil Nadu and Chittoor district of Kerala. The water so diverted is used for irrigation to 16,200 ha of land. The project also generates 185 MW of hydropower.

Kurnool-Cudappa Canal

A private company started this scheme in 1863. The project transfers water from Krishna basin to Pennar basin. A 8.23 m high anicut (weir) was built on the river Tungabhadra upstream of Kurnool town. A 304 km long canal with a capacity of 84.9 cumecs at its head extends from Krishna to Pennar basin and irrigates 52,746 ha. The scheme was taken over by Govt. of India in 1882.

Telgu Ganga Project

This project has been recently implemented primarily to meet the pressing need of water supply to Chennai metropolitan area. It brings

Krishna water from Srisailam reservoir through an open canal, first to Somasila reservoir in Pennar valley. This involves rock cuts upto 35 m deep. From Somasila, the water is taken through a 45 km canal to Kandaleru and then to Poondi reservoir in Tamil Nadu through another 200 km long canal. By mutual agreement, 12 TMC ft. of water is delivered to Tamil Nadu at the border from Krishna basin. This greatly augments the water supply to Chennai city. The canal also irrigates 2.33 lakh ha. in Andhra Pradesh enroute. The project was made possible by Maharashtra, Karnataka and Andhra Pradesh voluntarily foregoing 5 TMC. each from their entitlement. This project is a fine example not only of hydraulic engineering but also of Inter- State cooperation.

Beas-Sutlej Link

The work on the Beas Project was started to harness Beas water, comprising two units namely Beas Unit-1 which is the Beas Satluj Link Project and Beas Unit-II i.e. Beas Dam Project. The Beas Satluj Link Project completed in 1977, diverts 3.82 million acre feet (4716 million cubic meter) of Beas water to river Satluj through 37.26 Km long water conductor system consisting of two tunnels of 13.11 Km and 12.35 Km length and one open channel of 11.80 Km in between balancing reservoir. The diverted water generates 990MW of power at Dhero Power House in Himachal Pradesh. Beas Unit-II i.e. Beas Dam Project completed in 1976. It is a large storage dam which is main source of water to the desert lands of Rajasthan with 25.10 lakh ha Gross Command Area and 396 MW of power is also generated at this project.

Indira Gandhi Canal Project

The Indira Gandhi Nahar Scheme (IGNS), formerly known as Rajasthan Canal Scheme is one of the impressive schemes aiming to transform desert wasteland in agriculturally productive area. The scheme objectives include irrigation, drought proofing, providing drinking water, improvement of environment, afforestation, employment generation, rehabilitation and development animal wealth and increasing agricultural production.

The scheme was conceived in October 1948 with the consideration of bringing prosperity to the devastated area. The scheme with an estimated cost of Rs. 66.67 crores was sanctioned in July 1957. In 1956-57 the Government of India accepted the scheme in principle and IGNP Board was created in 1958. The charge of construction of the entire canal network and related infrastructures over the entire IGNP command area has ever since come under the Board. The construction commenced in 1958. The IGNP was designed to utilise 9.362 MCM/yr of the total 10.608 MCM/yr allocated to Rajasthan from the surplus waters of the Ravi and Beas rivers under "Indus Water Treaty' (1960) between Indian and Pakistan.

The construction work of the scheme was carried out in two stages.

Stage-I

Stage-I consists of a 204 km long feeder canal and 189 km long main canal and 3454 km long distribution system and serves 0.553 million ha culturable command area.

Stage-II

Stage-II consists of 256 km long main canal and 5606 km long distribution system and serves 1.41 million ha of culturable command area.

These examples show that for a country like India having such a huge population with uneven distribution of rainfall with respect to space and time, interlinking of river projects are need of the present and future.

Kosi-Mechi link project is the second intrastate link project of Bihar taken up by NWDA for preparation of DPR. This DPR is prepared by NWDA making use of consultancy services of GSI and CSMRS.

