

## EXECUTIVE SUMMARY

### 1.0 General

Ministry of Water Resources (MoWR), Govt. of India in the year 2004 decided to undertake comprehensive assessment of feasibility of linking of 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, 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.

The functions of NWDA were further modified vide MoWR resolution dated May 19, 2011 to undertake the work of preparation of Detailed Project Report (DPR) of intrastate links also by NWDA. Further, the Gazette Notification of the enhanced mandate was issued on June, 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 the Water Resources Department (WRD), Govt. of Bihar and NWDA on June 16, 2008 in Patna. In the said meeting, Govt. of Bihar requested NWDA to prepare the prefeasibility report of six intrastate links out of which two were irrigation schemes. The Kosi-Mechi intrastate link is one of them.

Accordingly, NWDA prepared the prefeasibility report (PFR) of Kosi-Mechi intrastate link and submitted it to the Govt. of Bihar in June, 2009. Further, a meeting was held on January 18, 2010 between officers of WRD, Govt. of Bihar and NWDA. In the meeting, the State Govt. desired

the preparation of the DPR of Kosi-Mechi link project as the scheme was found viable in the PFR stage. It was also decided that NWDA could go ahead with preparation of Detailed Project Report (DPR) directly to save the time instead of first preparing the Feasibility Report (FR) and then DPR.

Accordingly, NWDA directly took up the work of preparation of the DPR of the above link canal project. Further, in 27<sup>th</sup> Annual General Meeting (AGM) of NWDA held on March 31, 2012 Water Resources Minister, Govt. 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 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 Govt. 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, Govt. of Bihar during meeting taken by Principal Secretary, Govt. of Bihar on January 16, 2013.

The DPR of the project has been prepared by NWDA based on detailed surveys and investigations and considering suggestions/views of WRD, Govt. of Bihar and observations of CWC.

## **2.0 Aim and justification of the project**

The river Kosi is an international river originating from Tibet and flowing through 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 25<sup>th</sup> April 1954 for implementation of Kosi project. The Kosi project includes a barrage namely Hanuman Nagar barrage 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 Govt. of Nepal and India. Out of the total command area 4,45,000 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.

### **3.0 Methodology adopted**

PFR and PPR prepared by NWDA formed the basis for proceeding further for preparation of DPR based on detailed surveys and investigations, updated hydrological studies, irrigation planning and other studies. DPR of this project has been prepared by NWDA involving various Government departments/ organisations like CSMRS and GSI. Detailed topographical surveys of link canal, alignment, CD/CM structures, command area survey, plant and colony area survey and studies like hydrological, irrigation planning and command area development etc. have been carried out departmentally. EIA and socio-economic studies were outsourced to a specialized agency. The other field investigation works like geotechnical investigations, construction material surveys and geological investigations have been carried out by Government organizations viz. CSMRS and GSI.

### **3.1 Data collection**

Data/informations required for the preparation of DPR of Kosi-Mechi link canal project were collected from various organizations/departments and also during the course of field surveys and investigations. Data

regarding existing cropping pattern, crop yield per ha, cost of produce, cost of cultivation etc were collected from the Agriculture Department, Government of Bihar. The observed daily discharge data of Birpur G&D site located downstream of Hanuman Nagar barrage, inflow and outflow data of Hanuman Nagar barrage have been collected from WRD, Govt. of Bihar.

### **3.2 Surveys and investigations**

NWDA has adopted two pronged action for preparation of DPR of Kosi-Mechi link project. Major part of topographical surveys of the project for which inhouse capability was available has been done by NWDA itself, whereas other specialized surveys and investigations alongwith technical studies like environmental impact assessment and socio economic studies were outsourced to concerned Government departments/specialized reputed agency.

