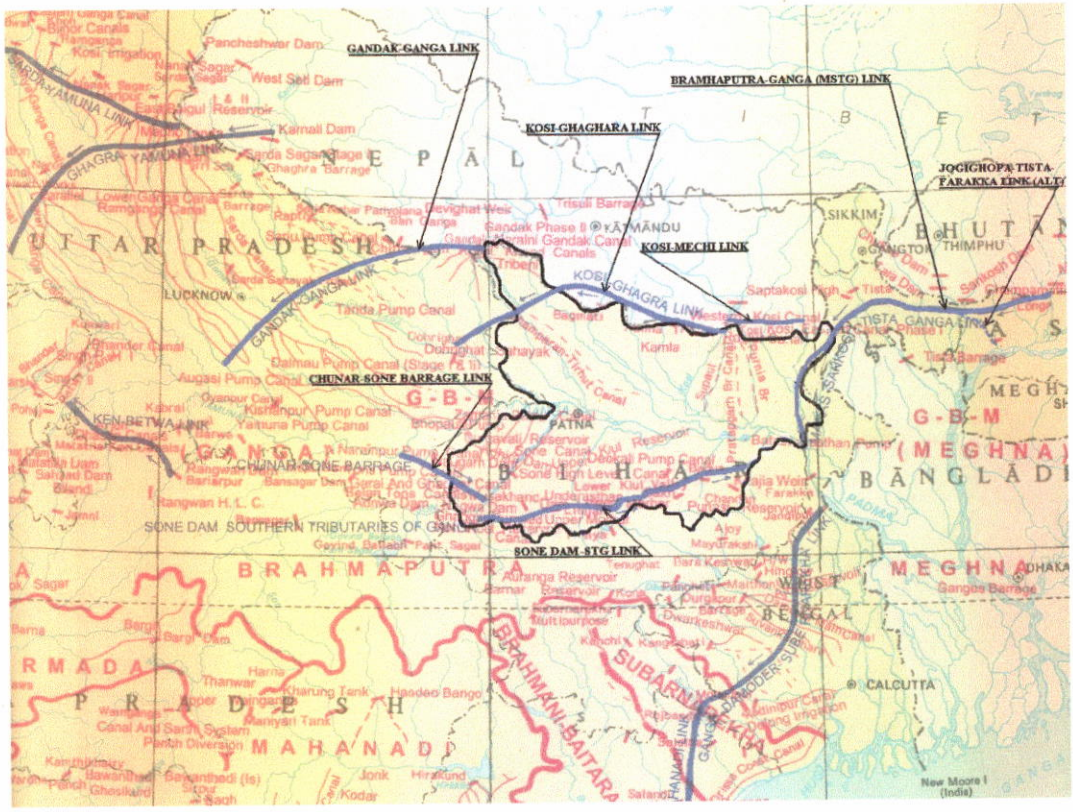
सत्यमेव जयते

REPORT OF EXPERT COMMITTEE ON IMPACT OF INTERLINKING OF RIVERS ON BIHAR



WATER RESOURCES DEPARTMENT
GOVERNMENT OF BIHAR

APRIL 2005

प्रेषक,

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अध्यक्ष,
विशेषज्ञ समिति (कमरा न0-211),
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पटना ।

सेवा में,

आयुक्त एवं सचिव,
जल संसाधन विभाग,
बिहार, पटना ।

विषय "राष्ट्रीय नदियों को जोड़कर जलान्तरण परियोजनाओं का बिहार पर प्रभाव " का दिनांक 4 सितम्बर 2004 को दिये गये प्रसांगिक बिन्दुओं पर आधारित प्रतिवेदन ।

प्रसंग बिहार सरकार, जल संसाधन विभाग की अधिसूचना संख्या-5/पी.एम.सी./(जल विज्ञान)/ 9-8/93 भाग-7-921 दिनांक 04.09.2004 ।

महाशय,

उपरोक्त पत्र के प्रसंग में दिये गये दिशा निर्देश एवं Terms of Reference के विभिन्न बिन्दुओं पर सम्यक अध्ययन एवं विचार-विर्मश के उपरान्त् बिहार किस तरह इन योजनाओं से प्रभावित होता है तथा उनका वैकल्पिक निदान की क्या संभावनाएँ है, इन सभी बिन्दुओं का समावेश करते हुए समेकित प्रतिवेदन दो प्रतियों में प्रेषित किया जा रहा है।

2. प्रतिवेदन में कई पूर्व की राष्ट्रीय समितियों एवं अध्ययनों के द्वारा प्रतिपादित सिद्धांतों का उद्धरण देना आवश्यक था, जो सभी अंग्रेजी भाषा में थे तथा गणना आदि की सुविधा के कारण समिति ने प्रतिवेदन अंग्रेजी भाषा में ही तैयार किया है।

अनुलग्नक-यथावत् ।

आपका विश्वासी
30-4-05
(कुबेरनाथ लाल)
अध्यक्ष, विशेषज्ञ समिति।

Preface

The Expert Committee constituted by the Govt. of Bihar was entrusted with job of studying the effect of the National effort of 'Interlinking of the Rivers' on the State of Bihar. Previous to this Report the Expert Committee had examined the status of Bihar with respect to Water Availability and its various need for 2050 AD considering conjunctive use. But as the government of Bihar has desired vide its Notification No.5/ PMC-921 dated 04.09.2004 that this study should be carried out only with respect to available water Resources and should give its recommendations on some specific term, the Committee considered it essential to project the need of irrigation as well as non-irrigational need till 2050 AD. The requirement of available water has variation in both space and time, where as, there is surplus of water in monsoon month, there is acute shortage in non-monsoon months. The committee took this opportunity to deal with and commenting on all the six Pre-feasibility report of interlinking scheme prepared by NWDA, related to Bihar.

Suggestion with respect to Kosi-Ghaghra-link Canal, Sone-Dam STG Link Canal and Chunar-Sone Barrage Link Canal have been dealt in details. Emphasis has been given to mitigate the flood peaks so to give some respite from recurring flood havocs.

The South Bihar admittedly has shortage of water but even North Bihar is unable to meet the projected requirement in non-monsoon month. The State is in urgent need to store monsoon water, which otherwise is going to drain down the sea, and there is urgent need of provision of more flow in Ganga so as to remove any de-facto restriction on use of Ganga water in Bihar. The study also reveals that for the ever- increasing population in Bihar by the year 2050 AD, the proposed intensity of irrigation is a necessity. Coverage of all possible land under irrigated agriculture with shortage of water in non-monsoon month in North Bihar may be met with use of ground water in that zone, but that in South Bihar will need special effort. Various suggestions have been given in the report by the Committee to enable reducing the gap. Conjunctive use of surface and ground water with special effort to enhance the recharge of ground water by surplus monsoon water of North Bihar may have to be adopted, in absence of sufficient additional storage reservoirs to store monsoon surplus before transfer to other part of the country.

(K. N. Lal) 30.4.06

Chairman

ACKNOWLEDGEMENT

The Government of Bihar vide Notification No. 5/PMC (Hydrology) 9-8/93 Part-7 - 921 dated 04.09.2004, constituted a Technical Committee of Engineers to study the effect of Interlinking of Rivers on Bihar and for advising the State Government accordingly. The notification is enclosed as Appendix-1.

2. The Committee held several sittings and went in great depth for about more than seven months. In the mean time Sri. S.C.Sinha after attending first two meetings went on a Foreign assignment. Thereafter, another learned member Sri. Ram Ratan Prasad underwent a surgery. In the month of February assembly election of Bihar state was held which also affected the progress of the work to a great extent necessitating the Committee for extension of time and number of sittings.

3. The Committee held its first meeting on 9.09.2004. Suggestion was given to constitute a cell of engineers under the leadership of the Chief Engineer, Hydrology & Project Planning to assist the Committee on the advice and direction of the Committee.

4. By the office order no. P.M.5 (International) 2-15/2003- part-II 1037, Patna dated 6.10.2004 the Government of Bihar constituted a cell with Er. K.D. Singh, Director, Hydrology Directorate, Patna, Er. Satyendra Kumar Sinha, Executive Engineer, Investigation and Project Preparation Division, and four Assistant Engineers viz. Er. Nagan Prasad, Er. Arti Sinha, Er.Timir Kanti Bhaduri and Er.Manoranjan Verma to assist the Committee in its computations and data collections.

Acronyms

AD	Ante Dommine
ALT.	Alternative
Av.	Average
BCM	Billion Cubic Meter
CC	Cement Concrete
CCA	Culturable Command Area
CD Works	Cross Drainage Works
cumec	Cubic Meter per second
cusecs	Cubic feet per second
C-SB	Chunar-Sone Barrage
CWC	Central Water Commission
DG	Director General
DPR	Detailed Project Report
D/s	Downstream
EL	Elevation above mean sea Level
EMC	Eastern Main Canal
FSD	Full Supply Depth
FRL	Full Reservoir Level
GCA	Gross Command Area
G&D	Gauge and Discharge
GDP	Gross Domestic Product
GOB	Government of Bihar
GOI	Government of India
GW	Ground Water
HW	Hot Weather
HYV	High Yield Variety
IWD	Integrated Water Resources Development
JTF	Jogighopa-Tista-Farakka
KHD	Kosi High Dam
Km.	Kilometre
Km^3	Cubic Kilometre
KW	Kilo Watt
L.ha	Lakh Hectare
L/s	Longitudinal Section
LUP	Land Use Planning
m^3	Cubic Metre
MAF	Million Acrefeet
MCM	Million Cubic Metre
MDDL	Minimum Draw Down Level
m	Metre
M ha.	Million Hectare
MI	Municipal and Industrial
MP	Madhya Pradesh

REPORT

ON

IMPACT OF INTERLINKING OF RIVERS ON BIHAR

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CHAPTER-I

THE PROJECT FOR INTERLINKING OF RIVERS

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THE PROJECT FOR INTERLINKING OF RIVERS

I.1 The Background

The following few facts describe the scenario prevailing in the country in the field of water resources, its status of development as well as problems and prospects as visualized today.

- India receives over 4000 cubic Km of water annually from average annual precipitation of 117 cm. The precipitation varies from 10 cm in western Rajasthan and Ladakh to over 1000 cm in parts of Meghalaya. The variation results into flood-drought-flood Syndrome.

- The annual water resources, both surface and ground, have been assessed as 1953 BCM and 431 BCM, respectively out of which utilisable water resources have been assessed as 1086 BCM which comprises 690 BCM from surface and 396 BCM from ground water.

- The estimated water resources of the country is only 4% of the fresh water of the world, with which it has to support about 16% population on 2.4% land of the world.

- The estimated water requirement of the country would be between 644 to733 BCM, 861 to 1027 BCM and 1221 to 1681 BCM by the year 2010, 2025 and 2050 respectively. Irrigation would continue to have the highest water requirement between 832-1191BCMby the 2050which is about 70% of the total requirement. (As per NCIWRD report Jan1999)

- **There are large disparities in the availability of water between different river Basins. Per-capita utilisable water availability based on 1991 population varies from 182 M^3 inSabarmati Basin to 2,500 M^3 in Mahanadi, and 3082 M^3 in Narmada Basin. Utilisable water availability per ha of culturable area varies from 1244 M^3 in Sabarmati Basin to 8320 in M^3 Mahanadi and 7669 M^3 in Narmada Basin.**

- Out of total geographical area of 328.78 M ha. of the country (land area being 297.319 M ha.), the culturable area is 184.376 M. ha.

- Over one million square kilometre i.e. nearly one third of the country, is drought prone, while 40 M ha i.e. 12% area of the country was considered flood prone at that time by the Rashtriya Barh Aayog (1980).

- With concerted efforts for developing water resources the total irrigation potential is expected to increase from 22.6 M ha (9.7.M.ha from major & medium and 12.9 M. ha. from minor irrigation schemes) during pre-plan period to an estimated 106.61 M. ha. (42.77 M. ha from major and medium and 63.84 M. ha. from minor

irrigation schemes) by the end of Ninth Five Year Plan (1997-2002), which is 76.2% of the revised ultimate irrigation potential of 139.89 M ha.

- Notwithstanding the impressive achievement in the creation of potential, the irrigation projects suffer from the following deficiencies:

  - lag in utilisation of irrigation potential (about 12.6% at national level)
  - low water use efficiency (less than 40%)
  - low productivity of irrigated agriculture (average- 2.33 T/ha).

- The production of food grains increased from 51 Million tones (MT) in 1950-51 to 203 MT in the year 1998-99

- In view of the rising trends in population, recent trend in food consumption and considering other socio-economic factors the total food requirement of the country has been assessed as 450 MT. Considering the feed requirement, losses in storage and transportation, seed requirement and carry over for years of monsoon failures in the country (which has been estimated at 12.5% of the food grains production) the total demand for the food grains have been estimated as 605 MT for the year 2050 when the population of the country is expected to stabilise around 1640 million as per NCIWRD Report (1999).

1.2. The Interlinking Schemes

Being faced with the daunting challenge of producing enough food grains to feed the ever increasing population and of meeting the exorbitantly increasing demand for water in all sectors, the project for interlinking of rivers of the country has been conceived and is being planned in the background of vast disparity in the availability of water in different river Basins.

The Interlinking Schemes envisage to conserve water in the basins considered surplus by constructing dams and transferring the surplus water after meeting all demands in that basin, to drought prone areas through link canals as conceived in National Perspective Plan detailed below.

1.2.1. National Perspective Plan

The National Water Policy has underlined the need for making water available to water short areas by transfer from water surplus areas including transfers from one river Basin to another, based on a national perspective, after taking into account the requirements, of the areas/basins. The Ministry of Water Resources has prepared in 1980 a National Perspective Plan for development of country's water resources, disregarding political boundaries of States. This National Plan is in two parts namely, (i) development of Peninsular Rivers which is entirely within the control of the central and state Governments and (ii) Himalayan Rivers Development which calls for cooperation of India, Nepal, Bangladesh and Bhutan. The Himalayan and Peninsular River Plan would add to the presently estimated ultimate irrigation potential besides providing large quantum of hydropower, flood control and in some reaches, navigation. Development and transfer of waters on inter-state and

international rivers will require new policy initiative by the Government in hammering out acceptable plans and financing them later on.

The National Perspective Plan would be one of the greatest water development projects of the world. It envisages the construction of about 180 BCM of storages which alongwith the interlink will facilitate additional utilisation of nearly 240 BCM of water for beneficial use in India. This will enable irrigation over an additional area of 25 Mha by surface water and besides 34,000 MW of substantial hydropower generation, flood control and other multifarious benefits. The distinct feature of the scheme is transfer of water essentially by gravity and only in small reaches by lift not exceeding 120 m. The technology proposed in the scheme is already known and tried successfully in India and, therefore, does not involve experimentation or research.

In formulation of the National Perspective Plan two important aspects namely, the economic aspect and the socio-economic and environmental aspect are required to be taken into account. The economic aspect is to study the comparative economics of in-Basin water development and inter-Basin transfer. The socio-economic and environmental aspect comprises the consideration of socio-economic factors, including displacement of population and their settlement that would be required to be dealt with while resorting to inter-Basin transfer of water.

The National Water Development Agency (NWDA) set up by the Government of India to carry out necessary surveys and prepare inter-basin transfer of water has completed pre-feasibility studies of 16 links in Peninsular component and 14 links in Himalayan component. It has also undertaken field surveys and investigation for preparation of feasibility reports. The feasibility studies of 3 links in Peninsular component namely Ken-Betwa Link, Par-Tapi Link, and Pamba-Achankovil Vaippar Link have already been completed and the remaining are being taken up in a phased manner. The implementation of the inter-Basin transfer proposals would require great understanding and cooperation among different states and financial support from Central Government.

The cost of implementing the inter Basin transfer proposals prepared by NWDA, at 2002 price level, is roughly Rs. 5,60,000 Crores for both Himalayan and Peninsular components. The cost of power components is Rs. 1,35,000 Crore while the remaining cost of Rs. 4,25,000 Crore is for irrigation and water supply.

The scheme of Interlinking of rivers has two components comprising 30 link canals

(i) Peninsular Rivers development comprising 16 link canals
(ii) Himalayan Rivers Development comprising 14 link canals

(vide Fig. 1.1)

1.2.2 Peninsular Rivers Component

The proposal of Peninsular River Development will enable additional use of about 84 km^3 of water to benefit the states of Orissa, Andhra Pradesh, Maharashtra, karnataka, Tamilnadu, Madhya Pradesh etc. This will provide additional irrigation benefits of over 13 million ha. It comprises 16 link canals as described below :-

(i) Amongst the Peninsular rivers, the Mahanadi and Godavari are considered to have sizeable surpluses after meeting the existing and projected needs of the states within these Basins .It is, therefore, proposed to provide terminal storages on Mahanadi and Godavari rivers to divert surplus flows of Mahanadi to the Godavari system and to further transfer surplus from the Godavari System to water short rivers namely, Krishna, Pennar and Cauvery. The link from Mahanadi to Godavari will be along the east coast and will not involve any lift. The link between Godavari and Krishna will be partly by gravity and partly in the ultimate stage, by lifts of the order of 120 m (maximum). The transfer of waters would enable irrigation in drought prone areas of Maharashtra , Karnataka, Andhra Pradesh and Tamil Nadu by successive exchange.

(ii) The Second component of this proposal is to divert a part of the water of the west flowing rivers of Kerala to the east for irrigating the drought prone areas of Tamil Nadu, apart from bringing new areas under irrigation in Kerala.

(iii) The third component is to construct storages and inter- link small rivers flowing along the west coast, north of Bombay and south of Tapi. This will enable partial release of water from Tapi and Narmada that may allow extension of irrigation to Saurashtra and Kutch areas. It will also enable provision of extra water to meet the growing needs of metropolitan area of Bombay as well as providing irrigation to the coastal areas in Maharashtra.

(iv) The fourth component envisages inter-linking of the southern tributaries of the Yamuna like the Ken and the Chambal in addition to construction of small storages on intermediate tributaries and a dam on the Yamuna at Panchnad. This will enable irrigation in Madhya Pradesh as well as in Rajasthan.

The Peninsular component of link canal comprises the following four systems of link canal as described above.

(1) The Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai Link running through the eastern region of the peninsular India and inter-connecting all the major east flowing rivers of the southern India is the main link of the peninsular rivers component. This link system has been divided into several parts as follows:

i) Mahanadi to Godavari

(a) Manibhadra- Dowlaiswaram Link

ii) Godavari to Krishna

(a) Inchampalli-Nagarjunasagar Link
(b) Inchampalli- Pulichintala Link
(c) Polavaram-Vijaywada Link

iii) Krishna to Pennar

(a) Almatti- Pennar Link
(b) Srisailam-Pennar Link
(c) Nagarjunasagar -Somasila Link

iv) **Pennar to Cauvery**
(a) Somasila- Grand Anicut Link

v) **Cauvery to Vaigai**
(a) Kattalai Regulator- Vaigai- Gundar Link

2. Par- Tapi- Narmada and Damanganga -Pinjal links under the component of interlinking of small west flowing rivers along the west coast south of Tapi and North of Mumbai.

3. Ken- Betwa and Kalisindh- Chambal links for inter-connecting the southern tributaries of Yamuna.

4. Pamba-Achankovil-Vaippar, Netravati-Hemavati and Bedthi-Varada links for the diversion of surplus waters of the west flowing rivers of Kerala and Karnataka to the east

1.2.3 The Himalayan Rivers Component.

The Himalayan Rivers Component envisages construction of storages on the main Ganga and Brahmaputra river and their principal tributaries in India, Bhutan and Nepal so as to conserve monsoon flows for flood control, hydropower generation and irrigation. Inter-linking canal systems will be provided to transfer so called surplus flows of the Kosi, Gandak and Ghaghra to the west. In addition, Brahmaputra-Ganga Link will be constructed for augmenting dry weather flows of the Ganga. Surplus flows available on account of inter-linking of Ganga and Yamuna are proposed to be transferred to the drought prone areas of Haryana, Rajasthan and Gujarat. The scheme will also enable large areas in South Uttar Pradesh and South Bihar to obtain irrigation benefits from the Ganga with a moderate lift of less than 30m. Further, all lands in Terai area of Nepal would also get irrigation apart from generation of about 30,000 MW of hydropower in Nepal and India. It will also provide flood moderation in the Ganga - Brahmaputra system. Through these Link proposals, about 140 km^3 of additional water would be made available from the Himalayan rivers system for irrigating an estimated 22 million ha, in the Ganga- Brahmaputra plains, apart from Haryana, Punjab, Rajasthan and Gujarat. It would also provide 1,120 cumecs (40,000 cusecs) to Kolkata Port and would provide navigation facilities across the country. The scheme will benefit not only parts of India but also neighbouring countries of Nepal and Bangladesh (NWDA, 1998).

The Himalyan River Components of the Interlinking of rivers comprises the following l4 link canals:

i. Kosi-Mechi
ii. Kosi-Ghaghra
iii. Gandak-Ganga
iv. Ghaghra-Jamuna
v. Sharda-Jamuna
vi. Jamuna-Rajasthan
vii. Rajasthan-Sabarmati
viii. Chunar-Sone Barrage

ix. Sone Dam-Southern Tributaries of Ganga (STG)
x. Brahmputra-Ganga (MSTG)
xi. Brahmputra-Ganga (JTF)-(Alternative)
xii. Farakka-Sunderbans
xiii. Ganga-Damodar-Subernarekha
xiv. Subernarekha-Mahanadi

1.2.3.1 Link Canals directly related to Bihar

Of the 14 Himalayan components, 6 river-link canals are directly related to Bihar. They are :

i Brahmaputra - Ganga (MSTG) / Brahmaputra-Ganga (JTF) - Alternative
ii. Kosi - Mechi
iii. Kosi-Ghaghra
iv. Gandak - Ganga
v. Chunar - Sone Barrage
vi. Sone Dam-Southern Tributaries of Ganga (STG)

The above schemes envisage construction of three dams across Kosi, Gandak and Sone river besides the concerned link canals. The Gandak - Ganga link canal is partly related to Bihar although it will not pass through Bihar as it will have significant impact on water utilisation and flood moderation in Bihar.

1.2.3.2. Link Canals Having Impact on Bihar

Besides the above six link canals of the Himalayan Components the following link canals will also have impact on Bihar :

i. Ghaghara -Yamuna

ii. Sharda -Yamuna

iii. Yamuna -Rajasthan

iv. Rajasthan- Sabarmati

Though these rivers and these link canals do not pass through Bihar, they are going to have significant impact on water resources and issues related to Bihar as they are located on the tributaries of Ganga. Bihar is already seriously affected by low discharge in Ganga during lean period. These schemes will have significant impact on the already dwindling discharge of Ganga in lean period. These link canals envisage to transfer water to some other Basin and finally to Rajasthan and Gujarat. They will thus adversely affect the discharge in Ganga, which is already dwindling during lean period.

1.2.3.3 The salient features of the schemes directly affecting Bihar are available in Annexure 1.1 and they are described below in very brief.

i. Brahmaputra - Ganga (Manas-Sankosh-Teesta-Ganga Link Canal) :

It envisages construction of 457 km long link canal and a dam on river Manas and a dam and a barrage on river Sankosh in Bhutan. There would be 7 numbers of falls on the canal, out of which 4 nos. of falls are located in Bihar. A total hydropower to the tune of 718 MW will be generated on these falls, out of which 393 MW will be generated on falls located in Bihar. The link canal will provide irrigation benefits to an area of 6.53 Lakh ha, out of which 2.64 Lakh ha are in Bihar.

ii. Kosi-Mechi Link Canal :

The 112.55 km. long canal will mainly pass through the 'Terai' area in Nepal. It will start from the left side of Chatra barrage and fall into river Mechi after crossing over three small rivers Bakra, Ratuwa and Kankai through syphon aqueduct. The canal's receiving capacity will be 1407.80 cubic metre per second (cumec) and discharge rate will be 97.64 cumec. The canal would provide irrigational facility to 4.74 Lakh hectares of land. Out of this, 1.75 Lakh hectares shall be irrigated in Nepal and 2.99 Lakh hectares in Bihar. Besides this, provision of 24 MCM water has been made for domestic and industrial requirements of the towns falling in between. As proposed, it would divert 883 MCM water at the rate of 28 cumec to river Mechi for increasing the water in river Mahananda. The canal would also provide navigational facility from Chatra to Ganga via Mechi and Mahananda rivers.

iii. Kosi-Ghaghara Link Canal :

The 428.76 km long canal, which will start from the right side of the Chatra barrage, will fall in Gaura river, a tributary of river Ghaghara, in Utar Pradesh after crossing over Tiljuga, Khanro, Bagmati and Lalbakeya rivers in Nepal area and river river Gandak in Bihar. The canal's receiving capacity will be 1021 cumecs while it will discharge 67 cumec in river Gaura. The total benefitted area through this link canals is 10.58 Lakh hectares. Out of this, 1.74 Lakh hectare area shall be of Udaipur, Saptari, Mahoitari, Sarlahi and Bara districts in Nepal and 8.17 Lakh hectare and 0.67 Lakh hectare of area of North Bihar and Uttar Pradesh, respectively. The canal would also provide 48 MCM water for domestic and industrial requirements of the towns on its way.

iv. Gandak -Ganga Link Canal :

The 639 km long canal, which would start from the right side of the proposed dam across Gandak river in Nepal, will fall in Ganga river near Mustafabad in Rai Bareli district of Uttar Pradesh. It will run through Nepal and various districts of Uttar Pradesh. Though this canal would not cross through Bihar it would make a big impact on the State by taming the flood waters of Gandak. There will be no irrigational facility in Bihar from this canal.

v. Chunar-Sone Barrage Link Canal :

The 149.10 km long canal will start from the right side of Ganga river near Chunar Tehsil of Mirzapur district in UP. It will fall into river Sone near Indrapuri barrage in Rohtas district. There would be lift of 38.8 meters, 16.10 meters and 4.4 meters at three

different places en route. In addition to taking over entire command areas of Western Sone high level and low level canals i.e. 5,12,032 ha. This link canal will provide irrigation in 52792 hectares of new area in Mirzapur, Varanasi and Gazipur districts of UP and 14001 hectares of new area in Bhabhua, Rohtas, Buxar and Bhojpur districts of Bihar.The total benefited area is thus 5,78,825 ha.

vi. Sone dam-Southern Tributaries of Ganga Link Canal :

The 339 km long canal will begin from the right side of the proposed dam across Sone river near Kadwan in Jharkhand. The canal would fall into Badua left bank canal after crossing over Morhar, Lilajan, Dhanarjayi, Sakri and Kiul rivers. Two hydel projects of 3.5 MW and 1.5 MW capacities are also proposed at km. 222.25 & 229.80 of the link canal besides 90 MW at Kadwan dam. The total benefited area through this canal will be 3.07 Lakh hectares in Patna, Nalanda, Gaya, Jehanabad, Munger, Bhagalpur, Nawada, Jamui and Aurangabad districts of Bihar and Palamu district of Jharkhand.

1.3 POLICIES, OBJECTIVE AND APPROACHES

Interlinking of rivers is the biggest water resources development project of the country and one of the biggest Water Resources Development Projects of the World. It is very important to review briefly the policies recommended by different Commissions such as National Water Policy (2002), Irrigation Commission (1972), National Commission on Agriculture (1976), Rastriya Barh Aayog (1980) and National Commission on Integrated Water Resources Development (1999). It is imperative that the objective for the Interlinking of rivers should be defined in light of the policies suggested by these Commissions. Accordingly the approach for planning, design and implementation should be adopted.

1.3.1 National Perspective Plan

The conservation of water by creating storages and inter Basin transfers of water by constructing carrier canals, from surmised surplus river basins to deficit Basins has been the guiding objective of projects of Interlinking of rivers of India. The broad approach adopted in the National Perspective Plan is as follows:

- Existing uses have to be kept undisturbed
- Normally water development under the existing legal and constitutional framework is assumed to take place fully by the turn of the century.
- The development envisaged is within the framework of all the existing agreements between the states.
- While planning inter-Basin and inter-state transfer of water, reasonable needs of the Basin states for the foreseeable future have to be kept in view and provided for.
- Most efficient use of land and water in the existing irrigation and hydro power stations should be a principal objective to be achieved.

1.3.2 Approach advocated by NCIWRD (1999)

The National Commission for Integrated Water Resource Development (NCIWRD, 1999) have studied the project for Interlinking of rivers of India and the basic approach suggested and adopted by them is as follows:

"In approaching this complex issue, we begin with the assessment that it will not be possible to persuade a state to spare water till its own demands are met to the maximum possible extent. In Basins with possible surpluses, near saturation utilisation of land and water has first to be aimed at subject to the condition that such utilisation is not based on impractical engineering, for example storage requirements for which reservoir sites are not available or involve very high lifts or wasteful use, for example, very low efficiency and excessive water application. This would include first priority domestic, industrial land environmental uses and then irrigation use. Provision must also be made for minimum flows during lean season to meet environmental requirements for maintaining water quality and for customary use by people living on river banks."

"After meeting all these essential requirements, if there is surplus water available in the Basin, its transfer to other Basins may be considered. Such Basins should first aim at efficient utilisation of all the in-basin resources. For deficit basins, the aim would be to meet domestic and industrial demand in full, but to achieve a lower cropping and irrigation intensity than that in case of well - endowed or surplus Basins. The overall approach should be that economic development of no part of the country should be constrained by shortage of water, at the same time the pattern of development could be different in states having adequate water and those to which water may have to be transferred at high cost. Food self- sufficiency is essential for the country as a whole but not necessarily for individual river Basins. Nevertheless, it has to be borne in mind that even in a Basin not endowed with ample water resources, almost two-thirds of the population is dependent on agriculture and sharp reduction in their numbers may not be feasible. Their quality of life can be improved only through increased agricultural productivity for which the first basic requirement is water. Hence, in all basins of peninsular rivers, the present irrigated area has to be substantially increased".

"Based on these considerations, we have worked out the water availability, projected demand of various sectors in the year 2050 and the water balance for six of the major east flowing rivers of the peninsula".

The NCIWRD have also observed that irrespective of present or future constitutional provisions, it would not be practical to transfer water without concurrence of donor states and such concurrence would be facilitated by some form of quid pro-quo.

1.3.3 Concept of Optimisation

In the various reports prepared by NWDA viz Preliminary Water Balance Study & Pre-feasibility Reports for different components of the Linking of Rivers Project, attempt has been made for optimum use of water resources and mention to this effect has been made in the reports at several places. In the first place optimization is a very good concept and the attempt to optimize the important resource like water must be appreciated and is

worth attempting. However, the most predominant use of water is for agriculture and hence optimum use of water has to be considered along with the optimization of land. As a matter of fact, the optimization study should be carried out jointly for both the resources-water and land. Secondly, regional / local problems are becoming more serious day by day and regional disparity and / or lack of development are getting reflected in form of social unrest / mass agitation ultimately breeding discontent leading to undemocratic and violent manifestation. Therefore, the small pockets of regional / local area remaining neglected so far, has to be given due importance and priority in optimisation of most important natural resources-water and land. Thus optimisation should include another most important resources i.e. land besides water and it should focus on the local / regional areas hither to neglected due to many reasons including absence of political force. Thirdly, after certain level of optimisation important aspects like sustainability, robustness and resilience should be given more importance over further optimisation. These are generally not to be found in the present reports.

1.3.4 Objective of Interlinking of Rivers

The prime objective of the proposed mega project of Inter linking of rivers of India is to transfer water from water rich Brahmaputra and lower Ganga Basins towards the west, finally conveying it to water short southern UP, Haryana, Punjab and to arid Rajasthan and Gujarat and also to the Basins of peninsular India. The scheme has been formulated in the background of large disparities in availability of water in different Basins of India, and the objective is to achieve equitable distribution of available water resources for increased economic efficiency, self sufficiency of food, providing livelihood and employment opportunities in site etc.

The objective as enumerated in various studies and reports prepared by NWDA is no doubt quite appropriate. However, it gives stress on the development of so called water deficit basin irrespective of its present level of development compared to that prevailing in surmised surplus basins. It completely ignores the problems related to water resources development in the Basin from which surplus water is proposed to be transferred. It also does not take into consideration the present level of development in the field of water resources, which may be too much below and far too low than that prevailing in the so called deficit Basin in which the water is proposed to be transferred. While talking of equitable distribution of water resources, it is quite appropriate and logical to take into consideration the lag in development of water resources in the donor Basin / states. Ignoring this issue will lead to further inequality and regional disparities. Since this present mega project of interlinking of rivers is going to be the biggest and the final plan in water resources development, any mistake in its planning and implementation will lead to very adverse and serious consequences, which will have no remedial measures and will be almost impossible to rectify in future.

In this background the objective of the project should be broadened to include all the problems related to the development of water and land in the donor Basin as well. In the context of Bihar, the objective should be expanded to include the solution of the burning problems in the field of water resources, such as flood, drainage congestion, augmenting lean flow in river Ganga and its tributaries, drought prone area and rapid development of irrigation.

Besides these objectives, it should also endeavour to bring equity in level of development of water resources in different river Basins of the country. It is very relevant to note that the perception of surplus or shortage of water in a particular Basin is very much linked with the level of development and quantum of utilisation.

In view of these discussions, the objectives of the project of interlinking of rivers should be as follows:

1 Equity in level of water resources development in different Basins - The developmental activities in the Basins regions/ states, which are lagging behind should be accelerated.

2 Equitable distribution of water resources: This should be in accordance with the potential for ultimate development in light of available important resources like land and its characteristics, water and population etc.

3 Comprehensive Approach: The approach adopted should be comprehensive and it should include all problems related to water in the Basins. In the context of Bihar it would be as follows -

i. Flood moderation
ii. Removal of drainage congestion and water logging.
iii. Augmenting lean flow in river Ganga and its major tributaries
iv. Development of drought prone area.
v. Rapid development of balance irrigation potential .

1.4 Approach Adopted by the Present Expert Committee

The approach adopted by the present Expert Committee in preparing & finalising its reports is as follows:

- The Director General NWDA informed in the 32nd meeting of the TAC held on 8.9.2003 at New Delhi under the chairmanship of Chairman C.W.C it was decided that the ground water should not be considered in the water balance studies as done by the N.W.D.A. Accordingly this Committee has also considered only surface water availability for its study.

- Availability of water of river in Bihar has been taken at their outfall points except those rivers in which Bihar gets imported/ allocated water.

- Examining the possibility of Kosi-Ghaghra Link canal for utilising it also as flood diversion channel to divert Kamala and Bagmati flood water as and when needed.

- Examining the possibilities of relieving water stagnation at the confluence point of Bagmati, Kamla and Kosi by diverting it into Ganga.

- Identifying the problems related to water resources development, as prevailing in the state.

- Assessing the most important resources related to agriculture- land & water mostly on the basis of the report of the NWDA report to the extent available and the report of Second Bihar State Irrigation Commission (1994)

- Examining the future cropping/irrigation intensities in light of available land and water resources with special reference to proposed water resources development through construction of dams in Nepal on tributaries of Ganga flowing through Bihar and on their sub tributaries.

- Assessing future demand for agricultural needs for the year 2050.

- Examining the adequacy or otherwise of the provision made in schemes for Linking of rivers related to Bihar.

- Suggesting suitable measures, wherever considered necessary, specifically for redressal of problem, meeting the needs and mitigating the sufferings.

- Examining / studying the reports prepared by NWDA for the component of Linking related to Bihar from Bihar's point of view and suggest modifications/ changes/ improvements wherever considered necessary.

Annexure 1.1

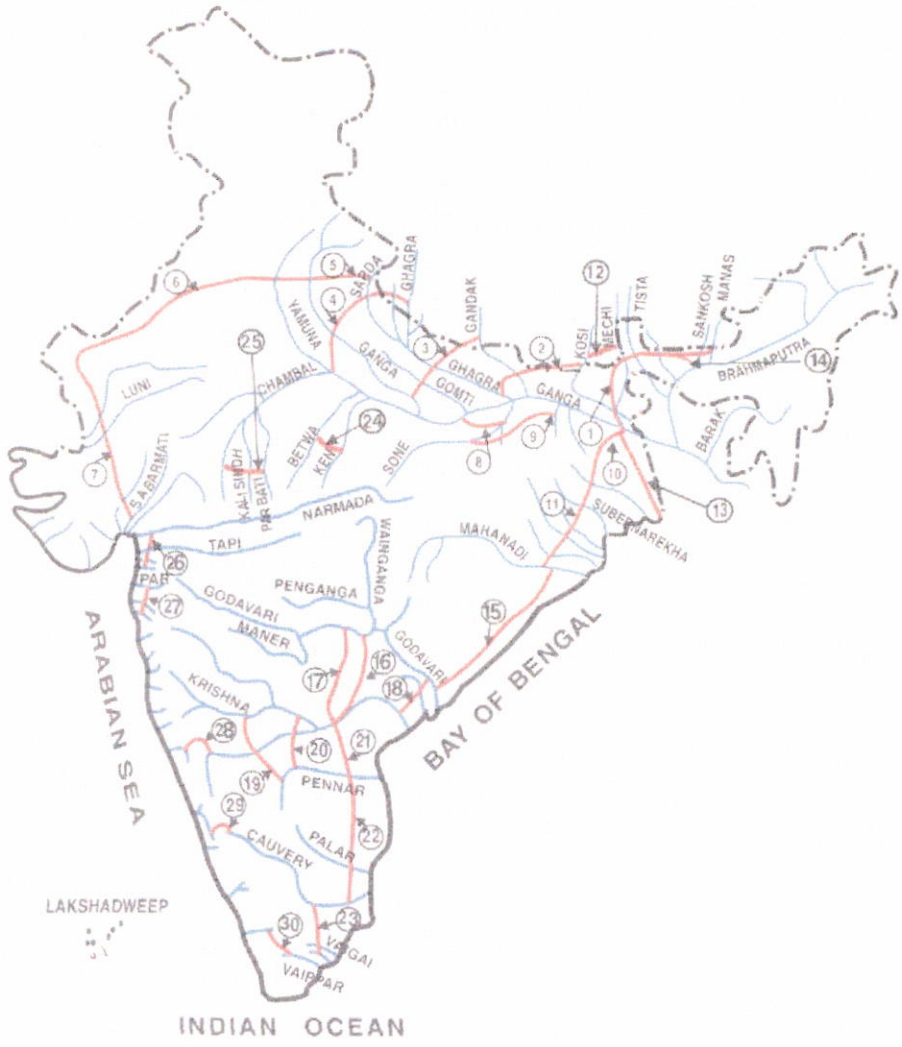
Details of Components of Interlinking of Rivers Directly Related to Bihar

Sl No	Particulars	Kosi-Mechi	Kosi-Ghaghara	Gandak-Ganga	Chunar-Sone Barrage	Sone dam-Southern Tributaries of Ganga	Manas-Sankosh-Tista-Ganga	Jogighopa-Sankosh-Tista-Ganga(Alt)
1	2	3	4	5	6	7	8	9
1	Location of control structure/dam	In Nepal	In Nepal	In Nepal	Chunar in Mirzapur (UP)	Indrapuri Dam (old name Kadwan (Bihar-Jharkhand)	Manas Sankosh (Bhutan)	Jogoghopa Assam Sankosh Bhutan
2	Live Storage (MCM)	9370	9370	1960	-	-	Manas 8950 Sankosh 4390	4930
3	Installed Capacity (MW)	3000	300	-	-	90	Manas NA Sankosh 1400	Jogighopa 300 MW Sankosh 1400 MW
4	Length of Canal (Km)	112.55	428.76	533	149	339	457	440.53
5	Capacity of Canal Head Tail(cumec)	1470.8 97.64	1021 67	1680 987	405.9 85.18	190.43 14.02	1370/2355	1804.17
6	Area Benefitted (LHa)							
	Nepal	1.75	1.74	2.41	-	-		
	Bihar	2.99	8.17	-	0.14(New) 5.12 (old)	2.99	2.64*	2.64*
	Jharkhand	-	-	-	-	0.08		
	U. P.	-	0.67	34.99 (Old) 3.00 (New)	0.53(New)	-		
	Total	4.74	10.58	40.44	0.67(New) 5.12(old)	3.07	6.536	5.94
7	Water Supply (MCM)	24	48	700	-	360		
8	Installed Capacity in canal (MW)	180	-	-	-	3.5 & 1.5	805 (In Bihar 399)	805
9	Lift of Pumping involved (M)	-	-	-	3 8.8, 16.1 & 4.4	-		100

* In Assam 1.3 Lha. and West Bengal 2.00 Lha.

Fig. 1.1

PROPOSED INTER BASIN WATER TRANSFER LINKS



HIMALAYAN COMPONENT

1. Manas –Sankosh - Tista - Ganga
2. Kosi – Ghagra
3. Gandak – Ganga
4. Ghagra – Yamuna *
5. Sarda – Yamuna *
6. Yamuna – Rajasthan
7. Rajasthan – Sabarmati
8. Chunar- Sone Barrage
9. Sone Dam – Southern Tributaries of Ganga
10. Ganga (Farakka) – Damodar – Subernarekha
11. Subernarekha – Mahanadi
12. Kosi – Mechi
13. Farakka – Sunderbans
14. Jogighopa – Tista – Farakka (Alternate)

* FR Completed

PENINSULAR COMPONENT

15. Mahanadi (Manibhadra) – Godavari (Dowlaiswaram) *
16. Godavari (Inchampalli) – Krishna (Pulichintala) *
17. Godavari (Inchampalli) – Krishna (Nagarjunasagar) *
18. Godavari (Polavaram) – Krishna (Vijayawada) *
19. Krishna (Almatti) – Pennar *
20. Krishna (Srisailam) – Pennar *
21. Krishna (Nagarjunasagar) – Pennar (Somasila) *
22. Pennar (Somasila)–Palar- Cauvery (Grand Anicut) *
23. Cauvery (Kattalai) – Vaigai – Gundar *
24. Ken – Betwa *
25. Parbati – Kalisindh – Chambal *
26. Par – Tapi – Narmada *
27. Damanganga – Pinjal *
28. Bedti – Varda
29. Netravati – Hemavati
30. Pamba – Achankovil – Vaippar *

CHAPTER-II

RESOURCE PROFILE OF THE STATE

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RESOURCE PROFILE OF THE STATE

2.1 General

The Following few facts describe the general situation in Bihar in field of Water resources and related aspects.

- After formation of Jharkhand State, Bihar with a geographical area of 93.81 Lakh Ha and a population of 8.29 crore (2001 Census), is the seventh largest State in respect of area and the third biggest State in respect of population.

- The density of population (2001) is 883.7persons per Sq. Km. against 324 persons per sq. km. for the country.

- The State's economy is predominantly agricultural as it contributes about 47.6% towards GDP, against 25% for the country on the whole.

- The State has plenty of plain & fertile cultivable land of 64.41 Lakh ha which is almost 70% of the geographical area.

- The soil is mostly alluvium and very fertile, most suitable for multiple cropping and irrigated agriculture.

- The State has to support about 8% population on 2.85% area of the country with 16% of surface and 6.5% ground water resources of the country.

- The soil is very fertile and the climatic factors are very favourable to agricultural practices.

2.2 The physiography

The State of Bihar, lies between latitudes $24^0$20'10"N and $27^0$31'15"N and longitudes $83^0$19'50"E and $80^0$17'40" E. The total reported geographical area of the State is about Ninety four thousand Sq.Km.

The State is bounded by Himalayan foot hills and terai region of Nepal on the north, West Bengal on the east, newly created State of Jharkhand on the south and part of Uttar Pradesh on the west.

The State comprises alluvial plains of Indo-Gangetic Basin in the north and Kaimur plateau in the south. The alluvial plain is divided into two by the river Ganga flowing from west to east. The State, therefore, can physiographically be divided into two regions viz. North Bihar and South Bihar.

2.2.1 North Bihar

It comprises the tract of alluvial plains north of Ganga, falling between the Ganga and Indo- Nepal border having general slope from north- west to south- east and is drained by the rivers Ghaghra, Gandak, Burhi Gandak, Kosi and Mahananda etc falling into the Ganga and Bagmati- Adhwara, Kamla-Balan etc. which also drain into the Ganga through the Kosi.

The Ghaghra, Gandak and Burhi Gandak rivers of North Bihar are now more or less stabilised. It is believed that river Gandak has traveled from near Burhi Gandak on the east to its present course on the west in course of last several hundred years. In this process of shifting, it has created numerous chaurs (saucer like depressions) and mauns (deep horse- shoe shaped water bodies formed due to avulsions/cut-offs) in the Basin. The other North Bihar rivers such as the Bagmati, Adhwara group of river, Kamla-Balan and Kosi are still very unstable due to steep slopes in their upper reaches and high silt charges and are always exerting tremendous pressure on the embankments within which they are presently contained at enormous cost and efforts. The river Kosi also shifted from near Purnea on the east to its present course on the west where it has been contained between the embankments. In its lateral travel of about 120 Km. in course of about two centuries, the Kosi has created a number of depressions chaurs & mauns in the Basin, apart from depositing coarse silt and sand in almost entire area.

The major rivers of North Bihar have Himalayan origin and considerable portion of their catchments lie in the glacial region. They are, therefore, snow-fed and perennial in flow. These rivers have catchments in the Himalayan region in Nepal. Some of them have catchments even in Tibet region. They receive very copious rainfall during monsoon when discharges of these rivers are about 80 to 90 times larger than fair weather flows. This causes frequent flooding of a large portion of North Bihar. Despite existence of flood embankments on most of them, about 73.63 per cent of the geographical area of North Bihar is considered to be prone to flooding, liable to be flooded if spill occurs from higher contour in India & mainly in Nepal.

The soil of North Bihar is sandy alluvial, rich in lime and often contains high proportion of clay. There are pockets where soils are calcareous with high proportion of calcium carbonate. The soils are among the most fertile in India and can support a variety of crops with appropriate land and water management.

The country slopes from north- west to south- east with general elevations falling from100 m at Valmikinagar in West Champaran district to about 23.5 m at Mathurapur in a length of about 550 Km.

The total geographical area of North Bihar is 53,741 Sq Km which is 57.3 percent of the area of the State and supports 63.5 percent of State populations and is covered by administrative divisions of Saran, Tirhut (Muzaffarpur), Darbhanga, Purnea and Kosi (Saharsa) and three CD blocks of Bhagalpur division.

About 1.92 percent land of this zone is covered by forest as per 1991 reports of the State Directorate of Statistics and Evaluation.

2.2.2 South Bihar

Prior to the formation of Jharkhand State, this portion of Bihar was called Central Bihar. It comprises of the flat alluvial plains having the Ganga on the north and the area to the west of Rajmahal hills and north of the Kaimur-Chotanagpur-Santhal Pargana plateau.In between, there are a few isolated hills namely Kaimur hills part of Vindhya Range in Kaimur & Rohtas, the Barabar hills in Gaya , the Rajgir hills in Nalanda and Kharagpur hills in Munger districts. The hills of Rajgir have an average elevation of 445 m. while the Kharagpur range has an average elevation of 300 m above MSL. This tract of land is drained mainly by the rivers Karmnasa, Sone, Punpun, Kiul,Badua Chandan etc all falling into the Ganga. These rivers are rain fed, having their origins either in the Vindhyachal hills or in the hills of Chotanagpur and Rajmahal. Hence, these rivers are either dry or carry scanty discharges in non-monsoon months.

The eastern portion of the alluvial plain of this region is interrupted by the Kharagpur hills extending north south and, therefore, a portion of the alluvial plain lies on the east of Kharagpur hills and extends up to Rajmahal hills in Jharkhand which forms its eastern boundary. The plain is far more extensive on the west and extends up to Bihar-U.P border. The western portion of this alluvial plain slopes from southwest to northeast. Central and eastern part of the plain slopes from south to north. The elevation of the region varies from 300 m down to 40 m above MSL.

In the central portion of this region, the southern bank of the Ganga is naturally formed as a levee obstructing the drainage of the land on the south of it, which extends up to the foot of Chotanagpur hills. The natural slope of this land is from south to north from foothills of the Chhotanagpur hills to Ganga. There are several rivers in this tract which drain the rain water of the tract and accumulate them behind the high bank of Ganga. This has resulted in formation of tals viz. Mokama Tal the area just on the south of the high Ganga bank, which comprises a group of Fatuha Tal, Bakhtiyarpur Tal, Barh Tal, More Tal , Mokama Tal, Barahiya Tal and Singhaul Tal. These tals also receive backwater of the Ganga when it is in high spate. Therefore, the tals get submerged in water during monsoon season and are thus deprived from Kharif cultivation in part of the area. Even after the monsoon season, entire area does not get drained into the Ganga quickly. However bumper Rabi & HW crops are grown in the Tal area that gets freed from water in time. Recent alluvium soils of non-calcarious and non-saline type suitable for growing vegetables and melons, are found along the banks and diara lands of rivers of this region. The soils of tal areas and in their vicinity are medium to heavy textured and slightly to moderately alkaline in reaction and are of good fertility status. Old alluvium heavy textured or grey catenary soils are found in the rest of the area that crack heavily on drying. These are fertile soils fit for cultivation of a variety of crops with irrigation. There are pockets of alkaline soils in the west and the foothills have yellow catenary soils of poor fertility.

The geographical area of South Bihar is 40,070 Sq.Km which is 42.7 percent of the area of the State and supports 36.5 percent of the State's population and is covered under administrative divisions of Magadh (Gaya), Patna, part of Munger and Bhagalpur.

About 21.43 percent of land is covered by forest as per 1991 reports of the Directorate of Statistics and Evaluation of the State.

2.3 Climate and Rainfall

Bihar has monsoon type tropical climate with high temperature and medium to high rainfall. The temperatures are lowest during December-January with an average minimum of 8^0C to 10^0C and maximum of 24^0C to 25^0C. The temperatures in the hottest months of April to June are minima 23^0C to 25^0C and maxima 35^0C to 38^0C. Gaya is the hottest place (46^0C) and May is the hottest month. Bihar's positional location within narrow limits of latitudes and longitudes precludes large variation in temperatures in its different regions.

The mean annual rainfall for the State is about 1270 mm varying from 1170 to 1580 mm in North Bihar and 990 to 1480 mm in South Bihar. Most of the rainfall (80% to 90%) is received from mid-June to mid-October. The late September-October rains (locally known as 'Hathia'), though only 50 to 100 mm in quantity, are very crucial to agriculture in the region and their timing and distribution make all the difference between plenty and scarcity. They fail once in 4 years in North Bihar and once in 3 years in South Bihar pointing towards necessity of construction of storages. Winter rains, though only about 40 mm are most beneficial for winter crops specially in rainfed areas.

There are, however, considerable inter-district variations in the quantum of rainfall received. There are also large variations within the season and from year to year which cause considerable instability in agricultural productivity and production. Even in the years when the total rainfall is normal, long drought spells or inadequate rainfall in crucial months of transplantation and plant growth adversely affect production.

Ganga plains have the least rainfall with largest variation (30%) along the river which diminishes both towards the northern border and over the plateau region in the south. Large areas in the districts of Nawada, Rohtas, Kaimur and small part of Monghyr comprising nearly 10% of the total area of the State , often suffer from calamitous droughts. As a result of heavy seasonal rainfall, the region is also prone to floods. Climatic factors have endowed the region with a comparative advantage to develop mainly a foodgrain (particularly rice) dominated agrarian economy. Bounties of nature, however, have led to complacency in the development of infrastructural facilities like irrigation and drainage and have made agriculture unduly dependent on rainfall.

2.4 Agro- climatic Regional Planning (1989)

With a view to achieve more scientific utilisation of available resources and maximum exploitation of potential for growth and diversification, the strategy of agro-climatic planning has been adopted by the Planning Commission. The country has been divided into 15 Regions delineated on the basis of a commonality of agro-climatic factors like soil type, rainfall, temperature, water resources etc. Each of these 15 primary agro-climatic zones was not considered adequately homogeneous for the purpose of detailed operational planning. Hence within each of them, sub-zones were delineated on the basis of their characteristics of soil, topography, climate and water resources. Districts generally formed the lowest unit of reckoning.

According to the Report, Bihar falls under Zone- IV Middle Gangetic Plains. The Agro-climatic zones of India are shown in Map available at Fig 2.1. The Zone has been characterised by rich water and soil resources, low productivity level, high population pressure on land and increased proportion of problem soil.

"Zone IV consists of 12 districts of Eastern Uttar Pradesh and 27 districts of Bihar Plains. This zone of Bihar has been further sub-divided into three sub-zones to take care of heterogeneity in soil, land use, topography and climatic factors. Strategy presented in this note, however refers to aggregated sub-zone. This Zone with a geographical area of 16.5 million hectares and population of 84 million presents a picture of high population density (530 persons/sq. km.), second highest poverty ratio (about 45 per cent in rural population) and low land productivity in spite of rich soil resources and favourable climatic factors. Rainfall is high and irrigation is fairly developed (39 per cent of GCA) with cropping intensity of 142 per cent. Irrigation is more developed in Eastern UP and correspondingly cropping intensity is also higher.

"Cropping is cereal- based (79 per cent in Eastern UP and 70 per cent in Bihar Plains) with predominance of rice (a little over 70 per cent in Eastern UP and 48 per cent in Bihar Plains). Productivity of rice is one of the lowest in the country particularly in Bihar Plains (less than 11 qtls. per ha. in 1984-85) which, however, is increasing matching that of Haryana in case proper irrigational & other support are made available. Productivity of other cereal crops like maize and wheat is close to that of national average, maize productivity being higher in Bihar Plains. Stabilization and improvement of productivity of Kharif rice along with crop diversification and substitution in areas not suitable for rice will form the important ingredients of crop production strategy in this zone."

2.4.1 Agro-climatic Sub-Zone

The entire Bihar falls under following three agro-climatic Sub-Zone 4,5,6 of Zone -IV as shown Map available at Fig. 2.2. The Bihar Plains have been divided in these three sub-zones, to take care of heterogeneity in soil, land use, topography and climatic factors:

(a) Sub-Zone no. 4 -
comprising the districts of Paschimi Champaran, Purbi Chmparan, Gopalganj, Siwan, Saran, Vaishali, Muzaffarpur, Sitamarhi, Madhubani, Darbhanga and Samastipur.

(b) Sub-Zone no. 5 -
comprising the districts of Begusarai, Khagaria, Madhepura, Saharsa, Purnea, Araria, Kishanganj and Katihar.

(c) Sub-Zone no. 6 -
comprising the districts of Rohtas, Kaimur, Bhojpur, Buxar, Aurangabad, Gaya, Patna, Nalanda, Nawada, Munger and Bhagalpur.

