

CHAPTER - I

INTRODUCTION

1.0 Background

Ministry of Water Resources, 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, 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 Report (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 May15, 2008 and submitted their proposals. Subsequently, a meeting was held between the officers of Water Resource 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 reports of six intra state links out of which four were flood moderation schemes. The Burhi Gandak-Noon-Baya-Ganga Link is one of them.

NWDA had prepared prefeasibility report of Burhi Gandak-Noon-Baya-Ganga link in June, 2009 and modified the same incorporating

comments of Govt. of Bihar and Ganga Flood Control Commission (GFCC) in March, 2010. Surveys & investigations for preparation of DPR of this link were taken up in 2011. Further, as per the request of Government of Bihar to prepare the Preliminary Project Report (PPR) in 27th Annual General Meeting of NWDA, NWDA has prepared and submitted the PPR to Govt. of Bihar and Central Water Commission in May, 2012.

1.1 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 through linking the Noon and Baya rivers, so that flood damages in the lower reaches of Burhi Gandak basin area falling under Samastipur, Begusarai and Khagaria districts of Bihar could be reduced to a great extent.

1.2 Earlier studies

1.2.1 Prefeasibility Report (PFR)

NWDA had prepared the prefeasibility report of Burhi Gandak-Noon-Baya-Ganga link project during March, 2010. The link canal envisaged diversion of 300 cumec of flood water (i.e. part quantity of total flood discharge) of river Burhi Gandak to the Ganga through linking the Noon and the Baya rivers 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. Divertible quantum of water through link canal was 10% of the total flood discharge of Burhi Gandak river of about 3000 cumecs at Rosera G&D site corresponding to 25 years return period.

The Burhi Gandak-Noon-Baya-Ganga link canal project was proposed to offtake from river Burhi Gandak near village Darhia Ramkrishanpur of district Samastipur at latitude 25°50' 19"N and longitude

85°53'24"E and outfalls into river Baya near Jhamatiaghat at latitude 25°35'02"N and longitude 85°52'39"E which ultimately joins river Ganga near village Roopnagar of Mokameh town. A spur/regulator was proposed at the offtake point. The total length of the link canal was divided into four reaches as given in **Table 1.1** below :

Table 1.1

Reach	Link alignment	RD (km)	Length (km)
I.	Lined canal	0.0-23	23
II.	River course of Noon	23-46	23
III.	Lined canal	46-49	3
IV.	River course of Baya	49-71	22

The link canal was proposed to offtake from river Burhi Gandak at FSL of 49 m. The bed width of canal was 30 m and full supply depth was 5 m. The bed slope of the canal was kept as 1:7500. A free board of 0.75 m was provided. The link canal was proposed to flow under gravity upto RD 23 km and outfall into river Noon. After traversing for a distance of about 23 km, the canal was proposed to join the river Noon near village Baikunthpur at FSL 45.24 m. The flood water carried through river course of the Noon from RD 23.0 km to RD 46.0 km was proposed to be diverted again into an offtaking canal from proposed barrage across river Noon at RD 46 km near village Fateha. Further, the flood water was proposed to flow through a 3 km long link canal i.e. from RD 46.0 km to RD 49.0 km and outfall into river Baya near village Jhamatiaghat. The flood water was again proposed to flow in river course of Baya and ultimately join river Ganga at RD 71 km near village Roopnagar.

The total estimated cost of the link canal project worked out to Rs. 407.33 crore at 2008-09 price level. Annual cost of the project was worked out as Rs. 69.25 crore. For calculating annual benefits, average annual flood damages occurring in the lower reaches of basin area falling under Samastipur, Begusarai and Khagaria districts were considered and worked out to be Rs. 95.31 crore. The benefit cost ratio of the link project worked out to 1.38 and hence, the proposed link project was found techno-economically viable.

1.2.2 Modified Prefeasibility Report (PFR)

The WRD, Govt. of Bihar and GFCC conveyed their views/suggestions to NWDA on the PFR of the link project. These views/suggestions were also discussed during the various meetings held with Govt. of Bihar and accordingly the PFR was modified.

The offtake point of the link canal was shifted a little downstream to a point near village Muriaro. The link canal was proposed to offtake from the right bank of the Burhi Gandak in southern direction. Divertible quantum of water through the link canal was kept as 10% of the flood discharge of river Burhi Gandak of about 3000 cumecs at Rosera G&D site corresponding to 25 years return period. The link canal after traversing over the ground for a length of 22.5 km and was proposed to joins the river Noon on its left bank near village Chakka. The diverted flood water of Burhi Gandak was proposed to flow through the natural course of river Noon for about 3.5 km and again diverted into an off taking canal from proposed barrage across river Noon at RD. 26.00 km near village Fateha. The link canal was proposed to outfall into the river Baya on its left bank at RD 29.0 km near Jhamatiaghat.