1.6 Project planning and optimization of benefits

The Kosi–Mechi Intrastate Link Project has been planned as an irrigation project. The project planning has been done to divert water with design capacity of 573 cumec at head which will provide annual irrigation to

the tune of 2.148 lakh ha in unirrigated enroute area of Mahananda basin between river Parman and Mechi of Araria, Purnea, Kishanganj and Katihar districts of Bihar. The gross command area and culturable command area of the link project are 2.75 lakh ha and 2.15 lakh ha respectively. The irrigation will be provided during monsoon period June to October in pre Sapt Kosi High Dam scenario. Rabi irrigation (November to May) will be possible only after coming up of Sapt Kosi High Dam. The annual benefits at present have been worked out to be Rs.1448.10 crore. The command area map of link canal is given as Plate 1.4 in Drawing Volume of the DPR.

The tail end discharge of the canal has been kept 27 cumec. Therefore, 27 cumec water can be dropped to Mechi river during the months in which Kosi basin experiences heavy rainfall resulting in a small accidental flood relief in Kosi basin. However, the provision being incidental, no firm quantum of water transfer in MCM to Mechi river is considered. In future, if Kosi High Dam comes up, 27 cumec water can be augmented to Mechi river in monsoon and non-monsoon months also. Domestic and industrial water supply may also be possible.

1.7 Methodology adopted

1.7.1 Survey and Investigation works

NWDA has adopted two pronged strategy for preparation DPR of Kosi-Mechi link project. Major part of the detailed field surveys and investigations of the project for which in house facilities were available has been done by NWDA itself where as other specialized surveys and investigations along with environmental impact assessment and socio-economic studies were outsourced to other Government departments/specialized concerned reputed agencies.

1.7.2 Topographical surveys

The following field surveys and investigations of the project have been carried out by NWDA.

(i) Link canal survey of existing EKMC RD 0.00 to 41.3 km and escape channel of 2.9 km.

(ii) New canal survey thereafter upto 117.50 km.

(iii) Grid survey of various CD/CM structures along the link canal.

(iv) River survey of Kawal/Kankai and Mechi river.

1.7.3 Sample command area survey

The proposed command area is identified from the culturable area computed from the latest five year land use statistics for the period 2005-06 to 2010-11 of Araria, Kishanganj, Katihar and Purnea districts of Bihar. The gross command area under the new canal is worked out as 2,75,000 ha. The culturable command area works out to 2,14,812 ha. The purpose of sample command area surveys is to assess the rate per hectare on development of command area. The sample command area surveys of 9325 ha i.e. about 5% of total CCA has been carried out departmentally. The sample command area survey maps are appended as Plate 4.4.1 to 4.4.4 in the Drawing volume of the DPR.

1.7.4 Survey and investigation carried out by other agencies

The following specialized survey and investigation works alongwith technical studies were outsourced to other Government organizations/ specialized agencies.

1.7.4.1 Geotechnical investigation, borrow area survey, construction material survey, testing of soil, sand and rock samples.

The work of geotechnical investigations, borrow area survey, construction material surveys, testing of soil samples etc. have been carried out by Central Soil and Material Research Station, New Delhi. Since in north Bihar, no quarries are available, collection of rock and sand samples carried out to ascertain the suitability for using as coarse aggregate and fine aggregate in the vicinity of proposed Burhi Gandak-Noon-Baya-Ganga link are proposed to be utilized in this project also. Total 9 representative rock samples and 4 natural sand samples were collected from identified quarries. The quantity of material available in various quarries have been tested by CSMRS, New Delhi and found suitable for utilizing as construction materials.

1.7.4.2 Geological and seismic investigations

The Geological Survey of India, Kolkata was entrusted the work of geological mapping along link canal alignment and important CD/CM structures across link canal in order to ascertain the feasibility of the project. The proposed Kosi-Mechi link is the extension of Existing Kosi Mechi Canal (EKMC) of 41.3 km. length offtaking from the left head regulator of Hanuman

Nagar barrage. The foundation investigation of head works and EKMC were not necessary. However, exploratory drilling along link canal and various canal structures, if any, may be taken up at next stage of the project. The main objectives of engineering geological investigations of the project assigned to GSI are (i) to identify the spots where deep open excavation for the canal may lead to slope failure and suggest protection measures for cut slope and (ii) geotechnical investigation to evaluate foundation strata of CD/CM structures.