The following field surveys and investigations for the project have been carried out:

- (i) Survey of existing Eastern Kosi Main Canal (EKMC) for its remodeling
- (ii) Link alignment survey of proposed Kosi-Mechi link canal (i.e. extension of Eastern Kosi Main Canal)
- (iii) Grid survey for various CD/CM structures along the link canal
- (iv) River survey at Mechi river upstream and downstream of the river at outfall point of link canal
- (v) Sample command area survey
- (vi) Survey of plant and colony area
- (vii) Borrow area and construction material survey by CSMRS in association with NWDA
- (viii) Geological mapping of major CD/CM structures and proposed link canal by GSI
- (ix) Communication and other allied surveys

#### **4.0 Climate**

The Mahananda river system in Darjeeling district experiences varying climatic conditions. Occasionally snowfall occurs in January and February at high altitudes for a few hours. During April and May short lived summer is experienced accompanied by summer rains for three months from June to August and the catchment is drenched with rain. The catchment in Jalpaiguri district experiences heavy rainfall. Its temperature is rarely excessive due to the proximity of the hills and the catchment is always green. The climate of the river system in Purnea, Kishanganj, Araria, Katihar and West Dinajpur districts is cold from November to February and hot from March to middle of June due to strong westerly winds. With the receding of the monsoon in the middle of October, the nights become appreciably cooler, though the days remain hot, sometimes longer. The relative humidity varies from 20% to 85%. It is lowest during April and May and highest in the months of June to September.

The average annual rainfall in Mahananda river system in India is about 2050 mm. About 80% of the rainfall occurs during the monsoon months. The usual direction of moisture laden current is generally northward. The annual rainfall in the upper catchment ranges from 100 mm to 1400 mm. As per the Bihar Statistical Hand Book-2012, annual normal rainfall in the districts of Araria, Purnea, Kishanganj and Katihar are between 1218 mm to 2041 mm and during monsoon the average rainfall is between 1067 mm to 1785 mm. The average numbers of rainy days in monsoon are 55 in these districts.

Except in the snow bound areas and the hills of Nepal, the basin experiences both hot summer and cold winters. The month of May is the hottest with the maximum temperature upto 40°C. The winter temperature goes down to nearly 4°C in January in the plains in the lower reaches while in the hills, it is still lower. There are two hydrometereological observatories in the Mahananda catchment one at Purnea and the other at Malda.

#### **5.0 Topography and physiography**

The topography of the Mechi basin (Mahananda river system) varies from rugged hills of Himalayas (in Nepal) to plains at its outfall into the

Mahananda. The upper portion of the catchment extends to an altitude of about 200 m and lies mostly in Himalayas in Nepal (a small portion is also in West Bengal) while the portion in plains lies mostly in India. The northern part of the river system is hilly and the southern part has mostly plain lands traced by a number of channels falling into the main river, Mahananda. The reach from origin upto Siliguri is mountainous covered with thick forest upto Sonapurhat 37 km, below Siliguri, the river bed consists of boulder and sand brought by the river during the floods and the banks are remarkably stable.

## **6.0 Geology and geotechnical studies**

### **(a) Geology**

The geological formations of the Mahananda river system in the northern area consist of unaltered sedimentary rocks confined to the hills on the north consisting of different grades of metamorphic rocks over the rest of the area. The outcrops of the various rocks form a series of bands more or less to the general line of the Himalayas, dipping one below the other into the hills. The characteristic feature of the southern area is that the older formations rest on the younger formations, showing complete reversal of the original order of superposition.

The Geological Survey of India, Kolkata was entrusted the work of geological mapping along link canal alignment and important CD/CM structures in order to ascertain the feasibility of the project. The proposed Kosi -Mehi link is the extension of Existing Kosi Mechi Canal (EKMC) of 41.30 km length off-taking from the left head regulator of Hanuman Nagar barrage. Therefore, the foundation investigation of headworks and EKMC were not necessary in this reach. But beyond RD 41.30 km upto the tail end links into Mechi river, the geotechnical investigations along link canal and various Cross Drainage (CD/CM) structures have been carried out by GSI. The main objectives of the investigations 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. Field investigations by GSI, Kolkata have been completed,

**(c) Geotechnical investigation borrow area survey and construction material survey**

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, the quarries identified for coarse and fine aggregates for Burhi Gandak-Noon-Baya –Ganga link are proposed to be utilized in this project also. The quality of material available in various quarries have been tested by CSMRS, New Delhi and found suitable for utilizing as construction materials.

## **7.0 Seismicity**

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 Intra state Link Project does not involve the construction of any headwork, no seismic studies have been carried out.