2.5 Land Potential

2.5.1 The Second Bihar State Irrigation Commission (1994)

The land use pattern of the State has been studied by SBSIC. The Commission has studied the land use pattern river Basin/sub-Basin wise. The river Basin/sub-Basinwise geographical area and Cultivable area is available in Annexure 2.1 and 2.2 respectively.. According to the Annexure 2.2 the cultivable land of the State works out to 64.41 Lakh ha, which is 68.67 % of the geographical area. The abstract of cultivable area for different agro-climatic Sub-Zones is given below :

Agro-climatic Sub-Zone	Geographical Area in Ha.	Cultivable Area in Ha.	Percentage CCA to GCA
Sub-Zone-4	25,19,309	18,23,358	72.38
Sub-Zone-5	28,54,777	20,87,922	73.14
Sub-Total	53,74,086	39,11,280	72.78
Sub-Zone 6(a)	20,93,828	14,07,592	67.23
Sub-Zone 6(b)	19,13,190	11,22,948	58.7
Sub-Total	40,07,018	25,30,540	63.15
Total	93,81,104	64,41,820	68.67

The total cultivable area of the State falls under following categories : (i) Existing Irrigation Scheme (ii) On-going Irrigation Schemes (iii) Proposed Irrigation Schemes and (iv) Not covered under any Irrigation Scheme which is the balance cultivable area where irrigation has to be provided. Annexure 2.3 shows the cultivable area under these categories composite Basin-wise under different agro-climatic Sub-Zones. The abstracts are as follows :

Categories	Sub-Zone No.4	Sub-Zone No.5	Sub-Zone No. 6(a)	Sub-Zone No. 6(b)	Total	%
(i)Existing Irrigation schemes	10,09,780	4,76,390	8,97,321	4,71,861	28,55,352	44.33
(ii)On-Going Irrigation schemes	-	3,21,600	1,48,628	53,613	5,23,841	8.13
(iii)Proposed Irrigation Schemes	1,28,700	3,43,551	61,850	2,20,838	7,54,939	11.72
Sub-Total (i) to (iii)	11,38,480	11,41,541	11,07,799	7,46,312	41,34,132	64.18
(iv)Area not covered in any Schemes	6,84,878	9,46,381	2,99,793	3,76,636	23,07,688	35.82
Total	18,23,358	20,87,922	14,07,592	11,22,948	64,41,820	100

2.5.2 SOILS OF BIHAR

2.5.2.1 Soils- Their Categories and Status.

Land use pattern in our country has been tradition based. With modernisation of agriculture, land use based on agro-climatic conditions and more so, in relation to the suitability of soil resources has been realised for sustainable development. Cropping pattern based on soil resource inventory has been recommended for every river Basin. The basis for land use planning rests on the capability of soil in relation to unique set of relevant characteristics and qualities. Such characteristics of Bihar soils have been identified and published by the following sources.

i. A reconnaissance soil survey of the State was conducted during 1954-66 to identify, describe and classify the soils of Bihar. The soil survey organisation of the Rajendra Agricultural University has divided the State in 24 broad Soil Association Groups based on common but important and striking soil characters. The soil map of the State has also been published.

ii. The National Bureau of soil survey and Land Use Planning (NBSS & LUP), an organisation established by Govt of India in 1958 and restructured in April 1969, has conducted detailed soil survey of the State. The detailed soil survey reports contain a large body of basic and derived data.

The features of soil contained in two types of survey throw a floodlight of information for use in agriculture, irrigational projects and schemes of ecological management.

2.5.2.2 Reconnaissance Soil Survey

Second Bihar State Irrigation Commission got soil association studied and compiled. Basin-wise delineation are marked and shown in map at fig. no. 2.3 and are summarized showing the area and type of soil at Annexure 2.4

2.6. WATER RESOURCES

2.6.1 Water Resources of India

It will be of interest to discuss the water resources of India before discussing the water resources of Bihar. This will provide an opportunity for a comparative study, in the back ground of surplus and / or shortage.

2.6.1.1 Water availability

Total amount of water on earth has been estimated as 1400 million Km^3. However only 2.7% of this is available as fresh water. Further majority of this lies frozen in polar region or is in deep aquifer, not available for use. Only a small fraction of total water is thus available for

use. With India's population as much as 16% of the World's population, it has only roughly 4% of world's fresh water resources. That makes the situation in country all the more critical. Even this availability of fresh water is very unevenly distributed. The average annual rainfall in India is about 1170 mm, which corresponds to an annual precipitation (including snowfall) of 4000 billion cubic metre (BCM). However there is considerable variation in rainfall both temporal and spatial.

Nearly 75% of this, that is, 3000 BCM occurs during the monsoon season confined to three to four months (June to September) in a year, necessitating creation of large storages for maximum utilisation of the runoff. Regional variations are also extreme in the country and the rainfall varies from 100 mm in Western Rajasthan to over 11000 mm in Meghalaya in north eastern India. The impact of the temporal and spatial variation is so critical that some part of the country is reeling under drought while some other part is suffering from the vagaries of floods and drought. Flood-drought syndrome haunts the country.

2.6.1.2 Utilisable Water Resources

Average annual surface water resource potential of the country is estimated as 1953 BCM. Considering the constraints of hydrology, topography and geological limitations, only 690 BCM of this resource can be utilised by conventional storage and diversion structures. Ground water is another important source of water. Its potential has been estimated on the basis of water table rise from rainfall and recharge from other sources and the specific yield of the formations that contain the ground water. On an average annual replenishable ground water has been assessed as about 431 BCM out of which 396 BCM is utilisable. The total utilisable water resources, both from surface as well as ground water, are about 1086 BCM ie., about 28% of the precipitation the country receives. The availability of utilisable flow in the country is very skewed. The Ganga-Bhramaputra-Meghna system accounts for as much as 62% of the available water resources whereas it's geographical area is only 33.5% of the countries geographical area. It is therefore imperative to optimally utilize the available water resources so as to minimise the stress conditions and maximise per hectare output.

National Commission for Integrated Water Resources Development Plan (NCIWRDP) in its recent report has indicated total annual water resources of the country as 1953 BCM. Out of this, the Commission has assessed that utilisable water resources will be 1086 BCM comprising of 690 BCM from surface flow and 396 BCM from ground water (out of total replenishable ground water resources of 431 BCM). In addition to the above availability the National Commission has observed that there is considerable utilisable return flow from irrigation, domestic, municipal and industrial uses. The Commission has estimated that with increased agricultural and other activities, the return flow available for reuse will substantially increase from present value of 90 BCM. This can be to an extent of about 169 BCM in 2050 and this quantity will be available over and above the utilisable water resources of 1086 BCM, but this will necessarily mean augmentation of utilisable water during lean period.

2.6.2 Water Resources of Bihar

2.6.2.1 Surface Water Availability

i As Assessed by Second Bihar State Irrigation Commission (1994)

The Second Bihar State Irrigation Commission (1994) has studied the water resources of the State. They have worked out Basin wise water availability of both surface and ground water. For rational, comprehensive and integrated planning of land and water resources, the commission has divided the state into fourteen river Basins. Of these fourteen Basins seven are in North Bihar, six are in South Bihar and Ganga Stem has been dealt as a separate Basin. Some of the Basins have been further divided into sub-Basins. These Basins / sub-Basins have been regrouped into 15 composite Basins taking into considerations the inter-Basin use of water. The Basins/sub-Basins have been shown in Fig-2.4. The surface water availability in different Basins / sub-Basin with the contribution from the catchments area outside and within the state as worked out by SBSIC, is tabulated in Annexure 2.5. The geographical area of the composite river Basins as regrouped by SBSIC is given in Annexure 2.1.

The abstract of water availability assessed by SBSIC is as follows vide Annexure 2.5. Surface water (75% dependability)

i)	from catchment area outside state	2,83,655 MCM
ii)	from catchment area within state	32,238 MCM
	Total	3,15,893 MCM

ii As Assessed by this Committee (2005)

The above figure of available Surface Water resources for Bihar amounting to 315893 MCM was assessed in 1994 by the SBSIC and does not represent true availability due to major changes in upstream utilisation of water resources that was treated as available from outside catchments especially that of Ghagra basin and Ganga Stem basin where they are either fully consumed or proposed to be fully utilized by upper riparian States. The surface water availability has been, therefore, reassessed by this Committee as explained below:

i. Ghaghra Basin

The total water availability at 75% dependability as assessed by the SBSIC works out to 68,855 MCM Comprising of 68015 MCM from catchments outside State and 840 MCM within the State. But it is found that Ghaghra water is no more available at the border of Bihar because if full diversion of its water in U/S catchments by the State of U.P. for its use through the construction of several Dams, Barrages and Pump Canal scheme on Ghaghra and its tributaries inside U.P.

In view of above only 840 MCM of water from catchments inside the State has been treated as water available from catchments inside the State has been treated as water available in Ghaghra basin.

ii. Gandak basin

The SBSIC assessed 50810 MCM of water available from catchments outside the State. But as per study done by NWDA the availability from outside catchments comes to 45109 MCM only as detailed below.

a)	Available flow at proposed Gandak dam after utilisation in Nepal as per water balance study of NWDA 52,146 - (368 + 507 + 1395) + 700 = 50576		50576MCM
b)	Less utilization in UP & Nepal as per SBSIC report (1994) Vol III Western Main Canal UP-	4383MCM	
	Nepal	325 MCM	
		4708 MCM	
	Eastern Main Canal -Nepal-	759 MCM	
		5467 MCM	(-)5467 MCM
	Available flow from outside catchments		45109 MCM

iii. Kosi Basin

Water availability assessed by SBSIC in Kosi Basin from outside catchments is 47065 MCM whereas it works out to 36461 MCM as worked out below.

a)	75% dependable yield at Kosi High Dam as per simulation study vide annex 5.2.2 of Pre-feasibility Report of Kosi-Mechi Link Project	40377MCM
b)	Less utilization in Nepal through Chatra Canal System	(-)3916 MCM
	Net availability below Dam	36,461MCM

iv. Ganga Stem Basin

As per assessment of SBSIC 85000 MCM of water is available in Ganga stem Basin at 75% dependability from catchments outside the State up to Buxar. But in reality this much of water is not available for Bihar. As per NWDA study at page 13 of Pre-feasibility study Report on Chunar-Sone Barrage Link project, only 1.08 Lakh MCM of water is available at Varanasi at 75% dependability while requirement of UP alone up to this point is 1.25 Lakh MCM.

This means that no surplus water is available at Varanasi from its own catchments. This situation continues up to Bihar border at Buxar since there is no major intake of water in between.

Thus water availability from outside catchments in Ganga Stem has been treated as nil by the Committee and only 2793 MCM available by catchments inside State has been treated as available.

v. Mahananda Basin

5612 MCM of water has been assessed as available water from outside State catchments in Mahananda basin by SBSIC. But the water available in Mahananda basin and that from Bharamputra tributaries brought to Mahananda through MSTG Link project is proposed to be diverted to Ganga to meet the needs of Farraka and further diversion to the south only 4027 MCM of water out of 43208 MCM of water available is earmarked for irrigation in en-route CCA of 6.536 LHa. out of which 2.64 LHa. of CCA lie in Bihar. The proportionate utilisation in Bihar for irrigation of 2.64 LHa. works out to 1627 MCM which only would be available from MSTG Link Project.

In view of above, water available from outside State catchments in Mahananda basin has been treated as 1627 MCM as against 5612 MCM assessed by SBSIC.

vi Sone Basin

17600 MCM of water has been assessed to be available from outside State catchments in Sone basin by SBSIC. But its actual availability is limited to only 7709 MCM as per Bansagar Agreement on Sone waters as per details below:

a)	Total Share of Bihar including Jharkhand as per Bansagar Agreement	9559 MCM (7.75 MAF)
b)	Less utilization in Jharkhand	(-) 1850 MCM (1.50 MAF)
	Balance for Bihar	7709 MCM (6.25 MAF)

vii. Karmnasa Basin

487 MCM of water is assessed to be available from outside State catchments in Karmnasa basin by SBSIC. But it has been kept limited to 308 MCM (0.25 MAF) that is available from Ganga at Zamania for diversion to this basin as per Bansagar agreement apart from that as per inter-state agreement on Musakhar dam -Latifsah barrage with U.P.

viii. Revised Surface Water Availability

In view of aforesaid modification in the surface water availability at 75% dependability from catchments outside the State, the revised surface water availability as assessed by this committee comes to 1,32,175 MCM only against 3,15,893 MCM assessed by SBSIC as shown in detail in Annexure 2.5. The breakup of which is as below.

i.	From catchments area outside State-	1,00,726 MCM
ii.	From Catchments area within State-	31,449 MCM
	Total-	1,32,175 MCM

2.6.2.2 Utilisable water

It is evident from the above figures that about 76.2% of yield of surface water is from the catchments area outside state and only 23.8% of the yield of surface water is the contribution from the catchments area located inside state. Again about 76% of the yield is available during monsoon period and there are no suitable sites available in North Bihar for construction of dam for conservation of water. As a result of this the quantity of utilisable water without backup of storage dam is very limited. According to an assessment made by the SBSIC, 1994 the utilisable water is about 37000 MCM which works out to 28% of available surface water (1,32,175 MCM). There are several international rivers like Kosi & Gandak and interstate rivers like Sone for which international and interstate agreements have already been executed and accordingly water has been allocated for use in Bihar. This has also resulted into limiting the utilisation of surface water.

2.6.2.3 Disparity in Water Availability in different Regions of Bihar:

The land and water resources of the three distinct regions of the state viz - North Bihar, Ganga Stem and South Bihar - have been tabulated in Annexure 2.6. This brings out very clearly the disparity in availability of water in the different regions of the state. Out of total cultivable area of the state 36.82% lies in South Bihar. But as regards availability of water, only 13.87%water resources is available in the region. Even within South Bihar the disparity between Sone Basin & other Basins is more glaring. Figures for cultivable land and available surface water in different river Basin of South Bihar are given in Annexure 2.7. This shows that while 24.09% of cultivable area lies in other Basin (excluding Sone Basin) the water available is only 6.42% of the State. In other words, for eastern sub-region of South Bihar surface water availability is only 6% for about 24% of cultivable area. It is important to note that most of the draught prone area lies in this sub-region.

This clearly brings out the need for transfer of water to this sub-region from other regions and Basins.

Annexure 2.1

Geographical area of Composite river Basins of Bihar

SN	Name of Basin	Geographical area (ha)
	NORTH BIHAR	
1A	Ghaghara-Mahi- Western Gandak composite	648728
1B	Upper Eastern Gandak- Upper Burhi Gandak composite	882398
1C	Lower Eastern Gandak-Baya- Lower Burhi Gandak composite	675666
2	Bagmati-Adhwara	649985
3	Kamla-Balan	448767
4	Kosi	1141019
5	Mahananda	615006
Total North Bihar		5061569
6	Ganga Stem	547327
	SOUTH BIHAR	
7	Karmnasa	512688
8	Sone-Kanhar (306480), Kao-Gangi (412880)	719360
9	Punpun	804670
10	Kiul	990070
11	Harohar	262950
12	Badua Belharna	221500
13	Bilasi- Chandan- Chir	260970
Total South Bihar		3772208
Grand Total		9381104

Source : The second Bihar Irrigation Commission (1994)

Annexure 2.2

Agro Climatic Sub-Zone wise cultivable Area (In ha.)									
Sl. No	Name of Basin	Geo. area GCA	Net Sown Area	Cul. waste	Current Fallow	Other Fallow	Area under current fallow + other fallow + culti. waste	Cul. area	% of Geo. Area
1	2	3	4	5	6	7	8	9	10
I	Agroclimatic Sub-zone 4								
1A	Ghaghra-Mahi Western Gandak Composite	648728	482423	1983	22314	12434	36731	519154	80.03
1B	Upper Eastern Gandak Lower Burhi-Gandak Composite	882398	547355	5492	36703	9484	51679	599034	67.89
1C	Lower Eastern Gandak Baya Lower Burhi Gandak composite	675666	459916	1402	26465	5865	33732	493648	73.06
2	Ganga Stem	312517	171462	3573	26040	10447	40060	211522	67.68
	Sub-Total	2519309	1661156	12450	111522	38230	162202	1823358	72.38
II	Agroclimatic Sub-zone 5								
3	Bagmati-Adhwara	649985	431852	1111	41713	7691	50515	482367	74.21
4	Kamla Balan	448767	279401	773	37173	4971	42917	322318	71.82
5	Kosi	1141019	709209	7086	90052	31753	128891	838100	73.45
6	Mahananda	615006	365766	3582	59821	15968	79371	445137	72.38
	Sub-Total	2854777	1786228	12552	228759	60383	301694	2087922	73.14
	Total I+II	5374086	3447384	25002	340281	98613	463896	3911280	72.78
III	Agroclimatic Sub-zone 6 a								
7	Karmnasa	512688	289955	7884	24377	4493	36754	326709	63.72
8	Sone & Kao Gangi composite	719360	463802	1769	19510	8040	29319	493121	68.55
9	Punpun	804670	416270	5893	98585	28359	132837	549107	68.24
10	Ganga Stem	57110	31333	653	4759	1910	7322	38655	67.69
	Sub-Total	2093828	1201360	16199	147231	42802	206232	1407592	67.23
IV	Agroclimatic Sub-zone 6 b								
11	Harohar	990070	516196	7467	42180	24833	74480	590676	59.66
12	Kiul	262950	73184	6215	26137	15421	47773	120957	46.00
13	Badua-Belharna	221500	98781	5148	19309	9292	33749	132530	59.83
14	Bilasi Chandan Chir	260970	106801	7253	26508	17942	51703	158513	60.74
15	Ganga Stem	177700	97494	2032	14806	5940	22778	120272	67.68
	Sub-Total	1913190	892456	28115	128940	73428	230483	1122948	58.70
	Total III+IV	4007018	2093816	44314	276171	116230	436715	2530540	63.15
Grand Total		9381104	5541200	69316	616452	214843	900611	6441820	68.67

Annexure 2.3

Assessment of cultivable area under Existing, On-going & Proposed schemes and area not covered under any Irrigation scheme in different Agro- climatic sub-zone.

In ha.

Sl. No	Name of the Basin	Total CCA	CCA				Uncovered CCA
			Existing	On-going	Proposed	Total	
1	2	3	4	5	6	7	8
I	Agroclimatic Sub-zone 4						
1A	Ghaghra-Mahi Western Gandak Composite	519154	449080	0	0	449080	70074
1B	Upper Eastern Gandak Lower Burhi-Gandak Composite	599034	385000	0	21700	406700	192334
1C	Lower Eastern Gandak Baya Lower Burhi Gandak Composite	493648	175700	0	90000	265700	227948
2	Ganga Stem	211522	0	0	17000	17000	194522
	Sub-Total	1823358	1009780	0	128700	1138480	684878
II	Agroclimatic Sub-zone 5						
3	Bagmati-Adhwara	482367	0	118300	87100	205400	276967
4	Kamla Balan	322318	36490	179142	0	215632	106686
5	Kosi	838100	439900	24158	0	464058	374042
6	Mahananda	445137	0	0	256451	256451	188686
	Sub-Total	2087922	476390	321600	343551	1141541	946381
	Total I+II	3911280	1486170	321600	472251	2280021	1631259
III	Agroclimatic Sub-zone 6 a						
7	Karmnasa	326709	210681	49058	0	259739	66970
8	Sone & Kao Gangi composite	493121	411565	0	12040	423605	69516
9	Punpun	549107	245945	99570	44290	389805	159302
10	Ganga Stem	38655	29130	0	5520	34650	4005
	Sub-Total	1407592	897321	148628	61850	1107799	299793
IV	Agroclimatic Sub-zone 6 b						
11	Harohar	590676	199441	0	205742	405183	185493
12	Kiul	120957	72215	19200	0	91415	29542
13	Badua-Belharna	132530	66249	12800	9496	88545	43985
14	Bilasi Chandan Chir	158513	102236	21613	5600	129449	29064
15	Ganga Stem	120272	31720	0	0	31720	88552
	Sub-Total	1122948	471861	53613	220838	746312	376636
	Total III+IV	2530540	1369182	202241	282688	1854111	676429
Grand Total		6441820	2855352	523841	754939	4134132	2307688

Annexure- 2.4

Area Under Different Soil Association

Soil Association Group	Area in Sq. Km	Location
1. Sub-Himalayan Hill & forest soil	825	Very small upper exteremity of Gandak Burhi-Gandak and Mahananda Basins
2. Recent alluvium terai soil	5,849	Small upper most parts of Burhi-Gandak, Bagmati and Kamla
3. Recent Alluvium non-calcareous non-saline soil	15,813	Entire Kosi and lower part of Mahananda Basin.
4. Young alluvium non calcareous non saline soil	6,446	Upper & Middle part of Burhi-Gandak, Bagmati-Adhwara and Kamla Basins
5. Youn alluvium calcareous soil	17,590	Mahi, Gandak, Baya & lower part of Burhi-Gandak Basin.
6. Young alluvium calcareous saline & saline alkai soil	2,413	
7. Non-Calcareous soil	371	Small part of Ghaghra Basin in Western part.
8. Recent alluvium Calcareous soil.	5,519	Entire length of Ganga stem.
9. Recent alluvium yellowish to reddish yellow non-calcareous saline soil	2,640	Land strip on both banks of Sone river.
10. Tal soil	2,877	Mokama Tal in lower portion of Harohar, Punpun on both side of Falgu river (Harohar Basin) and Central portion of Kao-Gangi Basin.
11. Old alluvium grey greyish yellow heavy textured cracking soil	5,849	
12. Old alluvium reddish yellow, yellow grey catenary soil.	13,773	Large part of Punpun, Harohar and Kao-Gangi Basin
13. Old alluvium saline and saline alkali soil	5,519	Upper position of Punpun and Harohar and Kao-Gangi Basins.
14. Old alluvium yellowish red yellow soil of foot hills	825	Most part of Karmnasa Basin
15. Red yellow light grey catenary soil	29,507	Badua-Belharna, Bilasi-Chandan-Chir Basin besides Ajay, Damodar Barakar & Subernarekha in Jharkhand

Annexure 2.5

Surface Water Resources in river Basins of Bihar

Sl. No.	Name of Basin	Catchments Area (Sq. Km.)			75% Dependable water availability in MCM					
					As assessed by SBSIC			As assessed by the Committee		
		Outside state	Within State	Total	Outside state	Within State	Total	Outside state	Within State	Total
1	2	3	4	5	6	7	8	9	10	11
1	Ghaghra	124955	2995.4	127950	68015	839.7	68855	*	840	840
	Mahi		2507.8	2507.8	0	799.1	799.1		799	799
2	Gandak	36610	4187.7	40798	50810	1173.9	51984	45109**	1174	46283
	Baya		2775.7	2775.7	0	1067.2	1067.2		1067	1067
3	Burhi-Gandak	2420	9601.4	12021	813.3	3226.7	4040	813	3227	4040
4	Bagmati-Adhwara	7884	6499.9	14384	5080.9	2184.4	7265.3	5081	2184	7265
5	Kamla Balan	2744	4487.7	7231.7	1741.3	1508.1	3249.4	1741	1508	3249
6	Kosi	62615	11410.2	74025	47065	5154	52219	36461**	5154	41615
7	Mahananda	7157.7	6150.1	13308	5612.4	4267.9	9880.3	1627***	4268	5895
Total North Bihar		**244385**	**50615.9**	**295001**	**179138**	**20221**	**199359**	**90832**	**20221**	**111053**
8	Karmnasa	2665.2	5126.9	7792.1	487.1	937	1424.1	308#	937	1245
9	Sone	67163	3064.8	70228	17600	335	17935	7709##		7709
10	Kao-Gangi		4128.8	4128.8	0	884.4	884.4		884	884
11	Punpun	979	8046.7	9025.7	244.4	2009.1	2253.5	244	2009	2253
12	Kiul	421	2629.5	3050.5	98	612.3	710.3	98	612	710
13	Harohar	4272.3	9900.7	14173	994.7	2305.3	3300	995	2305	3300
14	Badua-Belharna		2215	2215	0	736.8	736.8	0	737	737
15	BilasiChandan Chir	1483.3	2609.7	4093	540.4	950.7	1491.1	540	951	1491
Total South Bihar		**76984**	**37722.1**	**114706**	**19965**	**8770.6**	**28735**	**9894**	**8435**	**18329**
16	Ganga Stem		5473.3	5473.3	85000	2793	87793		2793	2793
Grand Total		**321369**	**93811.3**	**415180**	**284102**	**31785**	**315887**	**100726**	**31449**	**132175**

Source: The Second Bihar Irrigation Commission (1994)

Note:-

* Flows of river Ghaghra and Ganga from catchment area out side are considered not to be available for use in Bihar.

* * Flows of river Gandak and Kosi from catchment area out side state is taken as indicated below:

A. Gandak river basin:

Available flows at proposed Gandak regulatory dam after utilization in Nepal, according to Water Balance study of NWDA 50576 MCM.

Utilisation in U.P. & Nepal wide SBSIRC 1994 (page 18 Vol.III)

i. Western Main Canal U.P.(4383 MCM)+ Nepal (325 MCM)= 4708 MCM

ii. Eastern Main Canal Nepal (759 MCM)= 759 MCM

Total utilization in U.P.& Nepal below barrage 5467MCM

Thus net available flow for Bihar at Barrage 45109 MCM

B. Kosi river basin:

According to NWDA simulation study of Kosi High Dam

water to below dam = 40377 MCM

Use in Chatra Canal system (58,000 ha CCA) = 3916 MCM

Net availability below dam = 36461 MCM

*** In case of river Mahananda, a flow of 1627 MCM of water is proposed to be made available from MSTG Link. Hence only this very flow is considered to be available as flow from catchment area out side state.

In Karmnasa Basin, apart from Musakhand agreement, 308 MCM (0.25 MAF) from Ganga at Zamania as per Bansagar agreement is available for use and is considered from outside state.

In case of river Sone, no water from catchment below Indrapuri Barrage is considered to be available for the Sone canal Command. In this river basin the water available will be limited to 7709 MCM (6.25 MAF) as details given below:

i. Total share of Bihar including Jharkhand = 9559 MCM (7.75 MAF)

ii. Use in Jharkhand = 1850 MCM (1.50 MAF)

Balance for Bihar =7709 MCM (6.25 MCM)

Break up being 592 MCM (0.48 MAF) in U/S of Barrage and 7117 MCM (5.77 MAF) from Barrage.

Annexure 2.6

Land and Water availability in different Regions of Bihar

Sl. No.	Particulars	North Bihar	Ganga Stem	South Bihar	Total
1	2	3	4	5	6
1	Land				
	(i) Geographical Area (ha)	5061569	547327	3772208	9381104
	(%)	53.96	5.83	40.21	100.00
	(ii) Cultivable Area (ha)	3699758	370449	2371613	6441820
	(%)	57.43	5.75	36.82	100.00
2	Population (Yr. 2001) in Lakh	489.88	63.05	275.85	828.78
	Population (%)	59.11	7.6	33.29	100.00
3	Water Resources (MCM)				
	Surface Water	111053	2793	18329	132175
	(%)	84.02	2.11	13.87	100.00
4	Water Availability Surface Water				
	(i) Per-capita (Yr.2001)(Cubic metre)	2266.98	442.98	664.45	1594.83
	(ii) Per ha (Cubic metre)	21940.43	5102.98	4858.96	14089.49

Annexure 2.7

Land & Water availability in South Bihar

Sl. No.	Particulars	Sone Basin (including Karmnasa)	Other Basin	Total
1	2	3	4	5
1	Land			
	(i) Geographical (ha)	1232048	2540160	3772208
	(%)	13.13	27.08	40.21
	(ii) Cultivable (ha)	819830	1551783	2371613
	(%)	12.73	24.09	36.82
2	Population (2001) in Lakh	85.64	190.21	275.85
	Population (%)	10.33	22.95	33.29
3	Water Resources			
	Surface Water (MCM)	9838	8491	18329
	(%)	7.44	6.42	13.87
4	Water Availability Surface Water			
	(i) Per - capita (cu.m)	1149	446.4	657.31
	(ii) Per ha (cu. m)	7985.08	3342.70	4858.96

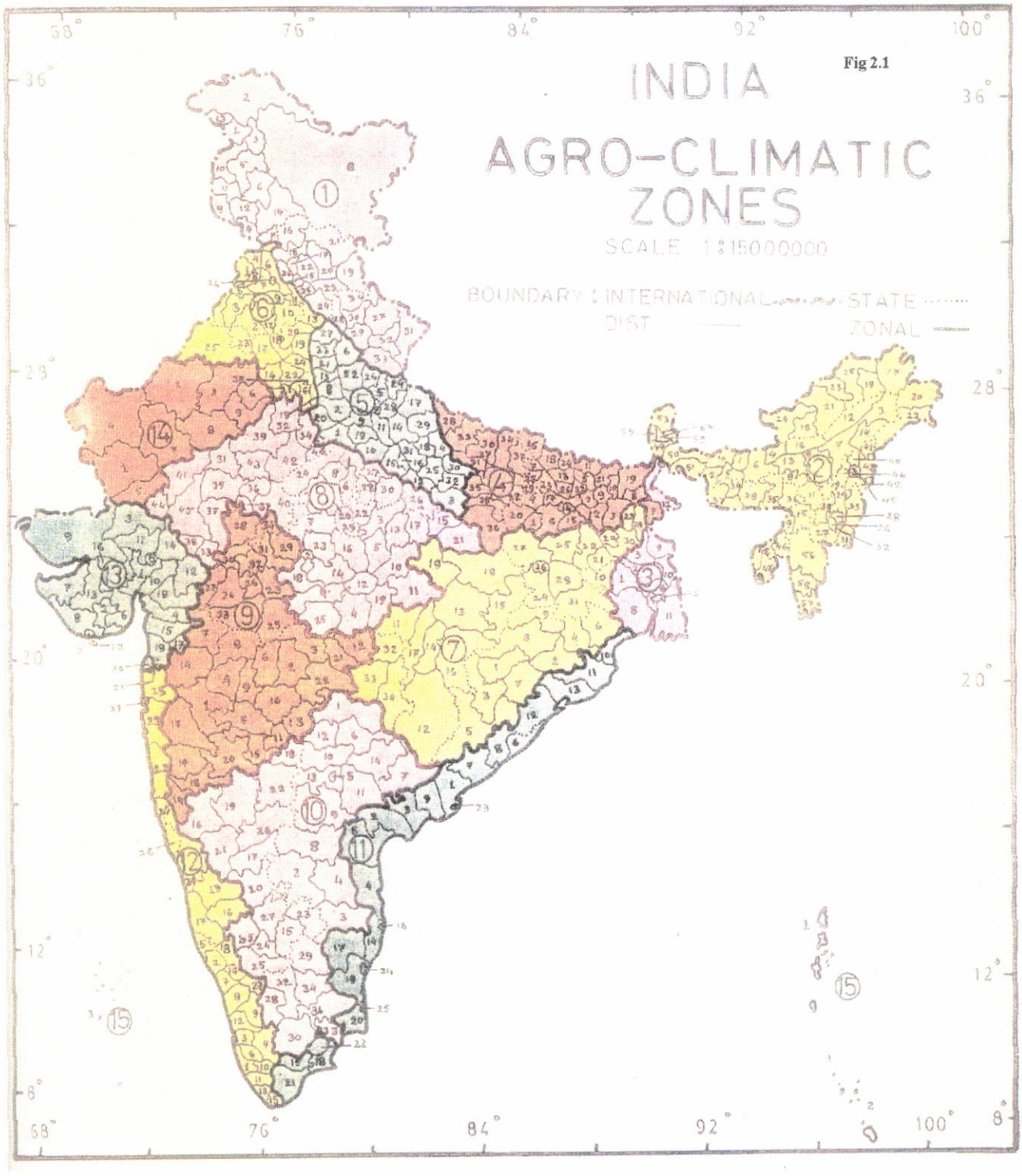

INDIA
AGRO-CLIMATIC ZONES
SCALE 1:15000000
BOUNDARY : INTERNATIONAL
STATE
DIST
ZONAL
68°
76°
84°
92°
100°
36°
28°
20°
12°
8°

Fig 2.1

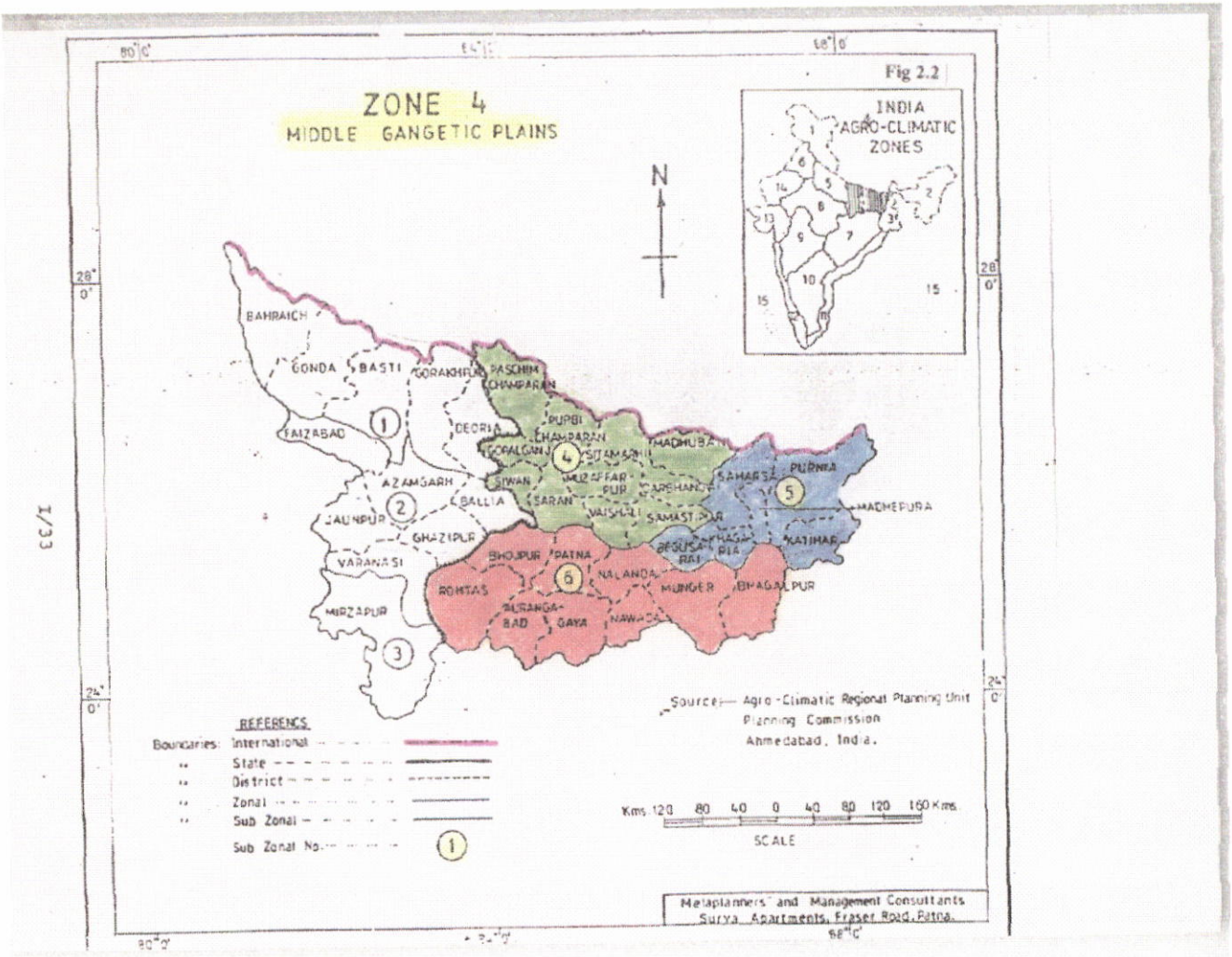


Fig 2.2
ZONE 4
MIDDLE GANGETIC PLAINS
INDIA
AGRO-CLIMATIC
ZONES
N
BAHRAICH
GONDA
BASTI
GORAKHPUR
PASCHIM CHAMPARAN
FAIZABAD
DEORIA
PURBI CHAMPARAN
MADHUBANI
GOPALGANJ
SITAMARHI
AZAMGARH
SIWAN
MUZAFFAR PUR
SAHARSA
PURNIA
JAUNPUR
BALLIA
SARAN
SHEOHAR
VAISHALI
SAMASTIPUR
MADHEPURA
GHAZIPUR
BEGUSA RAI
KATIHAR
VARANASI
BHOJPUR
PATNA
NALANDA
ROHTAS
MUNGER
BHAGALPUR
MIRZAPUR
AURANGA BAD
GAYA
NAWADA
REFERENCS
Boundaries: International
State
District
Zonal
Sub Zonal
Sub Zonal No.
Source:— Agro-Climatic Regional Planning Unit
Planning Commission
Ahmedabad, India.
Kms 120 80 40 0 40 80 120 160 Kms
SCALE
Metaplanners' and Management Consultants
Surya Apartments, Fraser Road, Patna.

I/33

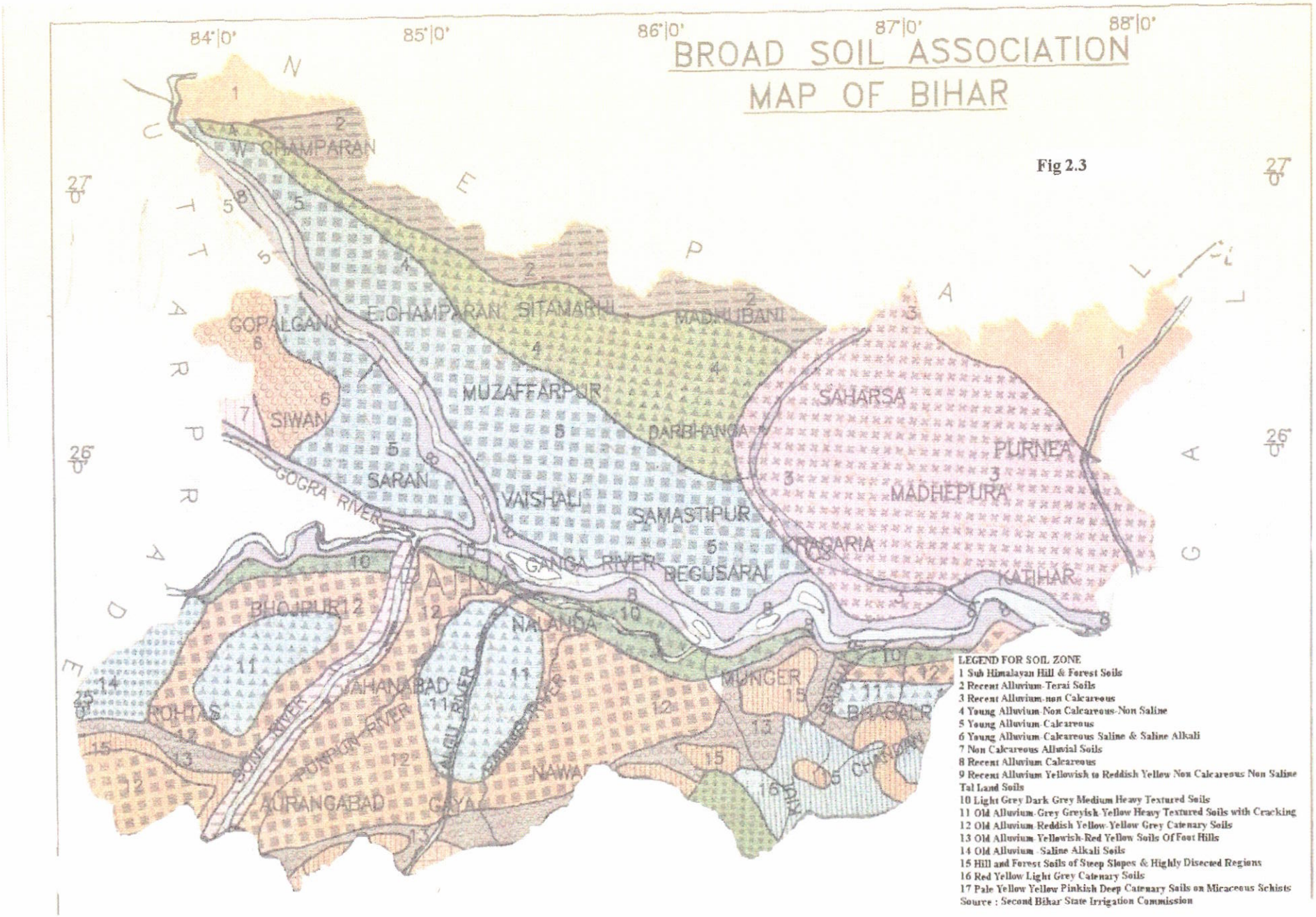
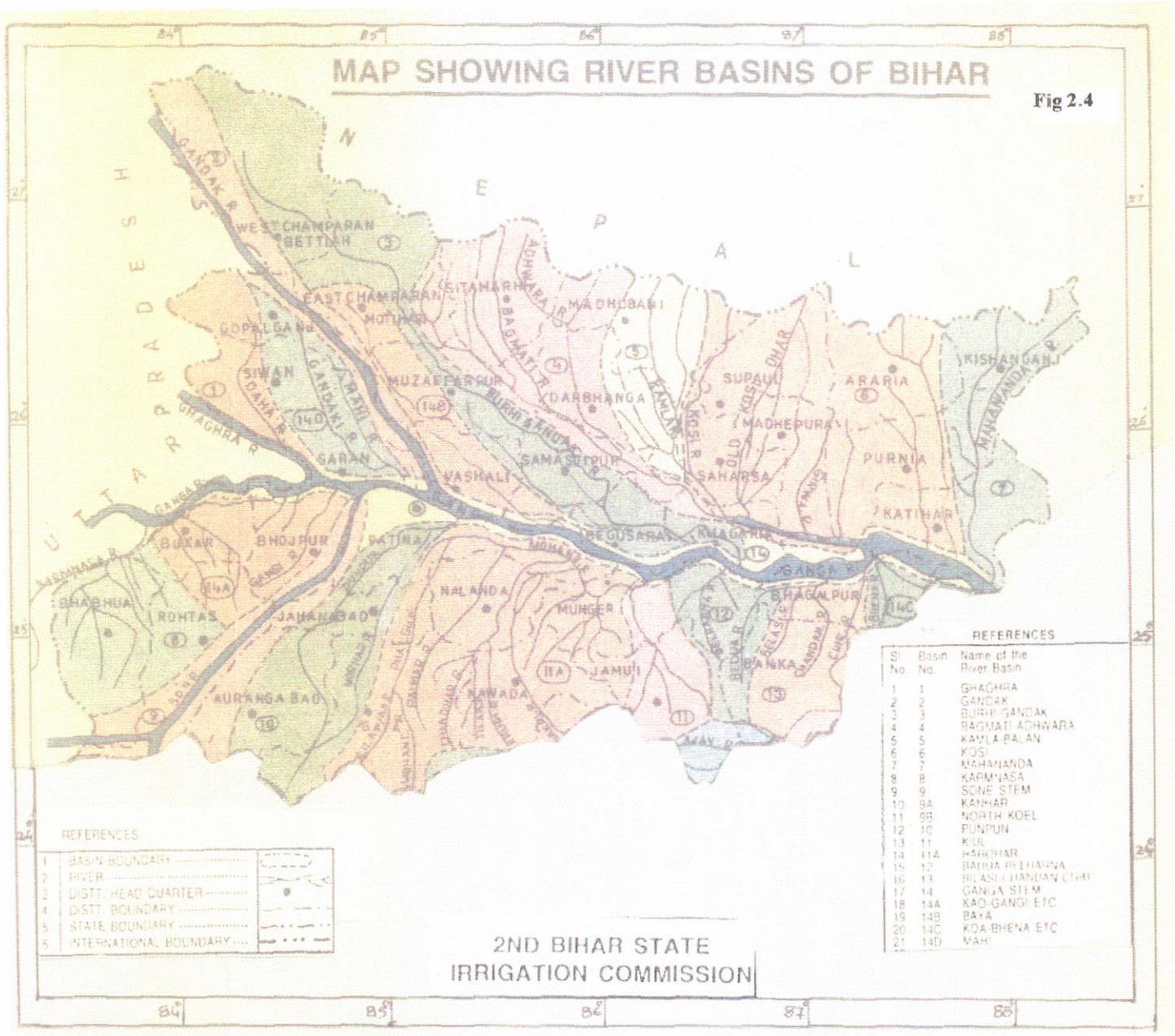


Fig 2.3

LEGEND FOR SOIL ZONE

1 Sub Himalayan Hill & Forest Soils
2 Recent Alluvium-Terai Soils
3 Recent Alluvium-non Calcareous
4 Young Alluvium-Non Calcareous-Non Saline
5 Young Alluvium-Calcareous
6 Young Alluvium-Calcareous Saline & Saline Alkali
7 Non Calcareous Alluvial Soils
8 Recent Alluvium Calcareous
9 Recent Alluvium Yellowish to Reddish Yellow Non Calcareous Non Saline Tal Land Soils
10 Light Grey Dark Grey Medium Heavy Textured Soils
11 Old Alluvium-Grey Greyish Yellow Heavy Textured Soils with Cracking
12 Old Alluvium-Reddish Yellow-Yellow Grey Catenary Soils
13 Old Alluvium-Yellowish-Red Yellow Soils Of Foot Hills
14 Old Alluvium - Saline Alkali Soils
15 Hill and Forest Soils of Steep Slopes & Highly Dissected Regions
16 Red Yellow Light Grey Catenary Soils
17 Pale Yellow Yellow Pinkish Deep Catenary Sails on Micaceous Schists

Source : Second Bihar State Irrigation Commission


MAP SHOWING RIVER BASINS OF BIHAR
Fig 2.4
NEPAL
UTTAR PRADESH
WEST CHAMPARAN
BETTIAH
EAST CHAMPARAN
MOTIHARI
SITAMARHI
MADHUBANI
SUPAUL
ARARIA
KISHANGANJ
GOPALGANJ
SIWAN
MUZAFFARPUR
DARBHANGA
MADHEPURA
PURNIA
KATIHAR
SARAN
VAISHALI
SAMASTIPUR
SAHARSA
BUXAR
BHOJPUR
PATNA
BEGUSARAI
KHAGARIA
BHAGALPUR
BANKA
BHABHUA
ROHTAS
JAHANABAD
NALANDA
MUNGER
JAMUI
AURANGA BAD
NAWADA
GHAGHRA R
GANDAK R
GANDAKI R
SON R
KOSI
KAMLA
BAGMATI R
ADHWARA R
BURHI GANDAK
MAHANANDA
KARMNASA
GANGA R
REFERENCES
1 BASIN BOUNDARY
2 RIVER
3 DISTT. HEAD QUARTER
4 DISTT. BOUNDARY
5 STATE BOUNDARY
6 INTERNATIONAL BOUNDARY
REFERENCES
Sl. No. | Basin No. | Name of the River Basin
1 | 1 | GHAGHRA
2 | 2 | GANDAK
3 | 3 | BURHI GANDAK
4 | 4 | BAGMATI ADHWARA
5 | 5 | KAMLA BALAN
6 | 6 | KOSI
7 | 7 | MAHANANDA
8 | 8 | KARMNASA
9 | 9 | SONE STEM
10 | 9A | KANHAR
11 | 9B | NORTH KOEL
12 | 10 | PUNPUN
13 | 11 | KOEL
14 | 11A | HARDHAR
15 | 12 | BADUA BETHARNA
16 | 13 | BILASI CHANDAN CHIR
17 | 14 | GANGA STEM
18 | 14A | KAO-GANGI ETC.
19 | 14B | BATA
20 | 14C | KOA-BHENA ETC.
21 | 14D | MAHI
2ND BIHAR STATE
IRRIGATION COMMISSION

CHAPTER -III

THE PROBLEMS AND PROSPECTS

CHAPTER -III

THE PROBLEMS AND PROSPECTS

3.1 GENERAL

The situation in Bihar can be described as poverty among plenty. It is bestowed with two most important natural resources- land and water. It has plenty of plain fertile land with alluvium soil and abundant surface and ground water. The climate is also very conducive to farming and agricultural practices. There are laborious and progressive farmers and there is no dearth of farm labourers. Traditionally, the State as well as the Eastern Region had been on the fore-front of agriculture production in the country. Notwithstanding all these, the State is economically backward. A comparative statement of important socio-economic indicators of Bihar and India is available at Table 4.1which shows how Bihar is lagging in different fields.

Table 3.1

Socio-Economic Indicator

Sl. no.	Item	Bihar	India	Reference
1	Population below poverty line	38.4 million	322 million	UNDP 1993-94 Published by Planning Commission
	(i) Rural	92%	76%	
	(ii) Urban	8 %	24 %	
2	Literacy	47.53%	65.38%	Based on 2001 census
	(i) Male	60.32%	75.85%	
	(ii) Female	33.57%	54.16%	
3	Agricultural yield Rate	1.37 T/Ha.	2.47 T/Ha.	Based on 1999-2000
4	Mortality Rate (Health)	8.8 per Thousand	8.5 per Thousand	Based on 2001 census
5	(i) Rural Population	89.53%	73%	Based on 2001 census
	(ii) Urban Population	10.47%	27%	
6	Population Density	883 per sq. Km.	324 per sq. Km.	Based on 2001 census
7	Irrigation Potential Created in Percentage	40%	71%	

Bihar is, predominantly an agricultural State and it has become more so after separation of Jharkhand. Agriculture contributes about 47.6 % towards Gross-Domestic Product (GDP) of the State, while the share of agriculture in GDP of the country is only 25%. In such a situation,

agriculture holds the key to the economic and overall development of the State. Further, the development of water resources (including the moderation of flood and solving the surface drainage congestion and water logging along with the development of irrigations) acts as the corner stone for the same. As a matter of fact, the economic development of any state/ region bears a very close and direct relation with the development of water resources. This is still more pronounced in case of Bihar.

The reasons for economic backwardness of Bihar, as usual, is not confined to a few spheres, rather they extend over a wide spectrum of geographical, historical, physical feature (topographical), political besides several socio-economic aspects. Technical aspect & the technical measures implemented so far are also to be blamed to some extent.

3.1.1 Geographical Reasons

The State of Bihar is situated in the middle Gangetic plains. The northern boundary of the State is the international boundary with Nepal. All the rivers of North Bihar (except Burhi Gandak) e.g. Ghaghra, Gandak, Bagmati, Kamla-Balan, Kosi and Mahananda originate in the Himalayas and flow for considerable length in Nepal before entering Bihar. They have considerable catchment area in Nepal. Suitable reservoir sites on these rivers and their tributaries are not available in Bihar. They are available only in Nepal. This is a major constraint in the development of water resources in Bihar for both flood management and irrigation. Optimum development of water resources of North Bihar, which contributes about 80% of the total surface water resources of the State cannot be achieved without full co-operations and active support and involvement of HMG Nepal.

3.1.2 Historical Reason

The following extracts from the report of the Committee on the Agricultural Productivity of Eastern India (Reserve Bank of India, 1984) very briefly summarizes the historical reason for economic backwardness of the Eastern India including Bihar.

"Eastern India comprising West Bengal, Orissa, Bihar and East U.P. is one of the most fertile regions in India. Historically it was the most prosperous agricultural tract in the country .It lost its pre-eminence due to a variety of reasons such as exploitation of the peasantry under the system of zamindari, talukadari and sub-infeudation, growing pressure of population on land and fragmentation of holdings, inadequate provision of bridges. Culverts and siphons in railways, roads and canals which interfere with natural flow of water and add to monsoon floods, water-logging, pests and diseases, neglect of irrigation, drainage and water management programmes and consequent difficulty in adoption of modern technology in agriculture. The Green Revolution which started in the mid 1960s in the wake of the adoption of HYV seeds, fertilizers, pesticides, etc., and transformed agriculture in Punjab and Haryana has not made any significant impact in the eastern region."

Notwithstanding the historical reasons in the distant past during British period, the Reports further reveals the reasons how not only Bihar but whole of Eastern India could not

keep pace with the development in the field of agriculture, which has taken place in other regions of the country. The following extracts illustrate the point.

" Historical record, however, provides a sharply contrasting picture of Eastern India. One and a half centuries ago, it was a very prosperous and agriculturally advanced region in the country. Its improvisation began during the British rule, but even at the time of Independence, its agriculture maintained a lead over other regions in the country. During the triennium ending 1950-51, the Eastern Region had recorded highest food-grains yield. However, since then and especially after the introduction of the new HYV seed and fertilizer technology in the country, the region, with the exception of West Bengal, has steadily lost its relative position. The Northern Region crossed the food-grains yield level of the Eastern Region by early 1960s and the Southern Region in 1970s,. It appears ironical that programmes and policies during the planning era, which have induced an acceleration in the pace of agricultural development in other regions, could not make sufficient impact in the Eastern Regions which was agriculturally so prosperous in earlier time."

3.1.3. Physical Features

Physical and topographical features of the State particularly North Bihar are also responsible for slow developments of water resources. Some of the features are described below:-

(i) It is a playground of many rivers, particularly in the alluvial belt. These rivers carry discharges much in excess of their channel capacity along with considerable amount of sediments from fragile slopes of the foothills of the Himalayas.

(ii) On emerging from the hills, their slopes remain fairly steep which become gradually flatter lower down in the plains which is associated with decrease in velocity and consequent deposition of more and more silt & sediment.

(iii) The heavy sediment deposition on the riverbed in flatter reaches reduces the capacity of the river to carry the flood discharge, which ultimately results in overtopping of the banks and inundating the adjoining area.

(iv) Due to silting up of the river bed, the river acquires tendency to erode its bank and change course abruptly. In such situation new spill channels are formed causing immense damage to the adjoining area.

(v) Delta formation takes place at the mouths of the tributaries near their outfall in the main river Ganga. A number of important towns and habitation are situated on the delta. These towns suffer from the problem of flood very frequently necessitating adequate flood protection measures for their safety and future growth.

(vi) Because of continuous deposition of sediment in the bed and spilling of the rivers, the banks of the river have acquired the shape of ridge.

(vii) Due to the above phenomenon and also due to existence of saucer shaped topography with large number of low pockets in the shape of chaurs, mauns and jheels (lakes), the floodwater gets entrapped and thus the problems of drainage congestion of surface water and water logging are prevailing.

(viii) The situations of flood, drainage congestion and water logging get further aggravated due to high stage of water in the main Ganga river at the outfall points of the tributaries.

3.1.4 Socio-Economic Factors:

There are several socio-economic factors that are working as constraint for development of Bihar in general and agriculture and water resources in particular. Most important among them are explosive growth of population, low productivity of agricultural produce, fragmentation of land holding, poor records of land reforms etc.

3.2 The Problems of the State of Bihar

The State of Bihar is situated in the middle of Gangetic Plain and River Ganga flows through the State dividing it into two parts- North & South, popularly called as North Bihar & South Bihar (before bifurcation of Jharkhand this part was called Central Bihar). The State is abut with foothills of Himalayas in the north. Rivers originating from the Himalayas in the north and from Chhotanagpur Hills and the Vindhya Ranges in the south traverse the State and join the river Ganga which is the master drainage channel of the State.

The State of Bihar is predominantly an agricultural State. Agriculture contributes about 47.6% towards Gross Domestic Products (GDP) of the State, while the share of agriculture in the GDP of the country is only 25 %. The state has plenty of plain and fertile land and sufficient water resources. Significant developments in the field of water resources have taken place. Notwithstanding all these facts, the state continues to remain one of the most economically backward states.

The main problems in the field of water resources with which the state is confronted and which are acting as deterrent for the overall economic development of the State are as discussed below in brief:

3.2.1 Flood Problem

Bihar is the worst sufferer state on account of flood. According to the assessment of the Rashtriya Barh Aayog (1980), 40 Mha. (about 12.5% of total area is flood prone in the country and data show that on average 7.563 Mha. area is affected by flood annually with a minimum of 1.46 M ha and maximum of 17.5 M ha . As per reports of Rashtriya Barh Aayog (1980), the flood prone area in Bihar was 42.6 M ha. The Second Bihar State Irrigation Commission (1994) has assessed the flood prone area in Bihar as 68.8 Lakh ha which is about 73% of total area of the State and 17.2% of total flood prone area in the country. The flood problem is more severe in North Bihar. The total flood prone area in North Bihar (excluding the stem of River Ganga) is 37.53 Lakh ha, which is 82.8% of the total drainage area of the different tributaries joining river Ganga from the north. In a single year the maximum affected area in Bihar was 42.9 Lakh ha (during 1971) and the minimum was 7.1 Lakh ha (during 1989) which are about 62.4% and 10.3% respectively of the total flood prone area of the State. These are much higher

than the corresponding figures for maximum & minimum flood affected area at national level which are 43.8% and 3.6 % respectively. On an average 17.5 Lakh ha. (26% of flood prone area) area is flood affected annually in the State, while at national level only 19% of the total flood prone are is flood affected annually.