By diverting flood water through this new route of link alignment, the length of link canal was reduced to 29 km including 3.5 km through river Noon from 49 km.

The WRD, Govt. of Bihar had suggested to join the river Baya to the Ganga through a cut, if hydraulically possible. This aspect was examined during the field visit. The link channel about 7 to 8 km long was required to be constructed to divert the flood water into the main stream of the Ganga. Local people of this area informed that during the monsoon season the entire area falling between the river Baya and main stream of Ganga are submerged for a period of about 2-3 months. The excessive discharge and sediment load carried by the river Ganga will certainly drown and silt up the link canal. Hence, this aspect did not seem to be hydraulically possible and economically viable.

The total estimated cost of the modified link canal project at PFR stage worked out to Rs. 382.00 crore at 2008-09 price level and the benefit cost ratio of the link project worked out to 1.46. Hence, the proposed link project was techno-economically viable for taking up DPR.

1.3 Present studies at DPR stage

To expedite the preparation of DPR of intrastate river linking projects of Bihar, a meeting was held on 18.01.2010 between officers of WRD, Govt. of Bihar and NWDA. In the meeting, the State Govt. requested NWDA to prepare the DPR of Burhi Gandak-Noon-Baya-Ganga 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, NWDA directly took up the work of preparation of DPR of the above link canal project. Further, in 27th Annual General Meeting of NWDA held on 31.3.2012, 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. Accordingly, NWDA prepared the PPR following the CWC guidelines for submission, appraisal and clearance of irrigation and multipurpose projects – 2010 and submitted the same to WRD, Govt. of Bihar and CWC in May, 2012.

The detailed field surveys and investigations were carried out to establish the techno-economic viability of the link canal project. Earlier at PFR stage no barrage was proposed across river Burhi Gandak near the offtake point and it was proposed to transfer water through a spur/ regulator. During course of surveys & investigations for firming up site for regulator, it was felt necessary to have a barrage across the river Burhi Gandak near the offtake point. This aspect was firmed up in consultation with GSI, Kolkata and NIH, Patna. As per the studies carried out by NIH, the entimated flood discharge at Sikandarpur G&D site corresponding to 50 years return period works out to 4920 cumec. 10% which i.e. 492 cumec has been considered for diversion through the link canal.

The link canal has been designed conducting simulation studies in two scenarios, i.e. (i) when there is high flood in river Burhi Gandak catchment and no flood in river Baya and (ii) when both Burhi Gandak and Baya/Ganga rivers are in spate. It was observed that during flood period, the

river Ganga inundates the whole area near the outfall point of the link canal and the river Baya and Ganga become one river.

The HFL of the river Burhi Gandak at the Samastipur Railway bridge is recorded as 49.38 m which is very near to the proposed barrage site. The highest water level of river Baya near outfall point has been computed with respect of HFL recorded at Burha sluice on river Baya which is in the upstream of 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. The same was also locally confirmed during the course of field surveys and investigations. As the difference between the 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 depth of the canal is 5 m, the flow in the canal has been considered to be non-uniform. Simulation studies were carried out and got vetted through NIH to compute backwater effect requisite velocity of flow after considering various resistance starting reachwise from outfall point i.e. joining river Baya/Ganga and backwards upto offtake point at an interval of 50m. Also, respective cross sections of canal have been computed at every 50m interval so that discharge of the canal may pass into river Baya/Ganga in the worst scenario when both rivers are in spate. Therefore, the link canal has been designed considering the non-uniform nature of the flow in canal and the backwater effect of the flood of river Baya/Ganga.

The index map of the Burhi Gandak-Noon-Baya-Ganga link project is appended as **Plate 1.1** in the Drawing Volume.

1.4 Variation in present studies from PFR stage.

The proposal of barrage made at PFR stage across river Noon near village Rajapur was not found suitable due to following reasons.

- 1) The flow details of the river Noon reveal that the highest discharge in the river ever recorded in the past was not exceeding 200 cumec. Thus, the

course of this river is not adequate to carry an additional huge discharge of 492 cumec without causing heavy flood damage to the nearest Dalsinghsarai town and other villages in the vicinity of this river.

