

## **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 function of NWDA Society.

The functions of NWDA were further modified vide MoWR resolution dated May 19, 2011 to undertake the work of preparation of DPRs 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 meeting, Govt. of Bihar requested NWDA to prepare the prefeasibility report of six intrastate links out of which four were flood moderation schemes. The Burhi Gandak-Noon-Baya-Ganga Link is one of them. Accordingly, NWDA prepared the prefeasibility report (PFR) of Burhi Gandak-Noon-Baya-Ganga Link and submitted to the Govt. of Bihar in May, 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 Burhi Gandak-Noon-Baya-Ganga link project as the scheme was found viable in the PFR stage. It was also decided that NWDA

could go ahead with preparation of DPR directly to save 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> AGM meeting of NWDA held on March 31, 2012 wherein, Water Resources Minister, Govt. of Bihar requested NWDA to prepare the Preliminary Project Report (PPR) of Burhi Gandak-Noon-Baya-Ganga 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 Burhi Gandak-Noon-Baya-Ganga 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 May, 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 & investigations and considering suggestions/views of WRD, Govt. of Bihar and observations of CWC.

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

As Burhi Gandak is a flood prone river and every year it damages the human lives, livestock, crops, houses and infrastructure of the area, it was felt by the Govt. of Bihar to divert the flood water to other basin through either by the new link or through existing river system to mitigate the devastation caused by river Burhi Gandak. The main aim of the Burhi Gandak-Noon-Baya-Ganga link project is to divert the part of the flood water of river Burhi Gandak to the Ganga so that flood damages in the lower reaches of Burhi Gandak basin area falling under Samastipur, Begusarai and Khagaria districts could be reduced to a great extent.

## **3.0 Methodology adopted**

PFR and PPR prepared by NWDA formed the basis for proceeding further for preparation of DPR based on detailed surveys & investigations, updated hydrological studies, irrigation planning and other studies. DPR of this project has been prepared by NWDA involving various Government departments/

organisations like NIH, CSMRS, GSI etc. Detailed topographical surveys of barrage site, link canal, CD/CM structures etc. have been carried out departmentally. However, for completing the work in a time bound manner some works like exploratory drilling work, sample command area survey and EIA studies were outsourced. 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 Burhi Gandak-Noon-Baya-Ganga link canal project were collected from various organizations/departments and during the course of field surveys and investigations. Rainfall and meteorological data were collected from IMD whereas hydrological observation data were collected from CWC and supplied to NIH for hydrological studies. Data regarding cropping pattern, crop yield per ha, cost of produce, cost of cultivation etc were collected from the Agriculture Department, Government of Bihar.

### **3.2 Surveys and investigations**

NWDA has adopted two pronged action for preparation of DPR of Burhi Gandak-Noon-Baya-Ganga 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 & investigations alongwith technical studies like hydrological studies and environmental impact assessment and socio economic studies were outsourced to concerned government departments/ specialized reputed agencies .

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

- i. River survey of Burhi Gandak, Noon and Baya rivers
- ii. Survey of barrage site proposed across Burhi Gandak river
- iii. Link canal survey.
- iv. Grid survey for various CD/CM structures along the link canal

- v. Borrow area and construction material surveys by CSMRS in association with NWDA.
- vi. Survey of outfall point of the link canal in Baya river
- vii. Geological mapping of barrage site, major CD/CM structures by GSI.
- viii. Plant and colony area survey
- ix. Communication and other allied surveys.

#### **4.0 Climate**

The project area of Burhi Gandak-Noon-Baya-Ganga intrastate link is situated between latitude  $25^{\circ}49'25''$  &  $25^{\circ}35'02''$ N and longitude  $85^{\circ}53'46''$  &  $85^{\circ}52'39''$ E. The climate is very hot during summer season and very cold during the winter season except in upper tarai region and the hills of Nepal. During the summer season, April and May months are the hottest and temperature goes upto  $44^{\circ}\text{C}$  and during the winter season January month is the coldest and temperature goes down upto  $5^{\circ}\text{C}$ . The annual rainfall in the catchment varies from 1141 mm to 1610 mm and the mean rainfall is about 1300 mm. The humidity is the lowest during April and May. The maximum humidity is observed during the month of July and August and it goes upto 80% or more.