The severity of the flood is more in term of damages to the property, loss of human life and cattle compared to the extent of flood affected area. The Second Bihar State Irrigation Commission (SBSIC) has analyzed the data for flood damages for the period 1968-1991, according to which the maximum value of flood damage, on the price level of 1991, was of the order of Rs. 1698.56 crore during 1987 and the minimum was of the order of Rs. 12.62 crore during 1989. The average annual damage due to flood in the State is of the order of Rs. 300 to 400 crore. It may be noted that for the period 1953 to 2000, the average value of damage due to flood at national level at constant price of 1982, was Rs. 1039 crore and the maximum is Rs. 3232 crore (during 1985). These figures are very much lower than actual damages as the loss in agricultural damages as computed shows only loss of input and not that of possible production.

In this context the flood of 2004 demonstrates the severity of flood problem when a vast area of 23.49 lacs ha was badly affected by the floods of Bagmati, Kamala & Adhwara groups of rivers causing loss of about 800 human lives, even when Ganga, the master drain was flowing low.

There is possibility of diverting early floods of small rivers into major rivers which are not in flood. For example the floods of Kamla,Bagmati etc may be partly diverted into Ghaghra, Gandak and that at confluence of these rivers with Kosi into Ganga by direct links.

The flood management works carried out so far at National level has provided reasonable degree of protection to an area of 14.374 M. ha. upto March 1993. The work consist of 16,199 Km of new embankment; 32,003 Km of drainage channels; 906 town protection works and raising of 4721 villages above flood level. This has been achieved at an expenditure of Rs. 12222.39 crore at current price at the end of Eighth Five Year Plan (1992-97).

In Bihar as flood protection measures 3435 Km of embankment and 47 town and village protection schemes have been implemented at an expenditure of Rs 1162 crore till the end of Ninth Five Year Plan (1997-2002), which have provided reasonable degree of protection from flood to an area of about 29.8 Lakh ha. out of total flood prone area of 68.8 Lakh ha.

It is to be noted that frequent flooding of entire North Bihar, main stem of Ganga and a part of South Bihar, is not only causing inconveniences and hardship, but is working as a major constraints in the over all economic development of the region in particular and State as a whole. The flood protection measures implemented so far is only in form of construction of embankment, which is only a short-term measure and does not ensure complete protection from flood. Construction of reservoirs on major rivers like Kosi, Gandak and their tributaries, Kamala & Bagmati for multipurpose with appropriate provision for flood cushion is considered necessary to provide flood protection in the flood prone area of North Bihar. Bihar

has been making efforts since long for construction of dams on these rivers but so far it has not been able to achieve any success. It is expected that through the implementation of the Inter-linking of rivers and construction of reservoirs on the tributaries of Ganga, with sufficient provision of flood cushion in the live storage, success in providing flood protection to a reasonable limit will be achieved.

3.2.2 Drainage Problem

Next to flood, congestion in drainage of surface water resulting into water logging is another major serious problem in the state related to the water resource development and management. About 9.41 Lakh Ha area is affected due to drainage congestion of surface water, which is about 10% of the area of the state. North Bihar is more severely affected as out of total area of 9.41 Lakh ha. affected due to drainage congestion about 8.35 Lakh ha lies in North Bihar, this is 15% of geographical area and about 23% of cultivable area. The balance 1.06 Lakh ha lies in Mokamah group of Tal area. The area affected by drainage congestion is not being properly used for cultivation which is causing great loss to the farmers as well as to the nation. The problem assumes more severity in light of high percentage of affected area compared to the cultivated area and heavy pressure of population on scarce land resource in the entire State in general and North Bihar in particular.

The main reasons for the drainage congestion and water logging are the topographical feature i.e. existence of a large number of saucer shaped chaurs and mauns; course of rivers acquiring the shape of ridge due to deposition of silt in due course; and high water level at the outfall of drainage channels in the tributaries and main Ganga river, which is the master drainage channel of the region.

It is expected that reservoirs proposed to be constructed on river Kosi, Gandak and Sone, which are the major tributaries of river Ganga, will help in reducing the peak flow, and lowering the water level in these major tributaries and main stem of river Ganga and the outfall condition of different drainage channels will improve. This will facilitate drainage of water logged area. This will also help in practicing improved cultivation and increase the agricultural production benefiting the farmers as well as the nation.

3.2.3 Problem of low flow in River Ganga during Lean period

Another major problem faced by Bihar in the field of water resources, which is linked with inter-linking of rivers, is the extremely low flow in river Ganga in its reach in Bihar during lean period. This problem is not confined to Bihar only, but the state is the worst sufferer on this account. The Ganga is an international river and there is an international agreement for ensuring certain discharge to Bangladesh during lean period. According to a study conducted by CWC during 1982, the anticipated flows in Ganga at Farakka during the lean months of February, March and April have been assessed as 1500 cumecs. This assessment has been based on the assessment of flow in the major tributaries of Ganga at their outfall points. The issue has also been examined by the Second Bihar State Irrigation Commission (1994). The contribution of major tributaries of river Ganga during lean months

February, March and April have been assessed by the Commission on the basis of data for the period 1959-60 to 1991-92 and it has been found that there are shortfalls of 309 cumecs during February, 469 cumecs during March and 174 cumecs during April from what has been assessed by CWC. It is very significant to note that study conducted by CWC is based on the discharge data of tributaries and river Ganga as available during 1960-1982 and the study does not take into consideration the under utilisation of the existing projects and the future utilisation by ongoing and proposed irrigation projects. The study undertaken by the Second Bihar State Irrigation Commission is based on the data for the period 1959-60 to 1991-92, which includes more recent and up to date data. The utilisation of water in different irrigation schemes located in Ganga Basin has very important impact on the availability of discharge in the tributaries of river Ganga at their outfall points especially during lean month of February, March and April. In this context it is very relevant to note that the utilisation in the existing irrigation projects in Bihar is far less than the ultimate irrigation potential of the projects, because of many reasons, the most important being the deteriorated conditions of the canal system. It is expected that once the ultimate irrigation potential of existing irrigation projects is restored the utilisation will increase and consequently the contributions of tributaries to main river Ganga will decrease. Besides these existing irrigation schemes, there are several ongoing (under execution) and a few more schemes in the process of getting sanction for implementation. When these schemes will be completed the contribution of the tributaries of Ganga at their outfall points will get reduced further and consequently the discharge in river Ganga will get reduced further. According to a rough estimate the impact of full utilisation by existing, on going and proposed irrigation projects in Ganga Basin in Bihar will result in further decrease in discharge in river Ganga by about 732 cumecs during February, 579 cumecs during March and 371 cumecs during April. Taking these developments into consideration the expected discharge will be 459 cumecs during February, 452 cumecs during March and 955 cumecs during April, against 1500 cumecs for February, March & April as assessed by the CWC. The severity of the problem and the gravity of the situation have to be realised in the light of the followings:

i. The course of river Ganga from Allahabad to Haldia has been declared National Waterway No.1. But due to low discharge during lean period, it is not possible to maintain adequate depth required for vessels to operate.

ii. The river Ganga is not only a river representing water body and source of water; rather deep social, cultural and religious sentiments of the people in the Basin are intimately linked with river Ganga and people perform many functions and religious rites along the bank of river Ganga. It has become a symbol of faith for the people residing in the basin. During recent times, the river almost disappears and very small discharge flows into one part of a very wide course of river which causes hardships to the people and consequently creates discontent.

iii. Due to extremely low discharge during lean period the water becomes polluted and unfit for human consumption, while it is source of drinking water supply and other domestic purposes for the people living in villages and towns situated on its banks.

iv. As explained earlier the development of irrigation and the utilisation of created irrigation potential to its fullest is hampered.

v. As per international agreement, a minimum water supply during lean period has to be ensured to Bangladesh. In order to fulfill the international commitment, the withdrawal by Bihar during lean period has been restrained. Putting such restriction on Bihar only and allowing other states to utilise its water unrestrained is a very glaring example of injustice to Bihar which has resulted in hampering of its development.

vi. In this context it is important that the link Canals viz. Sarda - Yamuna, Ghaghra - Yamuna, Yamuna - Rajasthan, and Rajasthan -Sabarmati are planned in such a way that required water is transferred in flood period only and stored in their own territories for use whenever required in order to prevent reduction in the flow in Ganga in lean period so vital for use of U.P and Bihar.

3.2.4 Problem of Drought

The Second Bihar State Irrigation Commission (1994) has assessed that 16.07 Lha area is drought prone in the State. This is mostly in South Bihar. This works out to 17% of the total geographical area of the State. Since the entire drought prone area is located in South Bihar this works out to 37% of the geographical area and 59% of the cultivable area of South Bihar. This is despite the fact that the average annual rainfall in the State is 1270 mm. the average annual rainfall in South Bihar varies between 990 to 1480 mm and the State has adequate surface and ground water and plenty of plain and fertile land. The following table shows the Basin wise drought prone area and its percentage with respect to total area of the Basin.

Basin/sub-Basin	Drought prone area in Lha	Percentage of total Basin area
1. North Bihar basins	Nil	Nil
2. Ganga stem-South Bihar	0.29	5.3
3. Karmnasa	2.59	50.5
4. Sone	2.51	26.8
5. Punpun	1.89	20.4
6-(a) Harohar	5.59	39.1
(b) Kiul	1.97	67.2
7. Badua- Belharna	0.24	10.8
8. Bilasi-Chandan-Chir	1.25	31.3
Total:	16.07	37.2%

3.2.5 Slow Development of Irrigation Potential

The development of ultimate irrigation potential in Bihar cannot be said to be satisfactory though the State is rich in water and land resources. The geographical area of the state is 93.8 L.Ha. and the cultivable area has been assessed as 64,41,820 ha which is 68.67% of the geographical area. The net sown area during 1999-2000 was 56.03 L.ha which is about

87% of the cultivable area. The gross cropped area during 1999-2000 was 79.46 L.ha and thus the over all cropping intensity is 142%. There are several constraints in the development of water resources. Some of major constraints are as follows:

i. Predominance and preoccupation with the problem of flood.
ii. Lack of adequate and suitable sites for dams.
iii. Interstate and international issues involving WRD projects.

The ultimate irrigation potential of the state assessed by the Second Bihar State Irrigation Commission and the irrigation potential created so far are as follows:

Category of Schemes	Ultimate Irrigation Potential (L.ha)	Irrigation Potential Created (L.ha)	Percentage
1. Major and Medium Irrigation	53.95	26.80	49.67%
2. Minor Irrigation			
(i) Surface	10.05	0.76	7.56%
(ii) Ground water	34.80	22.49	64063%
Sub total (i) and (ii)	44.85	23.25	51.84%
Total (1) and (2)	98.80	50.05	50.66%

(Source: SBSIC Report- 1994 - Vol-1 -Table-22)

It is very important to note that the assessment of ultimate irrigation potential by the Second Bihar State Irrigation Commission is under constraint. As adequate number of suitable site for construction of dam in major rivers are not available, most of the schemes are only run-off-the river schemes. These schemes have two major disadvantages viz. (i) schemes fail to store the monsoon flows which is wasted; and (ii) there is acute shortage of water during Rabi and Hot Weather seasons.

Now when construction of dams on Kosi, Gandak and Sone being major tributaries of river Ganga is envisaged in Inter-linking of Rivers Project, it is expected that monsoon flows of these rivers which is being wasted at present, will be stored and thus adequate water will be available for Rabi and hot weather seasons. This will help in bringing more area under irrigation as well as increasing the irrigation intensity commensurate with available land and water resources.

3.3 Technical Measures Taken So Far

Significant developments in the field of water resources development have taken place in the State during post independence period. Even during pre-independence period, water resources developments projects were implemented which included Sone Canal System and Tribeni Canal in the field of irrigation and embankment along the banks of river Gandak for flood moderation. In post independence period, major projects like Kosi Project, Gandak Project, Sone Remodelling (including construction of Sone Barrage in place of old anicut), Badua Reservoir Project, Chandan Reservoir Project and a large number of medium irrigation projects have been implemented. In flood sector also long embankments have been constructed

on almost all major rivers of North Bihar to provide protection from flood. There is no denying the fact that the State has been benefited from the implementation of these water resources development projects. However, the postfacto performance evaluations of some of these projects, both flood protection and irrigation, reveal major deficiencies and shortcomings in concept of planning design and implementation of these projects as discussed below with a view to take appropriate measures to avoid their repetition in the present planning of interlinking of rivers.

i. Only Short Term Measures Taken For Flood Moderation:

It will not be an exaggeration to call flood as the most burning problem of North Bihar. Next to it come the issues of surface water drainage congestion leading to water logging and irrigation. The flood management programmes implemented in Bihar comprises construction and maintenance of 3430 Km of embankments and about 47 town and village protection schemes which have provided reasonable degree of protection from flood to an area of about 29.16 lakh ha out of total flood prone area of 68.8 lakh ha. It is evident that these measures comprise only construction of embankment, which is only a short-term measure and is not sustainable on long-term basis. The most effective flood moderation measure consists of construction of dam to create reservoir with adequate storage capacity for retaining flood water and moderate and regulate the discharge to safe bankful capacity of the river. Since there is no suitable site available in Bihar, such sites are available only in Nepal, the flood moderation measures are at present not backed by the reservoir schemes. These are associated with all the disadvantages of embankment as flood moderation measures. In this context the construction of embankment with barrage on river Kosi as a flood control and irrigation measures is a glaring example of short-term measure implemented for flood protection. Now when dams are being proposed to be constructed on the major rivers of North Bihar like Kosi and Gandak, it is expected that adequate flood cushion will be provided in these reservoir to moderate and regulate the down stream discharge to safe carrying capacity of the river and make the flood moderation measures sustainable on long term basis

ii. Neglect of Drainage Aspects

Though drainage is considered an integral part of the irrigation project, it has hitherto, been ignored in case of major irrigation projects of North Bihar, where water logging due to surface drainage congestion is very acute. It has been estimated that out of 58.50 lakh ha being total area of North Bihar nearly 8.35 lakh ha is affected by drainage congestion problems. After implementation of major irrigation projects of North Bihar like Kosi Project and Gandak Project without including appropriate measures for removal of drainage congestion, the problem has further aggravated. As a result of this the accrual of irrigation benefit is not to the extent as originally envisaged. It is high time that remedial measures should be implemented and the situation should not be allowed to persist. At the same time it should not be repeated in future planning in this region.

It has been observed that appropriate measures for removal of drainage congestion was not included in the original reports of the major irrigation projects like Kosi & Gandak. Even

to date the schemes for drainage and irrigation are not duly integrated and they are being treated separately. The implementation of drainage schemes are lagging and they are not receiving due importance and priority in implementation.

iii. Incomplete Implementation

Another major shortcoming of the water resources development projects in Bihar is incomplete implementation. Bihar has been a major victim of incomplete water resources development projects. Glaring examples are Kosi Project. Gandak Project, Bagmati Multipurpose Project etc. Even Tribeni Modernisation Project could not be completed in all respects. The phenomenon is likely to be repeated in Sone Modernization project. As a result benefits are not accruing as envisaged and expenditure incurred are proving infructous.

The construction of canal system in Kosi Project and Gandak Project was continuing till March 1985, when the construction work in both the Projects was abruptly stopped on the suggestion of the Planning Commission on the plea that the projects were lingering since long. It was suggested that separate estimate should be prepared for the balance work and they should be implemented as Phase II. It is surprising to note that precious more than eighteen years have passed but project estimates for Gandak Project Phase-II and Kosi Project Phase II are still under bureaucratic and technocratic hibernation of sanction. Bagmati Multipurpose Project, comprising flood and irrigation components was started during seventies, First the construction of embankment was taken up and was partially completed in a length of about 61 Km against the total length of 190 Km. The irrigation component comprising barrage and canal system was not taken up at all. The project is now almost abandoned. The partially constructed embankments has been a great source of trouble for the people and they are always cursing the project and agitating for removal of the embankment. The partially constructed embankments as a measure for flood moderation, without adequate provisions for irrigation is depriving the farmers from the fertilizing effect of silt laden flood water. The farmers are not able to grow crop and they are economically ruined.

The post-facto performance evaluation studies of several major and medium irrigation projects in Bihar have also revealed the same story that projects have been declared complete although significant amount of work especially the canals system were not completed.

3.4 Prospects of Development from Interlinking of Rivers

The future prospects of development of Bihar are very much dependent on agriculture, which in turn depends on water resources development project planned for flood moderation, drainage and irrigation, with adequate provision for minimum flow during lean period to meet the requirements for navigation, ecology, pollution control and other environmental needs, as well as downstream riparian & perspective rights. The problems of Bihar related to different spheres of water resources development have been discussed briefly under Para3.2 above. Efforts have been made to identify the deficiencies and shortcomings of the existing WRD Projects in Bihar, in the previous sections. The objective and the approach to be adopted as recommended by various Commissions and Committees have also been underlined under

section 1.3 of Chapter-I. The project for Inter-linking of major rivers of India is going to be the final plan for the development of water resources of the country. Therefore, it should envisage to solve all the problems of water resources in every part, region, state, river basin of the country. It is also expected that Bihar will also be benefited from this Project and the Project will be able to provide solution to the problems of WRD with which Bihar has been struggling so far. It is quite natural to expect that the mistakes in planning, design and implementation, committed in the past will not be repeated and all modern / recent concepts, methodology and approaches will be adopted. Utmost caution is needed, as this being final plan, there will be hardly any scope for remedial measure and once any mistake is committed, it will doom the future.

It would be, therefore, essential to widen the objectives of the Interlinking of rivers as explained in Succeeding paras in order to achieve the desired results.

3.5 Need for Widening of Objectives of Interlinking of Rivers.

The mega project for Interlinking of major rivers of India, is going to be one of the biggest projects of not only the country, but of the world. The project is unprecedented in scale and magnitude and is being considered as ultimate plan for water resources development of the country. The project is very big and gigantic, ambitious, imaginative and extends over almost whole of the country. The information about the concept, planning and programme for implementation has raised very high hopes among the people, and it has raised their expectations very high. Water being State subject and the sphere of the project extends over several basins involving neighbouring nations like Bhutan, Nepal and several States within the country, the task of implementation becomes more difficult and challenging, which calls for making the Scheme socially acceptable and politically compatible besides taking into consideration the usual aspects like technical feasibility, economic viability, ecological stability and environmental quality.

Bihar too is going to be benefitted significantly. The different components of the project envisages the construction of dams on major rivers like Kosi, Gandak and Sone, which is expected to help in conservation of water, and thereby moderate floods and increase the utilisation of available surface water. However, several changes / modification in objectives, approach, methodology, planning, design, implementation and operation as well as alternatives are worth consideration to make it more beneficial and acceptable as detailed below.

i Equitable Distribution

The project for interlinking of rivers envisages and gives stress on equitable distribution of water in various river basins of the country. There is need for achieving equitable distribution of water resources in different regions, in different sub-basins and in the different parts of the command of the same project. The equitable distribution should not be based on the numerical calculation of water resources or land, rather it should be based on the potential of land for agricultural production and need of food production for the populations and available land & water resources.

There is also urgent need for establishing equity and balance in development of water resources in different basins, sub-basins, regions and sub-regions. More attention and efforts are needed for specially backward areas. This is considered essential to check the growing social tension turning into the form of violence.

In this context it may be mentioned that for equitable distribution water being transferred from MSTG Link Scheme to Ganga should first be utilized to meet the need of Bangladesh and West Bengal before transferring them to South as this will augment the lean flow in Ganga for use in Ganga valley and enable Bihar to use it during non-monsoon period.

ii Prime objectives

The various water balance studies and the Pre-feasibility Report prepared by NWDA, reveals that the focus is on the calculation of surplus water in the river basins of northern India and main thrust is on the transfer of the balance water as assessed by NWDA to Southern & Western river basin where as prime Objectives should be to include all problems of water resources development as follows :

- Flood moderation and drainage improvement
- Augmentation of lean flow of Ganga
- Rabi & Hot Weather crops' needs
- Ecological & environmental needs
- River morphology improvement
- Pollution control/ abatement
- Downstream riparian & prospective rights
- Navigation
- Drought prevention
- Development of irrigation
  - in entire balance area
  - with increased irrigation intensity commensurate with available resources
  - land
  - water and highest density of rural population

It is not enough to include these objectives in the Project, it is equally essential to create adequate storages by constructing dams, wherever technically feasible and economically viable and provide required flood cushion for flood moderation and adopt an operating policy which will facilitate a balanced trade off- between flood cushion and conservation storage.

For a sustainable development it is also required to take up soil conservation measures, in the catchment of the proposed reservoirs. This will help in achieving the following:

i) Minimise siltation in reservoirs, reducing the requirement of dead storage and increasing the useful life of reservoirs, and
ii) Optimise the benefits to Nepal, and
iii) Cater for requirements of non-monsoon period

3.6 Flood moderation through interlinking Schemes

3.6.1 Construction of Embankments-A Short Term Measure

As discussed earlier flood moderation measures have been implemented in the form of embankments along the banks of the river and town and village protection schemes. It is claimed that with the implementation of these short term measures out of total flood prone area of 68.8 Lakh ha. an area of 29.16 Lakh ha. (42 %) has been provided reasonable protection against flood. In this regard the following points are noteworthy:

i. After more than 50 years of planned development after independence reasonable protection against flood has been provided in less than 50% of flood prone area. This is more depressing and contradictory in face of the fact that it is envisaged to develop all water resources in the country through inter-linking of rivers by 2015.

ii. The protection of area, which is said to be provided with reasonable degree of protection against flood, through temporary measures of embankment, becomes vulnerable, when there is a breach, which is very frequent.

iii. The construction of embankment as a short term measure against flood, has been adopted under the constraint of non-availability of suitable sites for construction of dam in Bihar.

3.6.2 Reservoirs as Long Term Measures

Construction of dam to create reservoir with adequate capacity as flood cushion to store water during high discharge and release the same when critical conditions are over is very effective measure. The flood moderation envisaged to be provided with reservoir is more sound as compared to with embankment and is sustainable on long term basis. Thus reservoirs are very dependable and effective measures of flood management either by itself or in combination with other measures.

It is encouraging to note that under the scheme of Inter-linking of rivers dams are being proposed on Kosi and Gandak rivers. While the proposed dam on river Kosi is a high dam having adequate capacity to moderate flood, the proposed dam on river Gandak is a small diversion dam, which will not have enough capacity to moderate flood. The suggestions to construct dams on Kosi, Gandak and their tributaries will be a welcome step which will help in moderating the flood to a great extent and also ensure better utilisation of the available water resources.

3.6.3 Need For More Reservoir On Other Rivers Of North Bihar:

The flood problem of different river basins of North Bihar is linked with each other to some extent. The high stage of water in river Ganga at the outfall points of its tributaries from north and synchronizing with flood in the tributaries aggravates the flood problem. In the present case high dam on river Kosi has been proposed. There should, however, be planning to have dams on its tributaries viz. Sun Kosi and Arun Kosi also which would be very beneficial in all aspect to India as well as to Nepal. This will help in moderating the flood in Kosi basin

which has a flood prone area of 10.15 lakh ha (27%). Thus out of total flood prone area of 37.35 Lakh ha in North Bihar, the balance 27.20 Lakh ha (73%) will not have any advantage of flood moderation from the interlinking of rivers and the situation with respect to flood in all other river basins of North Bihar except Kosi will persist as usual. There is therefore, urgent need to consider the possibility of constructing reservoirs on other rivers of North Bihar like Burhi Gandak, Bagmati and Kamla. This will not only provide facility for flood moderation, but will also provide additional water for utilisation. The SBSIC (1944) has examined the scope of constructing dam on these rivers. The probable sites and other salient features of these dam reservoirs are available in Table 3.2.

Table-3.2

List of probable dam sites on Tributaries of River Ganga in North Bihar

Sl. No	Name of the tributary and location	Catchment area in Sq Km	Height of dam in M	Live storage capacity in MCM.
(1) GHAGHRA				
1.i	Rapti at Sikta(Nepal)	5260	61	1610
ii	Karnali at Chisapani (Nepal)	143480	106	2990
iii	Sarda at Puniagiri(Nepal)	15150	175	6350
(2) GANDAK				
2.i	Kali Gandaki (Nepal)**	9200	214	4480
ii	Burhi Gandaki (Nepal)**	6460	135	2652
iii	Marsyanadi (Nepal) **	7250	140	3824
iv	Seti (Nepal) **	2780	140	2640
v.	Gandak (Nepal)**	37,930	40.5	1960
(3) BURHI GANDAK				
3	River Masan at village Banwari of Ramnagar block under W.Champaran	350	26	145.56
(4) BAGMATI				
4	Noonthore Dam on Bagmati in Nepal	2706	115.824	233.60
(5) KAMLA				
5	Tetaria dam near Chisapani Nepal on Kamala	1409	66.14	1233.5
(6) KOSI				
6 i.	Sapt Kosi river at Barahkshetra**	59539	269.00	9370
ii	Sun Kosi (Tributary of Kosi)	-	147.00	4400 (Gross Storage)
iii	Arun Kosi (" ")	-	-	-
iv.	Tamur Kosi (" ")	-	-	
(7) MAHANANDA				
7.i	Mahananda Goyabari	69.93	45.75	30
ii	Balason Site No.III	222.74	122.00	120
iii	Mechi Site No I	129.50	122.00	120
iv	W.Kankai Site No.I	1108.52	167.75	880

Source : SBSIC Report, 1994, Vol. V ** As per NWDA Report on Gandak- Ganga Link Project (P-17-18)

List of probable dam sites on Tributaries of River Ganga in South Bihar

Sl. No	Name of the tributary and location	Catchment area in Sq Km	Height of dam in metre	Live storage capacity in MCM
(1) KARMNASA				
1i.	Chayya Dam	137.5"	22.55	28.38
ii.	Suara Dam	296.80	-	-
iii.	Kao Dam	-	-	-
iv.	Awsane Dam	137.5	-	-
(2) SONE				
2 i	Sone Dam (Kadwan)	-	45	4525 (Gross storage)
(2) PUNPUN				
2i.	Jarhi	69	-	-
ii.	Jagarnnath	45	-	-
iii.	Bulandih	-	-	-
iv	Baradih	1295	-	-
v	Madwar	40.24	-	-
(3) HAROHAR				
3i.	Tilaiya Dhadhar Diversion scheme(Length of diversion channel 97.26 Km.)	-	27.13	31.22
ii.	Khuri	-	-	-
iii.	Sakri Reservoir	1100	29.57	279.98
iv.	Lilajan	629	-	-
v.	Mohane	1025	-	-
(4) BADUA-BELHARNA				
4i.	Sindhwarni Res.	165.82	-	58.62
ii.	Amhara Res.	12.96	-	-
(5) BILASI-CHANDAN-CHIR				
5i.	Kudar Res.	183.96	-	-

Source: SBSIC Report, 1994

3.6.4 Need for Provision of Flood Cushion

The role of embankments as short term measure and that of reservoirs as a long term sustainable measure for flood moderation have already been emphasized. The proposals for construction of reservoirs as a part of interlinking of rivers have raised high hopes for achieving long term sustainable flood moderation. Reservoirs in general, play important role in flood-moderation. However, the role of operating policy and earmarking of flood cushion are very important for flood moderation. Three reservoirs – one on river Kosi, another on river Gandak, both in Nepal- and third on river Sone have been proposed by NWDA. The proposed dam on river Gandak and Sone is very small- only diversion dam. Hence, they cannot play significant role in flood moderation and there is no scope for reservation for flood cushion. But proposed Sapt Kosi dam too has not been provided with any flood cushion which should be provided for flood moderation as explained in succeeding para.

3.6.5 Comments on proposed Kosi dam

The subject of flood routing and the situation in respect of flood moderation from proposed Kosi High Dam (KHD) has been reviewed and the following situation emerges- The proposed Dam is 269 m high having MDDL at El. 259 m, the crest of spillway at EL 321.50, FRL at EL 335.25 M and MWL at EL 338.30 M. The computed PMF is 42475 cumecs (15 lakh cusec).

In the CWC report, which has been referred by NWDA the PMF of 42475 cumecs (15 lakh cusec) was routed with flood impinging level at the crest level of spillway (EL 321.50 M) and the routed maximum outflow worked out to be 14,000 cumec (5 lakh cusec), thus, accounting for flood storage of 2.60 MAF (3208 MCM) between crest level and MWL (EL 338.30 M).

The gross storage of KHD Project has been considered in NWDA report as 13455 MCM upto FRL (EL 335.25 M). Also, it has been mentioned in the CWC report that the reservoir level during the flood season is proposed to be maintained below the crest level (EL. 321.50 M) by regulating the releases through sluices and spillway gates.

Criteria for fixing spillway capacity (IS:11223) clearly indicates that in case of large dam, the design flood should be taken to be PMF. Hence, in case of Kosi High Dam, PMF must be considered as Design Flood and reservoir has to be kept empty upto the crest level of spillway (EL 321.50 M). In such a situation, the entire storage between the crest level upto FRL may not be available for conservation There will be always some chances for a part of reservoir remaining empty.

Further, the 100 years flood peak of 24,239 cumec (8.55 lakh cusec) as estimated by 2nd Bihar State Irrigation Commission 1994 Vol. V(II), page 574, has actually been observed at Barahkshetra in August 1954. This flood has been routed with flood impinging at FRL (EL. 335.25 M) as required by IS 5477 (IV) (Flood Storage). The maximum outflow comes out to be 9835 cumec (3.47 lakh cusec) with maximum reservoir level at 341.40 M, thus, encroaching MWL (EL 338.30 M) by 3.10 M.

In the next iteration, the same inflow hydrograph (peak of 8.5 lakh cusec) has been routed with a flood cushion of 4.25 M, corresponding to impinging level being EL 331.M. The maximum outflow came to be 8173 cumec (2.88 lakh cusec) with maximum reservoir level at 338.68, thus encroaching MWL by 0.38 M.

Further, the same inflow hydrograph was routed with impinging level at 330.50 M (ie., a flood cushion of 4.75 M). The maximum outflow came out to be 7900 cumec (2.79 lakh cusec) with maximum reservoir level at EL. 338.39 M, thus, encroaching MWL marginally. This corresponds to a flood cushion of 10% of live storage which may be just sufficient to keep maximum reservoir level around MWL (338.30 m). Moreover, the past observed maximum flood is 25,878 cumecs (9.13 lakh cusec) on 5th October 1968 at Barahkshetra. For want of the inflow hydrograph, it could not be used in routing study.

Hence, based on the above analysis, it seems that a flood cushion of 15% of the live storage must at least be provided for flood moderation. It will serve two purposes :-

i) **With the improved flood forecasting system, it may be possible to forecast for PMF and in such a case, reservoir level can be conveniently lowered to crest level of spillway from normal conservation level (NCL) for emergency operation, and for normal operation, the reservoir may be kept at NCL during flood season, NCL will be corresponding to level as per flood storage of 15% of live storage below FRL.**

ii) **The routed outflow with appropriate valley and channel storages will be limited to a maximum of 7082 cumecs (2.5 lakh cusec) - the safe carrying capacity of Kosi river.**

3.7 Drainage Improvement through Interlinking scheme

The extent of surface water drainage congestion and water logging and its severity have been discussed under para 3.2.2 above. While flood is a temporary phenomenon, water logging persists during Kharif, Rabi and in some cases hot weather also. Flood bestows some indirect benefits - like spreading silt which increases fertility. But water logging due to surface water drainage congestion withholds the cultivation of otherwise good fertile land in a bigger area during Kharif and comparatively smaller area during Rabi season. Blocked drainages in all trunk drains hence, must be cleared to optimise the utilisation of entire area.

3.7.1 Approaches

i. Integrated Approach

In view of serious nature of drainage problems, the Second Irrigation Commission (GOI, 1972) and the National Commission on Agriculture (GOI, 1976) have separately put emphasis on need to associate drainage as an integral part of an irrigation project. The Second Irrigation Commission (GOI,1972) has observed," an area once damaged by water logging and salt efflorescence is difficult and costly to reclaim. We, therefore, urge that in formulating irrigation schemes, the instructions already issued in respect of making adequate provision for drainage should be strictly enforced."

Thus an integrated approach with flood moderation, removal of drainage congestion of surface water and provisions of irrigation benefits is needed especially for North Bihar and Tal area of South Bihar.

ii. Area to be drained

Due to very high pressure of population on land, there is public demand for draining all water-logged area. But physically it may not be possible to provide drainage in entire water logged area, as it will depend on the topographical feature, stage of water in the main drainage rivers and also on the slope and other hydraulic characteristics of the subsidiary drainage channels

outfall conditions. In short, it is neither technically feasible, nor economically viable or environmentally desirable to drain entire water bodies, chaurs etc. A trade-off for area to be drained and balance area has to be made considering all aspects. The balance area the drainage of which is finally not found feasible should be considered for alternative use like growing Makhana and developing pisciculture.

3.7.2 Remedial Measures

The following actions are urgently called for providing remedial measures for solving the problem of surface water drainage congestion and water logging :

i. Comprehensive basin planning not for individual sub-basins of North Bihar but all sub-basins of Ganga basin integrating all major problems encompassing flood, drainage, augmentation of lean flow and irrigation. This will require very detailed an elaborate survey for the conditions at the confluence of tributaries of river Ganga and the stage of water level in the main stem of Ganga, the carrying capacity of the subsidiary drainage rivers and the proposed tertiary drains to connect the local depressions to the subsidiary drainage channels. It will also include the delineation of area which can be conveniently and economically drained and which cannot be finally drained, where growing of Makhana or developing pisciculture can be planned as an alternative to agriculture. It will also include the study of obstruction of natural drainage by the existing or proposed canal system and need for provision of adequate waterway.

ii. The comprehensive planning can be divided into the following components and should be taken up in coordinated way taking into consideration their linkages and inter dependence.

a) **Moderating high water level in major rivers** :
This can be achieved by the contemplated measures of flood moderation like provision of flood cushion in the reservoirs proposed on tributaries of river Ganga like Ghaghra, Gandak, Kosi etc. These measures, will facilitate in lowering water level in the major rivers, which will obviate spill of water and accumulation in depression and will also facilitate quick drainage of accumulated water permitted by slope and levels.

b) **Improving the Carrying Capacity of Subsidiary Channels** :
Improving the carrying capacity of subsidiary drainage channels have has been reduced due to siltation and/or has been obstructed due to several other natural and man-made reasons. There is urgent need to improve the carrying capacity of these channels by removing the silt, and widening and deepening the existing channels.

c) **Connecting Tertiary Drains :**
The local depressions where rain water, irrigation water and / or spill from major rivers gets collected and remain stagnant creating the problem of water logging, have to be connected to the subsidiary drainage channels. This has to be planned in light of existing physical features and topography as well as the existing and / or proposed canal system.

d) **By Flood Diversion :**
A places like waterlogged area at the confluence of Kareh, Kamla & Kosi rivers, early diversion of flood water into Ganga may relieve drainage congestion.

3.8 Augmentation of flow in major rivers during lean period

Ganga with its tributaries flowing through northern India provided two most important natural resources-land and water-which helped in development of the one of the oldest civilisation of the world and it has also been able to sustain so far. There has been significant development in form of implementation of water resources projects in Ganga basin (like other river basins of India) on main river Ganga and almost all major & minor tributaries, which in conjunction with other activities of people including the discharge of industrial and municipal effluents are now threatening the very existence of the mighty river. The utilisation of water in upper reach of river Ganga & its tributaries has increased to such an extent that the river is almost dry during the lean period before its enters Bihar. It is also evident from the computation made by NWDA according to which the total availability of water at Chunar is 1.08 lakh MCM against the proposed utilisation of 1.25 lakh MCM. Whatever flow that is available in the river Ganga beyond Chausa in Bihar where it enters the boundary of the State upto Farakka, the same is the contribution from its tributaries joining it in Bihar & Jharkhand. Even the meagre flow available at present during lean period is bound to decrease in future. The problem of dwindling discharge during lean period is serious. Hence there is urgent need to augment the same. It has been discussed in brief in para 3.2.3 above of the report.

3.8.1 Assessment for the requirement of minimum flow

It has been observed that a provision at the rate of ten percent of lean season flow has been made for environmental and ecological purpose. This provision is in general for all the components. This is supposed to be reserved in the reservoir to be released during lean period. It may be noted that the provision of 10% uniformly for all rivers is not logical. This will largely depend on the quantum of discharge of industrial and municipal effluent besides the downstream riparian rights. It is surprising that while planning, designing and operating the schemes on main stem of Ganga and its tributaries in its upper reach, this aspect has been completely lost sight of. Over and above de-facto restriction has been put only on Bihar in utilisation of Ganga water during lean period, while there in no such restriction on any other co-basin states.

3.8.2 Requirement for Navigation

Navigation in River Ganga is very important aspect. During recent time the importance of navigation in Ganga has increased in view of the increase in volume of transport in the background of increase in population and consequent development of trade. The course of river Ganga from Allahabad to Haldia has been declared National Waterway No.1. At present, the operation of vessels is handicapped due to inadequate depth of flow. Great efforts are called for to maintain required depth of flow to facilitate heavy vessels. If the requirement duly assessed for ecology, environment, riparian and prospective right as well as the commitment for Bangladesh as agreed in the International agreement taken together do not ensure minimum depth of flow required for plying of vessels, additional water along with proper river training measures are must for smooth operation of navigation. This quantity of water has to be assessed and reserved.

3.8.3 Commitment to Bangladesh

Ganga is an international river and an international agreement has been executed between India & Bangladesh, which provides mechanism for sharing of Ganga water at Farakka. At present this has been left to be met from the yield from the tributaries of Ganga in Bihar only and restrictions has been placed over utilisation of Ganga water by Bihar during lean period. Such restriction has not been placed on any other co-basin states in Ganga basin. This is affecting the development in Bihar and it is going to affect more in future.

3.8.4 Allocation of Ganga water to Co-basin States

The prime objective of the present Mega project of interlinking of rivers is to achieve equitable distribution of water available in different river basins of the country. This mega project envisages to transfer the surplus water of Ganga-Brahmputra-basin to Rajasthan and Gujarat in the west and Andhra and Tamilnadu in the South. But it is ironical that the co-basin states of Ganga basin do not enjoy the equitable distribution of water in the basin. The anomalies have been discussed above in brief. It is expected that with the implementation of this project, the existing anomalies will be removed. While allocating the Ganga water among the co-basin states, it is required to assess the requirement of minimum discharge in Ganga. For this purpose the entire stretch of river Ganga need to be divided in different strategic reaches depending, upon the location of confluence of major tributaries and other important features. The requirement of total discharge for each reach has to be assessed on the following counts.

i. Ecological and environmental
ii. River morphology
iii. Pollution control
iv. Down stream riparian & prescriptive right
v. Any other specific commitment.

If the combined requirement for either one or all is adequate to provide necessary draft for the vessel to operate, then there will be no need for any additional discharge for navigation, otherwise additional discharge will be required for navigation.

3.8.5 Augmentation of Lean flow in pre & post interlinking

The problem of ensuring minimum flow in Ganga and other tributaries as prevailing at present is very critical and serious. It is expected that this problem will be solved once the project of interlinking is implemented. This expectation is reasonable. However, there are two most important aspects of this problem. First, there is urgent need to assess the requirement of minimum flow in different reaches of Ganga as discussed above. In absence of such assessment the problem might persist notwithstanding the measures proposed to be implemented. Second, the implementation is expected to take long time, According to the reports prepared by NWDA , a construction period of 15 years have been assumed. The project specially the Himalayan component is in very initial stage; it is in pre-feasibility stage. It is likely to take several years in coming to implementation stage. The Himalayan components of interlinking of rivers have international aspects linked in the them, which may take some more time for their resolution. In this background, it is not advisable to allow the present problem of minimum discharge in different reaches of Ganga during lean period, to persist for long causing adverse impact.

3.9 Irrigation Intensity

The Second Irrigation Commission (GOI, 1972) has recommended the irrigation policy according to which the goal for irrigation planning in the Indian Gangetic Plain (in which whole of Bihar is situated) with high density of population, good fertile soil, and abundant surface and ground water but scarcity of land, should be to secure the maximum production per unit of land i.e., there should be no constraints of water. This is quite different from and in contrast to the policy for achieving maximum production for unit of water and maximum area served recommended for other areas.

The National Commission for Integrated Water Resources Development (1999) has also recommended that in the basins with possible surpluses, near saturation utilisation of land and water has first to be aimed at. This has been considered desirable as it will not be possible to peruse a State to spare water until its own demands are met to the maximum possible extent.

The Committee for Agriculture Productivity in Eastern India (RBI 1984) has highlighted the potential for development of agriculture in Eastern India including Bihar. It has observed " the fact that Eastern India has not been able to exploit fully its agricultural potential suggests that existing policies and programmes implementation for agricultural development are not adequate for efficient utilisation of the regions agricultural resource base. The committee has observed that Eastern India has the necessary potential to sustain long-run agricultural growth rate at much higher level than at present. It has rich soil, abundant manpower and receives plenty of rainfall. It has large untapped ground water resources, a patent factor in shaping of India's future agricultural growth pattern.

NCIWRD (1999) has observed that food self sufficiency is essential for the country as a whole but not necessarily for the individual river basin "Nevertheless it has to be borne in mind that even in a basin not endowed with ample water resources reduction in their number may not be feasible. Their quality of life can be improved only through increased agricultural productivity for which first basic requirement is water. Hence, in all peninsular rivers, the present irrigated area has to be substantially increased". Extending the same

argument and logic to Bihar in general and North Bihar in particular having very high density of population with plenty of water and scarce land resource deserves a high cropping and irrigation intensity.

However, it has been observed that while preparing the schemes for Interlinking of Rivers of India, NWDA has not taken the above recommendation and suggestion made by NCIWRD (1999), the Second Irrigation Commission (GOI, 1972) and the Committee for Agricultural Productivity of Eastern India (RBI 1984) into consideration for determining irrigation intensity. Contrary to these recommendations NWDA has proposed an irrigation intensity mere 100% in new area which is not covered under any irrigation project and proposed to retain the irrigation intensities of existing irrigation projects if it is more than 100%. No increase in irrigation intensity of existing projects has been proposed by NWDA, if it is more than 100 %.

It may be noted that most of the existing irrigation projects are run-off-the river schemes (they suffer from lack of support from storage) and have been planned and executed long back and therefore, the irrigation intensity is very low 115% for Kosi Project, 120% for Gandak Project. Now, when dams are proposed to be constructed on major rivers like Kosi, Gandak, Sone and possibly on their tributaries, water from these proposed reservoirs will be available to support the existing irrigation schemes; the project of Interlinking of rivers considered to be ultimate plan for water resource development and near saturation in utilisation of land and water is supposed to be aimed at in basin considered to be surplus, it is not logical to restrict the irrigation intensity to existing level and propose an irrigation intensity of 100% for new area. This assumption is very vital and critical for calculation of demand for agricultural purpose. If this assumption is allowed to be retained, this will prove a great constraint for future development of agriculture in Bihar.

In view of recommendations of various Commission and Committees as discussed above and taking into consideration the requirement for food and employment for growing population and the potential for development of agriculture in light of available water and land the following irrigation intensities are proposed for different agro-climatic sub-zones in Bihar.

Agro-Climatic	Name of Basin	Kharif	Rabi	Hot Weather	Total
1	2	3	4	5	6
North Bihar					
Sub-Zone IV-4	Kosi-Bagmati Mahananda	80	95	75	250
Sub-Zone IV-5	Gandak-Mahi	75	95	80	250
South Bihar					
Sub-Zone IV-6 (a)	Sone-Karmnasa	95	95	50	240
Sub-Zone IV-6 (b)	Rest of South Bihar	95	90	45	230

To achieve the above intensities the shortage of surface water can be met by

i. Storage Reservoirs &
ii. Improved Irrigation Practices.

3.10 Conservation of Water

The conservation of water is one of the prime objectives of the Interlinking of the Rivers. It is envisaged to achieve the conservation through construction of dam and storage of monsoon water for use during non-monsoon period. A part of this stored water is proposed to the basin which are considered as Deficit basins. The perusal of the pre-feasibility and water balance study reports prepared by NWDA suggests that there is enough scope for modification and improvement of NWDA proposals on this count. Some of them are as follows:

i. Water from en-route rivers

It has been observed that the water from several major rivers like Kamla, Bagmati, Burhi Gandak which are crossing Kosi-Ghaghra link canal has not been incorporated. In view of the fact that there is acute scarcity of water, and the appropriate land crossings have been provided at the proposed crossing, the water from all the en-route rivers should be accounted for.

ii. Diversion of Monsoon Surplus only:

With a view to removing regional disparities in Northern States themselves, Monsoon water must be stored on major rivers and their tributaries for meeting the need in Non monsoon in these states and only surplus monsoon flows after meeting all needs should be transferred to so called deficit States.

iii. Storage in deficit basins:

In view of prevailing monsoon climate in the country, the urgent need of storage of water in reservoirs by constructing dams can hardly be over emphasised. However, there is lack of sites suitable for construction of dam in North Bihar, whatsoever, a few & limited number of sites are available, they are located in neighbouring countries Nepal and Bhutan. The first charge on the water stored in these reservoir will be to fulfill the requirement of these basins and therefore, a limited quantity of water will be available for transfer to shortage basins. Therefore, the scope of locating dam sites in shortage basins in the background of topographical feature, even if there is no water available should be investigated and if available the construction of dams should be planned, where flood water during monsoon period may be diverted and stored. This will considerably increase the quantum of utilisable water and will help in overcoming the shortage of water.

iv. Conservation of water in deficit basins:

Out of total surface water of 1869 BCM annually available in the country at present only 690 BCM of water is considered utilisable and thus 1179 BCM of water being wasted to sea every year (934.42 BCM belongs to rivers in North India and 244.56 BCM belongs to rivers in Southern India). The scope of storage of the water, which is presently being wasted in shortage basins of Southern India, is worth consideration by constructing more reservoirs and/ or suitably increasing the storage capacity of existing reservoirs by adopting appropriate measures.

v. Improved practices to achieve Conservation of Water

By adopting efficient and modern irrigation field applications techniques, popularising less water consuming plant breed, improving irrigation efficiency of canal system, educating farmers encouraging OFD (On- Farm Development) and PIM (Participatory Irrigation Management)

CHAPTER-IV

SURFACE WATER BALANCE STUDY (TOR-I)

CHAPTER-IV

SURFACE WATER BALANCE STUDY (TOR-1)

4.0 Assessment of Water Requirement

The assessment of water for future demand is an initial step in planning for water resources development projects. It assumes much more significance for the interlinking of rivers for both types of basins - surplus and deficit. In case of surplus basins the future demand when compared with the availability will indicate the quantity of surplus water, which may be considered for transfer to the deficit basins. For deficit basins, it will give an idea of additional quantity of water, which is required to be transferred. According to the recommendations of the Second Irrigation Commission (GOI, 1972), the policy for the basins in Bihar considered to be surplus should be maximum production per unit area; in other words there should be no constraint on water, while the policy for deficit basin should be either maximum production per unit of water or maximum area served depending on level of water availability. However, there will be difference in approaches to be adopted for assessing future demand for surplus and deficits basins. For surplus basins, the approach may be a little liberal, while the same for deficit basins may be slightly conservative. This is considered essential to ensure justice in both types of basins. This has also been recommended by NCIWR (1999). The demand has to be assessed for all sectors - agriculture and non-agricultural sector which includes drinking water supply (rural & urban), industrial, ecological and environmental, hydro-power, navigation, recreational etc. It is proposed to assess the demand of water for the year 2050, when the population of the country is expected to stabilise at 1600 million and by that time the water for all sectors will also get stabilised.

4.1 Demand for Agriculture Sector

The demand of irrigation for agriculture sector as per National Commission on IWD is vital as it is the biggest of the demand for all the sectors. At present agriculture consumes about 83% of water resources. Because of the pressure of increasing demands for other sectors like drinking and industrial water supply, ecology and environment, the percentage of consumption for agriculture sector is expected to decrease to 68% though in absolute term the consumption is expected to increase considerably. Therefore, it deserves very careful consideration.

4.1.1 Potential for Development

The assessment of demand of water for agriculture sector will depend on the perspective crops, cropping pattern and intensity of irrigation and these, in turn, will depend primarily on climatic factors and land and soil characteristics, availability of water besides so many socio-economic and agro-economic factors. Though the present level of agriculture will be able to reflect these characteristics to some extent but it can not be taken as final as the system is performing under several big & small, minor & major constraints. Therefore, the potential of natural resources like land and water along with the climatic factors has to be taken into consideration. Besides the requirement of food and need for generation of employment opportunity keeping in view the growth of population. It is, therefore, considered prudent to refer to the comments and recommendations of a few Commissions and

Committees constituted at national / regional / state level to look into the problems related to agriculture, irrigation, flood etc.

i. The Second Irrigation Commission (GOI, 1972)

While discussing the policies regarding the use of water resources for irrigation, the 2nd Irrigation Commission has suggested the following policy, which is very relevant for deciding future cropping pattern and irrigation intensity. These are reproduced below :

"Broadly, the goals of irrigation policy may be classified under three heads viz.,

- maximum production per unit of area
- maximum production per unit of water, and
- maximum area served."

"The Brahmputra Basin in Assam has high rainfall and plenty of surface and ground water but very little land. Kerala has a high population density and tiny holdings but good rainfall. The Indo-Gangetic Plain has a high density of population, good fertile soil and abundant surface and groundwater. In all these areas, water resources are adequate but land is scarce and the aim should be to secure the maximum production per unit of area through multiple cropping, high yielding varieties and the latest technology."

"In most other parts of the country, water resources are insufficient to meet the irrigation requirements of the cultivated land. About 70 per cent of the cultivated area of India lies in regions of medium and low rainfall. Even in areas of high rainfall, abundance of water is limited to the short rainy season. Unless rainwater is stored for use later, there would invariably be a scarcity during the dry season. In fact, the only areas with abundant water resources are those parts of the alluvial tracts, which have plenty of ground water. In areas other than those with ample water resources, which we have attempted to define in the preceding paragraph, our policy should aim at securing the maximum crop production per unit of water."

"Low rainfall zones will mostly have rain-fed cultivation, and any increase in production will have to come through moisture conservation, the use of drought-resistant varieties, cultivation of pastures etc. But where water can be made available, either from local sources or by transfer from a neighbouring basin, the policy should be to benefit as large a section of the community as possible and at the same time enable farmers to obtain reasonable yields. Surface irrigation systems should be designed to irrigate compact blocks, the blocks being dispersed over a large area to benefit large number of farmers. The number of irrigations can be fewer than are required for high yields. Costly measures to cut down or to reduce losses, such as the lining of channels and use of water saving devices like sprinklers and tricklers, would deserve serious considerations."

In view of the above recommendation, the policy of maximum production per unit of area is proposed to be adopted for Bihar.

ii. The National Commission on Agriculture (GOI, 1976)

The above policy for irrigation as recommended by the Second Irrigation Commission (GOI, 1972) has been fully endorsed by the National Commission on Agriculture also.

iii. The Report of the Committee on Agricultural Productivity in Eastern India (RBI 1984)

The Committee has studied the problems of agriculture prevailing in Eastern India comprising West Bengal, Orissa, Bihar & Eastern UP and had made important observations and valuable recommendations which shows the potential for development of agriculture in this region. The following extracts show the potential for development of agriculture in Bihar -

"Eastern India has the necessary potential to sustain long-run agricultural growth rate at much higher level than at present. It has rich soil, abundant manpower and receives plenty of rainfall. It has large untapped ground water resources, a potent factor in shaping of India's future agricultural growth pattern".

"The fact, that Eastern India has not been able to exploit fully its agricultural potential, suggests that existing policies and programme implementation for agricultural development are not adequate for efficient utilisation of the regional agricultural resource base".

The following extracts from the Report of the above Committee are very relevant for judging the potential for agricultural development in Bihar.

"However, even after nearly two and half decades of this significant shift in production strategy, the process of intensification of agriculture through science-based and industry-linked farming has not spread uniformly in all parts of the country. Eastern India comprising West Bengal, Orissa, Bihar and East UP is a case in point."

"Eastern India presents a picture of the highest concentration of population and the lowest per capita food-grains production. Labour alone, obviously, is not enough for developing intensive agriculture. It is only when labour along with the complementary inputs of capital and skills (irrigation, drainage, yield augmenting inputs, efficient implementation, research, extension, etc.) are used intensively to make up for the scarcity of land that conditions are created for sustained increase in productivity."

"The application of fertilizers and use of HYV seeds in the Eastern Region (West Bengal, Orissa, Bihar and East UP) are still at a low level. Rate of fertilizer application in 1981-82 averaged around 25 kg/ha. Coverage of area under cereals with HYV seeds has also been low, less than 40 per cent. Raising the level of application of these two inputs alone can considerably improve land productivity of the region."

"Several other factors, however, are seriously limiting the use and level of application of these inputs. The most important factor is the lack of adequate and controlled water supply. Less than 40 per cent of the net sown area in the region is at present receiving irrigation, and that too, mostly of protective nature. As against this, most of the States in the Northern Region (Punjab, Haryana and West UP) are receiving adequate and controlled irrigation. Nearly 80 per cent of the net sown area in Punjab is now irrigated. Greater control on the supply of water through irrigation has helped Punjab to raise agricultural productivity. The intensity of irrigation in Punjab is nearly 170 per cent as against a little over 120 per cent in the Eastern Region.

"In Eastern India, water for crop production is available in relatively uncontrolled manners. It is too much and too uneven during monsoon and too little in the dry season. Heavy and highly uncertain rainfall in most parts of the region causes frequent flooding and water-logging and makes crop cultivation during the Kharif season extremely hazardous. Lack of adequate drainage facilities and flood control arrangements restrain the farmers from applying the recommended doses of fertilizers. Even when the recommended doses are used, they yield poor results as flooding or water-logging limit the full realization of the fertilizer response potential of the high yielding varieties of seeds."

"Irrigation, coupled with modern inputs and technology, results in transforming agriculture of a region in a spectacular manner when farmers have adequate control over its use and application. This has been the experience of Japan, Taiwan, South Korea and some parts of India.

"Tube-wells in Haryana and Punjab are operationally more efficient as bulk of them are under the control of farmers and are also energised with electricity. The energisation of tube-wells in turn, has been facilitated by the availability of electric power in all villages. In fact, the tube-well boom in Haryana and Punjab is due to rapid spread of rural electrification. The situation is different in the Eastern Region. Rural electrification has not made much progress and, as a result, development of tube-wells has been slow. Private tube-wells are few in number and even these are under utilised due to uncertain and erratic power supply."

"Scope for raising labour productivity is also eroding due to excessive dependence of workers on employment in agriculture. The wet rice eco-system of the region induces this process. A number of available studies suggest that the wet rice eco-system of monsoon regions has an extraordinary elasticity of response to additional inputs of labour and skill. Sowing, transplanting, weeding, bunding and a multitude of other activities involved in cultivating rice during the southwest monsoon period of heavy and erratic rainfall generate heavy demand for labour during critical periods of farm operations."

"The evolution of the Eastern Region to the present small and marginal farmer dominated agrarian economy is a consequence of this agricultural involution, an extreme form of which is seen in East UP and Bihar where 70-80 per cent of farm operators are marginal farmers holding one ha. or less."