## **8.0 Hydrology and water assessment**

The catchment area of Kosi river upto Hanuman Nagar barrage is 61792 sqkm. The hydrological studies of river Kosi at Hanuman Nagar barrage have been carried out on the basis of observed discharge data of Birpur Gauge and Discharge (G & D) site located downstream of Hanuman Nagar barrage maintained by Water Resources Department, Govt of Bihar for the period 1980 to 2013. It is observed that monthwise maximum flow of 6531 cumec occurred during August 1988 and minimum flow of 174 cumec during February, 1998. Since, there is no carryover storage in the barrage, monthwise working table considering outflow from the barrage through EKMC and WKMC from Hanuman Nagar barrage for the period 1980 to 2013 has been prepared.

The gross annual yield at 50% and 75% dependability works out to 49,889 MCM and 43,972 MCM 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 EKMC and WKMC alongwith downstream requirements, the net annual water balance at 75% dependability at Hanuman Nagar barrage works out to 27864 MCM.

As per the water balance studies carried out it is observed that there is a deficit in non-monsoon period at Hanuman Nagar barrage. Therefore, it is proposed to divert surplus water of Kosi through the proposed link canal in monsoon months only for providing kharif irrigation in new command areas of Mahananda basin. Possibilities for augmenting the link canal from enroute rivers were also explored but not found feasible due to topographical constraints.

Therefore, it is proposed to divert 1814 MCM of surplus water of Kosi through the proposed link canal i.e. 1718 MCM for enroute irrigation in the new command in kharif season in Mahananda basin and 96 MCM towards transmission losses which includes transmission losses of existing EKMC also.

The maximum annual flood discharge data of river Kosi at Barahkshetra and at Hanuman Nagar barrage gauge and discharge sites have been collected for periods 1947 to 2010 and 1964 to 2010 respectively. The peak flood discharges have been computed by Gumbels and Log Pearson methods at various return periods as given below:

Return period (years)	Peak discharge by Gumbel's method (cumec)		Peak discharge by Log Pearson method (cumec)	
	Barahkshetra G&D Site	Hanuman Nagar G&D Site	Barahkshetra G&D Site	Hanuman Nagar G&D Site
50	20235	17812	18519	17157
100	21555	18783	18994	18633

Since, the existing barrage is designed for a higher peak discharge of 26,900 cumec hence is considered to be safe.



Assessment of balance ground water potential for development of irrigation in Mahananda 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.

## **9.0 Irrigation and command area development**

It is proposed to provide irrigation in new command area lying between rivers Parman and Mechi covering Araria, Kishanganj, Katihar and Purnea districts of Bihar. The link will provide en-route irrigation to 98% of CCA of 2,14,812 ha in kharif season only depending upon the back-up storage in Hanuman Nagar barrage. Thus the link will irrigate an area of 2,10,516 ha. However, after the construction of the proposed Kosi High Dam by carrying out survey and investigations jointly by the Govt. of Nepal and India, the project will be able to provide irrigation and other benefits in Rabi period also.

As per the details collected from CWC, 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.

## **10.0 Design features**

The existing Hanuman Nagar barrage is in good condition and functioning well. The Kosi-Mechi link canal offtakes from the left Head Regulator of existing Hanuman Nagar barrage. The left Head Regulator is found adequate to divert entire discharge of 573 cumec of the link canal. Therefore, remodeling of head regulator is not required. The total length of link canal including EKMC (41.3Km) is 117.50 Km. The design of link canal has been bifurcated in 9 reaches of varying sections. 112 numbers of CD/CM structures enroute of the link canal have been proposed. These include 9 canal syphons, 14 syphon aqueducts, 42 road bridges, 9 hume pipe culverts, 28 head regulators and 9 cross regulators. The design of 42

structures (9 canal syphon, 14 syphon aqueducts, 3 head regulators, 3 cross regulators, 9 hume pipe culverts, 3 bridges and 1 settling basin) have been carried out departmentally following the guidelines laid down in the respective BIS codes of practices.