The project area lies in the Seismic Zone IV as per the seismic zoning Map of India as incorporated in IS Code Criteria for Earthquake Resistant Design Structures [IS:1893-(Part I)2002]. Since, the Kosi-Mechi intrastate link project does not involve the construction of a dam/reservoir etc., no seismic studies have been done or proposed in future.

1.7.4.3 Hydrological studies

National Water Development Agency has conducted hydrological studies of Kosi basin at Hanuman Nagar barrage. The objective of the studies is to estimate the water yield and conduct water balance studies at existing Hanuman Nagar barrage,

The catchment area of Kosi river up to Hanuman Nagar barrage is 61792 km^2. The hydrological studies of river Kosi at Hanuman Nagar barrage have been carried out on the basis of observed inflow data of Birpur G and D site at Hanuman Nagar barrage maintained by Water Resources Department, Government of Bihar for period 1980 to 2013. It is observed that month wise maximum flow of 6531 cumec occurs during August 1988 and minimum flow of 174 cumec during February, 1999. Since there is no carryover storage, month wise working table at Kosi barrage for the period 1981 to 2011 has been prepared.

The gross inflow yield at Hanuman Nagar barrage works out to 49,889 MCM and 43,972 MCM at 50% and 75% dependabilities respectively. The percentage of average non-monsoon yield to the average monsoon yield works out to 22.49%. After accounting the net upstream requirements to the tune of 790 MCM and barrage requirements through Eastern and Western Kosi Main canal along with downstream requirements, the net annual water balance at 75% dependability at Hanuman Nagar barrage works out to 27864 MCM.

1.7.4.4 Augmentation of Kosi-Mechi link canal from enroute rivers

As per the hydrological studies carried out, the water availability at Hanuman Nagar barrage in the non-monsoon period is observed as deficit, though sufficient water is available in monsoon season for diversion through link canal. Therefore as suggested by the Government of Bihar in their original proposal, possibilities were explored to augment the link canal from enroute rivers. However, as per the preliminary studies carried out, this proposal is not found techno-economically viable due to following reasons:

(a) The enroute topography is too flatter and there is no any possibility to create storage on the enroute rivers.

(b) The enroute rivers are seasonal rivers, originating from the proximity of the Himalayas. The main source of the runoff is rainfall only. In non-monsoon season, the flow in these rivers is very little, which is essential to maintain the ecology of these streams. Hence, the non-monsoon flow cannot be tapped for diversion.

(c) Level crossing would be the only way for diverting the monsoon flow of these rivers. Due to flatter topography, the FSL of the canal will have to be maintained below the bank level of the streams. As such, the proposed alignment of the link canal, as was proposed in the PPR, will be in full cutting throughout its length. In this case, enroute irrigation cannot be provided without lift. However if sufficient higher FSL is maintained to provide gravity flow to the command area then the tail end of alignment will require to be shifted about 15-20 km southwards. As a result, a major part of the CCA will not be covered and the basic aim of the Kosi-Mechi link canal project will remain unfulfilled.

(d) Further sufficient water is available at Hanuman Nagar barrage in monsoon months and therefore, the augmentation from enroute rivers is dropped.

As per the crop water requirements, total water needs for providing irrigation in kharif in new command works out to 1718 MCM. The transmission losses of entire link canal works out to 96 MCM. Thus total 1814 MCM of water is proposed for diversion in addition to existing requirements of existing Eastern Kosi Main canal of the order of 6082 MCM.

Thus the total diversion through the Kosi-Mechi link canal works out to 7896 MCM.

1.7.4.5 Irrigation planning and command area

The link canal is aimed to provide irrigation in new unirrigated areas lying between rivers Parman and Mechi covering Araria, Kishanganj, Katihar and Purnea districts of Bihar. The new culturable area covered by the link project for irrigation is 2,14,812 ha utilizing 1718 MCM of water.