2) The cross sections of this river also reveal that further addition of any discharge in this river will create havoc in the area.

In view of the above, the proposal of construction of Barrage across river Noon has been dropped, and as such the course of the river Noon will now be not available for canal to run through river course for a distance of 3.5 km. Therefore, the link canal from RD 21.450 km onwards has been realigned considering topographical constraint of the area. As per topographical surveys and local enquiry it is revealed that NSL & HFL of river Noon are 35.158 m & 43.61 m against bed level & FSL of canal as 40.415 m & 45.415 m respectively. Therefore, now the canal will cross river Noon through syphon aqueduct and thereafter it will run towards the river Baya for 7.5 km length. The link canal will outfall into river Baya to transfer the flood water of river Burhi Gandak to river Ganga. The total length of the link canal from its offtake point to its outfall point at river Baya is 28.95 km. The link canal on its way crosses a number of streams besides national and state highways, district and village roads and railway lines. Total 26 cross drainage/cross masonry structures have been identified across the link canal.

The variation in the link proposal at different stages i.e. at PFR stage, modified PFR stage and the PPR/DPR stage are furnished below in **Table 1.2**.

Table 1.2

Proposals	PFR Stage	Modified PFR Stage	PPR and DPR Stage
Head works	Regulator at offtake point	Regulator at offtake point	Barrage across river Burhi Gandak
Location	Near village Darhia Ramkrishanpur at latitude-25 ⁰ 50'19"N longitude-85 ⁰ 53'24"E	Near village Muriaro at latitude-25 ⁰ 49'35"N longitude-85 ⁰ 53'45"E	Near village Muriaro at latitude-25 ⁰ 49'35"N longitude-85 ⁰ 53'45"E
Quantity of flood diversion	300 cumec (10% of the flood discharge of river Burhi Gandak at Rosera G&D site corresponding to 25 years return period.)	300 cumec (10% of the flood discharge of river Burhi Gandak at Rosera G&D site corresponding to 25 years return period.)	492 cumec (10% of the flood discharge of river Burhi Gandak at Sikandarpur G&D site corresponding to 50 years return period).
Total length of link	Reach I- lined canal- 23 km Reach II- river course of Noon -23 km Reach III- lined canal- 3 km Reach IV- river course of Baya - 22 km	Reach I- lined Canal - 22.5 km Reach II- river course of Noon -3.5 km Reach III- lined canal-3 km Reach IV- river course of Baya -22 km	Lined canal- 28.95 km
Structure across anroute river Noon	Barrage	Barrage	Syphon aqueduct
Purpose	Flood diversion	Flood diversion	Flood diversion and irrigation
Benefit	Flood moderation	Flood moderation	Flood moderation and irrigation enrout the link canal
Cost	Rs. 407.33 crore (2008-09)	Rs. 382.00 crore (2008-09)	Rs.4284.87 crore (2012-13) (PPR) Rs.4213.75 crore (2012-13) (DPR)
B.C. Ratio	1.38	1.46	1.70(PPR), 1.54(DPR)

1.5 Lesson 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 Project: The project is the most notable endeavor of the 19th century in transbasin diversion. The project envisages 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 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: The project is a complex multi-basin multi-purpose project of seven streams, five flowing towards the west and two towards the east, which have been dammed and their reservoirs interlinked by tunnels. The project envisages transfer of water from Chalakudy basin to Bharatapuzha and Cauvery basins. The water is ultimately delivered to drought prone areas in Coimbatore district of Tamil Nadu and the Chittur area of Palakkad District of Kerala. The command area for irrigation is presently about 1,62,000 ha. There is a total of 185 MW power generation capacity at four power houses. This project was built during the second and third five year plans.

Kurnool Cudappah Canal: A private company started this scheme in 1863. The project envisages transfer of water from Krishna basin to Pennar basin. A 8.23 m high anicut 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.

Telugu Ganga Project: This project has been implemented during 2004 primarily to meet the pressing need of water supply to Chennai metropolitan area. It brings Krishna water from Srisailem 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 177 km long canal. By mutual agreement, 12 TMC of water is being delivered to Tamil Nadu at the border from Krishna basin. This will greatly augment 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 water resources engineering but also of Inter- State co-operation.