The existing EKMC is an unlined canal designed for maximum discharge of 425 cumec at head. This canal has now been proposed to be remodelled for 573 cumec discharge to cater the needs of the existing EKMC and proposed Kosi-Mechi link canal. The alignment of the link canal for the entire length of the existing EKMC i.e. upto RD 41.30 km has been kept unchanged. The design discharge of the link canal at head, river Parman, and tail point are 573 cumec, 191 cumec and 27 cumec respectively. The full supply depth from RD 0.00 km to RD 41.30 km is proposed as 3.5 m to 4.25 m with 0.75 m free board i.e. same as in the existing EKMC. While full supply depth from RD 41.30 km to RD 117.50 km is kept varying from 3.5 m to 2.00m. The bed slope is kept as 1:11000 between RD 0.0 km to RD 41.30 km and 1:12000 between RD 41.30 km to RD 117.50 km. The side slope of canal is proposed as 1:1.5.

The pond level of Hanuman Nagar barrage is 74.67 m. The HFL of river Mechi at tail end point is 52.50 m. The FSL, bed level of the link canal and bed level of Mechi river at outfall point are 54.238 m, 52.238 m and 47.881 m respectively. At the outfall point, the canal bed level is above the river bed level of Mechi and the full supply level of the canal is above the highest flood level of the river Mechi. Topographically and hydraulically, above levels are quite suitable to divert the flow into Mechi river through proposed link canal. Further, a freeboard of 0.75 m has been kept above the FSL of the canal to accommodate the anticipated afflux.

### **11.0 Accessibility and infrastructure**

The project area is well connected with road and railway networks. Forbesganj is the nearest rail head, located at a distance of about 5 km from link alignment and 42 km from Hanuman Nagar barrage. Bagdogra is the nearest airport located about 200 km from the Hanuman Nagar barrage.

### **12.0 Construction programme and equipment planning**

The schedule of construction of the link project is planned for a period of 5 years. The intra-structural development like project colonies,

approach roads, workshop, haul roads, stores, office buildings, etc. pre-construction surveys & investigations, preparation of design/specifications and tender documents have been proposed to be completed during first two years. In addition, the construction of all the structures has been proposed to be completed within 5 years. The requirement of important construction equipments has been assessed as per the guidelines for preparation of DPR, MoWR, Government of India, 2010.

### **13.0 Environment impact assessment and socio economic studies**

The environmental impact assessment and socio-economic studies have been carried by 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 of increased agricultural production. Further, there is no adverse impact 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 & R issues will be involved.

### **14.0 Project planning and optimization of benefits**

The Kosi–Mechi Intra State Link Project has been planned as an irrigation project. The project planning has been done to divert water with design discharge of 573 cumec at canal head which will provide kharif irrigation to the tune of 2,10,516 ha in unirrigated water short enroute areas lying between river Parman and Mechi falling in 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. Irrigation during rabi and other seasons will be possible only after construction of the proposed Sapt Kosi High Dam. The annual benefits at present have been worked out to be Rs.1448.10 crores.

The tail end discharge of the canal has been kept as 27 cumec. Therefore, 27 cumec water can be dropped into Mechi river during the months

in which Kosi basin experiences heavy rainfall resulting in a small accidental flood relief in Kosi basin. In future, when the Kosi High Dam comes up, 27 cumec water can be augmented in monsoon and non-monsoon months and domestic and industrial water supply in the enroute of the link canal may also be possible.

### **15.0 Legal status of the project**

Though there are large benefits that may accrue from the project, due weightage has to be given to social and environmental aspects. One of the important social considerations is the process of public consultation. The Wildlife (Protection) Act-1972 provides for protection of listed species of flora and fauna and establishes a network of ecologically important areas. The provisions of this Act have also been kept in view while dealing with the wildlife issues in the project area. Techno-economic clearance of the project is required from the CWC/MoWR. Attention has to be paid to the various provisions of National Policy on R&R and the policy enunciated by the Government of Bihar regarding the R&R of displaced people due to remodelling the existing EKMC and construction of proposed Kosi-Mechi link canal. As per the studies carried out for the project, there would not be any displacement of the people due to upcoming of the project.

### **16.0 Cost estimate**

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 Rate 2012-13 of WRD, Government of Bihar.

The total cost of canal and canalization including remodelling of existing EKMC and command area development of the link project works out to Rs.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.

## **17.0 Economic and financial evaluation**

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