"The problem is further complicated by the institutional barriers which the region had inherited from the British period. Even with significant land reform programmes carried out through various legislative measures, concealed tenancy exists and semi-feudal agrarian system still operates over large areas."

"Even with these constraints, public investment in infrastructure and supporting services could play a key role in accelerating the growth of agriculture. But the pattern of public expenditure reveals that investment on agriculture and irrigation per agricultural worker has been very low in this region. During 1969-85, expenditure on agriculture, irrigation and rural electrification per agricultural worker was the lowest in Bihar (Rs.1645) followed by West Bengal (Rs.1730), UP (Rs1870) and Orissa (Rs.2000). In contrast, in Gujarat, it was around Rs. 3980, in Kerala and Punjab, it was over Rs. 4000 and in Haryana over Rs. 5000."

"Notwithstanding some progress made in certain sectors benefiting from the various development programmes undertaken by the State Governments, the region continues to be one of the low agricultural efficiency regions of India. it is characterised by a slow growth rate in crop productivity and farm incomes. Due to limited employment opportunities in the industrial sector, bulk of the labour force looks for jobs in agriculture and remain under employed. The region has the highest incidence of poverty in the country."

"Historical record, however, provides a sharply contrasting picture of Eastern India. One and a half centuries ago, it was a very prosperous and agriculturally advanced region in the country. Its improvisation began during the British rule, but even at the time of Independence, its agriculture maintained a lead over other regions in the country. During the triennium ending 1950-51, the Eastern Region had recorded highest food grains yield. However, since then and specially after the introduction of the new HYV seed and fertilizer technology in the country, the region, with the exception of West Bengal, has steadily lost its relative position. The Northern Region crossed the food grains yield level of the Eastern Region by early 1960s and the Southern Region in 1970s. It appears ironical that programmes and policies during the planning era, which have induced an acceleration in the pace of agricultural development in other regions, could not make sufficient impact in the Eastern Region which was agriculturally so prosperous in earlier time."

iv. The Second Bihar State Irrigation Commission (1994)

The Commission has studied in detail the land and water resources of the state and has also examined basin-wise existing cropping intensity as well as the future cropping intensity in light of available water and land resources and prevailing constraints.

The Commission has analysed the existing cropping intensities in different river basins of the State. The result is available in Table 4.1. The data available in this table show that the existing cropping pattern varies between 100% to 165%. It is high in North Bihar viz. 134% to 165%. In South Bihar the percentage is high in Sone Basin only (140%) while in the rest of basin the percentage is low and varies between 100 % to 124 %. As regards the percentages of rainfed and irrigated area, there is wide variation in different river basins. The percentage of rainfed cultivation is very high in North Bihar. It varies between 79% to 123%. But it is low in South Bihar and varies between 29% to 73%. The percentage of irrigated cultivation varies between 40% to 68% in North Bihar. In South Bihar, it is very high in Sone(100%) followed by Karmnasa (95%), Punpun (85%), Harohar (74%) and in other basins it varies between 39% to 59%.

Table-4.1

BASINWISE PRESENT PERCENTAGE OF NET CULTIVATED AREA (1991-1992)

Sl No	Name of Basin	Intensity of cultivation		
		Irrigated	Rain-fed	Total
1A	Ghaghra-Mahi-Western Gandak Composite	68.39	82.95	151.34
1B	Upper Eastern Gandak-Upper Burhi Gandak	55.29	78.70	133.99
1C	Lower Eastern Gandak Baya-lower Burhi Gandak	57.72	95.53	153.25
2	Bagmati- Adhwara	47.25	99.91	147.16
3	Kamala- Balan	41.79	123.37	165.16
4	Kosi	63.50	93.18	156.68
5	Mahananda	39.55	107.79	147.34
6	Karmnasa	95.18	29.21	124.39
7	Sone- Kanhar & Kao-Gangi Composite	100.01	32.26	140.27
8	Punpun	84.96	36.37	121.33
9	Harohar	74.28	37.84	112.12
9A	Kiu.l	39.50	62.23	101.73
10	Badua- Belharna	59.30	58.84	118.14
11	Bilasi- Chandan- Chir	54.10	56.22	110.32
12	Ganga stem	50.07	49.09	99.16

The Commission has assessed the prospective cropping intensity for different basin to meet the food requrement by the year 2025 in light of available water and land potential. The details as worked out by the Commission are available in Table-4.2.

Table-4.2

BASIN-WISE PROSPECTIVE CROPPING INTENSITY

Sl No.	Name of the basin	PERCENTAGE OF CULTIVABLE AREA TO BE CROPPED IN		CROPPING INTENSITY (%)
		Rainfed situation	Irrigated situation	
1	Ghaghra-Mechi-Western Gandak Composite	46	151	197
2	Upper Eastern Gandak Upper Burhi Gandak Composite	49	142	191
3	Lower Eastern Gandak-Baya-Lower Burhi Gandak Composite	65	139	204
4	Bagmati-Adhwara	59	136	195
5	Kamla-Balan	59	143	202
6	Kosi	43	162	205
7	Mahananda	43	151	194
TOTAL NORTH BIHAR		50.9	147.7	198.6
8	Ganga Stem	65.0	95.0	160
9	Karmnasa	26	162	188
10	Sone & Kao-Gangi U/S (including Kanhar) D/S	56 27	94 163	150 190
11	Punpun	48	135	183
12	Harohar	62	118	180
13	Kiul	48	128	176
14	Badua-Belharna	39	144	183
15	Bilasi-Chandan-Chir	39	144	183
TOTAL CENTRAL BIHAR		45.2	136.8	182

From the perusal of Table 4.2 it will transpire that the Commission has suggested a cropping intensity of 204% (139% for irrigated & 65% for rainfed) for Gandak Project, 205% (162 % for irrigated & 43% for rainfed) for Kosi Project, and 190% (163% for irrigated and 27% for rain fed) for Sone Project Command area. This is to be noted that these recommendations are under the constraints that the irrigation schemes are only run-off-the river schemes as no storage sites are available within the State. Thus with only run-off-the river schemes an average cropping intensity of 199% for North Bihar and 182% for South Bihar have been recommended. With proposal of creation of reservoirs by construction of dams on major rivers like Kosi, Gandak and Sone. there is considerable scope of increasing the cropping and irrigation intensities over what has been proposed by the Second Bihar State Irrigation Commission with only run-of-the river schemes. An other important point is that the SBSIC has considered planning upto 2025 of where as in this case the planning period has been extended to 2050 as adopted by NCIWR (1999).

v. The National Commission for Integrated Water Resources Development (1999)

The Commission has recommended that the basins with possible surplus, near saturation utilization of land and water has first to be aimed at subject to the condition that such utilization is not based on impractical engineering, for example, storage requirements for which reservoir sites are not available or involve very high lifts or wasteful use, for example, very low efficiency and excessive water application.

vi. Project Report on the Restoration of Eastern Gandak Canal System (2003)

The Detailed Project Report (DPR) for the Restoration of Eastern Gandak Canal System (REGCS), a Project sponsored by the Planning Commission, Government of India, has been prepared by Water and Power Consultancy Services (I) Ltd. (WAPCOS), a Government of India undertaking. In this report WAPCOS has recommended an irrigation intensity of 228%. This has been possible, as exploitation of ground water has been undertaken on large scale through implementation of Million Shallow Tubewells in the area under a scheme undertaken by the Planning Commission and which is still under implementation. According to the Report prepared by WAPCOS an irrigation intensity of 228% is feasible with conjunctive use of surface and ground water. WAPCOS has proposed an irrigation intensity of 90% with ground water and 138% with surface water - both to be used conjunctively. The irrigation intensity adopted by WAPCOS for Eastern Gandak Canal System is available in Table - 4.3

Table 4.3
Proposed Irrigation Intensities for Eastern Gandak Canal System

Sl. No	Crop	Irrigation Intensity (%)		
		Surface water exclusively	Conjunctive use	Total
1	Kharif (L)		-	
	Paddy (M)	16	-	16
	Paddy (S)	20	-	20
	Paddy (E)	18	-	18
	Paddy	17	-	17
	Maize	15	-	15
	Sub Total	86	-	86
2	Rabi			
	Wheat	18	32	50
	Oilseeds	6	4	10
	Pulses	6	4	10
	Potato	4	-	4
	Vegetables	2	-	2
	Sub Total	36	40	76
3	Hot Weather			
	Greengram	1	9	10
	Vegetable	2	6	8
	Maize	8	35	43
	Sub Total	11	50	61
4	Perennial			
	Sugar-cane	5	-	5
	Total	138	90	228

It is very pertinent to note that the above irrigation intensity as adopted by WAPCOS is also based on run-of-the river scheme and is not supported by any reservoir. With the proposal of creation of reservoirs by constructing dam on river Gandak, there is scope of increasing the irrigation intensity further.

4.1.2 Agro-Climatic Zone & Sub-Zone

According to the study conducted by the Planning Commission for Agro-climatic Regional Planning (1989), the State of Bihar, lies in Agro-climatic Zone-IV ie - Middle Gangetic Plane. Zone-IV. This zone has been further sub-divided into six sub-zones, each having adequate agro-climatic homogenity for detailed operational planning, according to which whole of Bihar falls under sub-zone-4, Sub-zone-5 and sub-zone-6 as shown in Fig 2.3. However, taking into consideration the level of development in the field of irrigation and availability of water for the purpose of assessing demand for water in the present study, the sub-zone-6 has been further sub-divided into two parts viz sub-zone 6 (a) comprising the basins of Karmnasa, Sone & Punpun and Sub-Zone 6(b), comprising all other basins of South Bihar, east of Punpun. Thus in the background of the division of Agro-Climatic Zones & Sub-Zones, this has been slightly modified for the purpose of crop / irrigation planning as follows :

i.	Sub-Zone-4	Comprising the basins of Ghaghra, Mahi, Gandak, Baya & Burhi Gandak - located in the Western part of North Bihar
ii.	Sub-Zone-5	Comprising the basins of Bagmati, Kamala, Kosi & Mahananda - located in the eastern part of North Bihar.
iii.	Sub-Zone-6 (a)	Comprising the basins of Karmnasa, Kao-Gangi, Sone and Punpun - located in the western part of South Bihar
iv.	Sub-Zone- 6 (b)	Comprising the basins of Harohar, Kiul, Badua-Belharna, Bilasi-Chir-Chandan - located in the eastern part of South Bihar

4.1.3 Proposed Cropping & Irrigation Intensity for Future:

a) The discussions in previous section clearly show that there is enormous potential for development of agriculture in Bihar, which is located in the middle reach of Gangetic plain and which is endowed with plenty of plain and fertile land and vast water resources both. The following points as discussed above are therefore, very relevant and should be kept in view while deciding the cropping / irrigation intensities in Bihar.

i. Maximum production per unit area of land (i.e. no constraints on utilisation of water) as recommended by the Second Irrigation Commission (GOI, 1972) and endorsed by the National Commission on Agriculture (GOI, 1976) ;

ii. Inherent potential for development of agriculture in Eastern India as reflected by its glorious past as revealed in the report of the Committee on Agricultural Productivity constituted by the Reserve Bank of India (1984) ;

iii. The stress on development of agriculture in the middle Gangetic Plain Zone as proposed by the report on Agro-Climatic Regional Planning by the Planning Commission (GOI, 1989) ;

iv. The cropping irrigation intensities as suggested by the Second Bihar State Irrigation Commission (1994) ;

v. The proposed cropping / irrigation intensity as suggested by WAPCOS in the DPR for Restoration of Eastern Gandak Canal Scheme (2003); and

vi. The approach suggested by the NCIWRD (1999) according to which in the basins with possible surplus, near saturation utilisation of land and water has first to be aimed at and own demands are to be met to the maximum possible extent.

In light of above recommendations it was considered prudent to propose a moderately higher cropping intensity / irrigation intensity.

b) Cropping / Irrigation Intensity for different Agro-climatic Sub-zones

Taking into consideration available surface water, the soil and land characteristic and other socio- agro- economic factors different cropping / irrigation intensities have been proposed for different agroclimatic sub-Zones.

In view of the discussions in previous sections the following cropping & irrigation intensities are proposed to be adopted for assessment of demand for agricultural sector.

Unit:percentage

Sl No	Region		Irrigation Intensity			
			Kharif	Rabi	H.W.	Total
i)	Sub-Zone -4	North Bihar (West)	80	95	75	250
ii)	Sub-Zone -5	North Bihar (East)	75	95	80	250
iii)	Sub-Zone-6(a)	South Bihar (West)	95	95	50	240
iv)	Sub-Zone -6(b)	South Bihar (East)	95	90	45	230

It may be noted that the proposed irrigation intensity is higher (250%) for north Bihar. But irrigation intensity during Kharif in Sub-Zone-4 is higher (80%) and it is lower(75%) in sub- Zone 5. However the irrigation intensity during Hot weather in Sub- Zone-4 is lower (75%) and is higher (80%) in Sub- Zone-5. For Rabi season it is same for both the Sub-Zones in North Bihar. In South Bihar a total annual irrigation intensity of 240% for Sub-Zone 6(a) and 230% for Sub-Zone 6(b) have been proposed. The irrigation intensity during Kharif is the same 95% for both Sub-Zones 6(a)& 6(b). But in view of deficit of water a lower irrigation intensity for Rabi (90%) & hot weather (45%) has been proposed for Sub-zones-6(b) and slightly higher for Rabi (95%) and hot weather (50%) has been proposed for Sub-zone 6(a).Such intensity of irrigated agriculture is essential in view of highest rural density of population as well as likely high rise in population by 2050. This needs maximum production per unit area in planned condition of maximum utilization of surface water before transfer.

4.1.4 Ultimate Irrigation Potential

Based on above irrigation intensity the ultimate surface watere irrigation potential of Bihar has been assessed. This has been done for each agro-climatic Sub-Zone and within the agro- climatic Sub-Zone. The ultimate irrigation potential has been assessed for each basin / composite basin. These details are available in Annexure 4.1.4. The ultimate irrigation potential includes all categories e.g. existing, on-going / proposed projects and the command area presently not covered under any of the above categories .

4.1.4.1 Agro-climatic Sub-zonewise Irrigation Potential

The ultimate irrigation potential, works out to 1,57,39,201 ha. is proposed to be irrigated from surface water. The details of ultimate irrigation potential for different agro-climatic sub-zones and river basins are available in Annexure 4.1.4 and the abstract is as follows.

Table 4.4

Unit ha.

Agro-Climatic Sub-zones	Ultimate Surface Water Irrigation Potential				Percentage of Total
	Kharif	Rabi	Hot-Weather	Total	
1.Sub-Zone-4	14,58,686	17,32,190	13,67,519	45,58,395	28.97
2.Sub-Zone-5	15,65,942	19,83,520	16,70,337	5,21,980	33.16
Sub-Total	30,24,628	37,15,716	30,37,856	97,78,200	62.13
3.Sub-Zone-6 (a)	13,37,212	13,37,212	7,03,796	33,78,221	21.46
4.Sub-Zone-6 (b)	10,66,801	10,10,653	5,05,327	25,82,780	16.41
Sub-Total	24,04,013	23,47,866	12,09,123	59,61,001	37.87
Total	54,28,641	60,63,582	42,46,979	1,57,39,201	100
% of Total Ultimate Irrigation Potential From S.W.	34.49%	38.53%	26.98%	100%	
% of CCA	84%	94%	66%	244%	

The ultimate irrigation potential is 1,57,39,202 ha and the seasonal break up is as follow:

Kharif	- 54,28,641 ha
Rabi	- 60,63,582 ha
Hot Weather	- 42,46,979 ha
Total	1,57,39,202ha

Table 4.4 shows the season-wise breakup of ultimate irrigation potential as 84% for Kharif, 94% for Rabi, and only 66 % for Hot weather. As regards the percentage of CCA, the overall percentage for the entire state is 244% which is very moderate. This suggests that there is ample scope of increasing the irrigation intensity. However, in view of overall scarcity of water in the country and constraint on the scope of storage, no further increase has been considered. As regards season-wise breakup, the irrigation intensity is 84% for Kharif, 94% for Rabi & 66% for Hot Weather. It is pertinent to note that Rabi crop has been proposed to cover maximum area as its water requirement is minimum.

4.2 Demand of water

4.2.1 Demand for Agricultural Need

The final objective of these exercises is to assess the requirement for agricultural sector. This will depend on crops, cropping/ irrigation intensity, crop water requirement, which again depend on agro-climatic factors and efficiency of irrigation system. For the purpose of assessing the requirement of the agriculture sector, the crop water requirement & efficiency and other relevant data have been adopted as given in the report of Second Bihar state Irrigation Commission (1994). The details and Basin-wise requirement of surface water for three crop seasons are available in Annexure 4.2.1 according to which the total surface water requirement works out to 1,04,706 MCM. The Season-Wise breakup is as follows:

Kharif-	34,381 MCM (32.83%)
Rabi-	28,381 MCM (27.11%)
Hot Weather-	41,944 MCM (40.06%)
Total-	**1,04,706 MCM**

4.2.2 Demand For Non-Agricultural Need

Non-Irrigation water needs have also been assessed. It may here be mentioned that non irrigation requirements have not been assessed by NWDA while working out water needs of the command area. The Non-Irrigational need for the entire command have been assessed and placed in Annexure 4.2.2 based upon the following norms.

a) Domestic use-urban 200 litre/day/capita
   -rural 70 litre/day/capita
b) Live stock use 50 litre/day/head
c) Industrial use Same as total domestic water requirement
d) For Power, Navigation, Ecology & Evaporation losses etc.- As per norms adopted by National Commission for Integrated water Resources Development Report(1999).

The total non-agricultural need works out to 40,342 MCM as detailed below vide Table 4.6

a)	Domestic use	-	8417.24 MCM
b)	Industrial use-	-	9851.74 MCM
c)	Power needs-	-	5516.00 MCM
d)	Navigational Needs	}	
e)	Ecology Needs	}–	14010.16 MCM
f)	Morphological Needs	}	
g)	Evaporation losses	-	428.80 MCM
h)	Flushing Dose	-	2118.00 MCM
			40341.92MCM
			or Say 40,342 MCM

4.3 Water Balance

4.3.1 The water balance has been estimated by considering the water availability in different river basin from catchments inside the State as well as the catchments outside the state after deducting upstream uses outside the catchments as worked out by NWDA and

ultimate requirement of water for Bihar by 2050 AD. The water availability at 75 % dependability has been discussed in detail at Chapter-II at para 2.6.2 which works out to 1,32,175 MCM (vide details of Annexure 4.3.1). This available water takes into account) 1627 MCM of water to be made available in Mahananda Basin through MSTG Link Scheme of NWDA. To this, 5566 MCM of water to be transferred to Sone Basin through Chunar-Sone Barrage Link Scheme of NWDA has been added as surface water import bringing overall water availability of water to 1,32,175+5,566 i.e. 1,37,741 MCM.

4.3.2 Total water requirement of Bihar consisting of agricultural need and non-agriculture need, (i.e. Domestic, Industrial, Hydro-Power need etc.) as worked out at Annexure 4.2.1 and Para 4.2 respectively comes to about 145048 MCM (i.e. 140706 + 40342 MCM) . It may be stated that agricultural need is based on CCA as assessed by SBSIC and at projected irrigation intensity found suitable for the State, considering growth of population for the year 2050 AD.

4.3.3 The water balance has been worked out by deducting the total water requirement from the overall availability at 75% dependability regardless of its being utilisable, detail of which are presented below:

Table 4.5
Surface Water Balance

unit in MCM

1.	Availability				
	a. Gross Annual yield at 75% dependability				1,32,175
	b. Surface water Import				
	From Chunar-sone Link project				5,566
	c. Surface water Export				Nil
	d. Overall availability at 75% dependability				1,37,741
2.	Surface Water Requirement for				
	i.	Irrigation-	Kharif -	34381	
			Rabi -	28381	
			HW -	41944	
			-	104706	
	ii.	Domestic use	-	8417	
	iii.	Industrial Use	-	9852	
	iv.	Hydro-Power	-	5516	
	v.	Navigational Needs	}		
	vi.	Ecology Needs	}-	14011	
	vii.	Morphological Needs	}		
	viii.	Evaporation Losses	-	429	
	ix.	Flushing Dose	-	2118	
				40342	
		Sub-Total		1,45,048	1,45,048
3.	Regeneration				Nil
4.	Surface water Balance				(-) 7307

NB: Regeneration has been taken as nil as water availability has been taken at the outfall points.

4.4 CONCLUSION

1. Assumptions made by N.W.D.A. for arriving at water balance are not acceptable as actual culturable area, intensity of irrigated agriculture as well as need of projected population have not been assessed properly.

2. The surface water Balance study done by the Committee with water need assessed as per actual CCA and projected intensity of irrigation shows a net deficit of 7307 MCM (vide Table 4.5).

3. Season wise water balance has also been worked out Annexure 4.4 which will reveal that water need assessed by NWDA for various Link Canals schemes affecting Bihar is much less than that assessed by the committee. This is because of following two reasons.

a. CCA adopted by NWDA is much less than that assessed by SBSIC for these Basins

b. The crop intensity limited to existing or 100% whichever is more adopted by NWDA is too inadequate in comparison to 230% -250% projected by the committee to assess the 2050 AD needs.

4. The season wise surface water balance at Annexure 4.4 also shows that while there is surplus of 63,571 MCM of water during monsoon period (Kharif Season) there is a deficit of 70,880 MCM during non-monsoon period (Rabi and HW season). This indicates that there is urgent need to store the monsoon water in reservoir to prevent it from going to waste and utilise it in non-monsoon. If possible the reservoir should be over the year storage capacity.

5. This study also reveals that water is short in both monsoon and non-monsoon period for the South Bihar basins whereas there is surplus component in monsoon period and a deficit in non-monsoon period in North Bihar basins.

6. Overall surplus or deficit of water in the state does not at all reflect the correct and real picture. Surplus in monsoon only highlights the fact that 63,571 MCM of water though available is not utilisable on account of total absence of facility of storage and transfer for later use in other season or even in other region. Overall deficit in the present study has increased because high rural population density, trend of rise in population and surplus labour force necessitates optimum use of land and also highest possible irrigated agriculture.

7. Even if ground water, which has not been considered in the study, is utilised, the deficit shall still remain.

8. Some urgent steps may be necessary to even partially store the monsoon surplus water to reduce the deficit, since planning of optimum irrigation intensity cannot be reduced.

These steps may be:-

a. Transferring surplus monsoon water to other parts, on condition of getting the same in non- monsoon period in south Bihar.

b. Constructing maximum number of reservoirs to store the same in Nepal, South Bihar and Jharkhand with maximum capacity

c. Storing partially monsoon surplus as ground water to the extent possible.

d. Keeping South Bihar reservoirs existing / under construction / proposed as full for Rabi and Hot weather irrigation by pumping monsoon surplus of upper catchments and North Bihar through Ganga

e. Adapting improved agricultural practices and knowledge of modern science for saving water's need for crops & preventing wastages.

Annexure 4.1.4

Irrigation Potential (unit in Ha.)

Sl. No.	Composite Basin	CCA	Kharif	Rabi	HW	Total
1	2	3	4	5	6	7
I	Agroclimatic Sub-zone 4					
1A	Ghaghra-Mahi Western Gandak Composite	519154	415323	493196	389366	1297885
1B	Upper Eastern Gandak Upper Burhi-Gandak Composite	599034	479227	569082	449276	1497585
1C	Lower Eastern Gandak Baya Lower Burhi Gandak composite	493648	394918	468966	370236	1234120
2	Ganga Stem	211522	169218	200946	158642	528805
	Sub-Total	1823358	1458686	1732190	1367519	4558395
II	Agroclimatic Sub-zone 5					
3	Bagmati-Adhwara	482367	361775	458249	385894	1205918
4	Kamla Balan	322318	241739	306202	257854	805795
5	Kosi	838100	628575	796195	670480	2095250
6	Mahananda	445137	333853	422880	356110	1112843
	Sub-Total	2087922	1565942	1983526	1670338	5219805
	Total I+II	3911280	3024628	3715716	3037856	9778200
III	Agroclimatic Sub-zone 6 (a)					
7	Karmnasa	326709	310374	310374	163355	784102
8	Sone & Kao Gangi composite	493121	468465	468465	246561	1183490
9	Punpun	549107	521652	521652	274554	1317857
10	Ganga Stem	38655	36722	36722	19328	92772
	Sub-Total	1407592	1337212	1337212	703796	3378221
IV	Agroclimatic Sub-zone 6 (b)					
11	Harohar	590676	561142	531608	265804	1358555
12	Kiul	120957	114909	108861	54431	278201
13	Badua-Belharna	132530	125904	119277	59639	304819
14	Bilasi Chandan Chir	158513	150587	142662	71331	364580
15	Ganga Stem	120272	114258	108245	54122	276626
	Sub-Total	1122948	1066801	1010653	505327	2582780
	Total III+IV	2530540	2404013	2347866	1209123	5961001
Grand Total		6441820	5428641	6063582	4246979	15739201

Note: Intensity of Irrigation for

	Kharif	Rabi	Hw	Total
i. North Bihar West	80%	95%	75%	250%
ii. North Bihar East	75%	95%	80%	250%
iii. South Bihar West	95%	95%	50%	240%
iv. South Bihar East	95%	90%	45%	230%

Annexure 4.2.1

Season-wise water requirement for ultimate Irrigation Potential for Total Area (In MCM)

Sl.No.	Composite River Basin	CCA in Ha	Water Requirement for Irrigation (MCM)				Addi. req. of water for Non-Irrig. (taking 1/3rd in each crop season) (MCM)			Total Water needed seasonwise (MCM)			
			Kharif	Rabi	HW	Total	Kharif	Rabi	HW	Kharif	Rabi	HW	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	Agroclimatic Sub-zone 4												
1A	Ghaghra-Mahi Western Gandak Composite	519154	2700	2333	3933	8965	881	881	881	3581	3214	4814	11608
1B	Upper Eastern Gandak Upper Burhi-Gandak Composite	599034	3115	1992	4538	9644	642	3617	3617	3757	5609	8155	17521
1C	Lower Eastern Gandak Baya Lower Burhi Gandak composite	493648	2567	2068	3739	8374	881	881	881	3448	2949	4920	11017
2	Ganga Stem	56899	296	256	431	983	100	100	100	396	356	531	1283
	Sub-Total	1668735	8677	6648	12641	27967	2504	5479	5479	11181	12127	18120	41428
II	Agroclimatic Sub-zone 5												
3	Bagmati-Adhwara	482367	1809	2016	3898	7723	734	734	734	2543	2750	4631	9924
4	Kamla Balan	322318	1209	1347	2604	5160	514	514	514	1722	1861	3118	6701
5	Kosi	838100	4086	4379	6772	15237	832	4866	4866	4918	9245	11638	25802
6	Mahananda	445137	2170	2495	3597	8262	488	488	488	2658	2983	4085	9726
7	Ganga Stem	154623	804	695	1171	2670	272	272	272	1076	967	1443	3486
	Sub-Total	2242545	10077	10932	18042	39052	2840	6874	6874	12917	17807	24916	55640
	Total I+II	3911280	18755	17581	30682	67018	5344	12353	12353	24099	29934	43035	97068
III	Agroclimatic Sub-zone 6 (A)												
8	Karmnasa	326709	2017	1428	1666	5111	231	231	231	2249	1659	1898	5806
9	Sone & Kao Gangi composite	493121	3045	2155	2515	7715	616	1116	1116	3661	3271	3631	10563
10	Punpun	549107	3391	2400	2800	8591	557	557	557	3947	2956	3357	10261
11	Ganga Stem	38655	239	169	197	605	68	68	68	307	237	265	809
	Sub-Total	1407592	8692	6151	7179	22022	1472	1972	1972	10164	8123	9151	27437
IV	Agroclimatic Sub-zone 6 (B)												
12	Harohar	590676	3647	2445	2148	8241	854	854	854	4501	3299	3001	10801
13	Kiul	120957	747	501	440	1687	135	135	135	882	636	575	2092
14	Badua-Belharna	132530	818	549	482	1849	135	155	155	953	704	637	2293
15	Bilasi Chandan Chir	158513	979	656	576	2211	264	284	284	1243	940	860	3044
16	Ganga Stem	120272	743	498	437	1678	212	212	212	954	709	649	2313
	Sub-Total	1122948	6934	4649	4083	15666	1599	1639	1639	8533	6288	5722	20543
	Total III+IV	2530540	15626	10800	11262	37688	3071	3611	3611	18697	14411	14872	47980
	Grand Total	6441820	34381	28381	41944	104706	8415	15964	15964	42796	44345	57908	145048

Annexure 4.2.2

Basinwise Non Irrigation Surface Water requirement for 2050

Sl. No.	Name of Basin	Domestic Use	Industrial & Commercial Use	Power	Navigation/ Ecology/ Dose for River Morphology	Flushing Dose	Evaporation Losses	Anticipated Total water Consumption
1	2	3	4	5	6	7	8	9
I	Agro-climatic sub-zone 4							
1A	Ghaghra-Mahi Western Gandak Composite	865.87	1013.43	567.42	151.99		44.11	2642.82
1B	Upper Eastern Gandak Upper Burhi-Gandak Composite	669.69	783.82	438.86	5950.00		34.12	7876.48
1C	Lower Eastern Gandak Baya Lower Burhi Gandak composite	865.61	1013.13	567.25	151.94		44.10	2642.03
2	Ganga Stem	98.35	115.11	64.45	17.26		5.01	300.19
	Sub-Total	2499.51	2925.49	1637.99	6271.2	0.00	127.33	13461.52
II	Agro-climatic sub-zone 5							
3	Bagmati-Adhwara	721.34	844.27	472.71	126.62		36.75	2201.69
4	Kamla Balan	504.81	590.84	330.81	88.61		25.72	1540.78
5	Kosi	868.09	1016.03	568.88	5950.00	2118	44.22	10565.21
6	Mahananda	479.89	561.68	314.48	84.24		24.45	1464.74
7	Ganga Stem	267.27	312.82	175.15	46.92		13.62	815.78
	Sub-Total	2841.40	3325.64	1862.03	6296.38	2118	144.75	16588.21
	Total I+II	5340.91	6251.13	3500.02	12567.59	2118	272.08	30049.72
III	Agro-climatic sub-zone 6 (West)							
8	Karmnasa	227.49	266.26	149.08	39.93		11.59	694.35
7	Sone & Kao Gangi composite	642.29	751.75	420.91	1000.00		32.72	2847.68
9	Punpun	547.07	640.30	358.51	96.03		27.87	1669.78
10	Ganga Stem	66.79	78.17	43.77	11.72		3.40	203.85
	Sub-Total	1483.64	1736.49	972.26	1147.69	0.00	75.58	5415.65
IV	Agro-climatic sub-zone 6 (East)							
11	Harohar	839.00	981.98	549.81	147.27		42.74	2560.81
12	Kiul	132.53	155.11	86.85	23.26		6.75	404.51
13	Badua-Belharna	140.62	164.58	92.15	40.00		7.16	444.51
14	Bilasi Chandan Chir	272.62	319.08	178.66	47.85		13.89	832.10
15	Ganga Stem	207.92	243.36	136.26	36.50		10.59	634.63
	Sub-Total	1592.69	1864.12	1043.72	294.88	0.00	81.14	4876.55
	Total III+IV	3076.33	3600.60	2015.98	1442.57	0.00	156.72	10292.20
Grand Total		8417.24	9851.74	5516.00	14010.16	2118	428.80	40341.92

Note: 100% of Urban and 50% of Rural domestic demand is to be met from SW. Only 50% of Rural domestic demand and 100% of live Stock demand is to be met from GW. as per NWDA report.

For Rivers Gandak & Kosi, Navigation and Morphology demand is kept @ 283 cumecs for non-monsoon season (8 months) only since adequate water is available during monsoon months and not required to be released.

Annexure 4.3.1

Surface Water Resources in river Basins of Bihar

Sl. No.	Name of Basin	Catchments Area (Sq. Km.)			75% Dependable water availabilty in MCM					
					As assessed by SBSIC			As assessed by the Committee		
		Outside state	Within State	Total	Outside state	Within State	Total	Outside state	Within State	Total
1	2	3	4	5	6	7	8	9	10	11
1	Ghaghra	124955	2995.4	127950	68015	839.7	68855	*	840	840
	Mahi		2507.8	2507.8	0	799.1	799.1		799	799
2	Gandak	36610	4187.7	40798	50810	1173.9	51984	45109**	1174	46283
	Baya		2775.7	2775.7	0	1067.2	1067.2		1067	1067
3	Burhi-Gandak	2420	9601.4	12021	813.3	3226.7	4040	813	3227	4040
4	Bagmati-Adhwara	7884	6499.9	14384	5080.9	2184.4	7265.3	5081	2184	7265
5	Kamla Balan	2744	4487.7	7231.7	1741.3	1508.1	3249.4	1741	1508	3249
6	Kosi	62615	11410.2	74025	47065	5154	52219	36461**	5154	41615
7	Mahananda	7157.7	6150.1	13308	5612.4	4267.9	9880.3	1627***	4268	5895
Total North Bihar		**244385**	**50615.9**	**295001**	**179138**	**20221**	**199359**	**90832**	**20221**	**111053**
8	Karmnasa	2665.2	5126.9	7792.1	487.1	937	1424.1	308#	937	1245
9	Sone	67163	3064.8	70228	17600	335	17935	7709##		7709
10	Kao-Gangi		4128.8	4128.8	0	884.4	884.4		884	884
11	Punpun	979	8046.7	9025.7	244.4	2009.1	2253.5	244	2009	2253
12	Kiul	421	2629.5	3050.5	98	612.3	710.3	98	612	710
13	Harohar	4272.3	9900.7	14173	994.7	2305.3	3300	995	2305	3300
14	Badua-Belharna		2215	2215	0	736.8	736.8	0	737	737
15	BilasiChandan Chir	1483.3	2609.7	4093	540.4	950.7	1491.1	540	951	1491
Total South Bihar		**76984**	**37722.1**	**114706**	**19965**	**8770.6**	**28735**	**9894**	**8435**	**18329**
16	Ganga Stem		5473.3	5473.3	85000	2793	87793	*	2793	2793
Grand Total		**321369**	**93811.3**	**415180**	**284102**	**31785**	**315887**	**100726**	**31449**	**132175**

Source: The Second Bihar Irrigation Commission (1994)

Note:-

* Flows of river Ghaghra and Ganga from catchment area out side are considered not to be available for use in Bihar.

* * Flows of river Gandak and Kosi from catchment area out side state is taken as indicated below:

A. Gandak river basin:

Available flows at proposed Gandak regulatory dam after utilization in Nepal, according to Water Balance study of NWDA 50576 MCM.
Utilisation in U.P. & Nepal wide SBSIRC 1994 (page 18 Vol.III)

i.	Western Main Canal U.P.(4383 MCM)+ Nepal (325 MCM)=	4708 MCM
ii.	Eastern Main Canal Nepal (759 MCM)=	759 MCM
	Total utilization in U.P.& Nepal below barrage	5467MCM
	Thus net available flow for Bihar at Barrage	45109 MCM

B. Kosi river basin:

According to NWDA simulation study of Kosi High Dam

water to below dam =	40377 MCM
Use in Chatra Canal system (58,000 ha CCA) =	3916 MCM
Net availability below dam =	36461 MCM

*** In case of river Mahananda, a flow of 1627 MCM of water is proposed to be made available from MSTG Link. Hence only this very flow is considered to be available as flow from catchment area out side state.

In Karmnasa Basin, apart from Musakhar agreement, 308 MCM (0.25 MAF) from Ganga at Zamania as per Bansagar agreement is available for use and is considered from outside state.

In case of river Sone, no water from catchment below Indrapuri Barrage is considered to be available for the Sone canal Command. In this river basin the water available will be limited to 7709 MCM (6.25 MAF) as details given below:

i. Total share of Bihar including Jharkhand = 9559 MCM (7.75 MAF)

ii. Use in Jharkhand = 1850 MCM (1.50 MAF)

Balance for Bihar =7709 MCM (6.25 MCM)

Break up being 592 MCM (0.48 MAF) in U/S of Barrage and 7117 MCM (5.77 MAF) from Barrage.

Annexure 4.4

SURFACE WATER BALANCE

Sl. No	Name of project	Assessed by NWDA			Assessed by the Committee								
		CCA (ha.)	Water need (MCM)	Name of Basin	CCA (ha.)	Water need (MCM)			Water available from existing & proposed schemes (MCM)			Shortage (-ve) / Surplus (MCM)	
						Monsoon	Non Monsoon	Total	Monsoon	Non Monsoon	Total	Monsoon	Non-Monsoon
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Manas-Sankosh-Tista-Ganga Link	2,64,000	1,627	Mahananda	**2,64,137**	**1,577**	**4,194**	**5,771**	**2,822**	**1,338**	**4,160*** **	**1,245**	**-2,856**
2	(a) Kosi-Mechi Link	8,74,500	21,025*	Kamla-Balan	1,06,686	570	1,648	2,218	967	108	1,075	397	-1,540
				Kosi	8,38,100	4,918	20,884	25,802	29,353	12,262	41,615	24,435	-8,622
				Mahananda	1,81,000	1,081	2,874	3,955	1,562	173	1,735	481	-2,701
				Sub-Total	**11,25,786**	**6,569**	**25,406**	**31,975**	**31,882**	**12,543**	**44,425**	**25,313**	**-11,863**
	(b) Kosi-Ghaghra Link	8,17,281	6,250**	Bagmati	4,82,367	2,543	7,382	9,925	6,538	727	7,265	3,995	-6,655
				Kamla-Balan	2,15,632	1,152	3,331	4,483	1,957	217	2,174	805	-3,114
				Ganga Stem	1,54,623	1,076	2,410	3,486	1,049	117	1,166	-27	-2293
				Sub-Total	**8,52,622**	**4,771**	**13,123**	**17,894**	**9,544**	**1,061**	**10,605**	**4,773**	**-12,062**
				Total (2a+2b)	**19,78,408**	**11,340**	**38,529**	**49,869**	**41,426**	**13,604**	**55,030**	**30,086**	**-24,925**
3	Gandak-Ganga Link	13,63,790	15,272**	Ghaghra-Mahi-Western Gandak	5,19,154	3,581	8,027	11,608	14,891	1,655	16,546	11,310	-6,372
				Upper Eastern Gandak-Upper Burhi Gandak	5,99,034	3,757	13,764	17,521	17,474	1,942	19,416	13,717	-11,822
				Lower-Eastern Gandak- Baya-Lower Burhi-Gandak	4,93,648	3,448	7,568	11,016	15,360	1,707	17,067	11,912	-5,861
				Ganga-stem	56,899	396	887	1,283	386	43	429	-10	-844
				Total	**16,68,735**	**11,182**	**30,246**	**41428**	**48,111**	**5,347**	**53,458**	**36,929**	**-24899**
		33,19,571	44,174	Total North Bihar	**39,11,280**	**24,099**	**72,969**	**97,068**	**92,359**	**20,289**	**1,12,648**	**68,260**	**-52,680**

1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	Chunar-Sone Barrage Link	5,26,033	5,566	Karmnasa	3,26,709	2,249	3,557	5,806	657	588	1,245	-1,592	-2,969
				Sone-Kao-Gangi	4,93,121	3,661	6,902	10,563	5,040	8,527	13,567◆	1,379	1,625
				Punpun 40%	2,19,643	1,579	2,525	4,104	0	592	592	-1,579	-1,933
				Ganga stem	38,655	307	502	809	262	29	291	-45	-473
				Total	**10,78,128**	**7,796**	**13,486**	**21,282**	**5,959**	**9,736**	**15,695**	**-1,837**	**-3,750**
5	Sone Dam (a) Harohar Zone	2,98,846	2,512	Punpun 60%	3,29,464	2,368	3,788	6,156	2,073	180	2,253	-295	-3,608
				Harohar	5,90,676	4,501	6,300	10,801	2,914	386	3,300	-1,587	-5,914
				Kiul 40%	48,383	353	484	837	193	91	284	-160	-393
				Total	**9,68,523**	**7,222**	**10,572**	**17,794**	**5,180**	**657**	**5837**	**-2,042**	**-9,915**
	-STG Link (b) Badua-Chandan			Kiul 60%	72,574	529	726	1,255	300	126	426	-229	-600
				Badua-Belharna	1,32,530	953	1,340	2,293	427	310	737	-526	-1,030
				Bilasi-Chandan-chir	1,58,513	1,243	1,801	3,044	1,326	165	1,491	83	-1,636
				Ganga stem	1,20,272	954	1,359	2,313	816	91	907	-138	-1,268
				Total	4,83,889	3,679	5,226	8,905	2,869	692	3,561	-810	-4,534
		8,24,879	8,078	Total south Bihar	**25,30,540**	**18,697**	**29,284**	**47,981**	**14,008**	**11,085**	**25,093**	**-4,689**	**-18,199**
6	GrandTotal	40,86,669	52,252		**64,41,820**	**42,796**	**1,02,253**	**1,45,049**	**1,06,367**	**31,374**	**1,37,741◆◆**	**63,571**	**-70,879**

* Total diversion through Kosi-Mechi Link 23702 MCM, less for Nepal use (-) 1737 Tr. loss (-57) Export to Mahananda (-883) = 21,025 MCM

** Total diversion through Kosi-Ghaghra Link = 7482 MCM, less for Nepal use (-) 1232 = 6250 MCM

*** This study includes import from Bhramaputra's tributaries through MSTG Link (1627 MCM)

◆ This includes import from Ganga through C-SB Link 5,566 MCM

◆◆ Details of water availability i. vide Annexure 4.3.1 1,32,175 MCM

ii import from Ganga 5,566 MCM(Through C-SB Link)

Total 1,37,741 MCM

For water availability seasonwise & schemewise in different river basin refer table attached next page.

Water avaiability seasonwise & Schemewise in different river basin of Bihar

Sl No.	Name of Scheme	Name of Basin	Part of CCA	Total Water	Monsoon	Non Monsoon
1	2	3	4	5	6	7
1	MSTG	Mahananda	264137	4160	90% of (4160 -1627) + 1627/3 = 2822	4160-2280 = 1338
2	Kosi-Mechi	"	181000	1735	90% of 1735 = 1562	1735 - 1562 = 173
		Total	**445137**	**5895**		
3	Kosi Mechi	Kosi	**838100**	**41615**	90% of (41615-9000) =29353 (9000 kosi dam water used in non-monsoon)	41615-29353 = 12262
4	"	Kamla-Balan	106686	1075	90% of 1075 = 967	1075-967 = 108
	Kosi-Ghaghra	"	215632	2174	90% of 2174 = 1957	2174-1957 =217
		Total	**322318**	**3249**		
5	Kosi-Ghaghra	Bagmati	482367	7265	90% of 7265 = 6538	7265-6538 = 727
6	Gandak-Ganga	Ghaghra -Mahi-Western Gandak Composite	519154	16546	90% of 16546 = 14891	16546-14891 = 1655
7	"	Upper Eastern Gandak Upper Burhi Gandak Composite	599034	19416	90% of 19416 = 17474	19416-17474 = 1942
8	"	Lower Eastern Gandak-baya-Lower Burhi Gandak Composite	493648	17067	90% of 17067 = 15360	17067-15360= 1707
9	"	Ganga Stem Zone -4	56899	429	90% of 429 = 386	429-386 = 43
	Kosi-Ghaghra	Ganga Stem Zone -5	154623	1166	90% of 1166 = 1049	1166-1049 = 117
10	Chunar-Sone Barrage	Ganga Stem Zone-6a	38655	291	90% of 291 = 262	291-262=29
11	STG Link	Ganga Stem Zone-6b	120272	907	90% of 907 = 816	907-816=91
		Total	**370449**	**2793**		
12	Chunar-Sone Barrage	Karmnasa	326709	1245	308/3 (jamania)+ 95%of 583(runoff of karmnasa)= 657 [(937-354){354 in reservoir}) {1245-308=937-354= 583}	1245-657= 588
13	"	Sone-KaoGangi	493121	13567	5566/3 (ganga water via chunar) +7117/3 + 92% of 884 (runoff of Kao river)= 5040	13567-5040=8527
14	"	Punpun (40%)	219643	592	0	reservoir water =592
15	STG Link	Punpun (60%)	329464	2253	92% of 2253 = 2073	2253-2073 =180
		Total	**549107**			
16	"	Harohar	590676	3300	100 % of (3300-386)= 2914	reservoir water =386
17	"	Kiul (60%)	48383	284	100% of (284 - 91)=193	reservoir water =91
18	"	Kiul (40%)	72574	426	100% of (426 -126)=300	reservoir water =126
		Total	**120957**	**710**		
19	"	Badua-Belharna	132530	737	92% of (737-273)= 427	737-427=310
20	"	Bilasi-Chandan-Chir	158513	1491	100% of (1491-165) =1326	reservoir water =165
		Grand-Total	**6441820**	**137741**		

CHAPTER V

FOCUS ON FLOOD MODERATION
KOSI-GHAGHRA LINK SCHEME (TOR-2)

CHAPTER V

FOCUS ON FLOOD MODERATION- KOSI-GHAGHRA LINK SCHEME (TOR-2)

5.0 Kosi-Ghaghra Link Canal Project (As prepared by NWDA)

5.1 Objectives

The Kosi- Ghaghra link Canal project envisages transfer of 7482 MCM of water annually from right bank of the river Kosi at Chatra in Nepal to Ghaghra river in India in order to extend irrigation to un-irrigated portion of the region north of the Ganga lying between the west of the Kosi and east of the Ghaghra. The quantity of water that proposed to be transferred through this link, as indicated above, will cater to the en route water requirement of 7339 MCM, which includes irrigation, domestic & industrial use. A provision of 143 MCM of water has been made towards transmission losses.

An index plan showing the layout of the scheme is enclosed at Plate no. 1.

5.2 Salient Features

The salient features of the Kosi-Ghaghra link canal are as follow :

i. Off-takes with FSL 113 m at Chatra barrage having proposed pond level 113.4 m.
ii. Out-falls into river Gaura (a tributary of river Rapti which in turn joins the river Ghaghra) at FSL 74.51 m.
iii. Length of the link canal - 428.76 Km of which 278.29 Km lies in Nepal and 150.47 Km in India (76.19 Km in Bihar and 74.28 Km in Uttar Pradesh).
iv. En route irrigation to about 10.58 lakh ha. of CCA (1.74 lakh ha. in Nepal and 8.84 lakh ha. in India)
v. With intensity of irrigation 100% water needs for irrigation is 7291 MCM (1200 MCM in Nepal and 6091 MCM in India). Additional provision of 48 MCM for industrial and domestic water supply.
vi. Bed Slope 1:20,000
vii. Lined 1V : 1.5 H
viii. There is no major or medium reservoir project en-route to the Kosi-Ghaghra link canal.

5.3 General Outline of the Scheme

5.3.1. The proposed link canal takes off from right bank of Chatra barrage on river Kosi with FSL of 113 m and travels 428.76 Km to outfall into river Gaura in U.P. (which later joins river Rapti a few km downstream) with FSL of 74.51 m. There is no lift involved and the link canal flows under gravity with a bed slope of 1:20000. The link canal initially passes through Nepal up to 278.29 km after which it enters Indian territory near village Basantpur about 2 Km east of Mainatand where the canal crosses the Mainatand Bettiah PWD road at Km 280.40. The link canal thereafter runs through west Champaran district of Bihar crossing Ghorasahan Branch Canal, Triveni Canal just as it enters Bihar. It then crosses the distribution system of Triveni Canal on its way and finally crosses Trihut Main Canal near about village Belwa

before it turns in southerly direction to cross river Gandak at Km. 333.67, at village Rajwatia. The link canal thereafter passes through West Champaran district of Bihar upto km. 356.54 and then runs for 72.22 Km. in Deoria and Ghorakpiur District crossing western Gandak Canal on its way at Km. 357.81 near village Fakirahwan in UP before dropping finally in river Gaura at Km. 428.76.

5.3.2 En-route the link canal there is proposal to construct three barrages on major rivers namely i.)Kamla at 121.00 km, ii) Bagmati at 202.79 km and iii) Gandak at 333.67 km with head regulator and silt ejectors for flexibility of canal operation

5.3.3 On other river/canal crossings 82 nos. of C.D Works are proposed as below

Aquaduct	16 Nos.
Syphon Aquaduct	17 Nos.
Canal Syphon	43 Nos.
Super Passage	6 Nos.
Total	82 Nos.

Salient crossing points of the link canal are described below:

i. Km. 12.7 to Km. 18.7	-Runs through tunnel in Nepal
ii. Km 121.00	-Level crossing on river Kamla near village Betaha (Nepal)
iii. Km 202.79	-Level crossing on river Bagmati near village Hararia (Nepal)
iv. Km. 257.55	-Birganj Amlakhganj Rly line crossing near Birganj(Nepal)
v. Km. 299.99	-Darbhanga-Narkatiganj Rly line crossing near Pakri W.Champaran)
vi. Km 304.08	-Narkatiganj-Bagaha Rly line crossing near village Salempur (W.Champaran)
vii. Km. 317.43	-Super Passage on river Masan near village Raibari Mahuawa (W. Champaran)
viii .Km. 333.67	-Level crossing on river Gandak near village Rajbatia (W.Champaran)
ix. Km. 357.81	-Canal Syphon on Western Gandak Main Canal near Farikahwan U.P.

5.3.5 The link canal is designed as lined canal with cast-in-situ C.C. lining of M15 Grade. Its discharge at head reach 0 to 90 Km. is 1021 Cumecs which tapers down to 67.20 Cumecs in tail reach (Km. 330-Km.428.76). Its bed width varies from 74 m at head to 26 m at tail while FSD varies from 8.0 m to 3.0 m

5.4 WATER BALANCE STUDY BY NWDA

5.4.1 Yield Computations

NWDA has assessed the water availability of the Kosi river upto proposed Kosi High Dam at Barahkshetra. The annual flows available for the period from 1947 to 1990 (44 years) at Barahkshetra G&D site maintained by the CWC have been utilized for working out the 75%

and 50% dependable flows. The 75% and the 50% dependable yield at Kosi High Dam site at Barahkshetra are given below in the water balance computations.

5.4.2 Water Balance

The annual water Balance has been worked out by NWDA considering yield available from river Kosi only at Barahkshetra dam site after accounting all needs i.e. upstream requirements as well as downstream requirement for existing Eastern and Western Kosi canals at Hanumanagar Barrage including Eastern and Western Chatra canal as envisaged in the feasibility report of Kosi High Dam prepared by CWC. **The Balance water available from en-route river basins viz. Kamla-Balan, Bagmati, Burhi-Gandak & Gandak have not been included for diversion through the link since as stated by NWDA the link canal traverses in the central region of the catchments where surplus water in the rivers are not anticipated or studied and further detailed study has to be done to firm up the surplus at these crossing points.**

The water balance thus worked out shows an annual surplus of 19253 MCM at 75% dependability as computed below

Table- 5.1
Surface Water Balance of river Kosi upto Kosi high Dam

A. Surface Water		**Unit:MCM**
I. Availability		
a) Gross annual Yield		
i. At 75% dependability		46727.00
ii. At 50% dependability		52020.00
b) Surface Water export (-)		
i. Existing-Kosi Project-	3303.65	
ii. On-Going-	Nil	
iii. Proposed-		
Kosi High Dam Project		
Eastern Chatra Canal-	897.79	
Western Chatra Canal-	6071.04	
For increasing irrigation intensity of Kosi Project command by 35.5%	1358.49	
Existing Kosi Project	822.64	
Sub-Total	12453.61	(-) 12453.61
c) Overall Availability		
i. At 75% dependability		34273.39
ii.At 50% dependability		39566.39

II. Water Needs

a) Irrigation Use

i. Existing-Kosi Project-	2897.65	
ii. On-Going-	Nil	
iii. Proposed-		
Kosi High Dam Project		
Eastern Chatra Canal-	2304.76	
Western Chatra Canal-	2415.36	
For increasing irrigation intensity of Kosi Project command by 35.5%	884.68	
Sub-total	8502.45	8502.45

b) Domestic Use 42.00

c) Industrial Use Nil

d) Hydro Power(For evaporation) 238.00

e) Flushing Dose 2522.00

f) Upstream utilization for Nepal

i. Domestic	330.00	
ii. Industrial	330.00	
iii. Irrigation	3584.00	
	4244.00	4244.00
Subtotal		15845.45

III. Regeneration from upstream utilization 528.00

IV. Surface Water Balance

i. At 75% dependability	19252.94
ii. At 50% dependability	24545.94

5.4.3. Water Transfer Through the Link

Out of annual surplus of 19253 MCM at 75% dependability worked out above, 7482 MCM of water is proposed to be transferred through this Kosi-Ghaghra Link Canal to meet the irrigational, domestic and industrial uses of Nepal and India portion which are lying still un-irrigated. Out of 7482 MCM of water 7339 MCM is for en-route irrigation, domestic and industrial purposes while 143 MCM is for transmission losses.

5.5 WATER REQUIREMENT

5.5.1 Details of Command Area

The culturable area proposed to be commanded by the link canal has been worked out by deducting the CCA of existing/ongoing/proposed Major/Medium Projects from the CCA bounded by the link canal between west of Kosi and east of Ghaghara and north of Ganga since no provision for irrigation requirement has been made through this link canal for the existing/Ongoing/proposed projects command as it has been assumed by NWDA that there is sufficient water available in the command river system to meet the irrigation requirement of these projects having irrigation intensity more than 100%. Accordingly the area to be commanded by link canal comes to 1058135 ha as per details below:

Table- 5.2

Details of CCA of Link Canal (in Ha)

sl. no.	Country/ State	G.C.A.	C.C.A. covered by link Canal	CCA of Existing/ongoing Proposed Projects		CCA of Link Canal col.4 (-) col.5
1	2	3	4	5		6
1	Nepal	345410	276328	Kamla Barrage (existing)	25000	
				Bagmati (existing) Proposed-	37000 30,000	
				Chandra Canal (renovation)	8750	
				Chandra Canal extension	1460	
				Total	102210	174118
2	India					
	i. Bihar	3316416	2586695	Western Kosi Canal(on-going)	2,24,200	
				Balan Irrg.Project (existing)	3600	
				Kamala Irrg. Project (exising)	39900	
				Bagmati Irrig.Project(poposed)	110000	
				Lalbakiya Weir Scheme (existing)	14500	
				Burhi Gandak Barrage (existing)	90000	
				Gandak Project (existing) Eastern canal Western Canal	 696000 591215	
				Total	1769415	817281
	ii. U.P.	286517	243522	Western Gandak Canal (existing)	176785	66736
	Grand Total	3948343	3106545		2048410	1058135

Source: Annexure 7.2 of NWDA Report of Kosi- Ghaghra Link Project

5.5.2 Water requirement

i. The new un-irrigated culturable area of 1058135 Ha. of the link canal is proposed to be commanded with 100% intensity of irrigation. As per suggested cropping pattern based on climatological approach the weighted delta works out to 0.690 m. Accordingly the water requirement for the link canal has been computed below:

* Irrigation requirement = 0.69m x 1058135 ha.=	7291 MCM
* Domestic Requirement	24 MCM
* Industrial Requirement	24 MCM
	7339 MCM
* Transmission Loss	143 MCM
Total water requirement	7482 MCM

ii. The monthwise water requirement for the purpose of canal operation at 100% irrigation intensity works out as below

Table- 5.3

Monthly Water Demand **Unit: MCM**

Month	Water need for en-route Irrigation	Domestic Need	Industrial Need	Transmission Loss	Total water Demand	Demand in Cumecs
1	2	3	4	5	6	7
June	814.76	02	02	15.93	834.69	322.03
July	2433.7	02	02	47.6	2485.3	927.90
August	1460.23	02	02	28.56	1492.79	557.34
September	772.44	02	02	15.1	7921.54	305.38
October	52.91	02	02	1.03	57.94	21.63
Kharif	**5534.04**	**10**	**10**	**108.22**	**5662.26**	**428.34**
November	455.00	02	02	8.9	467.9	180.52
December	296.28	02	02	5.79	306.07	114.27
January	380.93	02	02	7.45	392.38	146.50
February	402.09	02	02	7.86	413.95	171.11
Rabi	**1534.3**	**08**	**08**	**30.00**	**1580.3**	**152.42**
March	95.23	02	02	1.86	101.09	37.74
April	63.49	02	02	1.24	68.73	26.52
May	63.49	02	02	1.24	68.73	25.66
HW	**222.21**	**06**	**06**	**4.34**	**238.55**	**30.01**
Total	7290.55	24	24	142.56	7481.11	
say	7291			say	7482	237.25

Source: Annexure 7.1 of NWDA Report of Kosi-Ghaghra Link Project

iii. From the above table the Season-wise water requirement works out as below:

Table- 5.4

Season-wise Water Requirement (Unit MCM)

Sl.No.	Season	Irrigation requirement	Transmission Loss	Total
1	2	3	4	5
1	Kharif	5554	109	5663
2	Rabi	1550	30	1580
3	HW	235	4	239
4	Total	7339	143	7482

5.6 OBSERVATIONS AND FINDINGS BY THE EXPERT COMMITTEE

5.6.1 *Provision of missing* Structures

A perusal of the pre feasibility report of link canal reveals that structures on crossings of Ghorasahan Branch Canal and Triveni Canal just after crossing Indo-Nepal Border and on crossing of Trihut Main Canal just before it joins Gandak are missing. These should be included while finalising the scheme.