Ravi-Beas-Sutlej- Indira Gandhi Nahar Project: Beas-Sutlej link in combination with the Indira Gandhi Nahar Project is a standing example of how the large inter basin transfers brought about all round socio-economic growth with overall enhancement in the ecology and environment of the region. Under the Indus Water Treaty, the waters of three eastern rivers viz., Sutlej, Beas and Ravi were allocated to India. As the land to be benefited in India, lies mostly to the east and south of these rivers, the rivers had to be interlinked and the water conveyed to canal systems for serving vast tracts in India. The main storage on Sutlej is at Bhakra, while that on Beas is at Pong. Bhakra system provides irrigation to 26.3 lakh ha. of new area besides stabilization of existing irrigation of 9 lakh ha. The aggregate generation capacity of power on Bhakra Nangal Project is 1,354 MW. A diversion dam, Pandoh, 140 km upstream of Pong on Beas, enables diversion of water from Beas to Bhakra reservoir and generates 165 MW of power. The Beas-Sutlej link is 37.25 km long of which 25.45 km is tunnel through difficult rock formations. The capacity of the tunnel is 254.70 cumecs. Another dam on Ravi namely, Ranjit Sagar dam will provide additional water to Beas and also generate a large amount of power. Subsequently, it was decided to link the Indira Gandhi Nahar Project with the river systems to provide 9.36 BCM of water to Rajasthan Canal for irrigating the areas of Thar Desert.

It is no exaggeration to say that the transfer of surplus waters of Ravi, Beas and Sutlej to Rajasthan right upto Jaisalmer and Barmer through Indira Gandhi Nahar Pariyojana has eliminated drought conditions, provided power benefits, transformed desert waste land into an agriculturally productive area by bringing irrigation and vegetation to about 2 million

hectare area. Contribution in agricultural production due to implementation of the project is worth Rs. 1,750 crore annually. Canal water is also available for meeting domestic needs. The project has substantially changed the living standard and socio-economic conditions of the people in the 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 Rivers Projects are need of the future.

Burhi Gandak–Noon-Baya-Ganga link project is the first intra-state link project of Bihar taken up by NWDA for preparation of DPR. This DPR is prepared by NWDA making use of consultancy services of various other Govt. departments viz. NIH, GSI and CSMRS.

1.6 Project planning and optimization of benefits

Burhi Gandak–Noon-Baya-Ganga link project has now been planned as a multipurpose project with flood control and irrigation benefit in downstream area of the project. 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 to establish diversion of flood waters from river Burhi Gandak to river Baya/Ganga in two scenarios (i) when only river Burhi Gandak is having flood and (ii) when both rivers Baya and Burhi Gandak are in spate. For accounting for backwater effect, the reverse simulation studies has been conducted from outfall point to offtake point and it is established that the diversion of Burhi Gandak flood water to Baya/Ganga is hydraulically possible.

(i) Benefits from flood diversion

Flood damage occurs in lower reaches of Burhi Gandak basin in the districts of Samastipur, Begusarai and Khagaria. The overall average annual damage considering the three districts for the period 1998 to 2012 works out to Rs. 204.73 crore. As per the studies carried out by NIH, it is revealed that the reduction in damages, due to reduction in inundation, in terms of damages to houses, crops, public utilities and infrastructure would be much

beyond 50% by diversion of Burhi Gandak flood water to the tune of 10% of the estimated flood discharge corresponding to 50 years return period. Since the reduction of flood damages in the considered area is directly proportional to the annual flood peaks occurred in Burhi Gandak river, the reduction in damages will vary from 50 to 90% on year to year basis.

In view of the above, an average reduction in flood damages to the tune of 70% of the average annual flood damages of the 15 years in the districts of Samastipur, Begusarai and Khagaria collected from Govt. of Bihar have been considered in the study to arrive at the benefits from flood control. Accordingly, total flood damage of Rs.143.31 crore has been considered as annual benefit from flood control.

(ii) Benefits from irrigation planning

This scheme was basically a flood moderation scheme but considering the availability of large fertile land enroute the link canal, it is also proposed to provide irrigation to the unirrigated enroute area of the link canal lying in Samastipur, Begusarai and Khagaria districts of Bihar during kharif season. The gross command area and culturable command area of link project are 1.76 lakh ha and 1.26 lakh ha respectively. The area proposed to be irrigated through this link canal considering intensity of irrigation of 100% is worked out as 1.26 lakh ha. Irrigations will be provided during kharif season only. The total annual benefits from irrigations works out to Rs. 587.10 crore.

(iii) Other benefits

The other benefits from the project will be reclamation of waterlogged area which would be made available for cultivation, development of agro based industries in the area, employment generation, development of tourist spots and infrastructure etc. This will result in upliftment of socio-economic conditions of the people and enhance revenue of the State .