The diversion through link canal is firmed up by considering observed inflows of river Kosi at Hanuman Nagar barrage site. The designed irrigation potential of Hanuman Nagar barrage is still not fully developed. The Central Water Commission has reviewed the barrage requirements and assessed the existing and proposed barrage requirements for its full development of irrigation potential. Therefore, diversion is firmed up by considering reviewed demands of barrage.

As envisaged in NPP, a 269 m high multipurpose dam is proposed on river Sapt Kosi. Therefore, the diversion of link canal is also firmed up in post Sapt Kosi High dam scenario.

a) Pre Sapt Kosi high dam:

The diversion through link canal under pre Sapt Kosi High dam scenario is firmed up by considering following inflows:

(i) Irrigation success for kharif is firmed up at 100% success by considering average ten daily discharge data of Hanuman Nagar barrage for the period 1980-81 to 2012-13 and corresponding water requirements.

(ii) As per the Detailed Project Report of Dagmara H.E. project of Bihar State Hydro-electric Power Corporation, prepared by WAPCOS, the Central Water Commission has recommended the net inflows available at Kosi barrage after meeting the full irrigation potential under its canal system. The DPR of Dagmara H.E. project is based on these inflows. The diversion of Kosi water for providing irrigation in new command is also firmed up by considering these proposed net inflows available at Kosi barrage at 100 % success for Kharif irrigation.

b) Post Sapt Kosi high dam:

As envisaged in National Perspective Plan prepared by CWC and MoWR, a 269.0 m high dam namely Kosi High Dam Project is proposed to be constructed on river Kosi in Nepal at Barahkshetra 56 km upstream of Hanuman Nagar barrage. The proposed Kosi High Dam is multi-purpose in scope and envisages power generation with an installed capacity of 3000 MW at the dam toe power house. As per the observations of CWC, the irrigation in new command is firmed up at 100% success for post Sapt Kosi high dam scenario also by considering the proposed release pattern including spills as firmed up by CWC.

1.7.4.6 Impact on international/ interstate agreements

The river Kosi and river Mahananda are the tributaries of river Ganga. In view of the location of the project, three international / interstate agreements would need to be examined to assess the impact of Kosi-Mechi link project. The agreements are (i) Agreements dated 25th April, 1954 and dated 19th December, 1966 between Government of India and HMG of Nepal, (ii) Interstate agreement between Government of Bihar and Government of West Bengal on sharing of Mahananda water and (iii) Bilateral agreement 1996 between Government of India and the Government of Bangladesh on sharing of Ganga water and on augmenting its flows.

The Kosi project was constructed after arriving an agreement between Government of India and the then Royal Government of Nepal and the link project is within the purview of the agreement. The Government of Bihar and Government of West Bengal have also reached an agreement on sharing of Mahanda water. Since the Kosi–Mechi link is not utilizing any waters from Mahananda, the bilateral agreement between two States is not affected. Further, the Kosi-Mechi link will divert water to new command only in kharif season, so that there will be no adverse impact on Indo-Bangla treaty on sharing of Ganga water in non-monsoon months.

1.7.4.7 Impact on downstream projects

The Bihar State Hydro-Electric Power Corporation Limited has proposed Hydro Electric Power Project at Dagmara located about 31 km in d/s from Hanuman Nagar barrage. The project envisages construction of a concrete barrage of 945 m length and earthen dam of about 5750 m length

across Kosi river with a surface power house having an installed capacity of 130 MW (26 units of 5 MW each). As per the DPR submitted to CWC, it is observed that while working out the water availability, the water needs of upstream proposed projects under NPP proposal i.e. Kosi-Mechi link and Kosi-Ghaghra link have not been considered by BHPC in their study.

Further, the proposal of Government of Bihar for extending the EKMC upto river Mechi for providing irrigation in unirrigated areas of Mahananda basin is also very old and the similar proposal has now been proposed as Kosi-Mechi intrastate link. The water requirement of this proposal has also not been considered in their DPR of Dagmara H.E. project. However in spite of non consideration of these requirements, studies have been carried out to assess the impact of diversion through link canal on power generation at Dagmara project by using the same available inflows as considered in DPR of Dagmara H.E. project.