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

The northern part of the river system lying in Nepal and West Champaran district of Bihar is hilly and occupied by fairly dense mixed jungle. The southern part is of alluvial gangetic plain falling in the districts of West and East Champaran, Muzaffarpur, Samastipur, Begusarai and Khagaria of Bihar. The alluvial plain is very flat and is one of the most fertile area in Bihar and is commonly known as the granary of Bihar. The topography of the Burhi Gandak river system varies from rugged hills at the origin to alluvial plain at its outfall. The ground level in the basin varies from RL 300 m near the origin to RL 35 m at its outfall into the Ganga.

#### **6.0 Geology and geotechnical studies**

##### **a) Geology**

The area under study belongs to a part of Burhi Gandak, Gangetic alluvial plain lying between Himalayan foothills in north and Chhotanagpur plateau in south. This area exhibits a flat country and shows presence of Neogene-

Quaternary terraces with master slope towards Ganga river. The area belongs to Ganga Kosi formation representing older flood plain deposits which consists of unoxidised to feebly oxidized dark grey clayey silt, sandy silt and silty clay. From the study, it is seen that the entire canal alignment alongwith CD/CM structures lies in the Indo Gangetic alluvial plains.

#### **b) Geotechnical study**

The foundation investigation of the proposed barrage site has been carried out through exploratory drill holes and required field and laboratory investigations. As proposed by GSI, out of 5 drill holes, 1 drill hole at either of the banks, 1 at centre and 2 drill holes at 20 m upstream and downstream of central hole have been drilled for ascertaining the foundation condition for the proposed barrage. In addition to the above, 17 drill holes along the canal and various canal structures were also drilled. The cores obtained from these drill holes have been tested by CSMRS for geotechnical investigations.

#### **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]. For this seismic zone, the value of horizontal seismic coefficient  $\alpha_0$ , and seismic zone factor for average acceleration spectra,  $F_0$  are 0.05 and 0.25 respectively. In view of target date of completion of DPR of this project, the above parameters recommended for seismic zone IV have been considered in the design of the barrage. The site specific seismic study of the project is being referred to National Committee on Seismic Design Parameters (NCSDP). In case of any deviation in the considered seismic design parameters, the design of the project will be suitably modified considering the parameters recommended by NCSDP at the time of detailed design of the project.

#### **8.0 Irrigation and command area development**

The link canal will provide irrigation to the unirrigated enroute area of the link canal lying in Samastipur, Begusarai and Khagaria districts of Bihar during kharif season. The GCA and CCA of the project are 1.76 lakh ha and 1.26 lakh ha respectively and the water utilisation for irrigation will be 450 MCM.

## **9.0 Hydrology and water assessment**

Hydrological studies of Burhi Gandak-Noon-Baya-Ganga link project have been carried out by NIH, Patna as a consultancy work. The objectives of the studies are to assess the water availability at the proposed diversion site to calculate the design flood for the diversion site, to conduct backwater analysis from river Baya/Ganga to diversion point to visualize hydraulic feasibility of the link canal and to suggest parameters of canal for optimal diversion. Design flood was arrived through flood frequency analysis using Gumbel and Log Pearson type- III distribution. The flood discharge corresponding to 50 years return period at Sikandarpur G&D site has been estimated as 4920 cumec, of which 10% i.e. 492 cumec has been considered for diversion through the link canal.

### **10.0 Design features**

The design work of various components of the project has been carried out departmentally as per the provisions laid down in relevant IS codes. The HFL of the river Burhi Gandak at the Samastipur Railway bridge which is very near to the barrage is recorded as 49.38 m. The HFL of the river Baya/Ganga near the outfall point of the link canal has been computed with respect to HFL recorded at Burha sluice on river Baya which is in the upstream of the outfall point and HFL recorded at Hathidah G&D site (CWC) on river Ganga which is in the downstream of the outfall point and is found to be 43.15 m. As the difference between HFL of the river Burhi Gandak at the offtake point and the HFL of the river Baya/Ganga at the outfall point of the link canal is only 5.85 m and considering the head losses of 2.845 m due to canal slope and various hydraulic structures across the link canal and the required full supply depth of the canal of 5 m, the flow in the canal has been considered to be non-uniform. The canal, therefore, has been designed considering the non-uniform nature of the flow and to counter the backwater effect of the flood in Baya/Ganga on the flow in the canal.