1.7 Methodology adopted

1.7.1 Survey and investigation works

NWDA has adopted two pronged action for preparation of DPR of Burhi Gandak-Noon-Baya-Ganga link project. Major part of detailed surveys & investigations 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 hydrological studies and environmental impact assessment & socio economic studies were outsourced to concerned Government departments/ specialized reputed agencies.

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

- i. River survey of Burhi Gandak, Noon and Baya rivers
- ii. Survey of barrage site proposed across Burhi Gandak river
- iii. Link canal surveys.
- iv. Grid survey for various CD/CM structures along the link canal
- v. Survey of outfall point of the link canal in Baya river
- vi. Plant and colony area survey
- vii. Communication and other allied surveys.

1.7.2 Surveys and investigations carried out by other agencies

The following specialized surveys & investigation works and hydrological studies were outsourced to the concerned government organizations/ specialized reputed agencies.

1.7.2.1 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 survey and testing of soil, sand and rocks samples have been carried out by CSMRS, New Delhi.

The foundation investigation of the proposed barrage site has been carried out through exploratory drill holes and required field and laboratory

investigations. Out of total 5 drill holes, 1 drill hole at either side of the river bank, 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 site . In addition to the above, 17 drill holes along the link canal and various canal structures were also made. The cores obtained from these drill holes have been tested by CSMRS for geotechnical investigations. The undisturbed and disturbed soil samples were collected from eight trial pits at eight different locations along the canal alignment at a regular interval of about 4 km and from the profile where there is a change in strata and topography. The CSMRS has conducted various laboratory tests on the collected soil samples to ascertain the state of foundation competence as well as suitability of soil as construction material.

The collection of rock and sand samples have been carried out in order to ascertain the suitability for using as coarse aggregate and fine aggregate. The requirement of construction materials for the project can be met from the nearby quarries. Total 10 representative rock samples and four natural sand samples were collected from identified quarries. The quality of the materials available in various quarries have been tested by CSMRS, New Delhi and found suitable for utilising as construction materials. Further, the construction materials like cement, steel etc. can be brought to the nearest railhead i.e. Angarghat or Samastipur for construction of barrage and other structures.

1.7.2.2 Geological investigation

Geological mapping of the proposed barrage across river Burhi Gandak and important CD/CM structures across entire length of 28.95 km long link canal has been carried out by GSI, Kolkata. 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. The study reveals that the entire canal alignment alongwith CD/CM structures will pass through Gangetic alluvial reach.

1.7.2.3 Sample command area surveys

The work of sample command area survey and preparation of maps was outsourced. About 10% of the CCA i.e. 12500 ha has been considered as the sample command area and surveyed using DGPS technique.

1.7.2.4 Hydrological studies

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. Burhi Gandak-Noon-Baya-Ganga link project envisages diversion of 492 cumec of flood water from the proposed barrage across river Burhi Gandak, to the river Baya/Ganga. Design flood was arrived through flood frequency analysis using Gumbel and Log Pearson type- III distribution. The flood discharge corresponding to 50 years returns 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.

1.8 Environmental impact assessment and socio-economic studies

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 Burhi Gandak-Noon-Baya-Ganga 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 flood control and increased agricultural production. Further, there is no adverse effect on the biodiversity as there is no forest area 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.

1.9 Financial and economic analysis

The total cost of the Burhi Gandak-Noon-Baya- Ganga link canal project works out to Rs. 4213.75crore at 2012-13 price level. The annual cost of the project including maintenance, depreciation of the project and interest on capital cost etc. works out to Rs. 474.75 crore. The annual benefits from the saving of flood damages and annual benefit from the irrigation are worked out to be Rs. 143.31 crore and Rs. 587.10 crore respectively. The benefit-cost ratio and Internal Rate of Return (IRR) have been worked to be 1.54 and 16% respectively.

1.10 Clearances required

Burhi Gandak-Noon-Baya-Ganga intra-state link project will require the following clearances from the departments/agencies indicated below in **Table 1.3**.

Table 1.3

Clearances required from other departments/agencies

S.No.	Clearance	Departments/agencies
(i)	Techno-economic	Central Water Commission / TAC, MoWR
(ii)	Environmental	State level Environment Impact Assessment Authority (SEIAA) or Central Govt.
(iii)	R&R Plan of Tribal population	Ministry of Tribal Affairs

Based on above, investment clearance will be accorded by Planning Commission.