As per the study, there will be a very negligible shortage of about 1.2% on annual working units and this shortage can be ignored keeping in view of the large irrigation benefits from Kosi–Mechi intrastate link project.

1.7.4.8 Discharge of river Kosi at various return periods

The annual peak discharge data of river Kosi at Barahkshetra and at Hanuman Nagar barrage discharge sites have been collected for periods 1947 to 2010 and 1964 to 2010 (Hanuman Nagar Barrage) respectively. The peak flood discharges have been computed by Gumbel's method and by Log Pearson method at various return periods as given in Table 1.3.

Table-1.3

Return periods (Years)	**Peak discharge by Gumbel's method (cumec)**		**Peak discharge by Log Pearson method (cumec)**	
	Barahkshetra	**Hanuman Nagar**	**Barahkshetra**	**Hanuman Nagar**
50	20235	17812	18519	17157
100	21555	18783	18994	18633

Assessment of balance ground water potential for development of irrigation in Kosi sub-basin (Indian portion) has been made based on the data obtained from Central Ground Water Board. The total replenishable ground water resources and net draft have been assessed as 3366 MCM and 1172

MCM respectively. Balance ground water available for future development works out to 1896 MCM.

1.8 Environmental impact assessment study

The environmental impact assessment and socio-economic studies have been got carried out through M/S Economic Development Trust (EDT), New Delhi. The main objectives of environmental impact assessment and socio-economic studies are to identify possible environmental and socio-economic effects due to the proposed Kosi-Mechi link project and to suggest measures to mitigate or ameliorate the anticipated adverse impacts on the environment.

From the above studies, it is revealed that the link project will have immense positive impacts on the regional and national economy by way increased agricultural production. Further, there is no adverse effect on the biodiversity as there is no forest area coming under submergence. It is seen that there will not be any displacement of the people due to construction of the project, as such no R and R issues will be involved.

1.9 Designs

Since, the link canal offtakes from the left head regulator of existing Hanuman Nagar barrage. The barrage and the off taking head regulator is found capable to divert entire discharge of link canal, therefore, designs of head work structures are not required. The link canal involves design of 9 canal sections for a length of 117.50 km and 113 enroute structures, out of which there are 9 canal syphons, 14 syphon aqueducts, 42 road bridges, 9 hume pipe culverts, 28 head regulators and 9 cross regulators. Out of these, the designs of 42 structures (9 canal syphon, 14 syphon aqueducts, 3 head regulators, 3 cross regulators, 9 hume pipe culverts, 3 bridges and 1 setting basin) have been carried out departmentally following the guidelines laid down in the respective BIS codes of practices.

1.10 Financial and economic analysis

The cost estimate has been prepared based on the quantities worked out from the field survey and the design of the various structures. While firming up the estimate, the rates have been taken from Schedule of Rates 2012-13 of WRD, Government of Bihar.

The total cost of canal and canalization including remodelling of EKMC and command area development of the link project works out to 2903.25 crore at 2013-14 price level after escalating the rates of 2012-13 for 1 year at the rate of 8% per annum. The annual cost of the project including maintenance, depreciation cost of the project and interest on capital cost etc. works out to Rs. 395.21 crore. The annual benefit from the link project is worked out to Rs. 1448.10 crore.

The Benefit-Cost Ratio and Internal Rate of Return (IRR) of the project have been worked out as 3.66 and 27% respectively considering life of project as 100 years.

The Index map of Kosi–Mechi Intrastate link project is appended as Plate 1.1 in Drawing Volume.

1.11 Clearance required

Kosi-Mechi intrastate link project will require the following clearances from the departments/agencies indicated below in Table 1.4.

Table 1.4

Clearances required from other departments/agencies

Sl. No.	Clearance	Departments/Agencies
(i)	Techno-economic	Central Water Commission/TAC, MoWR
(ii)	Environmental	State level Environment Impact Assessment Authority (SEIAA) or Central Government

The above clearances shall be obtained by the State Government and thereafter investment clearance will be accorded by Planning Commission.