### **10.1 Sediment studies**

The Burhi Gandak river is a left bank tributary of river Ganga and outfalls into Ganga at Khagaria. As per the Report of the Committee (2002) on “Siltation of Rivers in India” constituted by MoWR, GOI, the annual average sediment load at Sikandarpur and Rosera G&D sites are 9.13 million ton and 13.12 million ton of

which 98% and 99% sediment load observed during the monsoon period respectively. The average sediment during the decade of sixty is minimum and had gradually increased over the years and is maximum during the decade of eighties. The average monsoon sediment is 97% to 99% of the annual sediment.

The analysis of sediment data of Sikandarpur G&D site indicates that out of annual average suspended load of 9.13 million ton, 4.9% is coarse, 17.9% is medium and 77.2% is fine. Similarly, data of Rosera G&D site for the period 1978-89 indicates that out of annual average suspended sediment load of 13.12 million ton, 2.8% is coarse, 9.4% is medium and 87.8% is fine. These analysis show that the sediment load at Rosera site is more than the sediment load at Sikandarpur G&D site and the percent fraction of medium sediment at Rosera site is 9.4 % whereas for Sikandarpur it is 17.9%. However, at both the sites the suspended sediment mainly consists of fine sediment, the contents of which vary from 65 % to 91 % in case of Sikandarpur and 77% to 94% in case of Rosera site.

## **10.2 Hydraulic aspects of barrage**

It is proposed to construct a 611 m long barrage across river Burhi Gandak, out of which 189 m is the overflow section and the remaining 422 m is the earthen non overflow section. The length of undersluice bays and other bays are 160 m and 187.56 m respectively.

The barrage is designed considering the estimated flood discharge of 4920 cumec to 50 years return period. Three numbers of undersluice bays of 8 m x 14 m and 16 other bays of 8 m x 12.8 m each have been provided. Undersluice bays have been designed to pass about 20% of flood discharge and the remaining discharge will be passed through other bays.

## **10.3 Head regulator**

Head regulator has been proposed on the right flank of the barrage. The designed discharge of head regulator has been considered as 590 cumec including 20% extra for silt ejector. Thus, 3 bays of 9.0 m each with 2 number of piers of width 1.5 m have been provided to pass the required discharge. Total waterway will be 30 m. The crest level of undersluice is 35.00 m and head regulator is kept at 43 m i.e 8.0 m above the bed level of river.

#### **10.4 Silt ejector**

A silt ejector has been proposed at the canal at RD 1.00 km for extraction of silt from the canal as a remedial measure for silting of the canal.

#### **10.5 Lining of canal**

The canal lining with cement concrete of M 15 grade has been proposed with LDPE films in canal bed as well as in side slopes. The thickness of lining is kept as 12 cm as per IS code 3873-1978.

#### **10.6 Main parameters of canal design**

(i) Side slope	1.5:1
(ii) Velocity	1.07 m/sec.
(iii) Critical velocity ratio	0.69-0.70
(iv) Full supply depth and free board	5.00 m
(v) Free board	1.2 m

#### **11.0 Construction materials surveys**

The construction materials survey has been carried out by CSMRS, New Delhi. The rock and sand samples have been collected from identified quarries and laboratory tests conducted by CSMRS in order to ascertain their suitability for using as coarse aggregate and fine aggregate. The quality of the materials available in quarries has been found suitable by CSMRS for utilising as construction materials. Further, the requirement of construction material like cement, steel etc. can be brought to the nearest railhead ie. Angarghat, Samastipur for construction of barrage and other structures.

#### **12.0 Accessibility and infrastructure**

The project area is well connected with road and railway networks. The nearest railhead are Angarghat and Samastipur in Samastipur district. These are located at a distance of 5 km and 20 km respectively from the Burhi Gandak barrage site. Patna is the nearest airport located about 120 km from the barrage site.



### **13.0 Construction programme and equipment planning**

The project envisages the construction of a barrage, a 28.95 km long link canal and 26 CD/CM structures. The construction schedule of the link project is planned for a period of 3 years. The infrastructural development like project colonies, approach roads, stores, office buildings etc, pre-construction surveys & investigations, preparation of design/specifications and tender documents have been proposed to be completed during the first year and the construction of all project components have been proposed to be completed within three years in all respects.