5.6.2 Irrigation Intensity

The proposed irrigation intensity for the new area being commanded by the link canal is only 100%. While, no provision has been made for increase in irrigation intensity of the existing/On-going/Proposed projects falling en-route. This appears grossly inadequate.

As already explained in Chapter-II of this report the projected irrigation intensity should not be less than 250% by 2050 AD for this area in order to meet the food and fodder needs of growing population and growth of irrigation facilities with backup of storage reservoir. The water requirement should therefore be revised to achieve 250% intensity of irrigation. This is essential in view of fact that "Maximum Production per unit Area", must be achieved before transferring water.

5.6.3 Water Demand and availability

a. The water requirement in Kamla-Balan and Bagmati Basin falling in the command of link Canal has been thus re-estimated as follows

i. As part of Kamla-Balan basin and Ganga-stem basin is covered by proposed Kosi-Mechi Link Canal and Gandak-Ganga Link Canal respectively, the same has been excluded. Accordingly the net CCA covered by the Kosi Ghaghara Link Canal comes to 852,622 ha. as worked out below

Table-5.5

Sl. No.	Name of Basin	Total CCA in Ha.	CCA covered by other scheme in Ha.	CCA in Command of Kosi Ghaghara in Ha.
1	2	3	4	5
1	Kamla-Balan	3,22,318	1,06,686	2,15,632
2	Bagmati	4,82,367	nil	4,82,367
3	Ganga-Stem	3,70,449	2,15,826	1,54,623
4	Total	11,75,134	3,22,512	8,52,622

ii. Crop intensity of 250% (Kharif 75%, Rabi 95%, HW 80%) has been adopted as explained in chapter-IV of this Report, at Para 4.1.3

iii. Non irrigation needs have also been assessed as per norms explained in Chapter-II.

iv. In accordance with above the water requirement has been computed in enclosed Annexure 5.6.3 This annexure shows the demand as below.

Table 5.6

Water Demand (in MCM)

Sl.No.	Particulars	Monsoon	Non-Monsoon	Total
1	2	3	4	5
1	Irrigation demand	3422	10423	13845
2	Non-Irrigation demand	1349	2698	4047
	Total	4771	13121	17892

v. Annexure 5.6.3 also shows that against above water demand, the water available is 9,544 MCM in monsoon and only 1,061 MCM in non monsoon i.e. 10,605 MCM in total. The net result, therefore, is that while there is surplus of 4,774 MCM in monsoon there is huge shortage of 12,061 MCM in non-monsoon.

vi. **To offset the shortage of water in non- monsoon period, provision of storage reservoir on Kamla at Chisapani and on Bagmati at Noothore and Masan dam on Masan, Burhi-Gandak tributary, should also be incorporated in the Scheme. This will also provide some flood moderation in these basins.**

5.6.4 Problem of Flood

The proposal of construction of storage reservoir as part of interlinking of River scheme have raised high hopes for achieving long term sustainable flood moderation. But the pre-feasibility report prepared by NWDA reflects that while planning the Kosi-Ghaghra Link Canal, the prevailing problem of flood of the river basins lying en-route has been completely ignored whereas all the river basins lying en-route viz. Kamla Balan, Bagmati (with Adhwara group of rivers), Burhi Gandak and Gandak basins are badly affected by flood. In fact the area covered by the link canal is the worst flood affected area of Bihar.

On the major river crossing points viz. Kamla Balan (at Km 121.00). Bagmati (at Km 202.79) and Gandak (at Km 333.67) there is provision of constructing barrages only, which is not going to solve the problem of flood in any way. The other rivers lying in between are planned to cross the Kosi-Ghaghra Link Canal through Cross Drainage works although some of them carry substantial discharge during monsoon. The monsoon discharge carried through these rivers aggravates the problem of flood in major part of North Bihar

It is again to be added that out of the total geographical area of 58.50 L Ha of North Bihar 44.46 LHa i.e. 76.02% area is flood prone. As yet only 25.08 L Ha area has been brought under reasonable/short term protection by constructing embankment. On some of the rivers lying en-route of Kosi-Ghaghra Link Canal either there is no embankment or the embankments constructed are in part only. For example the Bagmati river is embanked in part and there is no embankment on the Adhwara Group of rivers which frequently cause catastrophe in the basin from flood water during monsoon. At the same time the basin suffers from drought for want of any irrigation system.

The embankment constructed (under short term measures) is meant to check the spill water only, but due to subsequent aggradation of river bed by silt deposition (in Bihar portion) the meandering tendency of the rivers has accelerated and the embankments are often put under erosion resulting frequent breaches. As such so long as the problem of flood is not solved, any attempt to provide irrigation will be of no use. The problem of flood as well as irrigation of the basins in question will have to be solved simultaneously. Whereas the study made by the NWDA does not include any device for the solution of the more pertinent problem of flood particularly of the river basins lying en-route to the proposed Kosi-Ghaghra Link Canal that needs to be addressed in the scheme.

It is, therefore, suggested that proposed dams on Kamla, Bagmati and Burhi-Gandak (Masan Dam) should also form part of Kosi-Ghaghara link scheme to fulfill its objective of flood moderation.

5.6.5 Flood Diversion from the link Canal

5.6.5.1 Under certain conditions flood moderation can be accomplished by transferring flood water from one catchments to other. In such cases a flood way can be used for transferring full or part of the discharge from one river to another river.

As the area falling in the command of the link canal covers the major flood prone area of Bihar lying between Kosi on east and Gandak on west as explained above, this link canal provides a golden opportunity of utilising it to function as a flood diversion Channel also besides functioning as irrigation channel

5.6.5.2 The feasibility of using the link Channel as a flood diversion Channel has accordingly been examined and it was found that it is possible to utilize the link channel for transferring part of Kamla flood to the extent of 960 cumecs into Bagmati and thereafter Kamla or Bagmati flood to the extent of 850 cumecs to either Gandak or Gharghra river which get flooded later than the flood of Kamla and Bagmati. A look at the dominant flood discharge of these rivers and discharge that can be diverted through the proposed link canal as given below will show that a good percentage of flood water can be diverted during high stage of these rivers which will bring immense relief to the flood affected people of these basins.

sl.no.	Name of the River	Dominant Flood Discharge	Flood Discharge that can be Diverted	Percentage of Flood Diversion
1	2	3	4	5
1	Kamla	3000 cumecs	960 cumecs	32%
2	Bagmati	4000 cumecs	850 cumecs	21%

5.6.5.3 As explained above the link canal capacity shall have to be 960 cumecs between Kamla crossing (121 Km.) to Bagmati crossing (202.79 Km.) i.e. between Kms 121 to 202.79 and 850 cumecs between Bagmati crossing to Gandak crossing (333.67 Kms) i.e. between Kms 202.79 - 333.67 for required flood diversion. But the present designed capacity of the link canal is less than the discharge required for flood diversion as detailed below

Reach in Km	0-90	90-150	150-174	174-230	230-333.67	333.67-428.76
Discharge in cumecs	1021	900.20 say 900	460	346.80 say 350	126	67.20
Bed width (m)	74.00	65.00	55.00	40.00	30.00	26.00
F.S.D (m)	8.00	8.00	6.00	6.00	4.00	3.00

It is thus evident that the present designed capacity of the link canal will have to be increased from Km 121 i.e. Kamla crossing to Km 333.67 i.e. upto Gandak crossing as below.

Reach	Present Capacity in Cumecs	Required capacity in cumecs
Km. 121-150	900	960
Km. 150 - 202.79	460/350	960
Km. 202.79-230	350	850
Km. 230-333.67	126	850

It is , however, seen that if present channel itself is widened to cater to the required capacity, it may lead to siltation of the channel when the canal will be running with low discharge varying from 460 cumecs to 126 cumecs for irrigation purposes in a channel having capacity of 960 cumecs to 850 cumecs.

5.6.5.4 Proposal for making the part of Kosi-Ghaghra Link canal as flood diversion channel

a For making the Kosi Ghaghra Link canal below km 101.0 as flood diversion channel it is proposed that the present designed capacity of the link canal beyond Km. 121.00 be increased by providing an additional parallel channel for the balance discharge as detailed below for use during flood diversion in conjunction with the irrigation channel

1	Km. 121 to 150	-The present capacity of link canal itself be increased from 900 cumecs to 960 cumecs
2	Km 150 to 202.79	-a. The link Canal should continue with 460 cumecs capacity even beyond 174 Kms upto 202.79 Kms -b. A parallel channel for balance 500 cumecs capacity should be provided so that a total of 460 + 500 = 960 cumecs can be diverted during flood.
3.	Km. 202.7-333.67	-a The link canal should continue with 350 cumecs capacity even beyond Km.230 upto Km 333.67 -b. A parallel channel for balance 500 cumecs capacity should be provided so that a total of 350 + 500 i.e 850 cumecs can be diverted during flood.
4	Km. 0 to 121 and 333.67 to 428.76	No change is required.

b) In accordance with above, additional H/R for parallel channel shall have to be provided at 121 Km., 150 Km. and 202.79 Kms. The H/R for irrigation purposes shall also have to be suitably modified accordingly.

5.6.5.5 The above proposal will have to be investigated and examined in detail with flood hydrograph and frequency of floods in Kamla, Bagmati and Gandak which could not be done by this committee in absence of required data.

5.6.6 Flood Moderation in Bagmati- Adhwara group of rivers

5.6.6.1 A rough study was made on the possibility of flood moderation in river Bagmati through Intra-State River Linking i.e. by linking of river Kosi-Bagmati with Ganga near Mansi.

It is seen that combined flow of Kosi and Bagmati near Badlaghat takes eastward direction and flows parallel to the Ganga for about 28 Kms. before joining it at Kursela. Before joining Kosi, the river Bagmati is joined by Kamla, Kareh, Gehua etc. and carries the combined flow into Kosi. But due to long travel of Kosi between Badlaghat to Kursela with very flat slope, the evacuation of floodwater of river Bagmati is delayed even if outfall condition is favourable i.e. Ganga is low as was noticed during floods of 2004. Bagmati generally gets flooded very early in July itself when Ganga is very Low. There is, therefore, possibility of its quick drainage into Ganga if the travel of floodwater draining into Ganga between Badlaghat to Kursela can be shortened. This appears possible by providing a suitable and well oriented cut in the river Kosi near Mansi for linking it with river Ganga. The length of this channel or cut will be much less than the present length of 28 Kms between Badlaghat to Kursela and slope of link/cut will also get steeper thus helping in quick drainage of flood water of Bagmati into Ganga.

5.6.6.2 Besides providing quick drainage of early flood in Bagmati- Adhwara group of rivers this link/cut will give following benefits

i. It will help in drainage of base flow of river Kosi-Bagmati, thus decreasing the drainage congestion of the area during flood and accelerate the drainage of water logged area after monsoon

ii. The water logged area at the confluence of Bagmati, Kamla and Kosi in Kuseshwarsthan and Madepur Block which remains affected by water accumulation almost throughout the year will get an outlet for quick drainage.

iii. The flow of Kosi diverted through the cut may be utilised for generation of hydel power by utilizing the differential head available at the outfall.

5.6.6.3 This proposal will involve provision of bridges on the NH 31 and Barauni-Katihar Rly line of NE railway, locks for navigation and hydro-power unit. Its effect on morphology of river Kosi also needs to be studied.

The Committee, therefore, suggests that proper survey, investigation, design and model tests may be conducted before embarking on the proposal to find out its real utility and benefits. It is, however, felt that the aforesaid problem viz. quick drainage of early flood in Bagmati-Adhwara group of rivers, removal of acute drainage congestion in this zone as well as generation of hydropower are very-very vital and pressing needs of State of Bihar. The proposal should, therefore, be pursued to its logical end.

5.7 Recommendations

In view of observations and findings discussed in foregoing paras following recommendations are made

1. The Kosi Ghaghra Link Canal as proposed by NWDA may be accepted with a proviso that it should cater for irrigation intensity of 250% for both un-irrigated area and area under existing/ongoing/proposed Irrigation Schemes falling in the en-route command. Water demand should be worked out accordingly.

2. To offset the shortage of water in the non-monsoon period and for flood moderation, provision of storage reservoir on Kamla at Chisapani and on Bagmati at Noonthore and Masan dam in Burhi-Gandak basin should be incorporated in the scheme.

3. Suitable structure on its crossing with a.) Ghorashan Branch Canal, b.) Triveni Canal and c.) Trihut Main Canal. which is missing in the proposal should be provided.

4. The Link Canal can be utilised for diversion of flood of river Kamla and Bagmati with some alteration and additions in the scheme as suggested in Para 5.6.5.4.

   NWDA should consider these proposals and carry out detailed survey and investigation for this purpose.

5. The feasibility of Kosi-Ganga link at Mansi to mitigate flood problem in Bagmati-Adhwara group of rivers and drainage congestion at the confluence of Bagmati, Kamla and Kosi needs to be examined in depth after detailed survey and investigation and model tests

Annexure: 5.6.3

Assessment of water requirement in proposed Kosi-Ghaghra link canal for irrigation & Non-irrigation needs

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA in KGLC command to be irrigated (Ha)	Total area to be irrigated in ha				Water demand irrigation (MCM)			
1	2	3	4	5	6	7	8	9	10	11	12
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
			Intensity	**0.75**	**0.95**	**0.8**	**Delta**	**0.5**	**0.44**	**1.01**	
1	Bagmati	482367	482367	361775	458249	385894	1205918	1809	2016	3898	7723
2	Kamla balan	322318	215632	161724	204850	172506	539080	809	901	1742	3452
			Intensity	**0.80**	**0.95**	**0.75**	**Delta**	**0.65**	**0.473**	**1.01**	
3	Ganga-Stem	154623	154623	123698	146892	115967	386558	804	695	1171	2670
	Total	959308	852622	647198	809991	674366	2131555	3422	3612	6811	13845

		Non- irrigation Demand (MCM)				Total Demand Season wise (MCM)			
		Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
		13	14	15	16	17	18	19	20
1	Bagmati	734	734	734	2202	2543	2750	4632	9925
2	Kamla balan	343	343	343	1029	1152	1244	2085	4481
3	Ganga-Stem	272	272	272	816	1076	967	1443	3486
4	Total	1349	1349	1349	4047	4770	4961	8160	17892

	water Available (MCM)				water deficit/surplus (MCM)		
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.
	21	22	23	24	25	26	27
Bagmati	6538	363.5	363.5	7265	3995	-2387	-4268
Kamla balan	1957	108.5	108.5	2174	805	-1136	-1977
Ganga-Stem	1049	58.5	58.5	1166	-27	-908	-1385
Total	9544	530.5	530.5	10605	4774	-4431	-7630

CHAPTER VI

STUDY FOR PROVIDING ASSURED IRRIGATION IN SOUTH BIHAR THROUGH CHUNAR-SONE BARRAGE AND STG-LINK SCHEME (TOR-3)
AND
STUDY OF PUMP CANAL SCHEMES TO CATER FOR SOUTH EASTERN PARTS OF BIHAR (TOR 4)

CHAPTER VI

STUDY FOR PROVIDING ASSURED IRRIGATION IN SOUTH BIHAR THROUGH CHUNAR-SONE BARRAGE AND STG-LINK SCHEME (TOR-3) AND STUDY OF PUMP CANAL SCHEMES TO CATER FOR SOUTH EASTERN PARTS OF BIHAR (TOR 4)

6.1 CHUNAR-SONE BARRAGE (C-SB) LINK PROJECT

6.1.1 NWDA PROPOSAL

6.1.1.1 Objective

The proposed Chunar -Sone Barrage Link Project envisages to transfer surplus water of river Ganga, available at Chunar to Sone river. It is proposed to take over the entire command of Western Sone Canal System through this link project, in order to reduce deficit in Sone river by substitution. The link also proposes to provide water at Sone Barrage for Eastern Sone Canal System. Thus additional water available in Sone river, as a result of proposed substitution (due to take over of entire WSLLC and WSHLC command by Chunar Link Canal), is proposed to be utilised on right side of Sone river through another link scheme at Kadwan Dam known as Sone Dam Southern Tributaries of Ganga (STG) link. The Chunar link canal also proposes to provide irrigation enroute to areas lying un-irrigated in the command in both Bihar and Uttar Pradesh.

An Index plan of NWDA showing lay out of the scheme is enclosed at Plate No - 2.

6.1.1.2 General Outline of the Scheme

i. Link Canal:

The link canal is 149.10 Km long. It takes off from right bank of river Ganga at Chunar with F.S.L. of 60.00 m and terminates in pond of Sone barrage at Indrapuri. Its design discharge is 405.09 cumecs at head and 85.18 cumecs at tail, to meet the maximum demand which is in July for Kharif irrigation .It passes through old Mirzapur and Varanasi District of U.P. and old Rohtas Distt- now Bhabhua and Sasaram District of Bihar. The Link Canal enters Bihar at about 51 Km. The project area is bounded by the river Ganga in the North, the river Sone in the South-East and the Mirzapur hills and escarpments in the West and South West directions.

ii. Pump Houses:

Three nos. of pump houses have been proposed to lift the water into the link canal as detailed below :

a) P.H.No.1- At 1.3 Km

It lifts the water from F.S.L. of 60.0m to F.S.L. of 98.8 m i.e. 38.8 m lift in non monsoon season and 33.8m in monsoon season. The Pump House is designed for 368.26

cumecs required in July with 40 pumps of 5000 H.P. and 4 stand Bye pumps of 2600 H.P. A maximum of 161.54 MW of power would be required in July at this point for running the P.H.

b) P.H no.2 at 12.9 Km.

The link canal out falls into Jirgo Reservoir at 12.9 Km. 2nd pump house is proposed here to lift the water by 16.10m i.e from F.R.L. 98.0m to F.S.L. of 114.10m. The maximum designed discharge of pumps and number of pumps to be installed here are same as P.H. No.1.

c) P.H. No.3 at 129.2 Km.

The link canal joins Kudra River at 129.2 Km where a barrage is proposed to raise the pond level up to F.S.L. of link canal i.e. 105.30m 3rd P.H. is proposed here to lift the water by 4.40 m into the link canal raising its F.S.L from 105.30m to 109.70m. The maximum designed discharge of pumps is 75.75 cumecs 7 Nos of pumps with 1 no as stand bye of 1000 H.P. will be installed.

A maximum of 6.28 MW power would be required in March to run the P.H.

iii. Inter connecting Reservoirs:

As the link canal traverses from Chunar to Sone Barrage at Indrapuri, it out falls into Jirgo, Ahraura, Musakhand reservoirs U.P. and Kohira Reservoirs in Bihar, the details of which are as shown in Table 6.1.

Table -6.1

Inter connecting reservoir and their details.

Sl. No	R.D. in Kms	F.S.L. of link canal	Name of Reservoirs	F.R.L. (M)	Live storage (MCM)
1	12.90	98.12	Jirgo	98.00	140.00
2	20.90	113.65	Ahraura	110.00	58.20
3	46.55	111.40	Musakhand	110.67	110.5
4	67.30	109.81	Kohira	104.42	25.5

iv. Kudra Barrage:

At R.D 129.2 Km, the link canal joins Kudra River where a new barrage is proposed across Kudra River to raise the W.L. of pond up to F.S.L. of 105.30m of link canal.

v. Feeder Channel:

From Kudra Barrage, the link canal bifurcates into two branches, viz (i) Feeder channel to feed the WSLLC and WSHLC (Western Sone Low Level Canal and Higher Level Canal) and (ii) Second link canal to lift water by 4.40 m up to F.S.L. of 109.70 through 3rd P.H. which will ultimately terminate and out fall into the pond of Sone Barrage at RD. 149.10 Km.

The feeder channel is proposed, to feed WSLLC and WSHLC and take over their command entirely, thus saving water at Sone Barrage by substitution. In effect, it means that Ganga water brought through Chunar-Sone link canal will be utilised to feed the entire command of WSLLC and WSHLC so that water thus saved at Sone Barrage can be diverted to feed the proposed S.T.G.link canal from Kadwan Dam.

6.1.1.3 WATER BALANCE STUDIES

6.1.1.3.1 Water Availability at Chunar For downstream utilisation.

The data of Varanasi G&D site which were available from June 1959 to May 1992 (33 years) have been considered for Water Balance study at Chunar site, since there is no appreciable difference in the catchment area of Ganga up to Varanasi G. & D site (4,89,087 Sq Km) and up to Chunar (4,87,533 Sq Km) and no important tributary joins river Ganga in between. Therefore yield at Varanasi G&D site has been adopted for Water Balance Study up to Chunar.

The NWDA have completed water Balance study of river Ganga at Chunar in March 1997. This study was further extended in July 1997 in order to work out total water availability at this site after taking into account the surplus flow expected to be available from Gandak - Ganga Link canal and Karnali-Jamuna link canal. The Water Balance of Ganga at Chunar is presented in Table 6.2.

Considering availability and projected needs up to Chunar and regeneration, the 75% annual Water balance of Ganga at Chunar would be 9834 MCM. The season wise break up is 8097 MCM during monsoon and 1232 MCM during non-monsoon season. After adding water transferred from Gandak basin as 5245 MCM and Karnali basin 4090 MCM, the availability increases to 19169 MCM as shown in table 6.2.

Table 6.2
Surface water Balance of Ganga at Chunar

Unit- MCM

S.N.	Description	Monsoon	Non Monsoon	Total
1	Gross yield			
	(i) At 75% dependability	87,232	14,177	1,01,914
	(ii) Import (+)	3,834	4,879	8,713
	(iii) Export (-)	(-)1,063	(-) 865	(-) 1,928
	Overall availability	90,003	18,191	1,08,194
2	SurfaceWater Requirement up to Chunar			
	(i) Irrigation including hydro power	84,501	18,247	1,02,748
	(ii) Domestic use	3,655	5,064	8,719
	(iii) Industrial use	5,804	8,043	13,847
	Sub Total (2)	93,960	31,354	1,25,314
3	Regeneration from			
	(i) Domestic use	2,924	4,051	6,975
	(ii) Industrial use	4,643	6,434	11,077
	(iii) Irrigation use	4,487	3,910	8,397
	Sub Total (3)	12,054	14,395	26,449
	Surface water balance at 75% dependability (1+3-2)	8,097	1,232	9834
4	Add water transferred from			
	(i) Gandak-Ganga Link	-	5245*	5245
	(ii) Karnali-Yamuna Link	-	4,090	4090
	Total Water available at Chunar	8097	10567	19169

Source:- 1. NWDA report on "Preliminary Water Balance Study of Ganga Basin upto Chunar,March 1997."
* 5245 MCM of Gandak water is being diverted in non-monsoon only as per para 2.13.1 of NWDA Report on Pre- Feasibility Report of Chunar- Sone Barrage Link Project (July 1997)

According to this table, total water available for utilisation in the command of Chunar-Sone Link and further downstream in Ganga basin will be 8097 MCM during monsoon and 10567 MCM during non-monsoon in a year which includes 5245 MCM being made available through Gandak-Ganga Link during non-monsoon.

It is stated elsewhere that out of 19169 MCM of surplus water available in river Ganga at Chunar, 5918 MCM of water will be transferred through Chunar-Sone Barrage Link to meet the demand of irrigation of the C.SB Link command. Break up of the proposed diversion is 3147 MCM during monsoon and 2771 MCM during non-monsoon.

This leaves a balance of 13251 MCM of water at Chunar in river Ganga to take care of ecological aspects and other water requirement downstream of river Ganga. The season wise break up of balance water at Chunar for use in Ganga basin in the downstream is 4950 MCM during monsoon and 7796 MCM during non-monsoon season.

6.1.1.3.2 G.C.A.and C.C.A. of the Link command and Water Requirement

i. The G.C.A. and C.C.A for entire Link command as assessed by NWDA are shown in table 6.3

Table-6.3

GCA & CCA of Link Command

Sl.No	Details of command	G.C.A in ha	CCA in ha.
1	Entire Command		
	(A) U.P.	2,94,591	2,36,600
	(B) Bihar		
	(i) Bhabhua Distt.	2,01,095	1,40,770
	(ii) Sasaram District	2,56,022	1,79,215
	(iii) Ara District	2,37,339	1,98,816
	(iv) Buxar District	1,66,999	1,48,854
	Sub Total (Bihar)	8,61,455	6,67,655
	Total Link Command =A+B	11,56,046	9,04,255
2	Less Area lying between Rly Line (Patna-Mugalsarai) and Ganga (to be irrigated by direct pumping from Ganga) (i)U.P. (ii)Bihar	 6,500 99,188	 5,525 84,900
	Sub total	1,05,688	90,425
3	Less C.C.A. of existing/ongoing projects		
	(i) U.P.		1,81,988
	(ii) Bihar		5,70,314
	Sub Total		7,52,302
4	Add additional command area to raise intensity of irrigation to 100%		
	(i) U.P.(Chandra Prabha canal)		3705
	(ii) Bihar (Suara irrigation Project)		1564
	Sub total		5265
5	New Area being covered by Link canal (1-2-3+4) U.P. Bihar		 52792 14001
	Sub total		66793

Source:- Annexure 7.1 (P 99) and Annexure 7.1.1 (page 101-102), Annexure 7.1.2 (page 102-103) of NWDA," Pre- Feasibility Report of Chunar-Sone Barrage Link Project,March 1997".

From above table, it will be seen that new CCA that is being brought under irrigation by the Chunar Sone Link canal is 66,793 ha of which 52,792 ha lies in U.P. and 14,001 ha lies in Bihar.

ii. Water requirement for the Link Command.

The water requirement has been assessed by NWDA on following premises:

a) Cropping intensity adopted for new area is 150% out of which 100% will be met by surface water through link canal and balance 50% will be met by ground water.

b) Cropping intensity of existing and on going schemes has been kept same, if it is above 100%. It has been increased to 100% in schemes, only where present intensity is less than 100% i.e Chandra Prabha canal system of U.P and Suara Irrigation Project of Bihar where it is only 74% and 45% respectively.

c) Provision has been made to feed not only new areas en route but the command of both WSLLC and WSHLC in Bihar through the link canal in order to take over the entire command of WSLLC and WSHLC, so that water thus saved in Sone river can be utilised to feed the proposed Sone Dam - STG link through Kadwan Dam at Sone for covering the unirrigated area lying between Sone and Chandan- Chir river on East.

d) No provision has been made for domestic and industrial uses in the link command though provision has been made for the same for requirement above Chunar by 2050AD

Accordingly, water requirement has been assessed as 5918 MCM including transmission losses @ 0.60 Cumecs/Sq Km of wetted areas as per details given in table 6.4,6.5 and 6.6. Out of this 4364.49 MCM (3989.31 MCM for WSLL canal + 375.18 MCM for WSHL canal) is being diverted to take over the entire command of WSHLC & WSLLC and after meeting enroute irrigation requirement of 426.45 MCM the balance 928.47 MCM will be diverted to Sone Barrage to benefit the area east of Sone in South Bihar which is subjected to frequent drought condition.

Table- 6.4

Estimation of Water Requirement by NWDA

Sl. No	Name of system	C.C.A. in Ha	Delta (Av.)	Crop intensity adopted	Water required for irrigation in MCM	Transmi -ssion Loss in MCM	Total Water required in MCM
1	2	3	4	5	6	7	8
1	Enroute command of link canal (New area) U.P.- Bihar-	 52,792 14,001	0.638	 Kharif-48% Rabbi- 48% HW- 4%			
	Sub total	66,793		100% (P)*	426.45	164.38	590.85
2	Western Sone LLC	4,54,142	-	125% (E)*	3989.31	25.06	4014.37
3	Western Sone High level canal	57,890	-	116% (E)*	375.18	-	375.18
4	For diversion to Sone Barrage	-	-	-	928.47	9.00	937.47
	Grand total	5,78,825	-	-	5719.41	198.44	5917.85
(P)* = Proposed (E)* = Existing						or say	5918 MCM

Out of 5918 MCM being diverted to link canal, withdrawal for Bihar works out to 5566 MCM as shown below on proportionate basis :

i.	For enroute command of 14001 ha in proportion of total CCA of 66,793 ha =426.45*14001/66,793	89.39 MCM
ii.	For WSLLC-	3989.31 "
iii.	For WSHLC-	375.18 "
iv.	For Sone Barrage-	928.47 "
v.	For Transmission loss in proportion of C.C.A.-(164.38/578825)*(578825-52792)+34.06	183.45 "
		5565.8MCM
	or say	5566 MCM.

Month wise requirement of water has also been estimated as shown in Table 6.5. Based on figure of Table 6.5 season wise requirement of water for whole command & Bihar has been assessed in Table 6.6. From Table 6.6 above it will also be seen that monsoon withdrawal from June to Oct is 3146.69 MCM i.e. say 3147 MCM while non-monsoon withdrawal from Nov. to June is 1637.19 + 1133.97=2771.17 or say 2771 MCM, total annual withdrawal being 5918 MCM.

Table 6.5
Month wise water requirement

(Unit M.C.M.)

Month	Water need in enroute command	Water need in WSLLC	Water need in WSHLC	Water for Sone Barrage	Transmission Loss	Total water Need
1	2	3	4	5	6	7
June	99.17	243.79	82.07	199.57	17.26	641.86
July	75.83	641.43	65.29	184.72	19.10	986.37
August	75.25	164.34	65.43		15.27	320.29
Sept.	41.19	500.45	35.37	-	16.17	593.18
Oct.	9.46	570.74	8.10	-	16.69	604.99
Total Kharif (A)	300.90	2120.75	256.26	384.29	84.49	3146.69
Nov.	30.31	241.23	27.75	50.82	15.74	366.05
Dec.	22.91	313.49	22.63	49.29	16.69	425.11
Jan.	25.70	321.78	26.17	39.96	16.77	430.38
Feb.	26.32	283.95	25.46	64.63	15.29	415.65
Total Rabi (B)	105.24	1160.45	102.00	204.70	64.79	1637.19
March	7.45	284.92	6.31	205.71	17.28	521.67
April	6.28	223.41	5.01	49.61	15.68	299.99
May	6.58	199.78	5.59	84.16	16.20	312.31
Total H.W.(C)	20.31	708.11	16.91	339.48	49.16	1133.97
GT-(A+B+C)	426.45	3989.31	375.17	928.47	198.44	5917.85

Table-6.6

Season wise water Requirement (Unit MCM)

Season	For entire Command	En-route U.P. Command			For Bihar Command
		Irrigation	Tran. Loss	Total (3+4)	Total (2-5)
1	2	3	4	5	6
monsoon Kharif	3146.69	37.82	6.38	244.20	2902.49
non-monsoon Rabi	1637.19	83.18	4.90	88.08	1549.11
HW	1133.97	16.05	3.72	19.77	1114.20
Total non monsoon	2771.16	99.23	8.62	107.85	2663.31
Total	5917.85 say 5918	337.05	15.00	352.05 say352	5565.80 say 5566

6.1.2 Observations on NWDA Proposal of the Committee

6.1.2.1 Ecological needs for use below Chunar Head works

Considering net water availability at Chunar (shown in Table 6.2) and the season wise requirement of water for the Chunar-Sone Link Command (shown in Table 6.6) the water balance for use below Chunar has been worked out as as shown in Table 6.7.

Table 6.7

Season wise water balance in Ganga at Chunar

Unit in MCM

Sl.No	Particulars	Monsoon	Non-Monsoon	Annual
1	2	3	4	5
1.	Surface water available in Ganga at Chunar (vide Table 6.2)	8097	1232	9834
2.	Transfer from Karnali-Yamuna link	-	4090	4090
3.	Transfer from Gandak-Ganga link	-	5245	5245
4.	Total water available at Chunar	8097	10567	19169
5.	Gross amount of water to be transferred through Chunar-Sone Barrage Link vide column 2 of Table 6.6	3147	2771	5918
6.	Balance for d/s use	4950	7796	13251

Thus, it has been shown that even after diversion to Chunar Sone Link, 13,251 MCM of water is left at Chunar to take care of ecological aspects and d/s use. But this availability for ecology is dependent on transfer of water from Karnali -Yamuna link and Gandak-Ganga link canal. In the event of non-availability of water from link canals, it is obvious that only 9834 MCM of water is available at Ganga below Chunar for down stream uses of which only 1232 MCM is available during non-monsoon which is too inadequate and disastrous for ecological needs of river Ganga below Chunar.

6.1.2.2 Water Balance Study

The observations of the Committee on Water Balance Study at Chunar is as given below.

i. In Water Balance Study of NWDA (para 6.1.1.3.1, Table 6.2), the gross yield at 75% dependability has been shown as 87,232 MCM and 14177 MCM during monsoon and non-monsoon season respectively and the annual flow has been shown as 101914 MCM.

Taking the availability of flows during monsoon season and non-monsoon season as 87,232 MCM and 14177 MCM respectively, the total comes to 101409 MCM which is less than annual figure indicated by NWDA. Since all the demands are taken for monsoon and non-monsoon season, and the annual demand is considered for the sum total of these two seasonal demands, it seems logical that the annual availability of water is also considered as sum total of monsoon available flow and non-monsoon available flow.

ii. In Water Balance Study of NWDA against the overall availability of flow at Chunar during monsoon as 90003 MCM and during non-monsoon as 18191 MCM, total utilisation envisaged in the upstream upto this point is 93,960 MCM during monsoon and 31,354 MCM during non-monsoon. It clearly indicates that proposed utilisation in the upstream during monsoon and non-monsoon season would be about 5% and 72% respectively higher than the water available at the point. Consequently, the excess utilisation will again consume the flow likely to be available from return flows and the lower down riparian state like Bihar will not get any virgin flow of river Ganga and it will have to depend only on remaining part of return flow, left out after full consumption by upper riparian states.

iii. The envisaged utilisation of Ganga water as 31354 MCM to Chunar during non-monsoon, against the overall availability of 18191 MCM during the season has completely ignored the riparian and morphological need of the lower portion. It is also not clear, how the water requirement for navigational need of Ganga from Chunar to Haldia port will be met.

iv It has been indicated in the study that at Chunar, a quantity of 5245 MCM water will be available from Gandak Ganga Link on annual basis, but its season wise break up has not been given.

However, it is mentioned in para 2.13.1 (page 14) of NWDA report on" Pre-Feasibility Report of Chunar-Sone-Barrage link Project, July 1997," that 5245 MCM unutilized water of Gandak-Ganga link could be available in non-monsoon period after construction of various storages proposed in Gandak sub-basin and regulating them as desired. This means that this flow will be available during non-monsoon season and that also subject to the condition that

a. Various storages proposed in Gandak sub-basin and regulating dam are constructed.

b. Gandak water is surplus after meeting all the demands in Nepal upstream of Gandak barrage together with those in Nepal, U.P. and Bihar below the barrage.

v .A quantity of 4090 MCM of Karnali water is also stated to be available at Chunar through Karnali-Yamuna link during non-monsoon season. This availability is also subject to the condition that the requirement of existing Sarda-Sahayak Pariyojna and ongoing Sarju Nahar Pariyojna, both in U.P. are fully taken over by Gandak-Ganga link.

The envisaged irrigation requirement of these two schemes as reported in NWDA Report are as indicated below:-

UNIT MCM

S.N.	Name of scheme	Irrigation water requirement		
		Monsoon	Non-monsoon	Total
1.	Sarda-Sahayak Pariyojna (Existing)	1980	5517	7497
2.	Sarju Nahar Pariyojna (Existing)	3275	437	3712
	Total	5255	5954	11209

Source: NWDA report on Pre-feasibility Report of Karnali-Yamuna Link Project, March 1996, Annexure 2.5.1 page 94 and Annexure 2.5.2 page 95.

vi. Observations iv and v given above, clearly, indicate that for availability of 5245 MCM through Gandak- Ganga Link and 4090 MCM through Karnali- Jamuna Link at Chunar the quantity of water to be spared from river Gandak would be 5255 MCM during monsoon season and 11199 MCM (ie. 5954 MCM + 5245 MCM) during non monsoon season, total being 16454 MCM.

But, the water balance studies conducted by the Committee **at Table 4.7** in Chapter iv indicate that the Gandak basin, itself, is short by 24899 MCM during non-monsoon. As such the proposal of NWDA for diverting of Gandak water to Chunar in non -monsoon is not possible.

vii In light of observations mentioned in i, iii and iv above, the revised water Balance at Chunar is given in Table 6.8.

Table 6.8

Water Balance of river Ganga at Chunar revised by the Committee

Unit MCM

S.N	Description	Monsoon	Non monsoon	Total
1	Gross yield at 75% dependability	87232	14177	101409*
	i Import (+)	3834	4879	8713
	ii Export (-)	(-) 1069	(-) 865	(-) 1928
	Overall availability	90003	18191	108194
2	Surface water requirement upto Chunar			
	i Irrigation including hydro power	84501	18247	102748
	ii Domestic use	3655	5045	8719
	iii Industrial use	5804	8043	13847
	Sub Total 2	93960	31354	125314
3	Regeneration from			
	i Domestic use	2924	4051	6975
	ii. Industrial use	4643	6434	11077
	iii. Irrigation use	4487	3910	8397
	Sub total 3	12054	14395	26449
4	Surface water Balance at Chunar (1+3-2)	8097	1232	9329*
5	Add water to be transferred from			
	i. Gandak Ganga Link	-	5245*	5245
	ii. Karnali Yamuna Link		4090	4090
6	Total Water available at Chunar	8097	10567*	18664*
7	Gross amount of water to be transferred through Chunar - Sone- Barrage Link	3147	2771	5918
8	Balance for downstream use	4950	7796*	12746*

NB * Figure revised from those indicated in Table 6.2 and have been taken as sum total of monsoon and non-monsoon yield.

The above table shows that only 12,746 MCM of water would be available at Chunar after diversion to C-SB Link & not 13,251 MCM.

6.1.2.3 Take over of Western Sone command by the Chunar - Sone Barrage (CSB) link canal.

i. According to the NWDA, C-SB Link Canal Scheme, essentially, envisages to utilise Ganga water to irrigate entire command of WSLLC and WSHLC and part of Eastern Sone canals, instead of, through Sone barrage. For this purpose,5918MCM Ganga water is proposed to be diverted through C-SB Link of which 352 MCM (including en-route transmission losses as 15 MCM) will be for use in UP and 5566 MCM (including enroute transmission losses of 183.44 MCM) will be for use in Bihar thereby, leaving 5566-183=5383 MCM as utilisable flow in Bihar. Out of 5383 MCM of water, 89 MCM is required for en-route irrigation in Bihar, 4364 MCM for feeding WSLLC (3989 MCM) and WSHLC (375 MCM) as well as 929 MCM for part of Eastern Sone Canal. It has, further, been indicated that 2512 MCM will be available for transfer to other Basins east of Sone command through proposed Sone dam at Kadwan. In addition, 198 MCM more will be supplemented to accommodate transmission loss.

However, from the studies carried out, it is seen that the stipulated takeover of command of WSLLC and WSHLC by C-SB Link canal is not possible with diversion of only 5566 MCM of water to Bihar in view of increase in water needs of the command over the assessment made by NWDA owing to the following reasons: (for which justification have been given earlier in the Report at Chapter-II)

i. Increase in the CCA of the command
ii. Increase in projected crop intensity
iii. Provision of water for M.I. uses

ii. C.C.A. of Existing/Ongoing Scheme

Study of figures of C.C.A. of existing/ongoing scheme in the command of link canal, falling in Bihar, as assumed by NWDA, reveals that they are at variance with figures worked out by the 2nd Bihar State Irrigation Commission of 1994, as some schemes do not appear to have been accounted for, while working out water availability and requirement as shown in the Table 6.9.

Table- 6.9

Comparison of C.C.A. Unit ha

S.N	Name of Irri. Scheme	C.CA by NWDA.	CCA as SBSIC
A	**Sone Basin**		
1	Western Sone		
	i)L.L.Canal	454142	
	ii) Area North of Rly	84900 539042	527432
	iii) H.L.Canal	57890	58000
2	Eastern Sone		
	i) L.L.Canal	-	164443
	ii)H.L. Canal	-	81200
3	Kao Weir Schme	5450	630
4	Chausa Pump canal	-	5500
5	Kumhari Weir Scheme	-	860
6	Awsane Res.Scheme	-	3684
B.	**Karmnasa Basin**		
1	Durgawati Res.Sch.	34000	34160
2	Suara Res.Scheme	2840	3640
3	Kohira Res.Sch.	15992	19682
4	Jamania Pump Canal	-	19150
5	Bharari irr. sch.	-	3850
6	Bahuara Pump Canal	-	6073
C.	Area not covered by above scheme	-	149824
	Total	6,54,424	10,78,128

iii. Crop Intensity

a) In N.W.D.A. proposal, the projected crop intensity has been kept same where existing intensity is above 100% while it has been raised to 100% only where existing one is less than 100% and for un-irrigated new area also. In addition 50% intensity is to be achieved by ground water.

b) As already explained in Chapter-II of this Report that the likely cropping pattern and intensity of irrigation by 2050 A.D. is expected to be not less than 240%. Keeping in view the growth of population, the heavy dependence on agriculture for economic growth in Bihar, food and fodder needs, land use practices, development of agro-based industries, growth of irrigation facilities with back-up of storage reservoirs, greater use of fertilizers, pesticides and likely spectacular strides in bio-technical research and development, more and more use of H.Y.V. seeds etc., a crop intensity of 240%, appear quite reasonable and fully achievable.

Accordingly, the Committee considers more appropriate to adopt crop intensity of 240% comprising of Kharif 95%, Rabi 95%, and H.W. 50% for estimating water requirement of the command area.

iv. Water Demand as assessed by the Committee

The Sone-Karmnasa-Punpun Composite Basin falling in the command of Link Canal consists of entire Sone and Karmnasa Basin and part of Punpun Basin (40%) covering area of Eastern Sone canal and North-Koel Project. The water requirement of this composite basin has been computed at Annexure 6.1.2.3.The computation is on the following basis:

a). Crop intensity of 240% has been adopted comprising of Kharif-95%, Rabi-95%, & HW 50% as already explained above.
Delta values as suggested by 2nd Bihar State Irrigation Commission has been adopted as below:

a.	Kharif	0.65 M
b.	Rabi	0.46 M
c.	H.W.	1.02 M

b). Non-Irrigation water needs have also been assessed .It may, here, be mentioned that non-irrigation requirements in the command have not been assessed by NWDA while working out water needs of the command area of the C-SB link canal, even though it was accounted for, while working out water needs u/s of Chunar. This has now been accounted for, on the basis of norms stated at para 4.2 of Chapter-IV of this Report

c) As per above norms and stipulations, the total water demand is now assessed as 21,281MCM vide Annexure 6.1.2.3. The season wise break up of this demand is 7795 MCM during monsoon and 13486 MCM during non-monsoon.

v. Water Availability as assessed by the Committee

Water availability re-assessed at Annexure 6.1.2.3 is 15,695 MCM, break up being 5959 MCM during monsoon and 9736 MCM during non-monsoon system wise details of water availability are as shown in Table 6.10

Table 6.10

S.N.	Name of the System	Monsoon	Non-monsoon	Total	Ratio of monsoon to non-monsoon Flow
1	2	3	4	5	6
1	Karmnasa	657*	588*	1,245	1:2
2	Sone-Kao-Gangi				
	Sone Agreement	2,372	4,745	7,117	1:2
	Kao-Gangi	813	71	884	92:8
	C-SB Link	1,855	3,711	5,566	1:2
	Sub total 2	5,040	8,527	13,567	
3	Punpun 40%	0	592	592	0:1
4	Ganga-Stem 6(a)	262	29	291	90:10
	Total 1+2+3+4	5959	9736	15,695	

NB * Water available for

i Monsoon season will be = 1/3 of Jamania water+ 95% 0f unstored Karmnasa water
= (308/3 + 0.95(937-354) MCM =657 MCM

ii Non-monsoon season will be = 2/3 of Jamania water + 5% of unstored Karmnasa water +Full stored water
= (2/3 of 308 + 0.05(937-354) + 354)MCM =588MCM

vi Surplus/Deficit in the Basin

From the re-assessment of surface water requirement and availability detailed at Annexture 6.1.2.3, it would be seen that, there is in fact shortage of water in the basin to the extent of 5586 MCM, even after consuming total water made available to Bihar through C-SB Link (5566 MCM), Sone water as per agreement (7117 MCM), water made available at Jamania 308 MCM and from en-route system. Thus, according to the present provision of diversion of Ganga water through C.SB Link canal, there is no scope of availability of surplus Sone water for its diversion to the command area east of river Punpun.

6.1.2.3 CONCLUSION:

i. The water demand in the Sone canal command with CCA of 10.78 Lakh ha and irrigation intensity of 240 %, together with other non-irrigation demand, in the command will be 21,282 MCM.

ii Against this demand, the water availability is 15695 MCM which includes 7117 MCM of Sone water released through Kadwan dam and 5566 MCM of Ganga water diverted through CSB Link. Thus, there is a shortage of 5586 MCM (ie. 1836 MCM during monsoon and 3750 MCM during non- monsoon) in the command.

iii The proposal of utilising Sone water at Kadwan for diversion towards Badua would be possible, only when the entire Sone canal demand of 7117 MCM and shortage of 5586 MCM in the Sone-Karmnasa-Punpun Basin (vide Annexure-6.1.2.3) is met by diverting water from Ganga to the extent of 18269 MCM (i.e. 5586MCM shortage+ 7117 MCM of Sone agreement + 5566 MCM presently proposed diversion) for Bihar and not merely 5566 MCM. This will enable transfer of 7117 MCM of Sone water through Sone dam, at Kadwan for diversion to STG Link Canal.

iv For meeting the shortage in the command, either partly as proposed by NWDA or fully as proposed by the Committee, the Ganga is the only source left to meet the demand and C-SB Link canal will serve the purpose of transferring Ganga water to this basin.

v. In view of shortage in the basin even after contribution of 5566 MCM of water from C-SB link canal, the proposed substitution of water required for WSLLC & WSHLC command through C-SB link & utilizing the water, thus saved for diversion to deficit area east of Punpun river up to Chandan Chir river through Sone-dam has been analysed in succeeding para dealing with proposed S.T.G LINK.

6.1.2.5 STUDY OF POSSIBILITY OF COVERING THE PROPOSED COMMAND THROUGH A GRAVITY CANAL FROM CHUNAR IN ADDITION TO PUMP CANAL (C-SB LINK CANAL)

6.1.2.5.1 Proposal

The present proposal of NWDA is to cover the whole command of WSHLC & WSHLC along with unirrigated area en-route through a pump canal scheme i.e. Chunar Sone Barrage Link canal taking off from Ganga at Chunar.

The possibility of covering this area as much as possible through a gravity canal also from Chunar was examined. From the available contour/ Topo sheets of the command area it was found that a gravity canal can take off from Ganga with a diversion structure viz. barrage provided across Ganga at Chunar. The barrage can have a maximum possible pond level of 85.0 m which is the highest contour around Chunar. With this pond level at head and a slope of 1 in 20,000 the gravity canal can cover about 5.00 Lac ha. in Bihar up to Sone river as shown in Index plan (Plate No2A) enclosed.

The canal after taking off from Chunar will have to run for a length of about 200 km. before it outfalls in Sone river near Arwal. As per rough alignment drawn on the Topo Sheet, it enters Bihar at about 50 Km. somewhere between Chand and Karmnasa after running through its command in UP. On its way, it will be crossing the existing Sone Canal System at following salient points besides major crossings on river Karmnasa and Durgawati.

Gara-Choubey Br. Canal	- about 4 Km. u/s of vill. Basawan
Buxar Canal	- Near vill. Natwar
Dumrao Br. canal	- Near vill. Josaldih
Bihea Br. Canal	- Near vill. Sikraul
Arrah Canal	- Near Harpur Lock

ii. The balance area of about 3.58 Lac. ha lying south of gravity canal up to Kaimur hills will still be left to be irrigated through the Chunar Sone Barrage Link canal as proposed by NWDA.

iii. The proposed gravity canal will have following advantages:

a. In NWDA proposed C-SB Link canal takes off with FSL of 60.00 m at head and involves a lift of 64.40 m up to Sone barrage. This lift of 64.40 m will be substantially reduced by about 24 to 25 m as the Link will now take off from Pond Level of about 85.0 m at Chunar.

b. This will reduce the cost of pumping considerably.

c. The amount of energy required for pumping will also be reduced substantially.

d. It will ensure uninterrupted irrigation which may not be the case in case of pump canal owing to uncertain power situation or sudden electrical or mechanical break down.

Looking to the advantages of the gravity canal with a barrage at Chunar, it is suggested that the proposal to irrigate the Karmnasa-Sone-Kao-Gangi-Punpun(Part) composite basin partly by gravity canal and partly by pump canal from Chunar to Sone Barrage should be given the weightage that it deserves and should be recommended to NWDA for adoption in lieu of one pump canal only involving high lift.

6.1.2.5.2 Water demand and Availability

In view of the above proposal, the Karmnasa-Sone-Kao-Gangi Punpun(Part) composite basin has been divided into three sub basins as below:

i. Karmnasa-Sone-Kao Gangi- Punpun (part) composite basin in the north of gravity canal.

ii. Karmnasa-Sone-Kao- Gangi Punpun (part) composite basin at higher contour, south of gravity canal.

iii. Karmnasa-Sone-Kao- Gangi Punpun (part) composite been, falling between river Sone in the west and river Punpun in the east.

The water demand and availability in the above, referred three sub-basins have been worked out and discussed in Para 6.3.4.1 and Para 6.3.5.1.

6.2 SONE DAM- SOUTHERN TRIBUTARIES OF GANGA.(S.T.G) LINK PROJECT

6.2.1 NWDA proposal

6.2.1.1 General Outline of the Scheme

The proposed Sone dam- STG link is proposed to divert about 2,512 MCM water to save the drought prone area of South Bihar. The districts to be benefited by this link are Patna, Nalanda,Gaya, Jehanabad, Nawada, Aurangabad, Munger and Bhagalpur.

The link canal takes off from tailrace of Kadwan Dam located on right bank at an elevation of 140 metre. The link canal benefits the un-irrigated areas of Central Bihar located between north of link canal upto 60 m contour line lying south of Ganga river and between Sone river to Badua river. The link canal will irrigate new command area and command areas under existing schemes that have less than 100% intensity of irrigation at enhanced 100% irrigation intensity. The link canal will also meet 50% of the domestic and industrial needs amounting to 360 MCM of water for enroute areas besides irrigation requirement of 1998 MCM of water to irrigate 3,06,846 ha (2,98,846 ha in Bihar and 8,000 ha in Jharkhand) and conveyance loss of 154 MCM of water. Thus the link canal will carry 1998+360+154= 2512 MCM of water for irrigation & M I uses.

This scheme consist of

i) A 32 m high earthen dam with central spillway is proposed to be constructed across river Sone. The gross capacity of the dam is 3250 MCM at MWL of 166m and is 3100 MCM at FRL of 165 M. A powerhouse of installed capacity 90 MW is also proposed at the dam site. The spillway is designed to pass the designed flood discharge of 38000 cumecs.

ii) A 339 Km long link canal is offtaking at FSL 140 m from tail race channel and outfalling into Badua left bank canal at FSL 92.771 m. Its design discharge is 190.43 cumecs at head and 14.02 cumecs at tail. The longitudinal slope of 1 in 20,000 and side slope of 1.5:1 for inner slope and 2:1 for outer slope is provided for the entire length of link canal. The bed width and full supply depth at head and tail are 30 m and 5 m respectively. The velocity of water at head and tail are 0.986 m/sec and 0.571 m/sec respectively.

iii) This link canal consists of 2 level crossing (barrages) at North Koel and Sakri rivers, 24 aqueducts, 7 super-passages and 14 canal syphons at the crossing of major drains and existing canals, 3 link canal head regulators 5 cross regulators and 10 HR for branch canals and 25 canal H/R. In addition 31 nos. of road bridges and 4 nos. railway bridges have been provided, out of which 3 nos. are on NH Crossing. Two hydel P.S. of 3.5 MW and 1.5 MW capacity are also proposed.

An Index plan of NWDA showing lay out of the scheme is enclosed at Plate No. 3

6.2.1.2 Hydrology

The Sone river one of the major Southern tributaries of the Ganga, joins Ganga from right side. Its total length is 784 Km. out of which 500 Km, 82 Km and 202 Km fall in M.P,U.P and Bihar respectively. The catchments area of the Sone river system is 69030 sq. Km. This river outfalls into the Ganga about 16 Km upstream of Danapur near Maner at Latitude 25^0 14'0" N and longitude $84^0$42'0"E.
The length of Sone river upto Kadwan dam is 605 Km and the catchment area upto dam site is 54,656 sq Km. out of which 1666 sq Km. lies in Bihar which is about 3.05% of total area.

6.2.1.3 Yield Computations

i. The Sone River Commission had computed the yield series at Kadwan dam site by considering 41 years data from 1940-41 to 1980-81 and found it to be 16069 MCM & 20633 MCM at 75% and 50% dependability respectively.

ii. In the Kadwan Reservoir Project report prepared by Water Resources Department, GOB. The 75% dependable flow was assessed as per the Bansagar Agreement and mentioned as 14654 MCM.

iii. The National Water Development Agency also assessed the Water availability at Kadwan dam by establishing the rainfall - runoff relationship at Japla G & D site which is located downstream of Kadwan dam site. The monthly rainfall data of 1940-41 to 1985-86 have been considered for assessing the water availability and yield found to be 16876 MCM and 20064 MCM at 75% and 50% dependability respectively which have finally been adopted for Water Balance Study.