### **14.0 Environmental impact assessment and socio-economic studies**

The objective of environmental impact assessment & socio-economic studies is to identify possible environmental & socio-economic effects due to the proposed Burhi Gandak-Noon-Baya-Ganga link project and to suggest measures to mitigate or ameliorate the anticipated adverse impacts on the environment. The study was assigned to M/s Economic Development Trust (EDT), New Delhi.

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 flood control and increased agricultural production. Further, there is no adverse effect on the biodiversity as no forest area is coming under submergence. The existing flora and fauna of the area will flourish even better after flood mitigation. It is seen that there will not be any displacement of the people due to the construction of the project, as such no R&R issues will be involved.

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

Burhi-Gandak-Noon-Baya-Ganga link project has been planned as a multipurpose project with flood control benefit in downstream area of the project and enroute irrigation to the tune of 1.26 lakh ha. Planning of the project has been done in such a way that 492 cumec of flood water of river Burhi Gandak will be diverted to Ganga through linking to Baya river so that flood water of river Burhi Gandak will flow within the river embankment without overtopping or breaching the embankments. Simulation studies have been carried out by NIH to establish the diversion of flood waters from river Burhi Gandak to river Baya/Ganga for various scenarios to establish the feasibility of the project.

**(i) Benefits from flood diversion**

Flood damages occur frequently in lower reaches of Burhi Gandak basin in Samastipur, Begusarai and Khagaria districts of Bihar. The overall damage due to flood has been worked out on the basis of average annual flood damage of the three districts and is found to be Rs.204.73 crore. As per the studies carried out, reduction in flood damages to houses, crops and public utilities would be of the order of about 70% of total flood damages. Thus, the annual benefits due to reduction in flood damages has been worked out to be 143.31 crore.

**(ii) Benefits from irrigation**

The Burhi-Gangak-Noon-Baya-Ganga link project was basically a flood moderation scheme but considering large fertile land enroute the link canal, irrigation to the tune of 1.26 lakh ha has been proposed during kharif season in the districts of Samastipur, Begusarai and Khagaria. The total annual benefit from irrigation works out to Rs.587.10 crore.

**16.0 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. NOC from Ministry of Coal & Mines is not required as no potential minerals are likely to be submerged due to the project. In Burhi Gandak-Noon-Baya-Ganga link project protection for wildlife and archaeological monuments as per 1972 act is not required due to absence of any wildlife and archaeological monuments under the project area. However, 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 the construction of barrage and 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.

## 17.0 Cost estimate

The cost estimate for the project has been prepared based on the quantities worked out from the field surveys and the designs of the various structures. While framing the estimates, the rates have been taken from CSR, 2012 of Government of Bihar.

### Classification of units

Unit - I: Head works – Burhi Gandak Barrage

Unit - II: Canal and canalization

Unit – VI: Command area development

The cost estimate of Burhi Gandak-Noon-Baya-Ganga link project works out to Rs. 4213.75 crore

### Unitwise costs of the Burhi Gandak-Noon-Baya-Ganga link Project

Unit : Rs. in crore

Unit-I	Unit-II	Unit-VI	Total
970.55	3025.42	217.79	4213.75

## 18.0 Economic and financial evaluation

The relief from flood and irrigation benefit to be accrued annually from the project are worked out as Rs. 730.41 crore.

Unit : Rs. In crore

S. No.	Particulars	Amount
i	Net annual benefits from flood protection	143.31
ii	Net annual benefits from irrigation	587.10
	<b>Total annual benefit</b>	<b>730.41</b>

The Burhi Gandak-Noon-Baya-Ganga link may also provide water for domestic and industrial water supply in the enroute command area. The possibilities can be explored by the State Govt. However, no monetary benefits in this regard have been considered in the study.

The benefit cost ratio has been worked out based on ‘Guidelines for Preparation of Detailed Project Reports of Irrigation and Multipurpose Projects-2010’ issued by MoWR, Govt. of India. The gross value of the benefits of the project for the pre-project and post-project scenarios have been computed adopting the yields and prices of commodities collected from agricultural and marketing departments of Govt. of Bihar. The net benefit from irrigation works out to Rs. 47.00 lakh per 100 ha of cropped area. The benefit cost ratio has been worked out as 1.54. The internal rate of return of the project considering 100 years life of the project has been worked out as 16%.