6.2.1.4 Water Balance Studies

i. The water balance worked out by NWDA is based on yield computation of 16,876 MCM (ie. 13.68 MAF) at 75% dependability.

ii. The export outside basin has been assessed as below -

S.N	Particulars of Project	Withdrawal in MCM
1	For Sone Barrage a) For Sone Low level canal in Bihar b) For Sone High level canal in Bihar Total	 6167.40 (5.0 MAF) 925.11 (0.74 ") 7092.51 (5.74 ") (1)
2	For Dhandhraul (Ghaghar) Project in UP	144.32 (0.12 MAF) (2)
3	(a) From Bansagar Project to MP (b) From Bansagar Project to UP Total	1851.51 (1.50 MAF) 962.11 2813.62 (3)
4	(a) Sone Pump Canal for UP (b) Sone Modernization for Bihar Total	271.37 61.67 (0.05 MAF) 333.04 (4)
	Grand Total-(1+2+3+4) =	10,383.49 (8.42 MAF)

Accordingly, 10384 MCM has been assessed as export out side Basin.

iii. Taking into consideration the export out side basin, the surface water needs and regeneration from irrigation and M.I. uses, the water balance upto Kadwan at 75% dependability works out to (-) 3020 MCM as shown in Table 6.10

TABLE- 6.10

WATER BALANCE OF THE SONE BASIN UPTO KADWAN.

		Unit in MCM	MAF
I	**Availability.**		
	Gross annual yield		
i.	75% dependability	16876	13.68
ii	50% dependability	20064	
b	Import	Nil	
c	Export	10384	
d	Overall availability		
	75% dependability	**6492**	
	50% dependability	**9680**	
II.	**Surface water needs:**		
i.	Irrigation use	7152	
ii	Domestic use	274	
iii	Industrial use	597	
iv	Hydro Power	1664	
v	Thermal power	998	
	Sub-Total	**10685**	
III	**Regeneration From:**		
I	Irrigation use	476	
ii	Domestic use	219	
iii	Industrial use	478	
	Sub total	**1173**	
IV	**Water Balance at**		
	75% dependability	**(-) 3020**	
	50% dependability	168	

6.2.1.5 Water Transfer Through SONE DAM- STG LINK

i) In the NWDA report, the Sone-STG link canal is proposed to off-take from the tailrace of Kadwan hydel project and outfall into Badua Left bank canal after traversing a distance of 339 Kms.

ii) The water balance study of surface water at Sone (Kadwan) dam reveals annual deficit of 3020 MCM (vide Table-6.10) which is worked out after accounting an export of 7093 MCM (5.67 MAF) water meant to be released from Kadwan dam for Indrapuri (Sone) barrage as committed release. Supplementing a quantity of 5702 MCM (3020 MCM for Kadwan dam deficit; 2512 MCM for Sone dam- STG link need and 170

MCM for Kadwan reservoir loss) through Chunar (Ganga)- Sone barrage link at Sone barrage, a net surplus of about 4073 MCM (7093-3020) of water will be available at dam site. Out of this surplus 2512 MCM is proposed to be diverted through Sone dam-STG link and balance 1391 MCM (7093-5702) will be left through river course for Sone barrage for meeting partial committed release of 7093 MCM.

6.2.1.6 Enroute Command of STG. LINK PROJECT

i. The un-irrigated culturable area lying east of Sone river and falling in Punpun, Harohar, Kiul and Chandan-Chir river Basins above 60 m contour forms the enroute command of the Sone Dam S.T.G. Link Project since the area below 60 m contour is proposed to be irrigated by pump canals direct from Ganga at suitable locations.

ii. The total C.C.A. between Link Canal and Ganga has been computed as 14,52,579 ha. After deducting an area of 644,297 ha for C.C.A. below 60 M contour the C.C.A. between link canal and 60 M contour works out to 8,08,282 ha. Out of this, the C.C.A. already covered by existing and on-going irrigation schemes in the area has been worked out as 5,62,360 ha. Deducting C.C.A. in canal deep cutting amounting to 6800 ha the net C.C.A. works out to 8,08,282- 5,62,360- 6800= 2,39,122 ha.

iii, As per norms adopted by NWDA for Himalayan component of the inter, linking schemes, the projects which have crop intensity less than 100% are to be enhanced to a level of 100% by way of additional intensification. 38 nos of irrigation projects lying in the command have been identified which would need additional intensification of crop intensity that works out to 67,724 ha.

iv. Thus the total C.C.A. to be benefited by the link thus works out to 3,06,846 ha as below:-

(i) New area to be commanded- 2,39,122 ha
(ii) Addl.area to be intensified - 67,724 ha
Total C.C.A = 3,06,846 ha

v. The above area lies between Sone river on west to Chir River on east which would need a link canal of 400 Km to reach the tail end. But since the area beyond Badua river (RD 339.85 Km) up to Chir River is very small i.e. 2957 ha only, the link canal is proposed to terminate at Badua reservoir left canal at 339.00 Km itself and the water needed to irrigate 2957 ha beyond Badua river is proposed to be released in Left canal for substitution in Right canal to cover 2957 ha up to Chir River.

6.2.1.7 Proposed Crop Intensity.

In the present scheme a crop intensity of only 100% has been adopted both for new command area and for intensification in areas, where existing crop intensity is less than 100%. The cropping pattern adopted is as below:

Kharif-	48 %
Rabi-	48 %
Hot Weather	4 %
	100 %

6.2.1.8 Water Requirement

(a) **Irrigation Needs**:

The month-wise and crop-wise water requirement has been worked out on modified Penman method with a project efficiency of 65% for paddy and 55% for other crops. Based on proposed cropping pattern and crop wise water requirement month wise water requirement was computed for 1000 ha which gave an overall delta of 0.651m.
Thus total irrigation water need works out to 1998 MCM as below:

To irrigate new area		1556.70 MCM
For additional intensification		440.93 MCM
	Total	1997.63 MCM
	or say -	1998 MCM

(b) **Domestic and Industrial Needs**:

(i) Based on per capita demand of 70 and 200 litres for rural and urban population the water need works out to 302.5 MCM and 107.2 MCM respectively.

(ii) The live stock need has been worked out as 36.9 MCM based on 50 litres per capita demand.

(iii) 50% rural and entire urban water needs are proposed to be met from surface water which works out to 258.5 MCM while the entire livestock and 50% of rural use are proposed to be met from ground water.

(iv) In absence of any details, the industrial need has been assumed to be equivalent to total domestic need which works out to 446.6 MCM as below:

Domestic need for rural area	302.5 MCM
Domestic need for Urban area	107.2 MCM
Live stock need	36.9 MCM.
	446.6 MCM

(v) Thus total surface water need for domestic and industrial use works out to 258.5+446.6= 705.1 MCM.
But as there are numerous schemes in the area, it has been proposed to meet 50% of the need i.e. about 360 MCM from the link canal.

(c) **Total Water Requirement**

Thus total water need for transfer through these link canal works out to 2512 MCM as below :

(i) Irrigation need	1998 MCM
(ii) M & I uses	360 MCM
(iii) Transmission Loss-	154 MCM
	2512 MCM.

6.2.2 OBSERVATIONS OF THE COMMITTEE

6.2.2.1 On Water Balance Study by NWDA:

According to Bansagar Agreement, the total 75% dependable flow of river Sone assessed at Indrapuri Barrage as 17,577 MCM (14.25 MAF), has been allocated between co-basin states as given here under,

Madhya Pradesh	6476 MCM (5.25 MAF)
Uttar Pradesh	1542 MCM (1.25 MAF)
Bihar (Now, Bihar + Jharkhand)	9559 MCM (7.75 MAF)
Total	17577 MCM (14.75 MAF)

Entitlement of MP & UP over Sone water is from the river upstream of Sone Dam at Kadwan. Thus the total utilisation upstream of dam should be limited to 8018 MCM (6.50 MAF). But the Water Balance study done by NWDA and presented in table 6.10 indicates total projected utilisation as given below:-

Surface water need U/S	10685 MCM
Regeneration	1173 MCM
Thus net utilisation U/S	9512 MCM

Further while calculating export outside basin, the NWDA has indicated utilisation of 2813.62 MCM in MP & UP from Bansagar dam as well as of 144.32 MCM from Dhandhraul (Ghaghara) project and 271.37 MCM from Sone Canal Pump Scheme both in UP (refer table in para 6.2.1.4)

Taking these two utilisations also into account, total utilisation in MP & UP upstream of Sone dam at Kadwan would be 12741 MCM (9512 MCM + 2813 MCM + 144.32 MCM +271.37 MCM). This is about 159 % of their allocate share. Obviously, this is an utter violation of the provisions of the Bansagar Agreement, which is a matter of great concern for Bihar. The NWDA should ensure that the

i The upstream utilizations in M.P and U.P are strictly limited to 8018 MCM (i.e. 6.50 MAF)

ii The availability of water as 8858 MCM from Kadwan reservoir for use in Bihar and Jharkhand.

6.2.2.2 Revised Water Balance Study by the Committee.

If utilisations in the upper states (ie. UP& M.P) are limited to their share according to Bansagar Agreement, the net water available at Kadwan for use below (ie Bihar and Jharkhand) will be 8858 MCM and not as (-) 3020 MCM as indicated by the NWDA in table 6.10. This will be clear from the revised Water Balance Study carried out by the Committee.

Water Balance of the Sone River at Kadwan carried out by the Committee

		Unit MCM	MAF
1	Availability at 75% dependability	16876	13.68
2	Utilisation in upper co-basin states limited to their share as per Bansagar Agreement		
	M.P	6476	5.25
	U.P	1542	1.25
3	Balance at Kadwan site for Use in Jharkhand and Bihar	8858	7.18
4	Diversion for use in Jharkhand	1850	1.50
5	Balance available at the dam for use in Bihar	7008	5.68
6	Yield from catchments between Kadwan Dam and Indrapuri Barrage (17577-16876=701 MCM)	701	0.57
7	Total Water available at Indrapuri Barrage	7709	6.25
8	Upstream Utilisation by Bihar	592	0.48
9	Balance for diversion through SD STG Link	7117	5.77

6.2.2.3 Other Comments :

Other comments on NWDA proposal are as follows

i) The crop intensity limited to 100% adopted for water planning by NWDA is too inadequate.

ii) The NWDA has reduced the height and other particulars of Kadwan Dam in the present link scheme as compared to the Kadwan Dam already proposed by GOB as shown below for stabilising irrigation in Sone canal System and generation of Hydel Power, much to the detriment of Bihar.

TABLE- 6.11

Kadwan Dam Particulars

Sl.No	Particulars	In NWDA Proposal	In GOB Proposal
1	Height	32.00 m	45.00 m
2	MWL	166.00 m	175.00 m
3	FRL	165.00 m	173.00 m
4	Gross storage -i. at MWL ii-at FRL	3250MCM 3100 MCM	5050 MCM 4525 MCM
5	Power generation	90 MW	450 MW.

iii) From Table 6.11, it will be seen that Bihar's proposal of generating 450 MW of Hydel Power has been drastically reduced to 90 MW in the NWDA proposal which goes against the interest of Bihar which is facing acute power shortage since bifurcation with Jharkhand State.

iv) Water balance status of en route rivers being crossed by the link canal have not been considered. This should be considered along with feasibility of storage schemes on the enroute rivers, as this will help in stabilising irrigation in this drought prone area and in increasing the crop intensity.

v) Navigation feasibility also has not been provided in the Link proposal.

vi) From the above observation, it would be clear that the present NWDA proposal of Sone dam - STG Link is not feasible unless adequate water is arranged from river Ganga at Chunar for diversion to meet the needs of South Bihar.

6.3 STUDY FOR STABILISING IRRIGATION IN SOUTH BIHAR.

6.3.1. General.

The geographical area of south Bihar is 37722 Sq. km. of which 160.2 sq km is drought prone. The present population of this portion of the state is 302.9 lakh as per census report of 2001. This population is expected to rise to 759.99 lakh by the year 2050. The culturable command area of this portion is 25305 Sq. Km. and total water available at 75% dependability has been assessed as 19527 MCM, the breakup being 12153 MCM during monsoon and 7374 MCM during non-monsoon. The water availability per ha. CCA is 7716 MCM and per capita of population is 645 MCM for the year 2001 . The per capita availability of water will reduce to 257 MCM by the year 2050. Considering the need of the population by the year 2050 the requirement of water for the south Bihar has been assessed as 47981 MCM **(vide Annexure 4.4).** The breakup of the demand is as given below:

Unit MCM

SN	Particulars of Demand	Requirement of water		Total
		Monsoon Season	Non-monsoon Season	
1	2	3	4	5
1	Irrigation	15627	22062	37689
2	Non-irrigation	3070	7222	10292
3	Total	18697	29284	47981

The NWDA has intended to divert 5918 MCM of Ganga water from Chunar for its utilisation in the south of river Ganga including U P & Bihar. Out of this, 352 MCM is for use in UP and the remaining 5566 MCM is earmarked for use in South Bihar (vide table 6.6). Taking this water also into consideration, total water availabile for the South Bihar will be 19527+5566 = 25093 MCM and its season-wise distribution will be 14008 (i.e.12153 + 1855) MCM during monsoon and 11085 (i.e. 7374+ 3711) MCM during non-monsoon. Even with this increase in water resources, this region will be in shortage of water to the tune of 22883 (i.e. 47981-25023 MCM break up being 4689MCM even during monsoon and 18199 MCM during non-monsoon as shown below

Unit MCM

S.N	Particulars	Monsoon	Non-Monsoon	Total
1	Water available fom resources within south Bihar	12153	7377	19527
2	Water made available through C.SB Link	1855	3711	5566
3	Total available water resources	14008	11085	25093
4	Demand of water for south Bihar	18697	29284	47981
5	Deficit (-)/Surplus (+) (3-4)	(-)4689	(-)18199	(-)22888

In order to meet this shortage of water, it is imperative to formulate comprehensive planning of the basins in this region.

6.3.2 Alternative proposal

The Committee after due deliberation have considered two alternatives proposals of water supply for irrigation and non-irrigation purposes for the entire culturable command area(i.e. 25,305 sq km.) falling in south Bihar . These two alternatives are explained below:

i. **Alternative I**

In this alternative, it is considered that the water demand of the Sone-Karmnasa-Punpun (Part) composite basin i.e. the area between the U.P- Bihar border in the west to the river Punpun in the east will be met by water resources available from river Karmnasa and following resources:

a) Allocated diversion from river Ganga at Jamania i.e 308MCM(0.25 MAF)
b) Surface runoff of river Kao- Gangi,
c) Water allocated from river Sone i.e.7117 MCM (5.77 MAF) and
d) Ganga water diverted through C-SB Link as proposed by NWDA(i.e. 5566 MCM).

In this alternative the allocated water of river Sone to be released below Sone Dam at Kadwan, will be fully consumed in this composite basin. Thus the Sone water will not be available for its diversion for the command area east of river Punpun

ii. **Alternative II**

In this alternative, it is considered that the allocated Sone water to be utilised in Sone canal command i.e. 7117 MCM will be saved by substitution of Ganga water diverted in this command through C-SB Link and thus saved water of river Sone will be released through Sone Dam at Kadwan for its use in the command area of South Bihar, in the east of river Punpun.

6.3.3 Water Availability and Demand in Composite Basins of South Bihar:-

6.3.3.1 In order to have a comprehensive planning of this portion of Bihar, the entire South Bihar has been spilt up into three composite basins, such as

i. **Sone-Karmnasa-Punpun(Part) composite basin**

This composite basin constitutes the area falling in Karmnasa basin, Sone basin and Punpun basin on left bank of river Punpun. The CCA for this composite basin is 10,78,128 ha. The irrigation intensity adopted for this basin is 240 % consisting of 95% Kharif, 95% Rabi and 50% Hot weather.

ii. **Punpun (Part) -Harohar-Kiul (Part) composite basin**

This composite basin constitutes the Punpun basin falling in the east of the river Punpun, complete Harohar basin and Kiul basin only in the west of river Kiul. The CCA of this composite basin is 9,68,523 ha. The irrigation intensity adopted for this composite basin is 240 % consisting of Kahrif 95%, Rabi 95% and Hot weather 50% for the area falling in the Punpun basin and 230% consisting of Kahrif 95%, Rabi 90% and Hot weather 45% in the rest of the composite basin.

iii. **Kiul(Part)-Badua-Belharna-Bilasi-Chandan-Chir-Ganga stem composite basin**

This composite basin constitutes the area falling in east of river Kiul extended upto complete Bilasi-Chandan-Chir basin excluding the area falling in the Jharkhand. The CCA for this composite sub-basin is 4,83,889 ha, the irrigation intensity adopted for this sub-basin is 230% comprising of 95% Kharif, 90% Rabi, and 45% Hot weather.

6.3.3.2 Composite Basinwise Water Availability from their own resources

The annual and season wise break up of the water resources of the individual composite basin from their own resources have been worked out at Annexure 6.1.2.2, 6.3.3.2 & 6.3.3.3. Their abstract is shown in Table 6.12 below.

Table 6.12

Available water resources of the composite basins at 75 % dependability (Unit MCM)

SN	Composite Basin	Source of Supply		Water Resources at 75 % dependability		
				Monsoon	Non-monsoon	Total
1	2	3		4	5	6
1	Sone-Karmnasa-Punpun (Part) (CCA 10,78,128 ha.)	i.	Karmnasa	657	588	937
		ii.	Jamania (from Ganga)			308
		iii.	Sone agreement	2372	4745	7117
		iv.	Kao-Gangi	813	71	884
		v.	Storages	0	592	592
		vi.	Ganga Stem, 6a	262	29	291
	Total without Chunar water			**4104**	**6025**	**10129**
		vii	Ganga water at chunar as per NWDA proposal	1855	3711	5566
	Total with Chunar water			**5959**	**9736**	**15695**
2	Punpun(Part)-Harohar - Kiul (Part) (CCA 9,68,523 ha.)	i.	Punpun	2073	180	2253
		ii	Harohar	2914	386	3300
		iii	Kiul (40%)	193	91	284
	Total			**5180**	**657**	**5837**
3	Kiul(part)-Badua-Belharna-Bilasi-Chandan-Chir-Ganga stem (CCA 4,83,889 ha.)	i	Kiul (60%)	300	126	426
		ii	Badua-Belharna	427	310	737
		iii	Bilasi-Chandan-Chir	1326	165	1491
		iv	Ganga stem 6b	816	91	907
	Total			**2869**	**692**	**3561**
	Total South Bihar, without Chunar water			**12153**	**7374**	**19527**
	Total South Bihar, with Chunar water			**14008**	**11085**	**25093**

6.3.3.3 Composite Basinwise Water Demand

Irrigation demand as well as non-irrigation demand for each composite basin of South Bihar has been worked at Annex 6.1.2.3, 6.3.3.2 & 6.3.3.3. Accordingly, the water demand for South Bihar is as furnished in Table 6.13

Table 6.13
Water Demand for the composite basins of South Bihar (Unit MCM)

SN	Name of composite basin	Irrigation Demand			Non-irrigation Demand			Total Demand		
		Monsoon	Non Monsoon	Total	Monsoon	Non Monsoon	Total	Monsoon	Non Monsoon	Total
1	2	3	4	5	6	7	8	9	10	11
1	Sone-Karmnasa-Kao-Gangi-Punpun (part) (CCA 10,78,128 ha.)	6657	10209	16867	1138	3276	4414	7796	13486	21282
2	Punpun (part)-Harohar- Kiul (part) (CCA 9,68,523 ha.)	5981	8089	14070	1241	2483	3724	7222	10572	17794
3	Kiul(part)-Chandan-Badua- Bilasi-Chir-Ganga Stem (CCA 4,83,889ha.)	2988	3763	6751	691	1463	2154	3679	5226	8905
	Total	**15626**	**22061**	**37687**	**3070**	**7222**	**10292**	**18697**	**29284**	**47981**

6.3.4 ALTERNATIVE I FOR EACH COMPOSITE BASIN

6.3.4.1 Sone Karmnasa Punpun (part) CompositeBasin

Water demand of this composite basin vis. a vis. water availability as worked out in Table 6.12 & 6.13 is presented in Table 6.14

Table 6.14
Availability of water vis. a vis. demand of water in Sone - Karmnasa-Punpun (Part) Composite Basin

(Unit MCM)

SN	Particulars	Monsoon	Non-monsoon	Total	Reference
1	2	3	4	5	6
1	Water availability on 75% dependability without Ganga water to be diverted through C-SB Link canal	4104	6025	10129	Table 6.12
2	Water Demand	7796	13486	21282	Table 6.13
3	Water deficit (-) or surplus (+) * (1-2)	(-) 3692	(-) 7461	(-) 11153	
4	Supplemented Ganga water through C-SB Link as proposed by NWDA	1855	3711	5566	Table 6.13
5	Net deficit (-) or surplus(+) ** (3+1)	(-)1837	(-)3750	(-)5587	

* Without Ganga water from Chunar
** With Ganga water from Chunar

This Table indicates that even after consumption of full amount of water from Kararnnasa, river Ganga at Jamania, Sone-Kao-Gangi, stored water in North Koel basin and that from Ganga stem, there is shortage of 3692 MCM of water during monsoon and 7461 MCM during non-monsoon total being 11153 MCM in a year. Against this, the NWDA proposal is to divert only 5566 MCM of Ganga water through C-SB Link. (for exclusive use in Bihar), the season-wise breakup being 1855 MCM during monsoon and 3711 MCM during non-monsoon period. Thus even after full consumption of proposed diversion of Ganga water at Chunar ie 5566 MCM and allocated water of river Sone as per Bansagar Agreement (ie.,7117 MCM), this basin itself is in shortage of 1837 MCM in monsoon and 3750 MCM in non-monsoon season, total deficit being 5587 MCM. As such, the question of diversion of Sone water to the quantum of 7117 MCM from Kadwan dam to be utilised in the area east of river Punpun is not possible.

6.3.4.2 Punpun (part) Harohar-Kiul (part) Composite Basin

The arrangement for stabalising irrigation in this command is shown in Plate no. 3 A.

6.3.4.2.1 Water Availability vis.-a-vis. Demand.

Water availability vis.-a-vis. demand of this composite basin is presented in table 6.15

Table 6.15
Availability of water vis.a.vis. demand of water in Punpun(part) Harohar-Kiul(part) composite basin

(Unit MCM)

SN	Particulars	Monsoon	Non-monsoon	Total	Reference
1	2	3	4	5	6
1	Water availability at 75% dependability	5180	657	5837	Table 6.12
2	Water demand for CCA of 9,68,523 ha.	7222	10572	17794	Table 6.13
3	water deficit (-)/ surplus (+) (1-2)	(-) 2042	(-) 9915	(-)11957	

This table indicates that even after consumption of full amount of water from river run off schemes, and reservoir storage, there is a shortage of water in the basin to the extent of 11957 MCM, consisting of 2042 MCM during monsoon and 9915 MCM during non-monsoon season. This deficit of 11,957 MCM can be supplemented with Ganga Water

In order to pump out the Ganga water, the Committee has formulated a pump scheme at Barh in the name of "Barh (Ganga)-Laundh Barrage Multipurpose Pump Scheme" detailed below.

6.3.4.2.2 Barh (Ganga)-Laundh Barrage Multipurpose Scheme

Out line of the scheme

This is an alternative Proposal of Sone Dam -STG Link proposed to irrigate area between Punpun and Kiul. Since very few storage schemes of low capacity exist in the area between Punpun and Kiul river, it is proposed to cover the area upto E.L. 120 m i.e. 6,50,817 ha. by pumping. 11,957 MCM of water from suitable location on Ganga, west of Barh into the existing rivers by making barrages on Dhowa, Goithwa, Panchane and Dhanarjai rivers as shown in the Index Map attached at Plate no.3 A. In this proposal, area between Punpun and Kiul rivers will be irrigated by gravity canal, which will take off the Barh(Ganga)-Laundh carrier canal at different locations. In this scheme, water will be lifted at different pumping stations during off period when power demand will be comparatively less. A schematic diagram of proposed scheme and L/s of Master Channel is shown at Fig. 6.1, 6.3 & 6.4

Component of the scheme

The components of the scheme will be as given below: -

i) An intake structure with suitable pump house located in the west of Barh to divert 2042 MCM of Ganga water during monsoon season and 9915 MCM during non-monsoon season.

ii) 124Km long carrier system, also called as Master Channel. This Master Channel will consist of

  a) 4.25 KM long cut from pump house west of Barh to river Dhowa, just before the confluence of Dhowa-Goithwa confluence.

  b) 119.75 KM long water carrier system running almost south ward right from river Dhowa to village Laundh at Dhanarjai.

  This carrier system will be constructed by utilising and remodeling existing natural routes of river system as described below: -

  a. River Goithwa from its confluence with river Panchane to its outfall in to river Dhowa, the length being about 53.75 KM.
  b. River Panchane from its confluence with river Dhanarjai to its outfall into river Goithwa, the length being about 15 KM.
  c. River Dhanarjai from village Laundh to its outfall into river Panchane, the length being about 51 KM.

iii) A series of barrages i.e., 14 in nos. for maintaining required water level in the master channel. These barrages will be located as indicated below: -

  a) Barrage no. 1 will be located across river Dhowa just below the confluence of Dhowa-Goithwa rivers.
  b) Barrage no. 2 & 3 will be located across river Goithwa
  c) Barrage no. 4 & 5 will be located across river Panchane
  d) Barrage no. 6 to 15 will be located across river Dhanarjai

iv) Canal system taking off either bank of Master Channel at its 0 KM, 6.72KM, 90.2 KM and 124 KM.

v) Locks on barrages to provide navigation facilities right from Laundh to Barh.

vi) Pump sets at each barrage site to raise the water level in the master channel.

vii) Hydel power generating stations to generate peaking hydel power for four hours by reversing the flow in the master channel.

A tentative schematic drawing of this scheme is enclosed at fig.no.6.1, & 6.3 which would need modification, as required necessary, after detailed investigations.

Function of the scheme

The system will involve a total lift of about 74 m i.e. from RL.46 m in Ganga to RL.120 m at Laundh barrage in Dhanarjai river with lift of about 5.5 m to 6m at each pumping point as proposed. In this system the water from Ganga will be pumped into River Dhowa, from Dhowa river to the Goithwa River, followed by Panchanae River, Khuri River, and finally into Dhnarjai River upto Laundh Weir. However, during monsoon period, water of Dhowa going to Mokama tal area will be pumped out into the Master Channel as far as, it is possible.

The pumped water in above network of Master Channel will be utilised in meeting the water demand in the command, through the canal system taking off either bank of the Master Channel at its 0 Km, 6.72 Km, 90.2 Km and 124 Km.

Off-taking channels

The proposed off-take Channels are enumerated below.

Km	Name of the river/ weir	Proposed percentage of area to be covered	Alignment of canal on West	Alignment of canal on East
0	Link Channel	5%	Along the railway line falling into river punpun	Along the railway line falls into river Harohar near Barahiya
67	Panchane weir	35%	U/S of Sansi weir Crossing the command area of Paimar weir to Nischalganj weir, D/S of Bharthunandan weir, Kankbigha weir crossing Dardha river, u/s of proposed Morhar barrage draining out to Punpun.	Firangibigha weir crossing the command of Tati Weir falling into Kiul River.
90.20	Dhanarjai	22%	Dhardha river, Paimar river, Phalgu river, upper Jamuna Irrigation scheme crossing lower Morhar canal to u/s of proposed Punpun barrage at Hamidnagar	Paura weir Chordarga weir Kapasi weir crossing the command of lower Kiul weir, falls into Kiul river.
120	Dhanrjai Laundh Weir	25%	Kadhar weir crossing Paimar river, Phalgu river D/S of Mahabodhi weir Lower Morhar weir scheme Dhawa weir to Batane river	Purain res. to Baksoti barrage, u/s Baghel weir, d/s of Nata weir, d/s of Kailash weir, falls into Kiul river.

The canals taking-off from Master Channel would be oriented such that it meets the water demand of existing irrigation schemes as well as the area, which are not being irrigated presently. The planning of the distribution system in this area is quite simple in view of extreme flatness of the command area. The off-taking canals are proposed to cross number of rivers & major drainage by level crossing and picking up water from these channels in the canal system. It is also proposed to upgrade the existing runoff scheme as well as the reservoir schemes such that the total area has a well-planned foolproof and assured irrigation system.

Benefits of the scheme

Besides the benefit of meeting the irrigational as well as non irrigational demand the other benefit likely to accrue due to implementations of this scheme are: -

i) Navigation

Provisions of locks at barrages and keeping a minimum depth of water as 1.5 meter in the Master Channel will make the channel navigable. This would facilitate carriage of non-perishable goods including coals from Jharkhand state to the Super Thermal Power Stations at Barauni and Barh, certainly at cheaper rate compared to the road transport.

ii) Relief to the tal area

The water coming to the tal area from south will be tapped by distribution network of the irrigation system and also flows of Dhow river in the lower portion can be diverted to the master channel to the possible extent. This will reduce the intensity of water stagnation in the tal area. This may make some area available for cultivation even during monsoon, which is presently not possible.

iii) Power generation:

There is possibility of hydel power generation to the tune of about 354 MW and 196 MW in non-monsoon and monsoon period, respectively, to meet the peak hour demand (6 pm to 10 pm) at different barrage sites during the reverse flow.

iv) Relief to the people leaving along the riverbank.

As the river get dry presently during summer season, the people leaving along the river bank face scarcity of water even for drinking purpose for themselves as well as for their live-stock. The Master Channel, becoming perennial, will make availability of water to them even during summer.

v) Ecological improvement: -

Presently all the river systems of the basin get dry during non-monsoon period. After implementation of the scheme, the Master Channel will become perennial. This will bring improvement in ecology along the rivers.

vi) Improvement in water table.

Irrigation in the basin to the extent of 230%, intensity will help in recharge of the ground water, which will control depletion of the ground water table.

vii) Pisciculture: -

The water mass contained in the series of barrage ponds will provide scope of pisciculture in the area.

6.3.4.3 Kiul (part)-Badua-Belharna-Bilasi-Chandan-Chir, Ganga Stem Composite Basin

6.3.4.3.1 Requirement of Water for the Composite Basin

It has been indicated in Table 6.13 that the demand of water in the composite basin (having CCA as 483889 ha) is 3679 MCM during monsoon season and 5226MCM during non-monsoon, totaling to 8905 MCM in a year. Against this, the water availability in the basin from its own resources is 2869 MCM during the monsoon season 692 MCM during non-monsoon season totaling to 3561 MCM in a year (refer table 6.12). On comparison of the water demand with the availability of water it will be seen that this basin is in shortage of 5344 MCM in a year. The season-wise break of this shortage is 810 MCM during monsoon and 4534 MCM during non-monsoon vide Annexure 6.3.4.3.1 This is also shown in Table 6.16 below.

Table 6.16

Availability of water vis-à-vis. demand of water in Kiul(Part)- Badua - Belharna, Bilasi- Chandan- Chir, Ganga Stem composite basin (Unit MCM)

SN	Particulars	Monsoon	Non-monsoon	Total	Reference
1	2	3	4	5	6
1	Water availability at 75% dependability	2869	692	3561	Table 6.12
2	Water demand	3679	5266	8905	Table 6.13
	Water deficit (-)/ surplus (+) (1-2)	(-) 810	(-) 4534	(-)5344	

The distribution of the annual demand of Ganga water worked out above as 810 MCM during monsoon and 4534 MCM during non-monsoon may vary depending on changes in storage capacities. For meeting this shortage, the only way left for this basin is to use Ganga water by pumping.

6.3.4.3.2 Proposal for meeting the shortage of water in this basin.

The topographical feature of the composite basin is such that scope of any Major irrigation scheme in this terrain is rare. Consequently this basin has to depend only on medium and minor irrigation schemes at higher level and on Ganga water pump schemes at lower level.

For a comprehensive water planning of the basin, it has been considered proper to treat the basin in two parts viz.

i The upper part being located above the contour of 60.0 m and extended uoto Bihar-Jharkhand border in the South. This part measures to 1,44,929 ha.

ii The lower part being located below contour of 60.0 m and extended upto the right bank of river Ganga in the north. This part measures to 3,38,960 ha.

There are a number of medium & minor reservoirs existing at higher contour like Chandan, Badua, Kudar, Darbhansi, Baskund, Belharna, Amhara, Dakra, Orni, Morwe. It is considered that the water available in these schemes will cater for the need of the upper portion of the composite basin ie. above 60.0 m contour covering a CCA of 1,44,929ha.

6.3.4.3.3 Review of Ganga Pump Canal Schemes:

After excluding the CCA above 60.0 m contour the lower portion of the command is totally dependent on Ganga water. This command (CCA= 3,38,960 ha.) will be taken care of by the free flows, coming down from the upper portion and by pumping 5344 MCM of Ganga water. It has been noticed that in this sub basin, there are already several pump schemes either ongoing or proposed as given below:-

i Barari pump canal scheme
ii New Pump canal Scheme near Mahadeopur
iii Dakra nala pump canal scheme phase I & Phase II
iv Ajgaibinath pump canal scheme
v Sakrigali pump canal scheme
vi Bateshwarsthan pump canal scheme
vii Surajgarha Pump canal Scheme

The CCA and the water use of the pump Scheme are shown in table given below

Details of Pump canal scheme in South Bihar in the Kiul (part) - Badua-Belharna- Bilasi- Chandan- Chir - Ganga stem composite basin.

S.N	Name of Scheme	CCA (Ha)	Water Use in MCM
1	Barari Pump Canal Scheme	5520	50.0
2	New Pump canal Scheme near Mahadeopur	17000	198.3
3	Surajgarha Pump canal Scheme	3642	28.2
4	Dakranala Phase I pump canal Scheme	15,280	152.8
5	Dakranala PhaseII pump canal Scheme	3620	47.9
6	Ajgabinath Pump canal Scheme	12820	880
7	Sakrigali Pump canal Scheme	1827	17.5
8	Bateshwarsthan Pump canal Scheme	27479	192.3
	Total	**87188**	775

(Source: Second Bihar State Irrigation Commission Report 1994 -vol.III)

This table indicates that presently, the capacities of these pump schemes and their conveyance system are capable of pumping about 775 MCM of Ganga water, annually to cover a CCA of 87188 ha, of course with lesser intensity. Obviously the capacities of these schemes are very low and not commensurate with the assessed need. In order to meet the anticipated demand of 3,38,960 ha. of the composite basin falling below 60.0 m contour, with 230% irrigation intensity, it is imperative that:

i. The existing Ganga pump canal schemes D/S of the confluence of river Kiul in Ganga may be remodeled and modernised for higher capacities.
ii Some more pump schemes may be installed, if needed.
iii. The conveyance system of all the pump schemes be extended and constructed to cover area upto 60.0 m contour.

However, remodeling, modernization and installation of further new pump schemes in this region will be successful subject to the condition that :

i. Sufficient water is available in river Ganga during non-monsoon season even after the implementation of interlinking schemes proposed by NWDA.
ii There is no restriction on this state on withdrawal of Ganga water during this period.

6.3.5 ALTERNATIVE II PROPOSAL FOR EACH COMPOSITE BASIN

In this alternative, as stated earlier in para 6.3.2, the Sone water i.e. 7117 MCM, to be released below Kadwan dam for utilisation in Karmnasa-Sone-Punpun(part) composite basin, will be saved with supplementation by Ganga water at Chunar and thus saved water will be diverted to the command area of south Bihar, in the east of river Punpun, through Sone Dam Southern tributaries of Ganga (STG) Link canal.

The NWDA has proposed to construct the STG link from Sone Dam at Kadwan upto left Badua canal. But considering the availability of water in the link canal and large demand in the canal, it would not be possible to cover the area beyond river Kiul. Hence the STG Link canal is proposed to construct only upto river Kiul. Thus the saved water of Sone will be available only upto Punpun(Part) Harohar- Kiul (part) basin and it will not be available beyond river Kiul. With this consideration, planning for utilisation of water for the two basins i.e. Karmansa -Sone -Punpun(part) Composite basin and Punpun(part) -Harohar-Kiul (part) Composite basin is required to be modified and that for the third basin i.e. Kiul (part)-Badua-Belharna-Chandan-Chir composite basin will remain unchanged.

6.3.5.1 Karmanasa-Sone- Kao- Gangi- Punpun (part) Composite Basin

This composite basin, for this alternative study is taken to be irrigated partly through a gravity canal taking off the right bank of Ganga barrage at Chunar (newly proposed by the Committee) and partly by the C-SB Link canal off-taking from pond of Chunar Barrage from higher level. These two possibilities have already been discussed in para 6.1.2.5

6.3.5.1.1 Karmanasa-Sone- Kao- Gangi-Punpun (Part) composite basin in the north of the Chunar-Sone-Gravity Canal.

The CCA of this sub-basin (i.e., below 80.0 meter contour) has been found to be 5,00,000 ha. The total water demand for this sub-basin has been found to be 3815 MCM during monsoon season and 6189 MCM during non-monsoon, the total being 10,004 MCM vide Annexure 6.3.5.1.1. The break up of this demand is given in table 6.17 below

Table 6.17
Requirement of water for the Karmnasa- Sone- Kao-Gangi- Punpun (part) Composite basin in the north of Chunar- Sone-Gravity canal

Sl. No.	Particulars	Monsoon	Non-monsoon	Total
1	2	3	4	5
1	Irrigation requirement at 240% irrigation intensity	3088	4735	7823
2	Non irrigation requirement	533	1648	2181
	Total	3621	6383	10,004

Against this demand, the availability of water at 75% dependability from its own resources and that to be available from river Ganga at Chunar but excluding releases below Kadwan dam has been estimated to be 3587 MCM during monsoon and 4045 MCM during non-monsoon as shown in table 6.18

Table No. 6.18
Assessment of water available for the Sone Command in the north of Chunar Barrage Gravity Canal

Sl. No.	Name of Source	Monsoon	Non-monsoon	Total
1	2	3	4	5
1	River Karmanasa free catchments below storage structures	554	29	583
2	Ganga water at Zamania (as per Bansagar Agreement	103	205	308
3	Kao-Gangi Catchment	813	71	884
4	Ganga Stem	262	29	291
	Sub Total	1732	334	2066
5	Ganga at Chunar (as per NWDA Report)	1855	3711	5566
6	Total including Ganga water at Chunar	3587	4045	7632

Taking this availability into account and the demand as indicated in table 6.17, it is found that this composite basin still has a shortage of 34 MCM during monsoon and 2339 MCM during non-monsoon, the total being 2372 MCM annually vide Table 6.19.

Table 6.19
Total need of Ganga water to be diverted from Chunar for the north of Gravity canal in the composite sub- basin

Sl. No.	Particulars	Monsoon	Non-monsoon	Total
1	2	3	4	5
1	Demand of water in command (vide table 6.17)	3621	6383	10004
2	Available water resources including Ganga water to be diverted from Chunar (vide table 6.18)	3587	4045	7633
3	Deficit of water	34	2339	2373
4	Ganga Water to be diverted from Chunar already taken into account in 2 (above)	1855	3711	5566
5	Total need of Ganga water to be diverted from Chunar (3+4)	1889	6050	7939

Thus, in order to meet the demand fully in the gravity canal, this shortage is also to be met with Ganga water at Chunar. This means total needed diversion of Ganga water at Chunar as shown in table 6.19 will be 1889 MCM during monsoon and 6050 MCM during non-monsoon, against the envisaged diversion of Ganga water from Chunar as per NWDA proposal being 1855 MCM during monsoon 3711 MCM during non monsoon.

The required diversion from Ganga thus gets enhanced to 7939 MCM as against present diversion of 5566 MCM in the NWDA scheme as shown above.

6.3.5.1.2 Karmnasa-Sone-Kao-Gangi-Punpun (part) Composite Basin at higher contour, south of Chunar Sone Gravity Canal

The CCA of this sub-basin has been found to be 358485 ha. The total water demand for the sub-basin has been found to be 2596 MCM during monsoon and 4577 MCM during non-monsoon the total being 7173 MCM annually. The breakup of this demand is as shown in table 6.20 (for details refer Annexure 6.3.5.1.1)

Table 6.20
Requirement of water for the Karmanasa- Sone -Kao-Gangi- Punpun (part) composite basin south of Chunar- Sone- gravity canal

Unit: MCM

SN	Particulars	Monsoon	Non-monsoon	Total
1.	Irrigation requirement at 240% irrigation intensity	2214	3395	5609
2.	Non-irrigation requirement	382	1182	1564
	Total	2596	4577	7173

Against this demand, the only possible water resources available for this sub-basin is that from storage structures in Karmnasa basin. This is expected to be about 354 MCM. It is considered that this stored water will be kept reserved for utilisation during non-monsoon period. As such this sub-basin will face a shortage of 2596 MCM during monsoon and 4233 MCM during non-monsoon, the total shortage being 6819 MCM annually vide Annexure 6.1.2.5

There is no way left to meet this shortage but to use Ganga water to be diverted through C-SB Link. Thus the C-SB Link canal, proposed by NWDA, is essential for stabilising the command area of this sub-basin. The needed diversion of Ganga water through this link canal for the composite sub-basin under consideration will be 2596 MCM during monsoon and 4223 MCM during non-monsoon season i.e. 6819 MCM annually.

6.3.5.1.3 Karmnasa-Sone-Kao- Gangi-Punpun(part) Composite basin falling in the east of river Sone upto river Punpun

The CCA of this sub basin has been found to be 2,19,643 ha. The total water demand for this sub-basin has been assessed as 1579 MCM during monsoon and 2525 MCM during non-monsoon, the total being 4104 MCM. The breakup of this demand is as given in table 6.21 (details given at Annexure 6.3.5.1.1)

Table 6.21
Requirement of water for the Karmanasa- Sone -Kao-Gangi- Punpun (part) composite basin falling in the east of river Sone upto river Punpun

Unit MCM

SN	Particulars	Monsoon	Non-monsoon	Total
1	Irrigation requirement at 240% irrigation intensity	1356	2080	3436
2	Non-irrigation requirement	223	445	668
	Total	1579	2525	4104

Against this demand, the possible water resources to be available is 592 MCM of water, stored in reservoirs upstream during monsoon period and to be utilised during non-monsoon period. As such this sub-basin will face shortage of 1579 MCM during monsoon and 1933 during non-monsoon; the total shortage being 3512 MCM.

The only way to meet this shortage in this sub-basin is also to take Ganga water from Chunar. This proposal will need a further, diversion of Ganga water from Chunar in addition to that mentioned in para 6.1.2.5.2. This will also necessitate the extension of C-SB Link canal from Kudra Barrage to Indrapuri barrage. Alternatively, this amount of water can be used from share of Sone water available to Bihar.

6.3.5.1.4 Water to be diverted from river Ganga at Chunar:

Table 6.14 indicates that total water required to be diverted through CSB Link canal is 11,153 MCM (i.e. 3692 MCM during monsoon and 7461 MCM during non-monsoon. Hence, in order to meet the demands of the Sone - Karmanasa- Kao- Gangi-Punpun (part) composite basin the proposed C-SB Link canal should be capable of diverting this much quantity of Ganga water from Chunar and not merely 5566 MCM as intended by the NWDA.

This table, further, indicates that even after consumption of full quantity of 5566 MCM, and entire Kadwan releases, this basin is in shortage of 5587 MCM of water. As such, there is no possibility of sparing Kadwan water to be released for the command area of south Bihar through STG Link. In order to spare Kadwan water for the STG Link, alternative arrangement has been suggested. For this total needed diversion of Ganga water at Chunar for exclusive use in Bihar will be 18,270 MCM annually as shown in table 6.22 (6064 MCM in monsoon and 12,206 MCM in non-monsoon).

Table 6.22
Total needed diversion of Ganga water at Chunar through C-SB Link Canal

unit MCM

S.N	Particulars	Monsoon	Non-monsoon	Total
1	2	3	4	5
1	For command north of Prop. Chunar-Sone through gravity canal (vide table 6.19)	1889	6050	7939
2	For command South of proposed Gravity (vide para 6.3.5.1.2)	2596	4223	6819
3	For command area in the east of river Sone upto river Punpun (vide para 6.3.5.1.3)	1579	1933	3512
4	Total (2+3)	4175	6156	10331
5	Total (1+2+3)	6,064	12,206	18,270

6.3.5.2 Punpun(part)-Harohar-Kiul(part) composite basin

In alternative II releases below Kadwan dam to the tune of 7117 MCM, earlier earmarked for utilisating in Karmansa-Sone-Punpun(part) Composite basin, is to be utilized in the area of the South Bihar east of river Punpun

It has been noticed earlier, in Table 6.13 that the total demand of this basin, irrigation and non-irrigation demands taking together, is 7222 MCM during monsoon and, 10572 MCM during non-monsoon, the total being 17794 MCM. Against this, the availability of water from its own resources is 5837 MCM annually(vide Table 6.12) and 7117 MCM from Kadwan dam. These two totals to 12954 MCM. Still there is shortage of 4840 MCM, which can be met with Ganga water by pumping. This has necesscitated bifurcation of the composite basin into two sub-basin, viz

i. The sub basin which can be irrigated through Kadwan water i.e. the sub basin to be commanded by poroposed STG Link Canals.
ii. The sub basins which can be irrigated through its own basins resources supplemented with Ganga water through lift canal.

Accordingly this composite basin has been divided into two parts viz.

i. The upper part will be above the contour of 88.0 m. This part will be served by proposed STG Link Canal taking off the Kadwan dam.
ii. The lower part will be below the contour of 88.0 m and will be served by proposed pump schemes at Barh through Master Channel taking off river Ganga at Barh and following the same alignment as that of Barh-Laundh Multipurpose Ganga Pump scheme but terminating at near about Nawada. These two proposals shown in Plate no.3B are discussed in following paragraph.

6.3.5.2.1 Upper portion of Punpun(part)-Harohar-Kiul(part) Composite basin

This sub basin will be bounded by river Punpun in the west, river Kiul in the east, alignment of the STG Link in the south and the contour of 88.0 m in the north vide index map at Plate no 3B. The CCA of this sub basin is 387378 ha. comprising of 131775 ha of Punpun river basin 236251 ha of Harohar river basin and 19352 ha of Kiul river basin falling on its left bank.

The irrigation and non-irrigation demand of this sub basin extracted from Annexure 6.3.5.2.1 is as shown in Table 6.23

Table 6.23
Demand of water in the upper part of Punpun(part)- Harohar-Kiul(part) Composide basin

Particulars	Monsoon	Non-monsoon	Total
A Irrigation demand			
Punpun basin, CCA 1,31,775 ha	814	1248	2062
Harohar basin, CCA 2,36,251 ha	1459	1837	3296
Kiul basin, CCA 1,9,352 ha	119	150	269
Sub total A (3,87,378 ha)	2392	3235	5627
B Non- Irrigation demand			
Punpun basin, CCA 1,31,775 ha	134	268	402
Harohar basin, CCA 2,36,251 ha	341	682	1023
Kiul basin, CCA 1,9,352 ha	22	44	66
Sub total B (3,87,378 ha)	497	994	149
Total demand (A+B)	2889	4229	7118

Against this demand total availability of water for this composite sub basin will be 7117 MCM to be released from tail race channel at Kadwan dam. Thus the demand of this sub basin will be fully met by the Kadwan releases

6.3.5.2.2 Lower Portion of Punpun(part)-Harohar-Kiul (Part) composite Basin.

The eastern and western boundary of this sub basin will be also be the same as that of upper sub basin indicated in para 6.3.5.2.1, but the southern boundary will be contour of 88.0 m and the northern boundary will be the right bank of river Ganga vide index map at Plate No. 3B The CCA of this composite sub basin has been assessed as 581145 ha. comprising of 197689 ha in Punpun basin 354425 ha. in Harohar basin and 29031 ha. in Kiul basin.

The irrigation and non-irrigation demand of this sub basin (extract from Annexure 6.3.5.2.2) is as shown in Table 6.24

Table 6.24
Irrigation and Non irrigation demand of the sub basin

Particulars	Monsoon	Non-monsoon	Total
A Irrigation demand			
Punpun basin, CCA 1,97,689 ha	1221	1872	3093
Harohar basin, CCA 3,54,425 ha	2189	2756	4945
Kiul basin, CCA 29,031 ha	179	226	405
Sub total A (5,81,145 ha)	3589	4854	8443
B Non-Irrigation demand			
Punpun basin, CCA 1,97,689 ha	200	401	601
Harohar basin, CCA 3,54,425 ha	512	1025	1537
Kiul basin, CCA 29,031 ha	33	64	97
Sub total B (5,81,145 ha)	745	1490	2235
Total demand (A+B)	4334	6344	10678

Against this demand, the availability of water from its own resources of the basin will be as shown in the Table 6.25 given below

Table 6.25
Availability of water for the Lower Punpun (part)-Harohar-Kiul(part) sub basin
Unit MCM

SN	River basin	Monsoon	Non monsoon	Total
	Spill over from upper sub basin			
1	Punpun basin (60%)	2074	180	2253
2	Harohar	2914	386	3300
3	Kiul(40%)	193	91	284
	Total	5181	657	5837

Taking into consideration the water availability shown in table 6.25 and the demand shown in Table 6.24 the sub basin will be in surplus by 847 MCM during monsoon and in shortage by 5687 MCM during non monsoon. This shortage in this sub basin has to be met by pumping of Ganga water from Barh.

For this purpose the earlier proposal of Barh (Ganga)-Laundh Multipurpose Scheme has to be modified to the extent that :-

i. The Master Channel running from Dhowa cut to village Laundh will be terminated at Nawada at Km 90.2 causing thereby reduction in length of the channel by 29.8 Km.
ii. The carring capacity of Master Channel will be reduced from 9915 MCM to 5687 MCM during non monsoon period.
iii. The lifting head of the Ganga water will be reduced from 74.0 m to 44.0 , the required lift being from RL 46.0 m in river Ganga to 90.0 m i.e. the Pond level of the upper most Barrage across the Master Channel at Nawada.
iv. The number of barrages in this system will reduce to 9 from 14 in the earlier Barh - Laundh Multi- purpose Project.
v. There is no need of lifting of Ganga water during monsoon period.
vi. Power generation during peak demand (i.e. 6 pm to 10 pm) by reversing the flow at different barrages will be about 380 MW during non monsoon period
vii. The outline of the alignment of off taking canal, area irrigated, and capacity of pumps are presented in Table 6.26

Table 6.26
Outline of Barh-Nawada Multipurpose Scheme

Km	Name of the river/ weir	Proposed percentage of area to be covered	Alignment of canal on West	Alignment of canal on East
4.5	Link Channel	5%	Along the railway line falling into river punpun	Along the railway line falls into river Harohar near Barahiya
67	Panchane weir	50%	U/S of Sansi weir Crossing the command area of Paimar weir to Nischalganj weir, D/S of Bharthunandan weir, Kankbigha weir crossing Dardha river, u/s of proposed Morhar barrage draining out to Punpun.	Firangibigha weir crossing the command of Tati Weir falling into Kiul River.
90.20	Dhanarjai	45%	Dhardha river, Paimar river, Phalgu River, upper Jamuna Irrigation scheme crossing lower Morhar canal to u/s of proposed Punpun barrage at Hamidnagar	Paura weir Chordarga weir Kapasi weir crossing the command of lower Kiul weir, falls into Kiul river.

A Schematic diagram of the scheme including L/S and location plan is shown at Figure 6.2, 6.3 and 6.4.

6.3.5.2.3 Water required to be diverted from river Ganga at Barh

Water required to be diverted from river Ganga at Barh for meeting the demand of Punpun(part)-Harohar-Kiul(part) composite basin for two alternative proposals are submersed in Table 6.27 given below:

Table 6.27

Summary of Ganga water required to be diverted at Barh

Unit MCM

SN	Particulars	Monsoon	Non-monsoon	Total	Remarks
1	2	3	4	5	6
1	Alternative-I (vide table 6.15)	2042	9915	11957	Without release below Kadwan dam
2	Alternative-II				With release below Kadwan dam
	i. Above 88.0 m contour (Vide para6.3.5.2.1)	-			
	ii Below 88.0 m contour (Vide para 6.3.5.2.2)	-	5687	5687	
	Total	-	5687	5687	

6.3.5.3 KIUL(PART)-BADUA-BELHARNA-BILASI-CHANDAN-CHIR-GANGA STEM COMPOSITE BASIN

As STG Link Canal is to be terminated on the left bank of river Kiul, there is no scope of alteration in the water resources of the composite basin under consideration. As such planning of stabilization irrigation in this composite basin will be the same as discussed in para 6.3.4.3.

6.3.6 QUANTITY OF WATER REQUIRED TO BE ENSURED IN RIVER GANGA

A At Chunar

i Requirement of flow of river Ganga at Chunar

The prospect of the people of the South Bihar is very closely linked with the success of the two scheme i.e. C.SB Link Canal and SD.STG Link canal and for protecting the prospect of these people, it seems imperative that availability of water in Ganga at Chunar, in adequate quantity, is ensured by the NWDA.

The Second Bihar State Irrigation Commission in 1994 has analysed the observed inflow yield of river Ganga at Buxar for the period from 1959-60 to 1991-92. The Commission has worked out monthwise 75% dependable flow for all the twelve months. The monthwise 75% dependable flow for the non-monsoon month is extracted at table 6.29.

Table 6.28
Monthwise 75 % dependable flow of the river Ganga at Buxar

Unit MCM

Month	Flow at Buxar at 75% dependability
1. November	2599.9
2. December	1794.1
3 January	1430.1
4. February	1153.6
5 March	1067.2
6 April	882.4
7. May	875.0
Total non-monsoon flow	9802.3, say 9802

Thus, 9802 MCM of water is the minimum value of non monsoon flow at Buxar , which should be maintained, in all cases, in order to protect the riparian rights of people living in Bihar below Buxar and also to protect ecology and environment of the region.

Keeping, this in view, and also the required drawal through Chunar Sone barrage (C-SB) Link canal alone or taking together with that through Chunar Barrage Sone gravity canal, the required quantity of Ganga water at Chunar has been assessed as given in table 6.29.

Table 6.29
Required quantity of Ganga water at Chunar for diversion to Chunar-Sone Barrage Link

Unit MCM

Particulars	Monsoon	Non-Monsoon	Total
A. Alternative I * 1. For meeting the shortage in Sone command and STG Link Command (part) vide (Table 6.14)	3692	7461	11153
2. For utilisation in U.P. as proposed by N W D A vide col 5 of table 6.6	244	108	352
3. 75%dependable non-monsoon flow.(vide table 6.28 as assessed earlier at Buxar by the SBSICR 1994)	-	9802	9802
Total 1 to 3	3936	17371	21307
B Alternative II **			
1. For meeting the shortage in Sone command and STG Link Command (part) vide Table 6.22)	6064	12206	18270
2. Total of 2 to 3 of alternative I	244	9910	10154
Total	6308	22116	28424

* If Sone water is supplemented by proposed 5566 MCM of pumped water in existing Karmnasa Sone-Kao-Gangi-Punpun(part) Composite basin

** If Sone water is diverted into Punpun (part)-Harohar-Kiul(Part) Composite

This table indicates that for Alternative I condition, minimum quantity of Ganga water to be ensured at Chunar would be 3936 MCM during monsoon and 17371 MCM during non-monsoon while the same for Alternative II condition would be 6308 MCM and 22116 MCM respectively.

ii Availability of water

It has been indicated in NWDA report on " Preliminary Water Balance Study of river Ganga at Chunar that the virgin inflow yield of the river at the site is 87,232 MCM during monsoon season and 14,177 MCM during non-monsoon season (vide table 6.2). This report further mentions that after complete implementation of river interlinking schemes in the regions, the water balance at Chunar for use in the Chunar-Sone Barrage Link and below will be 8097 MCM during monsoon and 10567 MCM during non-monsoon season. This availability is also subject to the condition that

i. 5245 MCM of water will be available through Gandak-Ganga Link, eventually during non-monsoon.

ii. 4090 MCM will be available through Karnali-Ganga Link during non-monsoon.

The availability of Karnali water is also on the condition, that Gandak water is diverted to Rapti-Saryug basin, on right side of river Ghaghra, to the tune of 5255 MCM during monsoon and 5954 MCM during non-monsoon. Thus total proposed diversion of Gandak water for this purpose, through Gandak-Ganga Link is 5255 MCM during monsoon and 11,209 MCM during non-monsoon (vide para 6.1.2) The water balance study of Gandak-Ganga Link conducted by the Committee indicates that the Gandak river basin itself is in shortage of 24,820 MCM during non-monsoon. Even if all the identified storage schemes in this basin (totaling to 15,553 MCM) are constructed, still this basin will be in shortage of 9267 MCM during non-monsoon. As such diversion of Gandak water to other basin during non-monsoon period is not at all possible. In case Gandak water is not diverted to Rapti-Saryug basin, the water available at Chunar during monsoon and non-monsoon period will be limited to 8097 MCM and 1232 MCM respectively (refer Table 6.2). The non-monsoon flow of river Ganga at Chunar as 1232 MCM during non-monsoon is equivalent to 67.9 cumec i.e. 2400 cusecs (taking non-monsoon period as 7 months only). If it so happens, river Ganga will lose its identity below Chunar and that will be detrimental for the people of south Bihar who are very much dependant on Ganga water.

iii Suggestions

It has been observed in Table 6.29 that, during non-monsoon period required quantity of Ganga water at Chunar for diversion to C-SB Link is 17,371 MCM for Alternative I and 22116 MCM for alternative II. This is quite higher than that proposed by NWDA as 3711 MCM, and that also subject to diversion of 11199 MCM of Gandak water, during the lean season, through Gandak-Ganga Link which is a remote possibility.

In order to protect the interest of people of South Bihar, it is suggested that the state Govt. may impress upon the NWDA and GOI, to ensure availability of 22116 MCM water at Chunar during non-monsoon period by making suitable adjustment, in the envisaged diversion of Ganga water into the Narmada basin through Sarda-Yamuna, Yamuna-Rajasthan, and Rajathan-Sabarmati Link and also in envisaged utilisation by the upper riparian states

B At Barh

It has been shown in Table 6.27 that the Punpun (part)-Harohar-Kiul(part) composite basin has a requirement of 5687 MCM during non-monsoon in Alternative no II.

In post River-Interlinking scenario it is considered that all the water of individual tributaries will be consumed in their own command. In Ganga also below Chunar, there will be no surplus water excepting that for ecological balance and environmental protection. As such, any additional withdrawal of Ganga water below Chunar may create environmental problem. Taking this into view, the only water, which can be tapped for utilisation downstream would be that available due to regeneration. The basins likely to contribute flow in river Ganga due to regeneration between Chunar and Barh are

i. Karmanasa-Sone-Kao-Gangi-Punpun(Part) composite basin
ii. Ghaghra-Mahi-Western Gandak composite basin
iii Only 40% of Upper Eastern Gandak -Upper Burhi-Gandak Composite basin

The likely availability of water due to regeneration through these basins is as worked out in Table 6.30

Table 6.30

Expected contibution of flow in river Ganga due to regeneration between Chunar and Barh **(Unit MCM)**

SN	Name of composite basin	Monsoon	Non-monsoon	Total
A	Irrigation water supply			
I	Karmnasa-Sone-Kao-Gangi-Punpun(part)	6657	10210	16067
ii	Ghaghra-Mahi-Western Gandak	2700	6265	8965
iii	Upper Eastern Gnadak-Upper Burhi Gandak	3115	6529	9644
iv	Upper Eastern Gandak Upper Burhi Gandak (only 40% of iii)	1246	2612	3858
	Total Irrigation Water Supply (I+ii+iv)	10,603	19087	29690
B	Non-Irrigation water Supply			
I	Karmnasa-Sone-Kao-Gangi-Punpun(part)	1471	2943	4414
ii	Ghaghra-Mahi-Western Gandak	881	1762	2643
iii	Upper Eastern Gandak-Upper Burhi Gandak	721	7156	7877
iv	Upper Eastern Gandak Upper Burhi Gandak (only 40% of iii)	288	2862	3150
	Total Non-irrigation water supply (I+ii+iv)	2,640	7567	10207
C	Flow available in river Ganga at Barh			
I	Due to irrigation water supply @ 10% of A	1060	1909	2969
ii	Due to Non-irrigation water supply @ 80% of B	2112	6054	8166
	Total	3172	7963	11135

On comparison of expected available flow in Table 6.30 with the demand of Ganga water indicated in Table 6.27 for the alternative II which only is recommended by the Committee it is found that the demand of Ganga water at Barh during non monsoon period i.e. 5687 MCM is less than the expected available flow (ie. 7963 MCM) at the site:

C Below Barh

Water available in river Ganga for the Kiul (part) Badua- Belharna, Bilasi- Chandan Chir Ganga stem Composite basin will be the flow available due to regeneration of water supply in

i 60% of the Upper Eastern- Gandak- Upper Burhi Gandak composite basin
ii Lower Eastern -Gandak- Baya- Lower Burhi Gandak composite basin
iii Ganga stem basin
iv Command area of Kosi- Ghaghra Link
v Command area of Kosi- Mechi Link (only Kamla & Bagmati river basin)
vi Punpun (part) Harohar-Kiul (part) composite basin.

The expected water to be available in river Ganga due to regeneration is worked out at table 6.31

Table 6.31

Expected contribution of flow in river Ganga due to regeneration below Barh

Unit MCM

Name of basin		Monsoon	Non-Monsoon	Total
A	Irrigation Water Supply			
i.	Upper Eastern Gandak-Upper Burhi Gandak Composite basin	3115	6529	9644
ii	60% of Upper Eastern Gandak-Upper Burhi Gandak Composite basin (i.e 60 % of i)	1869	3917	5786
iii	Lower Eastern Gandak- Baya- Lower Burhi - Gandak Composite basin	2567	5807	8374
iv	Ganga stem	296	687	983
v	Command area of Kosi-Ghaghra Link	3197	10453	13650
vi	Command area of Kosi-Mechi link			
	* Kamla river basin	400	1308	1708
	*Kosi river basin	4086	11151	15237
vii	Punpun (Part) Harohar Kiul(Part) composite basin	5981	8089	14070
	Total irrigation water supply (ii to vii)	18396	41412	59808
B	Non-irrigation Water supply			
i.	Upper Eastern Gandak-Upper Burhi Gandak Composite basin	721	7155	7876
ii	60% of Upper Eastern Gandak-Upper Burhi Gandak Composite basin (i.e. 60% of i)	433	4293	4726
iii	Lower Eastern Gandak- Baya- Lower Burhi- Gandak Composite basin	881	1761	2642
iv	Ganga stem	100	200	300
v	Command area of Kosi-Ghaghra Link	1349	2698	4047
vi	Command area of Kosi-Mechi link			
	* Kamla river basin	170	340	510
	*Kosi river basin	832	9733	10565
vii	Punpun (Part) Harohar Kiul (Part) composite basin	1241	2483	3724
	Total Non- irrigation water supply (ii to vii)	5006	21508	26514
C	Flow available in river Ganga below Barh			
i.	Due to irrigation water supply @ 10% of A	1840	4141	5981
ii	Due to Non-irrigation water supply @ 8% of B	4005	17206	21211
	Total C	5845	21347	27192

Comparison of expected availability of flow in river Ganga indicated in Table 6.30 with the demand shown in table 6.16, transpires that the latter is much less than the expected availability. Thus, it puts no restriction on use of Ganga water in the basin below river Kiul.

D Below Bihar W.Bengal border

Above paragraphs reveal that there is acute shortage of surface flows in river Ganga and in its tributaries, and even the flows expected to be available due to regeneration on account of irrigation and non-irrigational water supply in the upper commands are to be fully consumed in lower commands, Hence the possibility of availability of flows at Farakka to meet the International Commitment and W. Bengal need is very limited. It is, hence, proper that Brahmaputra water in adequate quantity may be made available to Ganga as a first charge to meet demand in Ganga basin including that at Farakka and the remaining only be diverted to South India.

6.4 RECOMMENDATIONS:-

6.4.1 Recommendations on Providing Assured irrigation in South Bihar through Chunar-Sone-Barrage (C-SB) Link and Sone Dam-Southern Tributaries of Ganga (SD-STG)Link Canals. (TOR-3)

1. In order to substitute Sone water at Kadwan (7117) MCM for diversion to cover area east of river Punpun and to meet deficit in Sone-Karmanasa command (11,153 MCM), a quantity of 18270 MCM would be required to be diverted from river Ganga at Chunar which should be made available to Bihar at Chunar through the proposed River-Interlinking Schemes viz. Kosi-Ghaghra Link, Gandak-Ganga Link, Ghaghra Link and Sharda (Karnali)-Yamuna Link, before transferring any water to other basins from Bihar.

2. The water of 18270 MCM available at Ganga may the be diverted by constructing
   i. A barrage across river Ganga at Chunar with proposed Chunar-Sone Gravity Canal, taking off the barrage to divert 7,939 MCM of Ganga water annually.
   ii Chunar-Sone Barrage Link Canal as proposed by the NWDA with modification to increase its capacity to divert 10,331 MCM annually instead of 5566 MCM for Bihar as envisaged in the present C-SB Link scheme.
   iii. Sone-Dam Southern Tributaries of Ganga (SD-STG) Link canal to divert 7117 MCM of Sone water from proposed Kadwan dam instead of only 2512 MCM of water as envisaged in the present SD-STG Link canal Scheme and as proposed by NWDA.
   iv. As SD-STG Link will cover only 3,87,378 ha. of CCA between Punpun and Kiul, the balance CCA of 5,81,145 ha. should be covered through Barh(Ganga) Nawada multipurpose pump Scheme proposed by the Committee by diverting 5664 MCM of Ganga water at Barh during the non-monsoon period. The water demand in this command during the monsoon period will be met by its own resources.
   v. All identified reservoir schemes in the command of Punpun (part) -Harohar-Kiul (part) composite basin and Kiul(part)-Badua-Bilasi-Beharna-Chandan-Chir river basin may be constructed with priority to utilise all possible runoff.

vi. Further reservoirs on rivers like Suara, Kao, and Awsane in Karmnasa basin; Jagarnath, Bulandhi, and Madar in Punpun river basin; Dhadhar, Tilaya, dhanarjai, sarkri, Lilajan and Mohane in Kiul-Harohar river basin be investigated and constructed to supplement the water requirement in the basin.

3. The Sone dam project at Kadwan, proposed by the government of Bihar, should not be allowed to be modified at all as has been proposed by the NWDA, since it will not only reduce the storage capacity but will also reduce the power generation drastically from 450 MW to 90 MW only, which will not be in the interest of Bihar.

6.4.2 Recommendation on Pump Canal schemes to cater for the South Eastern part of Bihar (TOR-4)

1. **Pump Canal Scheme on right bank of river Ganga**

All the existing, on-going and proposed pump canal schemes on right bank of Ganga, be modernised / implemented to meet the demand of water in the command of south Bihar in the east of river kiul, falling below 60.0 m contour, as proposed by the NWDA. The Ganga water required to be pumped through these scheme is 810 MCM during monsoon and 4534 MCM during non-monsoon. (refer para 6.3.4.3.1)

This can be achieved by:

i Meeting entire need of Bangla desh and west Bengal from proposed diversion of Bhamaputra basin water into Ganga and allowing free use of Ganga water in Bihar in both monsoon and non monsoon seasons

ii. Giving preference to Ganga basin itself for utilisation of water of this basin before transferring to other basin.

iii. The water to be transferred by Gandak-Ganga Link and Kosi-Ghaghra Link etc. in monsoon , be allowed to flow down in the Ganga in non-monsoon period, from reservoirs on Ganga basin including those on its tributaries.

2. **Construction of reservoirs**

Reservoirs like Sindhwarni and Amhara in Badua , Belharna river basin as well as Kudar in Bilasi-Chandan Chir river basin may be constructed as quickly as possible. Besides these identified reservoir, attempt should be made to explore further reservoir schemes and be constructed as quickly as possible.

6.4.3 General recommendations

1. **Over utilisation of Sone water in UP and MP at Kadwan**

According to Bansagar agreement, entitlement of MP and UP for utilisation of sone water is 6476 MCM and 1542 MCM respectively, all being in the upstream of Kadwan. Against this, the total utilisation in these two states, as indicated in the NWDA report, is 12470 MCM (refer para. 6.2.2.1). This is utter violation of provision of Bansagar agreement. This may be protested strongly for protecting the rights of people in Bihar and Jharkhand on use of Sone water.

2. **Requirement of Ganga water at Chunar.**

The NWDA and GOI may be impressed upon to make sufficient water available at Chunar, so that without causing any adverse effect on the ecology and environment of the river Ganga below Chunar, it may be possible to divert 18270 MCM of Ganga water at this site.

3. **First charge on use of Bhramaputra water.**
The first charge on the additional water, thus transported from Barmaputra's tributaries into Ganga must be, to fulfill the shortage of water in the Mahanada basin in Bihar and the commitment of water made to Bangla Desh and West Bengal below Farakka, and thereby removing restriction on Bihar from using Ganga water to meet its requirement.

4. **Utilisation of water diverted through Gandak-Ganga and Kosi-Ghaghra etc.**
The water to be transferred by Gandak-Ganga and Kosi-Ghaghra etc. in monsoon, be allowed to flow down in the Ganga in non-monsoon period from the reservoirs in the Ganga basin including those on its tributaries for utilisation in Bihar.

5. **Storing of surplus monsoon flow in ground water through wells**
Additional wells be dug all along the geographical area of the state with the aim of increasing storage of ground water specially in south Bihar, and to the extent of raising depth of ground water aquifer in north Bihar.

This will facilitate storing of surplus monsoon flow. The surcharged ground water will result into increase in base flow of the rivers, which can be used during the lean period. At the same time, the water percolated below the ground will reduce the surface flow, thereby providing relief to the surface water drainage congestion in lower valleys.

According to Annexure 4.4, total surplus water during monsoon period is 68,260 MCM in North Bihar. If by any means, only 25% of this is allowed to be stored in ground water, it will hardly cause an increase of 40 cm in the ground water. Thus the area where minimum depth of ground water is below 3 m to 4 m, this technique can very safely be applied.

6. **Research Work**
The bare truth and fact, considering the ever growing population on the planet and the geographical compulsion, is that in future, grave situation of extreme shortage of fresh water specially in non monsoon season is growing to mount. In order to overcome this situation it is suggested that in addition to all efforts suggested above, research must begin to have control on

i) Evaporation of sea water at selected places

ii) Formation of cloud

iii) Convection of cloud in selected direction and upto prefixed locality and

iv) Precipitation of the same to the extent desired

The rate at which the Science and Technology has advanced in the last century, such an achievement seems to be quite possible. Only concerted effort must be started and the entire residents of this planet must co-operate not only for achieving such technology but also for operating the same.

Annexure 6.1.2.3

Assessment of water requirement in **Sone-Karmnasa-Punpun(Part) Composite Basin** irrigation & Non-irrigation needs

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA considered for command to be irrigated (Ha)	Total area to be irrigated in ha				Water Demand for Irrigation (MCM)			
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3	4	5	6	7	8	9	10	11	12
			Intensity	95%	95%	50%	Delta	0.65	0.46	1.02	
1	Karmnasa	326709	326709	310374	310374	163355	784102	2017	1428	1666	5111
2	Sone-Kao-Gangi	493121	493121	468465	468465	246561	1183490	3045	2155	2515	7715
3	Punpun (40%)	549107	219643	208661	208661	109821	527143	1356	960	1120	3436
4	Ganga Stem	38655	38655	36722	36722	19328	92772	239	169	197	605
5	Total	1E+06	1078127.8	1024221	1E+06	539064	2587507	6657	4711	5498	16867

	Non Irrigation Demand (MCM)				Total Season wise demand (MCM)			
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
	13	14	15	16	17	18	19	20
Karmnasa	231	231	231	694	2249	1659	1898	5806
Sone-Kao-Gangi	616	1116	1116	2848	3661	3271	3631	10563
Punpun (40%)	223	223	223	668	1579	1182	1343	4104
Ganga Stem	68	68	68	204	307	237	265	809
Total	1138	1638	1638	4414	7795	6349	7136	21281

	Water Available seasonwise (MCM)				Water Deficit/surplus (MCM)		
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.
Karmnasa	657	294	294	1245	-1592	-1365	-1604
Sone-Kao-Gangi	5040	4264	4264	13567	1379	993	633
Punpun (40%)	0	296	296	592	-1579	-886	-1047
Ganga Stem	262	15	15	291	-45	-222	-251
Total	5959	4868	4868	15695	-1836	-1481	-2268

Annexure 6.3.3.2

Assessment of water requirement in **Punpun(Part)-Harohar-Kiul(Part) Composite Basin** irrigation & Non-irrigation needs

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA as command to be irrigated (Ha)	Total area to be irrigated in ha				water Demand for Irrigation (MCM)			
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3	4	5	6	7	8	9	10	11	12
			Intensity	95%	95%	50%	Delta	0.65	0.46	1.020	
1	Punpun (60%)	549107	329464	312991	312991	164732	790714	2034	1440	1680	5154
			Intensity	95%	90%	45%	Delta	0.65	0.46	0.808	
2	Harohar	590676	590676	561142	531608	265804	1358555	3647	2445	2148	8241
3	Kiul (40%)	120957	48383	45964	43545	21772	111280	299	200	176	675
4	Total	1260740	968523	920097	888144	452309	2260549	5981	4085	4004	14070

	Non-Irrigation Demand (MCM)				Total Demand Season wise (MCM)			
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
	13	14	15	16	17	18	19	20
Punpun (60%)	334	334	334	1002	2368	1774	2014	6156
Harohar	854	854	854	2561	4501	3299	3001	10801
Kiul (40%)	54	54	54	162	353	254	230	837
Total	1241	1241	1241	3724	7222	5327	5245	17794

	water Available Season wise (MCM)				Water Deficit /surplus (MCM)		
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.
	13	14	15	16	17	18	19
Punpun (60%)	2073	90	90	2253	-295	-1684	-1924
Harohar	2914	193	193	3300	-1587	-3106	-2808
Kiul (40%)	193	46	46	284	-160	-209	-184
Total	5180	329	329	5837	-2042	-4998	-4917

Annexure 6.3.3.3

Assessment of water requirement in **Kiul(Part)-Badua-Belharna-Bilasi-Chandan-Chir-Ganga stem Composite Basin** irrigation & Non-irrigation needs

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA as command to be irrigated (Ha)	Total area to be irrigated in ha				Water Demand for Irrigation (MCM)			
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3	4	5	6	7	8	9	10	11	12
			Intensity	95%	90%	45%	Delta	0.65	0.46	0.808	
1	Kiul (Part)	120957	72574	68945	65317	32658	166921	448	300	264	1012
2	Badua-Belharna	132530	132530	125904	119277	59639	304819	818	549	482	1849
3	Bilasi-Chandan-Chir	158513	158513	150587	142662	71331	364580	979	656	576	2211
4	Ganga Stem	120272	120272	114258	108245	54122	276626	743	498	437	1678
5	Total	532272	483889.2	459695	435500	217750	1112945	2988	2003	1759	6751

	Non Irrigation demand (MCM				Total Demand season wise (MCM			
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
	13	14	15	16	17	18	19	20
Kiul (60%)	81	81	81	243	529	381	345	1255
Badua-Belharna	135	155	155	445	953	704	637	2293
Bilasi-Chandan-Chir	264	284	284	832	1243	940	860	3044
Ganga Stem	212	212	212	635	954	709	649	2313
Total	691	731	731	2154	3679	2735	2491	8905

	Water available seasonwise (MCM)				Water Deficit/ Surplus (MCM)		
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.
	21	22	23	24	25	26	27
Kiul (60%)	300	63	63	426	-229	-318	-282
Badua-Belharna	427	155	155	737	-526	-549	-482
Bilasi-Chandan-Chir	1326	83	83	1491	83	-858	-778
Ganga Stem	816	46	46	907	-138	-664	-603
Total	2869	346	346	3561	-810	-2389	-2145

Annexure 6.3.5.1.1

Assessment of water requirement in **Sone-Karmnasa Composite Basin**

Irrigation & Non-irrigation needs (Alternative-II)

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA as command to be irrigated (Ha) Ganga	Total area to be irrigated in ha				water demand for Irrigation (MCM)			
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3	4	5	6	7	8	9	10	11	12
			Intensity	95%	95%	50%	Delta	0.65	0.46	1.020	
2	North of gravity Canal	500000	500000	475000	475000	250000	1200000	3088	2185	2550	7823
3	South of Gravity Canal at Higher contour	358485	358485	340561	340561	179243	860364	2214	1567	1828	5608
4	punpun 40%	549107	219643	208661	208661	109821	527143	1356	960	1120	3436
4	Total	1407592	1078128	1024221	1024221	539064	2587507	6657	4711	5498	16867

		Non Irrigation Demand				Total demand season wise			
		Kharif	Rabi	HW	Total	Kharif	Rabi	HW	Total
1	north of gravity Canal	533	824	824	2182	3621	3009	3374	10004
2	South of Gravity Canal at Higher contour	382	591	591	1564	2596	2158	2419	7172
	punpun 40%	223	223	223	668	1579	1182	1343	4104
	Total	1138	1638	1638	4414	7795	6349	7136	21280

		Water available				Water Deficit/Surplus			
		Kharif	Rabi	Hw	Total	Kharif	Rabi	Hw	Total
1	north of gravity Canal	3587	2023	2023	7632	-34	-987	-1352	-2372
2	South of Gravity Canal at Higher contour	0	177	177	354	-2596	-1981	-2242	-6818
	punpun 40%	0	296	296	592	-1579	-886	-1047	-3512
	Total	3587	2496	2496	8578	-4208	-3854	-4641	-12702

Annexure 6.3.5.2.1

Assesment of water requirement in **Punpun-Harohar-Kiul part Composite Basin** irrigation & Non-irrigation needs for area to be commanded by SD-STG Link Canal (7117 MCM) (Alternative-II)

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA as command to be irrigated (Ha)		Total area to be irrigated in ha				water demand for Irrigation (MCM)			
			STG-Canal 7117 MCM		Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3		4	5	6	7	8	9	10		11
				Intensity	95%	95%	50%	Delta	0.65	0.46	1.020	
1	Punpun 60%	549107	131775		125186	125186	65888	316260	814	576	672	2062
				Intensity	95%	90%	45%	Delta	0.65	0.46	0.808	
2	Harohar	590676	236251		224438	212626	106313	543377	1459	978	859	3296
3	Kiul (40%)	120957	19352		18384	17417	8708	44510	119	80	70	270
	Total	1260740	387378		368009	355229	180909	904147	2392	1634	1601	5628

		Non Irrigation Demand				Total demand season wise			
		Kharif	Rabi	HW	Total	Kharif	Rabi	HW	Total
1	Punpun 60%	134	134	134	401	947	710	806	2463
2	Harohar	341	341	341	1024	1800	1319	1200	4320
3	Kiul (40%)	22	22	22	65	141	102	92	335
	Total	497	497	497	1490	2889	2131	2098	7118

Annexure 6.3.5.2.2

Assessment of water requirement in **Punpun-Harohar-Kiul part Composite Basin** irrigation & Non-irrigation needs Excluding the CCA to be commanded by SD-STG Link Canal (Alternative-II)

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA as command to be irrigated (Ha)		Total area to be irrigated in ha				water demand for Irrigation (MCM)			
			Ganga	STG-Canal 7117 MCM	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
				Intensity	95%	95%	50%	Delta	0.65	0.46	1.020	
1	Punpun 60%	549107	197689	131775	187805	187805	98845	474454	1221	864	1008	3093
				Intensity	95%	90%	45%	Delta	0.65	0.46	0.808	
2	Harohar	590676	354425	236251	336704	318983	159491	815178	2189	1467	1289	4945
3	Kiul (40%)	120957	29031	19352	27579	26128	13064	66771	179	120	106	405
	Total	1260740	581145	387378	552088	532915	271400	1356402	3589	2451	2402	8442

		Non Irrigation Demand				Total demand season wise			
		Kharif	Rabi	HW	Total	Kharif	Rabi	HW	Total
		14	15	16	17	18	19	20	21
1	Punpun 60%	200	200	200	601	1421	1064	1209	3694
2	Harohar	512	512	512	1537	2701	1980	1801	6482
3	Kiul (40%)	32	32	32	97	212	153	138	502
	Total	745	745	745	2235	4334	3196	3147	10677

		Water available				Water Deficit/Surplus			
		Kharif	Rabi	Hw	Total	Kharif	Rabi	Hw	Total
		22	23	24	25	26	27	28	29
1	Punpun 60%	2074	90	90	2253	653	-974	-1119	-1440
3	Harohar	2914	193	193	3300	213	-1787	-1608	-3182
4	Kiul (40%)	193	46	45	284	-19	-107	-93	-218
	Total	5181	329	328	5837	847	-2867	-2819	-4839

Annexure 6.3.4.3.1

Assessment of Water Requirement in Chandan-Chir-Bilasi-Ganga stem Composite Basin

Irrigation & Non-irrigation needs (Alternative-II)

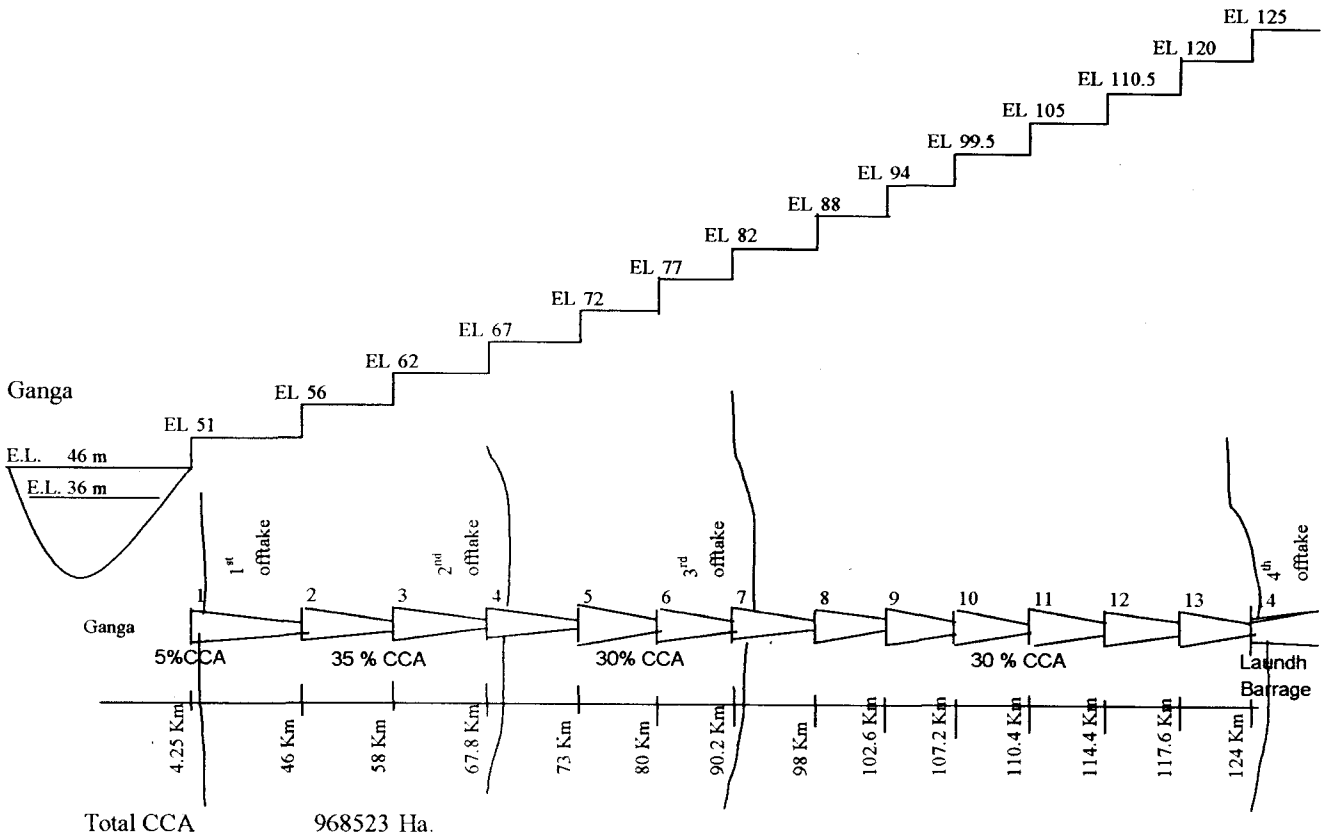
Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA as command to be irrigated (Ha) Ganga	Total area to be irrigated in ha				water demand for Irrigation (MCM)			
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3		5	6	7	8	9	10		11
			Intensity	95%	90%	45%	Delta	0.65	0.46	0.808	
1	Kiul (60%)	120957	72574	68945	65317	32658	166921	448	300	264	1012
2	Badua-Belharna	132530	132530	125904	119277	59639	304819	818	549	482	1849
3	Bilasi-Chandan-Chir	158513	158513	150587	142662	71331	364580	979	656	576	2211
4	Ganga Stem	120272	120272	114258	108245	54122	276626	743	498	437	1678
	Total	532272	483889	459695	435500	217750	1112945	2988	2003	1759	6751

		Non Irrigation Demand				Total demand season wise			
		Kharif	Rabi	HW	Total	Kharif	Rabi	HW	Total
1	Kiul (60%)	81	81	81	243	529	381	345	1255
2	Badua-Belharna	135	155	155	445	953	704	637	2294
3	Bilasi-Chandan-Chir	264	284	284	832	1243	940	860	3043
4	Ganga Stem	212	212	212	635	954	709	649	2313
	Total	691	731	731	2154	3679	2735	2491	8905

		Water available				Water Deficit/Surplus			
		Kharif	Rabi	Hw	Total	Kharif	Rabi	Hw	Total
1	Kiul (60%)	300	63	63	426	-229	-318	-282	-829
2	Badua-Belharna	427	155	155	737	-526	-549	-482	-1557
3	Bilasi-Chandan-Chir	1326	83	83	1491	83	-858	-778	-1552
4	Ganga Stem	816	46	46	907	-138	-664	-603	-1406
	Total	2869	346	346	3561	-810	-2389	-2145	-5344

Barh(Ganga)-Laundh(Dhanarjai) Pump Canal Scheme

Fig. 6.1



Total CCA 968523 Ha.

Area to be irrigated through first offtake 5%, second offtake 35%, third offtake 30% and through fourth offtake 30%

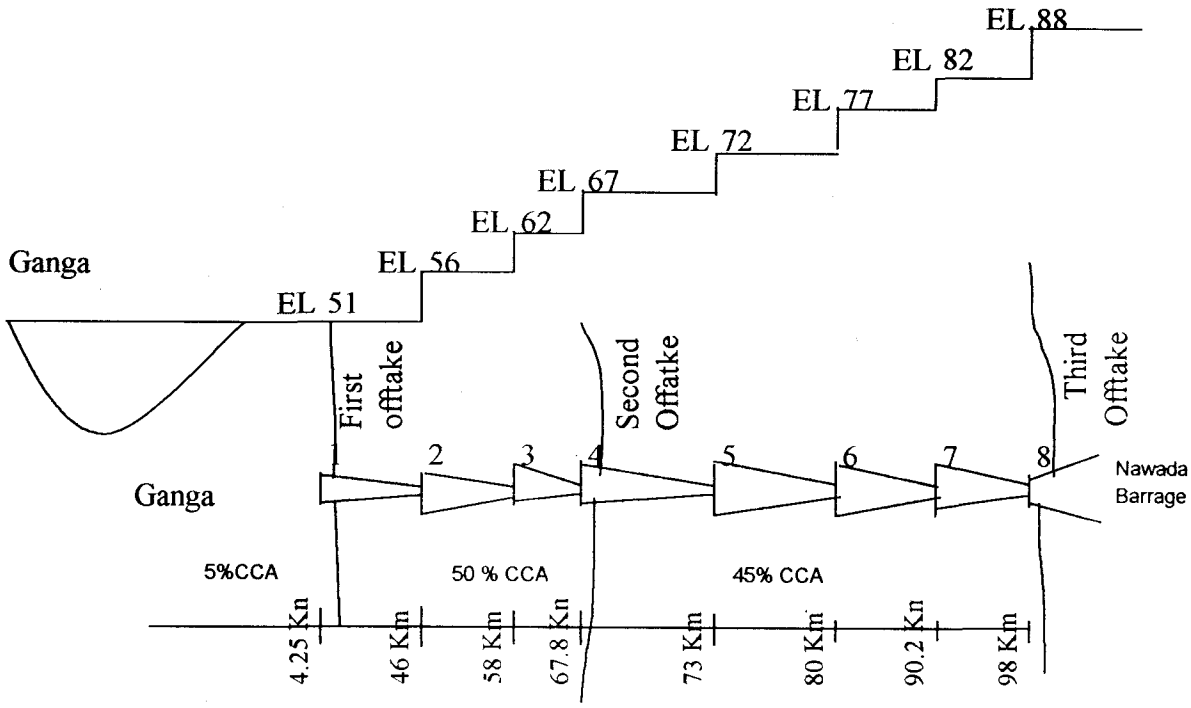
Water Demand in MCM	Kharif	Rabi	HW	total		
	7222	5327	5245	17794	Base period	120 days
First offtake 5% area	**Kharif**	**Rabi**	**HW**	Remarks	Hours of Pumping	16 hrs
Water Demand	361	266	262	In MCM	Peaking Power	5 hrs
	415	306	302	After adding 15% for losses in transmission & evaporation		
	60	44	44	In cumecs (for 120 days and 16 hrs pumping with 15% loss)		
	555	409	403	Cumulative pumping in cumecs		
Second offttake 35% area	**Kharif**	**Rabi**	**HW**	Remarks		
Water Demand	2528	1864	1836	In MCM		
	2907	2144	2111	After adding 15% for losses in transmission & evaporation		
	421	310	305	In cumecs (for 120 days and 16 hrs pumping with 15% loss)		
Actual pumping need	168	124	122	In Kharif 60% to be met from river runoff at level crossing in canal		
	495	365	359	Cumulative pumping in cumecs		
Third offttake 30% area	**Kharif**	**Rabi**	**HW**	Remarks		
Water Demand	2167	1598	1574	In MCM		
	2492	1838	1810	After adding 15% for losses in transmission & evaporation		
	360	266	262	In cumecs (for 120 days and 16 hrs pumping with 15% loss)		
Actual pumping need	144	106	105	In Kharif 60% to be met from river runoff at level crossing in canal		
	326	241	237	Cumulative pumping in cumecs		
Fourth offttake 30% area	**Kharif**	**Rabi**	**HW**	Remarks		
Water Demand	2167	1598	1574	In MCM		
	2492	1838	1810	After adding 15% for losses in transmission & evaporation		
	360	266	262	In cumecs (for 120 days and 16 hrs pumping with 15% loss)		
Actual pumping need	144	106	105	In Kharif 60% to be met from river runoff at level crossing in canal		
	182	134	132	Increased for peaking power by factor by 1.26		

Peaking power Generation in different season in MW

Sl.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Barrage head	5	5	6	5	5	5	5	6	6	5.5	5.5	5.5	9.5	5
Kharif	23	21	25	21	14	14	14	9	9	8	8	8	14	8
Rabi	51	15	18	15	10	10	10	7	7	6	6	6	11	6
HW	50	15	18	15	10	10	10	7	7	6	6	6	10	6

Barh-Nawada Pump Canal Scheme

Fig. 6.2



Total CCA 581145 Ha.

Area to be irrigated through first offtake 5%, second offtake 50% and through third offtake 45%

Water Demand

Kharif	4334 MCM	Base period	120 days
Rabi	3196 MCM	Hours of pumping	16 hrs
HW	3147 MCM	Peaking power	5 hrs
Total	10677 MCM		

First offtake 5% area	**Kharif**	**Rabi**	**HW**	Remarks
Water Demand	217	160	157	In MCM
	249	184	181	After adding 15% for losses in transmission & evaporation
	36	27	26	In cumecs (for 120 days and 16 hrs pumping with 15% loss)
Actual pumping need	344	595	586	Cumulative pumping in cumecs
Second offttake 50% area	**Kharif**	**Rabi**	**HW**	Remarks
Water Demand	2167	1598	1574	In MCM
	2492	1838	1810	After adding 15% for losses in transmission & evaporation
	361	266	262	In cumecs (for 120 days and 16 hrs pumping with 15% loss)
Actual pumping need	144	266	262	In Kharif 60% to be met from river runoff at level crossing in canal
	308	568	559	Cumulative pumping in cumecs
Third offttake 45% area	**Kharif**	**Rabi**	**HW**	Remarks
Water Demand	1950	1438	1416	In MCM
	2243	1654	1629	After adding 15% for losses in transmission & evaporation
	324	239	236	In cumecs (for 120 days and 16 hrs pumping with 15% loss)
Actual pumping need	130	239	236	In Kharif 60% to be met from river runoff at level crossing in canal
	164	302	298	Increased for peaking power by factor 1.26

Peaking power generation in different season

Sl.No	Barrage head	Kharif	Rabi	HW	**Peaking power generation for 5 hrs**
1	5	14	74	73	In non monsoon Ganga level goes down to 36 m EL
2	5	13	24	23	Hence head at first barrage is taken as 15m in Rabi and HW
3	6	15	28	28	
4	5	7	13	12	
5	5	7	13	12	
6	5	7	13	12	
7	5	7	13	12	
8	6	8	15	15	

L-Sectin of Master Channel of Barh(Ganga)-Laundh Barrage/Nawada Schemes showing location of Barrages

Fig. 6.3

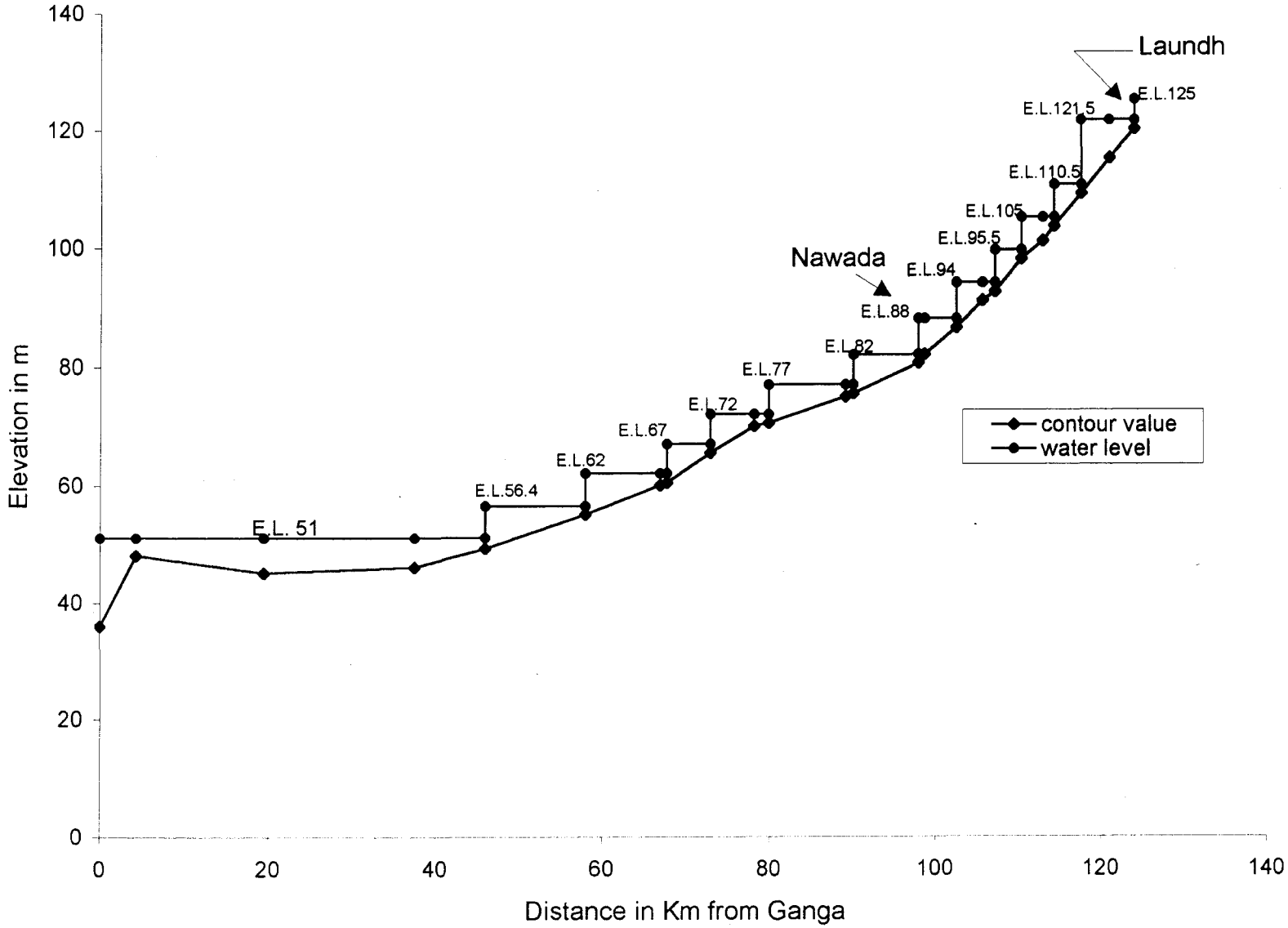
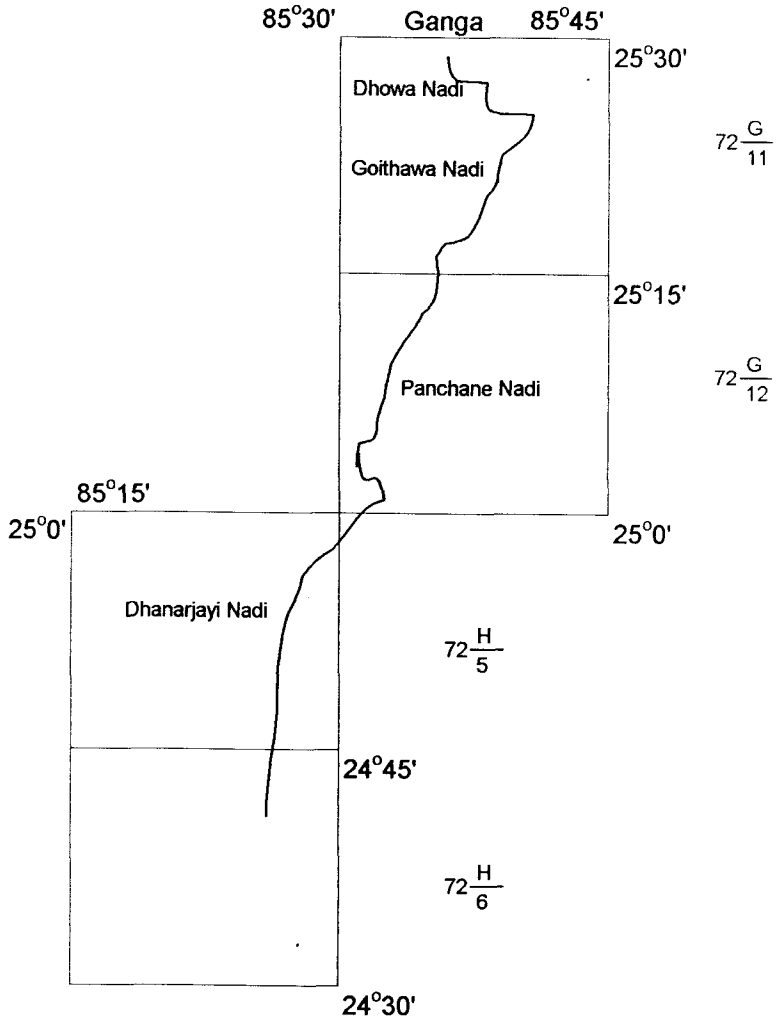


Fig 6.4

Location Map of Master Channel of Proposed Barh(Ganga)-Laundh Barrage/Nawada



Index Map

CHAPTER-VII

PER CAPITA WATER AVAILABILITY IN BIHAR- PER YEAR (TOR-5)

CHAPTER- VII

PER CAPITA WATER AVAILABILITY IN BIHAR - PER YEAR (TOR-5)

7.1 The Norm of water availability Per-Capita

Water availability per person is a broad indicator for security of health and sustainable development potential of a region. In this connection, there are two standard norms, having world-wide acceptance. These norms, are as mentioned below:-

A. If water availability per capita per year is

i. 1000-2000 m^3, the region is considered as "water stressed"

ii. <1000 m^3, the region is considered " water scarce."

The Second situation puts severe constraint on production of food, economic development and protection of natural systems.

B. If water availability per capita per year is

i. 1000-1700 m^3, the region is considered water stressed.
In this situation, the region is to face local and rare shortage.

ii. 500-1000 m^3, the region is considered as water scarce.
This situation begins to hamper health, economic development and human well being.

iii. <500 m^3, Water supply becomes a primary constraint to life.

The National Commission for Integrated Water Resources Development Plan, has considered the second norm and has analysed the situation taking river basin as a basic hydrologic unit.

7.2. Analysis of the situation on national level.

The Indian Water Resources Society, in its theme paper on" Water :Vision 2050" for water Resources Day, 1999, have presented basin wise per capita water availability. This is reproduced in table at Annexure 7.1. This table is based on population of the country pertaining to year1991. According to this table the water availability per capita per year in Ganga river basin in which the Bihar State is situated, is only1471 m^3, while the same for the country as a whole is 2214 m^3. This situation will further deteriorate, with rise in population in the next five decade. It has been noted by the Society in its theme paper on " River Basin Management: Issues and options "Water Resources Day 1997, that the Ganga river basin which is presently in "water stressed" zone will go to "water scarce" zone by the year 2025.

7.3 Analysis of the situation on state level.

7.3.1. Present and Future population.

The population of the state has increased from 6.45 Crores in the year 1991 to 8.29 Crores in the year 2001. This gives a growth rate of 2.54 per cent per year.

The National Commission for Integrated Resources Development Plan has made a population fore cast for the country as a whole for two alternative scenario i.e. High Urban Projection and Low Urban Projection. Accordingly, the population of the country has been indicated as given below.

(Unit Crores)

Year	High Urban projection	Low Urban Projection
2000 AD	102.2	99.5
2025 AD	139.2	133.3
2050 AD	164.0	158.1

Taking only High Urban Projection scenario, the growth rate during the period 2000-2025 is 1.24% per year and that during 2025-2050 as 0.65% per year. This growth rate is applicable for the country as a whole which includes Kerala and Tamilnadu also where TFR (Total Fertility Rate) of 2.1 has already reached while for Bihar it is likely to be attained in the year 2032.

Ruddar Dutt and KPM Sundhran in their Book on "Indian Economy" (1998 publication) has estimated annual growth rate of population for Bihar as 1.75 percent for the period from 1996 to 2016.

Population of Bihar has increased from 6.45 Crores in 1991 to 8.29 Crores in 2001. This shows an annual increase rate of 2.54. This is perhaps the highest rate of population growth which is expected to decline with the mass awareness of family planning scheme and education programme.

It is considered that the population of Bihar will stabilise in the next five decades with an average annual growth rate of 1.85%

Accordingly the population of the state has been estimated at 13.13 Crores and 20.79 Crores corresponding to years 2025 and year 2050 respectively. The basin wise population of the state corresponding to the year 2025 and 2050 is shown in table at Annexure7.2 This table also indicates break up of Urban and Rural population. The ratio of urban and rural population considered for the year 2025 is 37:63 and that for the year 2050 is 46:54.

7.3.2. Available Water Resources

As per assessment made by this Committee 75% dependable flow of the State has been estimated as 1,32,175 MCM vide para 2.6.2.1 (ii) and Table 2.4 of chapter II. which is reproduced at Annexure 7.3 of this chapter for ready reference. This availability is inclusive of an inflow yield 1,00,726 MCM to be available from the catchments area

outside the state as shown in Annexure 7.3. Based on this reassessment, the region wise inflow yields available for use in Bihar is as given below.

Unit MCM

S.N.	Region	Flows available from Catchments area		Total
		outside state	within state	
i.	North Bihar	90,832	20,221	1,11,053
ii.	Ganga Stem	-	2,793	2,793
iii.	South Bihar	9,894	8,435	18,329
	Total	1,00,726	31,449	1,32,175

7.3.3. Per Capita water availability:-

Per capita water availability for different river basins of Bihar has been worked out for populations of 1991,2001,2025 and 2050 (shown in Annexure 7.2) and inflow yield (shown in Col.11 of Annexure 7.3). The results are shown in Col.8 to 11 of Annexure 7.4. Graphical presentation of per-capita availability for different river basins in Bihar ia shown in Figure 7.1 and 7.2.

A review of the result indicates that:-

i. The river Kosi is the only river which has got its water availability more than 1700 m^3 per capita per year throughout the period from 1991 to 2050. Thus this river basin is water surplus basin throughout the period under cosideration.

ii. The Gandak river basin is, though, surplus upto the year 2001, comes in the category of water stressed basin (1000-1700 m^3 per capita per year) in the year 2025 and water scarce basin (500-1000 m^3 per capita per year) in the year 2050.

iii. Sone-Kao-Gangi, Mahananda and Bagmati river basins are already in water stressed (1000-1700 m^3 per capita) condition. The situation in these basin further gets deteriorated during the year 2025, when these are converted to water scarce river basin. The situation in Mahananda and Bagmati river basin further worsens in the year 2050, when the availability of water in these two river basins goes even below 500 m^3 per capita.

iv. The other river basins such as Kamla Balan(North Bihar), Ganga stem (Central Bihar), Karmanasa, Punpun, Kiul, Harohar, Bilasi-Chandan Chir, and Badua-Belharna (all of South Bihar) were already in water scarce category in the year 1991. Out of them situation in Ganga stem, Karmanasa, Punpun and Harohar basins gets critical as per capita availability in these basins dwindle to even less than 500 m^3 per year which means, these will get converted into the category where water availability becomes primary constraint to life, in the year 2001 and beyond & The river basins of Kamla Balan,Bilasi Chandan Chir,Kiul and Badua-Belharna will also get converted in the same category in the year 2025.

v. In the year 2050, the Kosi river basin is the only basin which may be considered as surplus. The other two river basins such as Gandak and Sone - Kao-Gangi remain in the water scarce category. The remaining river basins of

the state will have to face acute water scarcity condition where water availability shall be less than even 500 m^3 per capita.

vi. In terms of population it may be inferred that in the year 2050

a) Out of 20.79 Crores of population in the state, only 2.15 Crores population (ie about 10%of total population) may remain in a comfortable position with respect to water availability.

b) 7.52 Crores population (5.93 Crocres of Gandak +1.59 Crores of Sone-Kao-Gangi) may be having water supply in the range of 500-1000 m3 per capita which is a situation of water scarcity.

c) Rest of the population i.e. 11.12 Crores (Which is about 55% percent of total population) will have to face acute water scarcity (availability<500 m^3 per capita).

Situation of (b) and (c) are indicative of a very grim situation and needs immediate steps to be taken to provide security to food, fibre and health of 18.64 crores of likely population of Bihar in the year 2050.

7.3.4. Quantity of water required for the state of Bihar to achieve the national level of water availability during 2050

Total water resources of the country has been assessed as 1952.87 BCM of which utilisable surface water is only 690 BCM and the population in the year 2050 for high urban as well as low urban population projection as 1640 million and 1581 million respectively. Considering the higher population projection the per capita utilizable water availability on national level will be 420.73 m^3, Taking this very availability to be applicable for Bihar, this state will require 87,469.76 MCM of utilisable water in the year 2050 whereas its total utilisable water deducting surplus monsoon flow (Annexure 4.4) is 74,173 MCM. This is maximum possible ultimate utilisable water in Bihar. It can by 2050 be augmented by storing monsoon flow in Gandak basin to the tune of 13,596 MCM maximum (Table 3.2 of Chapter III) i.e. total utilisable surface water becomes 87,766 MCM(i.e. 1,37,741 - 63571 + 13596) which is no better but almost the same stressed condition as that of the nation.

Regional disparity in availability of utilisable water in the state is glaring, which is apparent from Annexure. 7.2

The availability of overall per capita water is far short in the state if it is compared with the national average of availability of overall surface water projected till 2050; which is revealed in Annexure No. 7.5

Annexure No. 7.5

Additional quantity of water required for Bihar to achieve the National Level in the year 2050.

Sl No	Region	Water availability on 75% dependability MCM	Population in Lakh	National level water availability in m^3/ capita projected for 2050	Water required to achieve the national level water availability (MCM)	Balance water required for Bihar MCM
1	2	3	4	5	6	7
1.	North Bihar	1,11,053	1229.0	1191	146,374	35,321
2.	Ganga stem	2,793	158.0	1191	18,818	16,025
3.	South Bihar	18329	692.0	1191	82,417	64,396
	Total	132175	2079.0	1191	247,609	115,741

In this background it is suggested that this state may be assured to get an additional quantity of 1,15,741 MCM of water through River Inter Linking Schemes, in addition to the state's own resources, in order to get the national level of water availability per capita for its sustainable development and security of food, fibre and health of its population expected in the year2050.

7.4 CONCLUSION

1. In the scenario of 1991 the Ganga river basin stands in the 10th position so far as per capita water availability is concerned. This is as high as 16617 M^3 for the Bramhaputra-Barak river basin, which stands at the highest position whereas only 1471 M^3 per capita is available for Ganga river basin ranking at the 10th from the top vide Annexure 7.1.

   The other main rivers of the nation, which has got per capita water availability of more than 1471 M^3 are

   i. Indus upto border
   ii. Godavari
   iii. Mahanadi
   iv. Barahmani and Baitarni
   v. Narmada
   vi. West flowing river from Tapi to Tandra
   vii. West flowing rivers from Tapi to Kanyakumari
   viii. Minor rivers draining into Bangladesh

2. The Per Capita water availability in all the rivers in south Bihar excepting Sone Karmanasa Composite basin and even in the Kamla river basin in the north Bihar, is less than that in Krishna, Cauvery and Pennar basins which are being considered as shortage basins and where water is proposed to be transferred.

As such diversion of Ganga waters to any other river basins of South India does not appear justified.

3. With rate of fast growing population in the Ganga river basin, this basin is expected to come into the category of water scarce river basin by the year 2025. Hence it would be proper that before diversion of Brahmaputra waters to Southern India, its water must be diverted in sufficient quantity to Ganga river basin, being adjacent one.

4. Bihar is situated in this very Ganga river basin and the scenario of water availability per capita in this state is shown in table at Annexure 7.4.This table indicates that the availability of water in various river basins of the state is very poor. By the year 2050, all the river basins of the state excepting Kosi, Gandak and Sone-Kao-Gangi basin will fall in the category of severe -water scarce basin. This means about 55% of the total population will face the situation in which water availability becomes primary constraint to health.

About 35% of the state population (i.e. population living in Gandak basin and Sone - Kao- Gangi basin) will have to survive in water scarcity condition (water availability per capita being in the range of 500 M^3 to 1000 M^3 per capita per year.

Only 10% of the state population (i.e. population of Kosi basin only) will be in ease situation.

The above situation obviously indicates that the future of about 90% of the state population in the year 2050 is very grim as far as water availability is concerned.

5. In order to provide availability of expected ultimate utilisable water at the level of national figure of 421 m^3 in the year 2050, the state will require 87,469.76 MCM utilisable water. Attempt may be made to utilise all available water in non-monsoon & enhancing storage capacity of monsoon surplus to the maximum extent. This can just be achieved.

6. Simultaneous attempt must be made to reduce the rapid rate of growth of population, trying to keep it static i.e no growth which has unfortunately been 28% as against 11% of Kerala.

7. The fact remains that Bihar being almost at tail end of Ganga, will have no authority or control over Ganga water which will definitely be used up and lifted by upper riparian state, and in non-monsoon month, there will be extreme scarcity. Unless Nepal & U.P. co-operate in storing monsoon water and making it available to Bihar. South Bihar will need help of Jharkhand for storage and self help for augmenting ground water by pumping monsoon flow from the Ganga.

Annexure 7.1

Per Capita Water Availability in The River Basins of India

S N	Name of the River Basin	Per Capita Available Surface Water (M^3)	Rank
1	Indus (upto Border)	1750	IX
2	(a) Ganga	1471	X
	(b) Brahmaputra,Barak & Others	16617	I
3	Godavari	2048	VIII
4	Krishna	1285	
5	Cauvery	728	
6	Pennar	652	
7	East flowing rivers between Mahanadi & Pennar	954	
8	East flowing rivers between Pennar & Kanyakumari	364	
9	Mahanadi	2514	VII
10	Brahmani & Baitarni	2915	VI
11	Subarnarekha	1308	
12	Sabarmati	360	
13	Mahi	1052	
14	West flowing rivers of Kutch, Saurashtra including Luni	683	
15	Narmada	3105	V
16	Tapi	1005	
17	West flowing rivers from Tapi to Tadri	3388	IV
18	West flowing rivers from Tadri to Kanyakumari	3483	III
19	Area of Inland Drainage in Rajasthan desert		
20	Minor river Basins draining into Bangladesh & Burma	14762	II

Source: Theme Paper on "Water Vision 2050".water resources day '99, Indian water resources Society.(Table 1.1)

Annexure 7.2

Basin wise population of Bihar and its projection for 2025 & 2050 AD in Lakh

Sl. No	Name of Basin	Population in 1991	Population in 2001	Population in 2025			Population in 2050		
				Urban	Rural	Total	Urban	Rural	Total
1	2	3	4	5	6	7	8	9	10
I	Agroclimatic Sub-zone 4								
1A	Ghaghra-Mahi Western Gandak Composite	66.38	85.25	49.97	85.08	135.04	98.40	115.51	213.91
1B	Upper Eastern Gandak Lower Burhi-Gandak Composite	51.34	65.94	38.64	65.80	104.45	76.10	89.34	165.44
1C	Lower Eastern Gandak Baya Lower Burhi Gandak composite	66.36	85.23	49.95	85.05	135.00	98.37	115.48	213.84
	Ganga Stem	7.54	9.68	5.68	9.66	15.34	11.18	13.12	24.30
	Sub-Total	191.62	246.11	144.24	245.59	389.83	284.05	333.45	617.49
II	Agroclimatic Sub-zone 5								
4	Bagmati-Adhwara	55.3	71.02	41.63	70.88	112.50	81.97	96.23	178.20
5	Kamla Balan	38.7	49.70	29.13	49.60	78.73	57.37	67.34	124.71
6	Kosi	66.55	85.47	50.09	85.30	135.39	98.65	115.81	214.46
7	Mahananda	36.79	47.25	27.69	47.15	74.85	54.54	64.02	118.56
	Ganga stem	20.49	26.32	15.42	26.26	41.68	30.37	35.66	66.03
	Sub-Total	217.83	279.77	163.97	279.19	443.15	322.90	379.05	701.95
	Total I+II	409.45	525.87	308.20	524.78	832.98	606.94	712.50	1319.44
III	Agroclimatic Sub-zone 6 (a)								
9	Karmnasa	17.44	22.40	13.13	22.35	35.48	25.85	30.35	56.20
10	Sone & Kao Gangi composite	49.24	63.24	37.06	63.11	100.17	72.99	85.68	158.67
11	Punpun	41.94	53.87	31.57	53.75	85.32	62.17	72.98	135.15
	Ganga Stem	5.12	6.58	3.85	6.56	10.42	7.59	8.91	16.50
	Sub-Total	113.74	146.08	85.62	145.78	231.39	168.60	197.92	366.52
IV	Agroclimatic Sub-zone 6 (b)								
12	Harohar	64.32	82.61	48.42	82.44	130.85	95.34	111.93	207.27
13	Kiul	10.16	13.05	7.65	13.02	20.67	15.06	17.68	32.74
14	Badua-Belharna	10.78	13.85	8.11	13.82	21.93	15.98	18.76	34.74
15	Bilasi Chandan Chir	20.9	26.84	15.73	26.79	42.52	30.98	36.37	67.35
	Ganga Stem	15.94	20.47	12.00	20.43	32.43	23.63	27.74	51.37
	Sub-Total	122.1	156.82	91.91	156.49	248.40	180.99	212.47	393.46
	Total III+IV	235.84	302.90	177.52	302.27	479.79	349.60	410.39	759.99
Grand Total		645.29	828.77	485.73	827.05	1312.77	956.54	1122.8	2079.43

Note: a) Population in 2025 - Urban 37%, Rural 63%

b) Population in 2050- Urban 46%, rural 54%

Annexure 7.3

Surface Water Resources in River Basins of Bihar

Sl. No.	Name of Basin	Catchments Area (Sq. Km.)			75% Dependable water availability in MCM					
					As assessed by SBSIC			As assessed by the Committee		
		Outside state	Within State	Total	Outside state	Within State	Total	Outside state	Within State	Total
1	2	3	4	5	6	7	8	9	10	11
1	Ghaghra	124955	2995.4	127950	68015	839.7	68855	*	840	840
	Mahi		2507.8	2507.8	0	799.1	799.1		799	799
2	Gandak	36610	4187.7	40798	50810	1173.9	51984	45109**	1174	46283
	Baya		2775.7	2775.7	0	1067.2	1067.2		1067	1067
3	Burhi-Gandak	2420	9601.4	12021	813.3	3226.7	4040	813	3227	4040
2	Bagmati-Adhwara	7884	6499.9	14384	5080.9	2184.4	7265.3	5081	2184	7265
3	Kamla Balan	2744	4487.7	7231.7	1741.3	1508.1	3249.4	1741	1508	3249
4	Kosi	62615	11410.2	74025	47065	5154	52219	36471**	5154	41615
5	Mahananda	7157.7	6150.1	13308	5612.4	4267.9	9880.3	1627***	4268	5895
	Total North Bihar	244385	50615.9	295001	179138	20221	199359	90832	20221	111053
III	Karmnasa	2665.2	5126.9	7792.1	487.1	937	1424.1	308#	937	1245
6	Sone	67163	3064.8	70228	17600	335	17935	7709##		7709
7	Kao-Gangi		4128.8	4128.8	0	884.4	884.4		884	884
8	Punpun	979	8046.7	9025.7	244.4	2009.1	2253.5	244	2009	2253
9	Kiul	421	2629.5	3050.5	98	612.3	710.3	98	612	710
10	Harohar	4272.3	9900.7	14173	994.7	2305.3	3300	995	2305	3300
11	Badua-Belharna		2215	2215	0	736.8	736.8	0	737	737
12	Bilasi Chandan Chir	1483.3	2609.7	4093	540.4	950.7	1491.1	540	951	1491
	Total South Bihar	76984	37722.1	114706	19965	8770.6	28735	9894	8435	18329
	Ganga Stem		5473.3	5473.3	85000	2793	87793	*	2793	2793
	Grand Total	321369	93811.3	415180	284102	31785	315887	100726	31449	132175

Note:-

* Flows of river Ghaghra and Ganga from catchment area out side are considered not to be available for use in Bihar.

* *Flows of river Gandak and Kosi from catchment area out side state is taken as indicated below:

A. Gandak river basin:

Available flows at proposed Gandak regulatory dam after utilization in Nepal, according to Water Balance study of NWDA 50576 MCM.

Utilisation in U.P. & Nepal wide SBSIRC 1994 (page 18 Vol.III)

i. Western Main Canal U.P.(4383 MCM)+ Nepal (325 MCM)= 4708 MCM

ii. Eastern Main Canal Nepal (759 MCM)= 759 MCM

Total utilization in U.P.& Nepal below barrage 5467MCM

Thus net available flow for Bihar at Barrage 45109 MCM

B. Kosi river basin:

According to NWDA simulation study of Kosi High Dam

water to below dam = 40377 MCM

Use in Chatra Canal system (58,000 haCCA) = 3916 MCM

In case of river Sone, no water from catchment below Indrapuri Barrage is considered to be available for the Sone canal Command. In this river basin the water available will be limited to 7709 MCM(6.25 MAF) as details given below:

i. Total share of Bihar including Jharkhand = 9559 MCM (7.75 MAF)
ii. Use in Jharkhand = 1850 MCM (1.50 MAF)
Balance for Bihar =7709 MCM (6.25 MCM)
Break up being 592 MCM (0.48 MAF) in U/S of Barrage and 7117 MCM (5.77 MAF) from Barrage.

Annexure 7.4

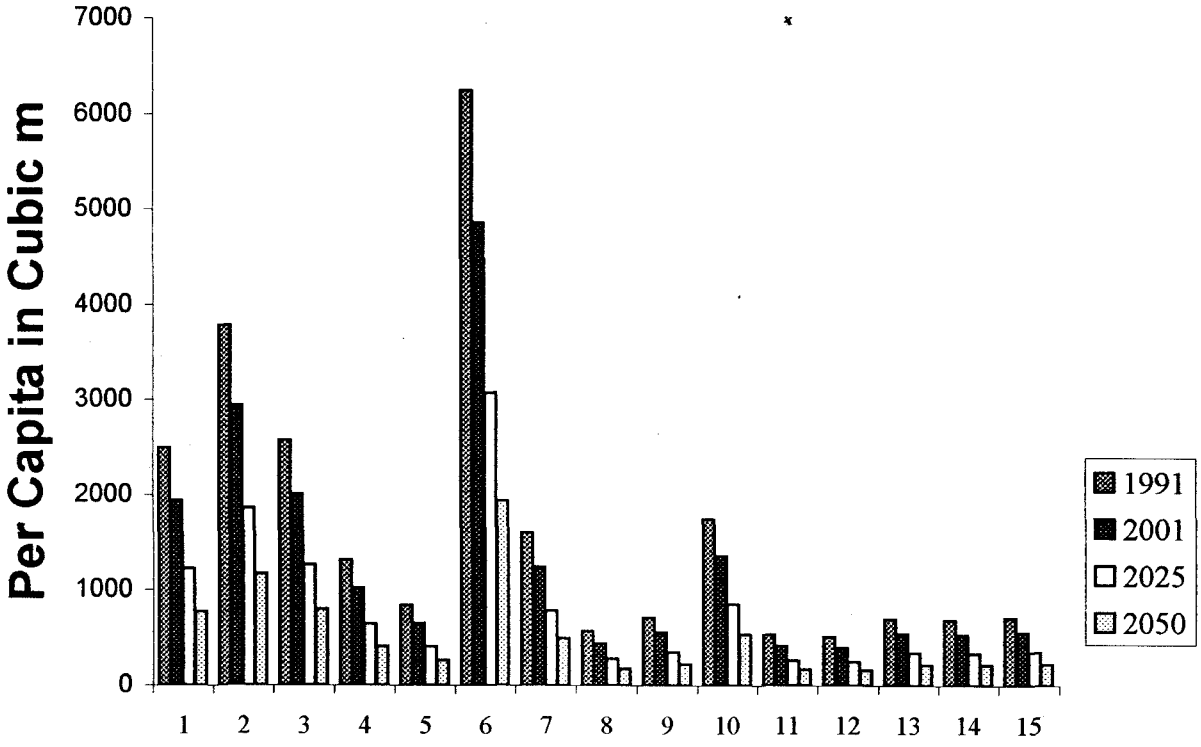
Water Availability (Per Capita Per Year for different river Basins for Bihar)

Sl. No	Name of Basin	Total surface water in MCM	Population (vide Annexure 7.2) Lakh				Water Availability Per Capita in m3			
1	2	3	4	5	6	7	8	9	10	11
I	NORTH BIHAR		1991	2001	2025	2050	1991	2001	2025	2050
1A	Ghaghra-Mahi Western Gandak Composite	16546	66.38	85.25	135.04	213.91				
1B	Upper Eastern Gandak Upper Burhi-Gandak Composite	19416	51.34	65.94	104.45	165.44				
1C	Lower Eastern Gandak Baya Lower Burhi Gandak composite	17067	66.36	85.23	135.00	213.84				
	Sub-Total Gandak	53029	18408	236.42	374.49	593.19	2881	2243	1416	894
2	Bagmati-Adhwara	7265	55.30	71.02	112.50	178.20	1313.74	1022.89	645.77	407.68
3	Kamla Balan	3249	38.70	49.70	78.73	124.71	839.53	653.67	412.67	260.52
4	Kosi	41615	66.55	85.47	135.39	214.46	6253.19	4868.80	3073.74	1940.49
5	Mahananda	5895	36.79	47.25	74.85	118.56	1602.34	1247.60	787.62	497.24
	Total North Bihar	111053	381.42	489.87	775.96	1229.1	2911.57	2266.98	1431.17	903.52
II	Ganga Stem									
	Ganga Stem in Sub-Zone 4	429	7.54	9.68	15.34	24.30				
	Ganga Stem in Sub Zone 5	1166	20.49	26.32	41.68	66.03				
	Ganga Stem in Sub-Zone 6a	291	5.12	6.58	10.42	16.50				
	Ganga Stem in Sub-Zone 6b	907	15.94	20.47	32.43	51.37				
	Sub-Total Ganga Stem	2793	49.09	63.05	99.87	158.2	568.95	442.98	279.66	176.55
III	South Bihar									
6	Karmnasa	1245	17.44	22.40	35.48	56.20	713.88	555.83	350.90	221.53
7	Sone & Kao Gangi composite	8593	49.24	63.24	100.17	158.67	1745.13	1358.77	857.81	541.55
8	Punpun	2253	41.94	53.87	85.32	135.15	537.20	418.27	264.06	166.70
9	Harohar	3300	64.32	82.61	130.85	207.27	513.06	399.47	252.19	159.21
10	Kiul	710	10.16	13.05	20.67	32.74	698.82	544.11	343.50	216.86
11	Badua-Belharna	737	10.78	13.85	21.93	34.74	683.67	532.32	336.06	212.16
12	Bilasi Chandan Chir	1491	20.90	26.84	42.52	67.35	713.40	555.46	350.67	221.38
	Total South Bihar	18329	214.78	275.85	436.95	692.12	853.38	664.45	419.48	264.82
	Total Bihar (I+II+III)	132175*	645.29	828.77	1312.7	2079.4	2048.30	1594.83	1006.84	635.63

* of this only 70879 MCM is maximum ultimate utilisable, and with construction of reservoir may go upto 84872 MCM maximum

Fig 7.1

Per Capita availability of water in river Basins of Bihar



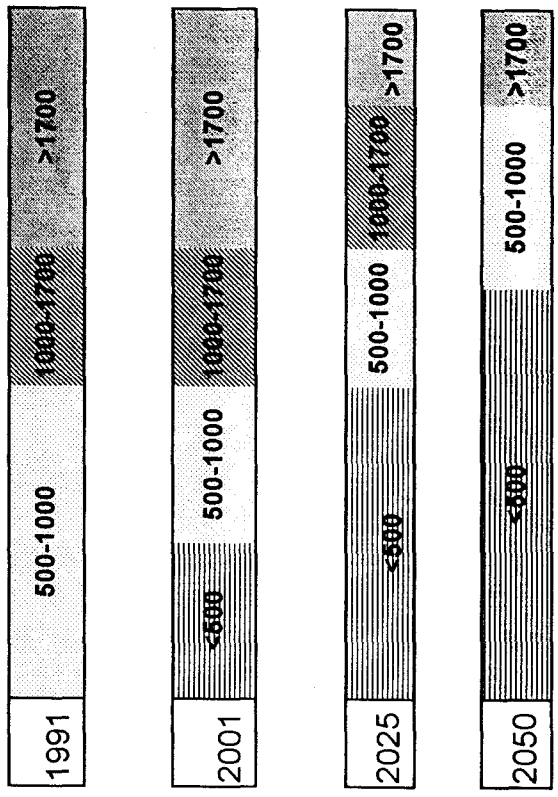
Basin

1 Ghaghra-Mahi Western Gandak Composite
2 Upper Eastern Gandak Lower Burhi-Gandak Composite
3 Lower Eastern Gandak Baya Lower Burhi Gandak composite
4 Bagmati-Adhwara
5 Kamla Balan
6 Kosi
7 Mahananda
8 Ganga Stem
9 Karmnasa
10 Sone & Kao Gangi composite
11 Punpun
12 Harohar
13 Kiul
14 Badua-Belharna
15 Bilasi Chandan Chir

Fig 7.2

Water Availability (on 75% Dependability) in different River Basins in Bihar in m^3/Capita/Year

1	Kosi Basin
2	Gandak Basin
3	Sone-Kao-Gangi Basin
4	Mahananda Basin
5	Bagmati-Adhwara
6	Kamla-Balan Basin
7	Bilasi-Chandan-Chir Basin
8	Kiul Basin
9	Badua-Belharna Basin
10	Ganga Stem Basin
11	Karmnasa Basin
12	Punpun Basin
13	Harohar Basin
	Year



Legend:

Sl.no.	Range m^3/capita/year	Symbol	Descriptive Feature
1	>1700		Water Surplus
2	1000-1700		Water stressed Local & Rare Shortage
3	500-1000		Water Scarce, Begins to Hamper Health, Economic development and Human well Being
4	<500		Water supply becomes primary constraint to life

CHAPTER-VIII

COMMENTS ON OTHER SCHEMES OF NWDA AFFECTING BIHAR AND THEIR IMPACT ON DRAINAGE AND ENVIRONMENTS (TOR-6)

CHAPTER- VIII

COMMENTS ON OTHER SCHEMES OF NWDA AFFECTING BIHAR AND THEIR IMPACT ON DRAINAGE AND ENVIRONMENT (TOR-6)

8.1 GANDAK-GANGA LINK PROJECT

8.1.1 THE SCHEME AS PREPARED BY NWDA

8.1.1.1 General outline of the scheme

The Gandak-Ganga Link canal scheme envisages diversion of 32,746 MCM of annual surplus water available at proposed Gandak Regulating Dam, 6 Km u/s of existing Gandak barrage of Valmikinagar, to meet the irrigation requirement of about 25,867 MCM in the command areas of i) Sarda-Sahayak-Pariyojna and ii) Sarju Nahar Pariyojna in addition to irrigation need of new areas of 1.78 lakh ha in Nepal and 5.41 lakh ha in U.P. en-route and then allow the remaining water of 6,879 MCM left in the link canal to drop into the Ganga near Mustafabad in U.P. The water thus saved in Sarda and Karnali river, due to taking over of the command by the proposed Gandak-Ganga Link canal, can be transferred to the water short areas of U.P., Delhi, Haryana, Punjab, Rajasthan and Gujarat through the proposed i) Sarda-Yamuna link and ii) Karnali-Yamuna link. Also due to supplementation of 6,879 MCM of water to the Ganga, the water availability in Ganga will increase at Chunar near Varanasi for further diversion to Sone basin through the proposed Chunar-Sone Link.

The proposed Gandak-Ganga Link Scheme comprises the following components:

i) A regulating dam across the river Gandak near Triveni Ghat, 6 Km u/s of existing Gandak barrage at Valmikinagar.

ii) Headworks consisting of a head regulator, under sluice and a silt excluding device located on the right bank of the Gandak river.

iii) A 362.0 Km long link canal, off taking from head works of the Gandak dam, with F.S.L. at 152.55m and joining Sarda Sahayak Pariyojna feeder channel at its 106 th km for further conveyance of water for en-route irrigation and transfer to Ganga river.

iv) A re-sectioned Feeder channel of Sarda-Sahayak Pariyojna for carrying link water from RD 106 Km (Joining point of Link) to the Ganga river (RD 277 Km) by traversing a distance of about 171 Km.

An index map showing layout of the scheme is enclosed at Plate No.6.

8.1.1.2 Objectives:

The objectives of the scheme are as given below:-

i) To provide irrigation to new area of 5.41 lakh ha in the Terai region of Nepal and U.P. in India, at 100% intensity of Irrigation.

ii) To take over the command of 18.23 lakh ha of Ghaghra-Rapti and Rapti-Rohini doab under Sarju Nahar Pariyojana and provide irrigation with an intensity of 117%.

iii) To take over the command of 19.20 lakh ha of Ghaghra-Ganga doab under the existing Sarda-Sahayak Pariyojna and provide irrigation with intensity of irrigation increased from existing 96% to 100%.

iv) To transfer 6879 MCM of water available at tail end of the link, after meeting irrigation and non-irrigation demand en-route, into Ganga river which will increase the water availability to Ganga at Chunar for further diversion to Sone basin in U.P. and Bihar through Chunar-Sone barrage link canal scheme as detailed in Chapter-VI.

8.1.1.3 Water balance study by NWDA

In the main Project Report i.e. Pre-feasibility Report 1997 (Tech.study no. PFR(iii)/8/97), the preliminary water study was first carried out at existing Gandak barrage and that at proposed Gandak dam located, 6 Km u/s of the barrage was worked out from the computations at the barrage in proportion to catchment area of both sites. This study (1997) was based on data at Gandak barrage for the period from the year 1960-61 to 1964-65 and 1973-74 to 1991-92.

The NWDA revised this study in Jan. 2003 vide Tech. Report No. PWBS(H)14/93 of Jan.2003 by incorporating further flow data at the barrage site from the year 1992-93 to 2000-01. The surface water balance, so worked out at Gandak dam in the year 1997 and again in the year 2003, are given below.

Surface Water Balance at proposed Gandak Dam (Unit: MCM)

Sl.No.	Particulars	Annual Yield (1997 Report)	Annual Yield (2003 Report)
1	Availability a) Gross Yield		
	i) At 75% dependability	54136	53828
	ii) At 50 % dependability	57125	57133
	b) Surface Water Import(+)	NIL	NIL
	c) Surface Water Export(-)	19285	19708
	d) Overall availability		
	i) At 75% Dependability	34851	34120
	ii) At 50% dependability	37840	37425
2	Water Requirement		
	i) Irrigation	NIL	NIL
	ii) Domestic Use	144	368
	iii) Industrial Use	330	507
	iv) Hydropower needs (Evap.)	1359	1395
	v) Environment & Ecology	650	NIL
	Sub-Total	**2483**	**2270**
3	Regeneration from		
	i) Domestic Use	114	294
	ii) Industrial Use	264	406
	iii) Irrigation Use	NIL	NIL
	Sub-Total	**378**	**700**
4	Surface Water Balance		
	a) At 75% dependability	32746	32550
	b) At 50% dependability	**35735**	**35855**

8.1.1.4 Water transfer through the Link Canal

As computed above the balance flow of Gandak dam/Barrage after keeping provisions for various u/s and d/s utilisation works out to 32,746 MCM as per 1997 study and 32,550 MCM as per 2003 study at 75% dependability. Though the water balance study was revised in 2003 the Link Scheme prepared in Sept. 1997 has not yet been revised and is based on 1997 study of water balance of 32,746 MCM.

This entire balance water i.e. 32,746 MCM is proposed to be diverted through the Gandak-Ganga Link as per details shown in Table below:-

Table 8.1.1

SN	Particulars	CCA in ha.	Planned annual irrigation in Ha.	Water need in MCM
1	For irrigation in un-irrigated area in Nepal Tarai	240570	240570	1516
2	For irrigation in un-irrigated area in UP en-route command	300434	300434	1892
	Sub-Total new area	541004	541004	3408
3	For irrigation in existing project viz. Sarda-Shayak-Pariyojna and Pump canals	2048890	2048890	13552
4	For irrigation in on-going projects viz. Saryu-Nahar-Pariyojna and pump schemes	1245810	1449810	7139
	Sub-Total Existing and on-going projects	3294700	3498700	20691
	Total for irrigation	3835704	4039704	24099
5	Domestic and industrial need			700
6	Transmission loss			1068
	Total for irrigation and non-irrigational use			25867
7	Transfer into river Ganga			6879
	Grand Total			**32746**

Source: Annex: 7.6 & para 7.6 of NWDA report (1997)

From above table, it will be seen that out of 32,746 MCM available flow, only 6879 MCM is being transferred to Ganga while rest i.e. 25,867 MCM is being considered for irrigational & non-irrigation uses en-route command in Nepal and UP in India.

8.1.2 CULTIVABLE AREA

8.1.2.1 CCA assessed by NWDA

The NWDA in its report (Technical Study no PWBS(H) 14/93-Jan-2003) has reported the culturable command area, annual irrigated area and gross water use from existing and on-going projects. These figures are extracted at Table 8.1.2 given below.

Table 8.1.2

S.N.	Country/State	CCA Ha.	Annual irrigation Ha.	Water use in MCM		Annual
				Monsoon	Non-Monsoon	
1.	Nepal	44,100	53,000	210	133	343
2.	U.P - M.W.Canal	3,95,000	3,31,800	2,485	1,515	4,000
	Bihar.					
	Eastern Gandak canal	5,46,200	7,77,330			
	Western Gandak Canal	4,49,080	5,86,460	7,983	5,892	13,875
	Sub-total	9,95,280	13,63,790			
	Total(Nepal, UP & Bihar	14,34,380	17,48,590	10,678	7,540	18,218

Source: Annexure 6.3.2 of NWDA report PWBS (H) 14/93- Jan 2003

From above table it transpires that -

i. Total culturable command areas and irrigation potential of the project including Nepal, U.P. and Bihar are 14,34,380 ha. and 17,48,590 ha. respectively. The annual water requirement is18,218 MCM (10678 during monsoon and 7540 MCM during non-monsoon).

ii. Culturable command area and irrigation potential in Bihar are 9,95,280 ha. and 13,63,790 ha. respectively.

iii. Annual water utilisation in Bihar through this project is 13,875 MCM the break up being 7983 MCM during monsoon and 5892 MCM during non-monsoon.

iv. The figures of annual irrigation and C.C.A shown in the table indicate the intensity of annual irrigation as120% for Nepal portion, 84% for U.P. portion and 134 % for Bihar portion.

8.1.2.2 CCA assessed by The Second Bihar State Irrigation Commission

Gandak Project is a major project in the area and it provides irrigation in Nepal, UP and Bihar States in India. The command of Gandak Project is located on both banks of the river and it is not confined to Gandak Basin, rather, it extends to Ghaghra basin in the West (on right bank) and to the basin of Burhi Gandak in the North & East (on left bank). Besides these three sub-basins, there are two more small sub-basins draining directly to Ganga. They are (i) Mahi Sub-basin on the left bank between Gandak & Ghaghra sub-basins and (ii) Baya sub-basin on the left bank between Gandak and Burhi Gandak Sub-basins. The SBSIC (1994) has studied the land resources of the different river basins in Bihar. They have assessed the cultivable area in the composite basin of Ghaghra-Mahi-Gandak-Baya-Burhi Gandak. For the purpose of detailed study of land resources in the composite basins, they have divided the entire area of composite sub-basin according to the command of Western & Eastern Canal systems into following composite basins :

Eastern Side:

The area falling in the Gandak-Baya-Burhi Gandak Composite Basin is located on the left side. The area is served by the Eastern Canal System. The SBSIC has divided the area into two parts- upper reach and lower reach. Accordingly they have been called as:

i. Upper Gandak-Baya-Burhi Gandak Composite sub-basin
ii. Lower Gandak-Baya-Burhi Gandak sub-basin.

Western Side:

iii. Ghaghra-Mahi-Gandak Composite sub-basin: This is located on the right bank and is served by the Main Western Canal (Saran Canal) System.

The SBSIC have assessed the area for the following categories of land in the above composite basins and the command of Gandak Project:

i) Total cultivable area in the composite sub basin
ii) Cultivable area included in the command of Gandak Project
iii) Cultivable area to be served by on going and proposed irrigation systems
iv) Balance cultivable area, where irrigation is to be provided.

The study undertaken by the SBSIC is based on the constraint that no storage facility was available and the proposals for area to be irrigated and the irrigation intensity to be adopted were based on run-off-the-river schemes.

The details of cultivable area as assessed by SBSIC are given in Table 8.1.3

TABLE 8.1.3

Details of Cultivable Area In Ghaghra-Mahi-Gandak & Gandak-Baya-Burhi Gandak Composite Basins.

Sl. No	Composite sub basin	Total cultivable area	Covered under the command of Gandak Project	Covered by future proposed scheme	Total area covered by irrigation scheme (4+5)	Balance to area where irrigation is to be provided
1	2	3	4	5	6	7
1	Eastern Upper Gandak-Upper Burhi Gandak Composite Sub Basin	5,99,034	3,85,000	21,700	4,06,700	1,92,334
2	Lower Gandak-Baya-Lower Burhi Gandak Sub-Basin (Lower Part of TMC)	4,93,648	1,75,700	90,000	2,65,700	2,27,984
	Sub Total	10,92,682	5,60,700	1,11,700	6,12,400	4,20,282
3	Ghaghra-Mahi Western Gandak Composite Sub Basin	5,19,154	4,49,080	-	4,49,080	70,074
4	Ganga Stem	56899	0	0	0	56899
	Total CCA	16,68,735	10,09,780	1,11,700	11,21,480	5,47,255

This shows that out of total cultivable area of 16,68,735 ha. in the composite basins of Ghaghra-Mahi-Gandak on the West and Gandak-Baya-Burhi Gandak on the east, 10,09,790 ha. of CCA is covered under Gandak Project, 1,11,700 ha. is proposed to be covered under on-going & proposed schemes and 5,47,255 ha. of cultivable area is not covered under any irrigation scheme. Therefore, it is considered imperative to provide irrigation in this balance area and the requirement of water for providing irrigation in this area should be included in the future demand of water for Bihar.

8.1.3 OBSERVATIONS & FINDINGS OF THE COMMITTEE

8.1.3.1. Culturable command area

a) The CCA of Gandak Project for Bihar has been shown as 9,95,280 ha. According to the Report of the SBSIC this should be 10,09,780 ha. (vide Table 8.1.3). Though the difference is very insignificant it should be reconciled, as it will have impact on water requirement.

b) Table 8.1.3 indicates that out of total cultivable area of 16,68,735 ha. of Ghaghra-Mahi-Gandak-Baya composite basin, up-till now 11,21,480 ha only has been covered by irrigation projects either existing or on-going. Thus a balance cultivable area of 5,47,255 ha is to be covered under new Irrigation Project and water requirement for the same has to be provided in the new scheme. In the Report prepared by NWDA, the CCA for proposed new schemes is not given. However, the annual irrigation in the command of Gandak Project (on-going) has been shown as 4,63,790 ha. (vide Table 6.3 of PWBS(H) 14/93 - Jan. 2003) and water utilisation for the same has been given as 4719 MCM. There is thus imperative need to modify the figures of CCA and to provide for irrigation of area under proposed schemes and balance area not covered by any scheme so far. The water utilisation will accordingly get modified.

8.1.3.2. Irrigation Intensity

a Irrigation intensities as adopted by NWDA.

This issue of irrigation intensity proposed to be adopted by the NWDA has been examined in detail under Chapter-III of this Report. Limiting the irrigation intensity of Gandak Project to the existing percentage of 121% and providing irrigation intensity of 100% in new area are not commensurate with the policy, principles, objectives and approaches as recommended by different Commissions and Committees constituted by GOI and State Govt. from time to time. If this is not modified and allowed to be retained, it will result into sealing the future of development of agriculture in Bihar and will perpetuate poverty and economic backwardness in Bihar. This will not help in development of agriculture in Bihar. Rather it will result into great injustice to Bihar.

b. Irrigation Intensity as proposed now.

The existing Gandak Project was planned during sixties and several modern concepts are not incorporated into it. However, the planning, execution and operation of Gandak Project have been done under great constraint of non-availability of storage and the Project is entirely run-off-the river scheme. Now when the interlinking of rivers and construction of storages are proposed, it is expected that the constraint of Gandak Project will be removed. With the availability of storage water, Bihar will be able to increase the command, provide irrigation in balance cultivable area in the basin and will also increase the irrigation intensity befitting to the soil, climate, water availability and need of the State.

In view of above facts and also as stated in para 4.1.3 of chapter IV the overall irrigation intensity of 250% (Kharif- 80%, Rabi- 95% and H.W- 75%) has been proposed. Future water requirement for agriculture has been assessed accordingly. The assessment of future demand of water for agricultural as well as non-agricultural purposes is available at Annex 8.1.3

8.1.3.3 Demand and Availability of Water

A comparative statement of future demand of water to be met from Gandak River as assessed by NWDA and as assessed by the Committee vide Annex. 8.1.3.3 is given below:

	Future Demand for Water		
	NWDA*	As assessed by the Committee	Remark
1. Area (CCA in ha.)	13,63,790	16,68,735	
2. Water Utilisation (MCM)			
i) Irrigation	13,875	27,966	The demand exceeds
ii) Non-irrigation	1,397 **	13,462	by 28,325 MCM
Total	15,272	41,428	

Source * NWDA Technical Study no. PWBS(H) 14/93 of Jan. 2003

** 321 MCM for domestic w/s + 381 MCM for industrial w/s + 695 MCM for environmental protection.

The season wise break up of future demand as proposed now vide annexure 8.1.3.3 would be as given in table below:

Table 8.1.4

Unit MCM

Purpose	Monsoon	Non-monsoon	Total
i. Irrigation	8,677	19,289	27,966
ii. Non-irrigation	2,504	10,958	13,462
Total	11,181	30,247	41,428

Against this demand the availability of water works out to 48111 MCM in monsoon and 5347 MCM in non-monsoon i.e. 53458 MCM in total vide Annexure 8.3.3.3 Thus while there is surplus of 36,929 MCM in monsoon, there is deficit of 24,899 MCM in non-monsoon.

8.1.3.4. Water Balance at Gandak Barrage for use in Bihar and diversions.

It is seen that water available at Gandak Barrage for use in Bihar and diversion through Gandak-Ganga Link canal would not be surplus after taking into account the utilization in Nepal upstream of barrage and that in Nepal as well as U.P. below barrage through the existing canal system as will be evident from water balance study done in Table 8.3.5 below. As already mentioned NWDA revised the Yield Study in Jan 2003 by incorporating further flow data of the barrage site from the year 1992-93 to 2000-02. The revised yields are as below.

Season	Yield at 75% dependability	Yield at 50% dependability
Monsoon	43,313 MCM	48,339 MCM
Non-monsoon	8833 MCM	9639 MCM
Total	52146 MCM	57978 MCM

As the above values are based on latest data, the 75% dependable flow of 52146 MCM has been adopted for working out water balance at Gandak Barrage

Table 8.1.5

Water Balance at Gandak Barrage.

(Unit MCM)

S.N.	Particular	Monsoon	Non-monsoon	Annual(3+4)
1	2	3	4	5
1.	75% dependable inflow yield at Gandak Barrage	43,313	8833	52146
2.	Demand U/S of proposed regulating dam in Nepal vide NWDA Technical Study N. PWBS (H/14/93, January 2003).			
	i.Irrigation	-	-	-
	ii.Domestic use	153	215	368
	iii.Industrial use	211	296	507
	iv.Hydro power need	581	814	1395
	Sub- total 2	945	1325	2270
3.	Regenration			
	i.Domestic use	122	172	294
	ii.Industrial use	169	237	406
	Sub -total 3	291	409	700
4.	Surface water balance for use below existing barrage (1-2+3)	42659	7917	50,576
5.	Demand for U.P. & Nepal in the existing command below barrage. vide Table 8.3.2	2695	1648	4343
6.	Availability of water for use in Bihar + Diversion to Gandak Ganga Link. (4 - 5)	39964	6269	46233
7	Contribution from free catchment below Barrage	6457	718	7175
8	Total availability for use in Bihar (6+7)	46421	6987	53408
9.	Demand for use in Bihar as worked out now (vide Table 8.3.4)	11,181	30,247	41,428
10.	Water Balance at Gandak Barrage Link. (8 - 9)	(+) 35,240	(-) 23,260	(+) 11,980

This table indicates that

a) The available flow of the river Gandak is Surplus only in monsoon period and is excessively short during non-monsoon.

b) The surplus during Monsoon is 35,240 MCM and deficit during non-monsoon 23,260 MCM, leaving thereby only a surplus of 11,980 MCM in a year.

c) In order to meet this shortage some arrangement has to be made for storage of its monsoon season flow by constructing reservoirs and utilizing the stored water in the basin during the non-monsoon period.

d) After construction of reservoirs of capacity 23,260 MCM (i.e. 15,553 MCM identified storage capacity + 7,707 MCM storage capacity further to be explored), maximum water that could be spared for diversion to other basin during monsoon period will be 9,654 MCM (i.e. 11,980 MCM - 10% of 23,260 MCM as reservoir evaporation losses)

8.1.3.5 Storage facilities

It has been indicated in para 2.14 of the Report prepared by NWDA that storage facilities proposed to be created in different tributaries of Gandak for generation of power is 13,593 MCM. The live storage of proposed diversion dam on Gandak is 1960 MCM. This makes the total storage to be made available in future 15,553 MCM. The proposed Scheme envisages to utilise the total 75% dependable water of 52,146 MCM as assessed by NWDA. It appears that the proposed storage facilities are inadequate to facilitate the utilisation of 52,146 MCM, the 75% dependable water of river Gandak. In order to utilise the surplus flow of the basin during monsoon, it seems proper that-

a. The proposed dams are constructed immediately.

b. Further storage sites may be explored and be developed without further losing time.

8.1.3.6 Long Term Storage for flood moderation

Ghaghra, Gandak and Burhi Gandak basins, in which the Command of Gandak Project in Bihar is located, and like other basins of Bihar, are severely affected due to flood. Like other basins of North Bihar. Embankments which are only short term measures, have been constructed along both banks of river Gandak for the purpose of flood moderation,. But this is not found sustainable on long term. Therefore, there is urgent need for reservoirs with adequate provision of flood cushion.

8.1.4 RECOMMENDATIONS

1. Since Gandak river is a life line for major part of North-West Bihar comprising six very populous districts on which irrigation system has been planned and executed and is one of the major source through which water can be transferred to river Ganga for utilisation in South Bihar, any work intended to reduce flow of water in this river is not at all acceptable to Bihar.

2 In order to increase the utilisable flow in the basin during the non-monsoon season it is recommended that:

   i. All reservoir schemes on Gandak and its tributaries (having storage capacity upto 15,553 MCM) already identified by the NWDA viz. Kali Gandaki, Buehi Gandaki, Marshyandi, Seti and Gandak reservoirs may be implemented at priority.

   ii Further reservoir schemes for storing 7,707 MCM may be explored and implemented simultaneously.

   iii. Proposals in (i) and (ii) may be treated and constructed as a part of NWDA River Interlinking Schemes.

3. In succinct, not a single drop of Gandak water is surplus for diversion during non-monsoon and diversion of monsoon flow only from Gandak-Ganga Link canal, that too only to the extent of 9,654 MCM, can be agreed, provided the same amount of water is made available to Bihar at Chunar during non-monsoon period.

8.2 KOSI-MECHI LINK PROJECT

8.2.1 THE SCHEME AS PROPOSED BY NWDA

8.2.1.1 General outline of the scheme

The Kosi-Mechi Link project is proposed to divert the Kosi river supplies for irrigating the un-irrigated areas in both Nepal and Bihar in India, besides transferring part of it into Mahananda for ultimate use in Ganga. The water of Kosi river is proposed to be stored in the proposed Kosi high dam at Barahkshetra in Nepal. The regulated releases from the reservoir, after generation of power at the toe of dam, are proposed to be diverted from proposed Chatra barrage at 8 km d/s of dam for irrigation and diversion in Kosi- Mechi Link canal on left and Kosi- Ghaghra Link canal on right.

A power channel is also proposed to take off from the right bank of Kosi-Mechi link canal at 6.4 Km to meet the water requirement of existing Kosi canal system ex - Kosi barrage at Hanuman Nagar after power generation at three falls in the power channel.

The Kosi-Mechi link canal will comprise the following components.

i. Headworks consisting of a 269.0 m high dam on Kosi at Barahkshetra with a gross capacity of 13450 MCM, an installed capacity of 3000 MW of power and a barrage at Chatra on Kosi 8 Km d/s.
ii. 3 nos of barrages at level crossings on Burhi Khola, Lohandra Nadi and Biring river
iii. Three canal power houses at 3 drops of 12.2 m each in the power channel which takes off from right bank of link canal at 6.40 km. The installed capacity of each power house is 60 MW.
iv. A 112.55 km. long link canal traversing entirely in Nepal only and off-taking from proposed Chatra barrage at FSL of 113.0m on left bank of Kosi river with discharge of 1407.80 cumecs and bed width of 155.0 m in head reach and 97.64 cumecs and 10.0 m in tail reach.

An Index Map showing lay out of the scheme is enclosed at plate No.5.

8.2.1.2 Benefits

The scheme envisages to provide following benefits :

i. Power generation of 60 MW each at 3 places along the power channel i.e. total of 180 MW.
ii. Irrigation benefits in total area of 4,74,000 ha both in Nepal and Bihar in India out of which 1,75,000 ha lies in Nepal (including 68000 ha of existing Chatra canal system) and 2,99,000 ha in Bihar.
iii. Domestic and Industrial water supply for the en-route towns.
iv. Inland navigation through Purnea Br.canal by remodelling the canal and extending it upto Ganga.

8.2.1.3. Water balance study by NWDA

The surface water balance of Kosi sub-basin at Kosi high dam at Barahkshetra has been worked out by NWDA as below:

	Surface Water Balance at Kosi High Dam			**Unit -MCM**
1.	Availability:			
	a) 75% dependable yield at Kosi high dam			46,727
	b) Import			Nil
	c) U/S utilisation for Nepal portion on approximate basis	i) Domestic		330
		ii) Industrial		330
		iii) Irrigation		3584
	Sub Total:			**4244**
	d) Regeneration from u/s utilisation			528
	e) Overall availability at 75% dependability(a+b-c+d)			43011
2.	D/s water requirement for			
	i) Domestic use			42
	ii) Industrial use			Nil
	iii) Hydro power needs (Evaporation Loss)			238
	iv) Flushing Dose			2522*
	Sub total(I)			**2802**
	v) Irrigation			
	a) Existing Projects			
	i) Kosi Project- Eastern Kosi canal 2638.32			
	Western Kosi canal- 259.33			
	2897.65			2897.65
	b) On-going Projects			Nil
	c) Proposed Projects			
	i) Kosi High Dam Proj- Eastern Chatra canal - 2304.76			
	Western Chatra canal -2415 36			
	For increasing irrigation intensity of Kosi Project command by 35.5%	884.68		
		5604.80		5604.80
	Sub- total (II)			**8502.45**
(vi)	Export to other command/basins viz Mahananda, Kamla, Bagmati & Burhi Gandak through			
	(a) Existing Projects			
	(i) Kosi project- Purnea Branch(To Mahananda)		991.35	
	Araria Branch (To Mahananda)		446.80	
	West Kosi canal above RL 44.2 m (to Kamla Bagmati)		1865.50	

(b) On-Going Projects	Nil
(c) Proposed Projects	
i) Kosi High dam- Eastern Chatra canal (to Mahananda)	897.79
Western Chatra canal (to Kamla,Bagmati Burhi Gandak)	6071.04
For increasing irrigation intensity by 35.5%	1358.49
ii) Kosi project-(Existing))	
Extension of E.Kosi canal (to Mahananda)	468.20
W.Kosi canal below RL 44.2m (to Kamla, Bagmati)	354.44
Sub total (III)	12453.61
Total D/s water requirement (I+II+III)	23758.06
3. Water balance at 75% dependability (1-2)	19252.94
or say	19253 MCM

*Flushing dose provided for Eastern Chatra canal as per the project report of Kosi high dam.

As per above study it will be seen that after meeting all commitments 19253 MCM is available as surplus at Kosi dam which can be used for diversion elsewhere like Kosi- Ghghra diversion.

8.2.1.4 Water transfer through the link canal

a) The Kosi- Mechi link canal provides irrigation to en-route command areas of both Nepal and India (4640 MCM) in addition to stabilizing the existing irrigation in Kosi command. The quantity of water to be diverted through the link canal is, therefore, inclusive of annual water requirement of existing Kosi Project (9268 MCM) and annual requirement of Navigation (8830 MCM). In addition, the link canal will cater the quantum of water to be exported to Mahananda basin @ 28 cumecs (883 MCM) including domestic and industrial needs (24 MCM) of en-route towns also. Besides transmission loss in the channel @ 0.60 cumec per Sqm accounts for 57 cumecs.

Taking all these committed needs viz en-route irrigation, requirement of existing irrigation Schemes and power channel, export to Mahananda; drinking and industrial needs, the total quantity of water proposed to be diverted through Kosi Mechi Link canal works out to 23702 MCM as detailed below.

i) For en-route command	4640 MCM
ii) For power channel a) Eastern Kosi canal	6082 MCM
b)Western Kosi canal	3186 MCM
c) Navigation	8830 MCM
iii) For export to Mahananda-	883 MCM
iv) For drinking use	12 MCM
v) For Industrial use	12 MCM
vi) Transmission loss	57 MCM
Total	23702 MCM.

b) It may be mentioned that a provision of 2118 MCM has been kept in the reservoir for flushing dose to eastern Chatra canal while a provisions of 7482 MCM has been kept for diversion to proposed Kosi-Ghaghra link canal on Western side of the river out of surplus available at dam site. Thus annual withdrawal from the Kosi reservoir works out to 23702 + 2118 + 7482 = 33302 MCM

c) The quantity required for existing Kosi canals and navigation i.e. 9268 + 8830 = 18098 MCM is to be diverted through the link canal upto RD 6.4 Km only after which it will be routed through the power Channel off-taking to the right from 6.4 Km of Link canal to generate 180 MW of hydro power at three canal power houses by utilising the available drop of 12.0 m at each power house.

After power generation, a quantum of 9268 MCM of water would finally be discharged into Kosi river upstream of the existing Hanuman nagar barrage to meet the requirement of eastern and western Kosi canals. The remaining quantity of 8830 MCM would be released @ 280 cumecs round the year to permit inland navigation. The existing Purnea Branch canal of Kosi Project is proposed to be used for navigation by re modeling the canal and extending it upto Ganga for which a detailed survey and investigation is proposed to be carried out by NWDA.

8.2.2 OBSERVATIONS AND FINDINGS OF THE COMMITTEE

8.2.2.1 CCA to be covered by the link canal

Table 7.1 of the NWDA Report of September 1997, indicates that the K.M. Link Project will provide irrigation benefit to 1,75,000 ha. CCA in Nepal and 7,50,000 ha CCA in India (Bihar)

The breakup of the area benefited given in that Table is extracted below:

Table 8.2.1

S.N.	Name of Project	Culturable Command area in ha.		
		Nepal	India (Bihar)	Total
1	Hanuman Nagar Barrage (Existing)			
	i. Eastern Kosi Main Canal	-	3,48,000	3,48,000
	ii. Rajpur Br. Canal	-	1,03,000	1,03,000
	Sub Total-1	-	4,51,000	4,51,000
2.	Link Canal	-		
	i. Eastern Chatra Canal	1,75,000	56,000	2,31,000
	ii. Additional New area (en-route)	-	2,43,000	2,43,000
	Sub-Total-2	1,75,000	2,99,000	4,74,000
	Total 1 & 2	1,75,000	7,50,000	9,25,000

source: Table 7.1 of Pre feasibility Report of Kosi Mechi link project, 1997

This table does not mention about the command area of Western Kosi canal, though a quantity of 3186 MCM of water is proposed to be diverted in the pondage of Hanuman nagar barrage for this canal-command vide Annexure 3.2.2 of NWDA Report. Taking into account this quantity of water, the area benefited due to Western Kosi canal is also to be added. Area

to be benefited by this canal according to history of Kosi project Vol. 1 of December 2002,page 143, is 24,500 ha in Nepal (13,200 ha by pump and 11,300 ha by gravity) and 1,24,500 ha in India (Bihar).

Therefore, taking this area also in account, total benefited area would be 1,99,500 ha (1,75,000 ha +24,500 ha) in Nepal and 8,74,500 ha (7,50,000 ha +1,24,500 ha) in India (Bihar).

8.2.2.2 Availability of water

The annual surface water resources assessed at Kosi high dam site has been carried out by various organization/ agencies at different times as indicated below:

S.N.	Name of organisation / Agency	75%dependable annual flow in MCM
1.	C.W.C. in 1981 (Feasibility Report of Kosi high dam, 1981)	45,115
2.	C.W.C. in 1984 (Perspective Plan of Water Resources Development for Kosi - Mahananda sub basin Vol.1,1984)	45,443
3.	N.W.D.A. in 1997 (Pre feasibility Report of Kosi - Mechi Link Project,1997) study based on annual flow data from the year 1947 to 1989	46,727

On the basis of 75 % dependable inflow yield as 46727 MCM, the N.W.D.A. worked out the water resources available for use in downstream of Kosi dam as 43011 MCM as given here below :-

SN	particulars	In MCM per annum
1	75% dependable yield at Kosi High Dam	46,727
2	U/S utilization for Nepal portion considered on approximate basis	
i.	Irrigation	3,584
ii	Domestic w/s	330
iii	Industrial w/s	330
	Sub total 2	4,244
3	Regeneration from u/s utilization	528
4	Overall availability at 75% dependability 1-2+3	**43,011**

The N.W.D.A report further indicates that according to the simulation study this value of 43011 MCM gets reduced to 40377 MCM, (vide Annex-3.2.1 & 3.2.2 of NWDA Report) the breakup being 26395 MCM for monsoon and13982MCM for non- monsoon season. No explanation to this reduction has been given by the NWDA. This, being the latest figure, has been adopted by the Committee for working out the Water Balance at Kosi dam as detailed in following paragraph.

8.2.2.3 Water Balance at Kosi dam as per revised yield

Water balance as per revised yield of 40,377 MCM at the dam (based on simulation studies of NWDA) is presented below:

Sl. No.	Particulars	Water availability / requirement		
		Monsoon	Non-monsoon	Total
1.	**75% dependable annual inflow yield for use below dam**	26,395	13,982	40,377*
2.	**Requirement below Dam:**			
A	**Kosi- Mechi Link :-**			
i.	En-route irrigation: (4,74,000 ha)	2,984	1,656	4,640
ii.	Requirement of power channel / irrigation:			
a	Kosi Eastern canal & Rajpur Branch canal	4,476	1,606	6,082
b	Kosi Western canal	2,345	841	3,186
c	Navigation @ 28 cumec	3,701	5,129	8,830
	Sub-total ii	10,522	7,576	18,098
iii	Drinking water need in Nepal below dam	5	7	12
iv	Industrial water need in Nepal below dam	5	7	12
v	Export to Mahananda basin through river Mechi for irrigation of 93,520 ha CCA.	568	315	883
vi	Transmission loss in Kosi-Mechi Link canal	36	21	57
	Sub-total A. Kosi- Mechi link (sum of i. to vi)	14,120	9,582	23,702
B	Flushing dose	2,118	0	2,118
C	Kosi-Ghagra link			
i.	Requirement of irrigation	5,554	1,785	7,339
ii.	Transmission loss in Kosi- Ghagra link	109	34	143
	Sub total C. Kosi -Ghagra link (I+ii)	5,663	1,819	7,482
3.	Total demand below dam (A+B+C)	21,901	11,401	33,302
4.	Balance water after meeting the d/s demand (1-3)	4,494	2,581	7,075

Source:- Required figure extracted from Table 3.2.2 page 102 of NWDA Pre-feasibility Report of Kosi-Mechi Link project, September 1997 * Vide Annex 3.2.1 of NWDA Report

This table shows that only 14557 MCM of water (7075 MCM + 7482 MCM) is available below Dam after meeting all commitments but before diversions into Kosi-Ghaghra Link. Against this the NWDA, has shown a quantity of 19253 MCM in their Water Balance Study vide para 8.2.1.3. This needs to be rectified.

8.2.2.4. Availability of water for use in Bihar through Kosi-Mechi link as per NWDA proposal

According to NWDA proposal the water to be used in Bihar will be as given here under:-

i. Water to cater the irrigation demand in the existing Kosi canals ex. Hanuman nagar Barrage

ii Water to cater the irrigation demand for the CCA of 2,99,000 ha. falling in Bihar out of total of 4,74,000 ha. of en-route CCA of Kosi-Mechi Link

iii Water to cater the inland navigation.

Details of water demand for the purposes mentioned above are presented in Table 8.2.2

Table 8.2.2

Sl No	Particulars	Water requirement in MCM		
		Monsoon	Non-Monsoon	Total
1	Irrigation requirement of command area of			
i.	Kosi Eastern Canal & Rajpur Canal	4,476	1,606	6,082
ii.	Kosi Western Canal	2,345	841	3,186
	Sub-Total	6,821	2,447	9,268
2a	Irrigation requirement in Kosi- Mechi Link Canal (Total CCA=4,74,000 ha.)	2,984	1,656	4,640
2b.	Proportionate water for use in Bihar for CCA of 2,99,000 ha.	1,882	1,045	2,927
3.	Navigation	-	8830	8830
4.	Total for use in Bihar through Kosi-Mechi Link (1+2b+3)	8703	12322	21,025

Thus, according to above requirement NWDA has proposed that water available for Bihar would be 8703 MCM during monsoon, and 12232 MCM during non-monsoon totaling to 21,025 MCM in a year.

8.2.2.5 Water demand and availability

i) Cultivable Area:

The Committee has reviewed the CCA of the Kosi Basin and that to be covered by the Kosi- Mechi Link canal as shown in Index Map attached. As part of Kamla- Balan and Mahananda basin is also covered by proposed Kosi- Ghaghra link canal and M.S.T.G Link canal respectively the same has been excluded to work out the net C.C.A covered by Kosi-Mechi Link canal which comes to 11,25,786 ha as shown in Table below.

Table 8.2.4 **(unit Ha)**

Sl. No	Name of Basin	Total CCA	CCA covered by other schemes	CCA to be covered by Kosi- Mechi Link Canal
1	Kamla Basin	3,22,318	2,15,632	1,06,686
2	Kosi Basin	8,38,100	Nil	8,38,100
3	Mahananda Basin	4,45,000	2,64,000	1,81,000
	Total	16,05,418	4,79,632	11,25,786

ii) Water demand

On perusal of the figures presented ly in the above two tables it is revealed that in Kamla- Kosi-Mahanada Composite basin present area under irrigation, is proposed to be increased to 11.26 L. ha. with intensity of irrigation of 75%, 95% & 80% of CCA for Kharif, Rabi & Hot weather crop respectively.

Annexure 8.2.2.5 shows that out of the total CCA 11.26 L ha., the areas to be covered under Kharif, Rabi & Hot weather are 8.44 L ha., 10.69 L ha., and 9.00 L ha with the enhanced intensity of irrigation. The water requirement for this area works out to 5368 MCM, 5840 MCM and 9096 MCM for Kharif, Rabi and HW crop respectively. The seasonwise irrigation demand will be 5368 MCM during monsoon and 14936 MCM during non-monsoon aggregating to 20304 MCM annually. The non-irrigation demand for the command area is 1201 MCM for monsoon period and 10470 MCM for non-monsoon period which brings the total demand to 6569 MCM during monsoon and 25407 MCM during non monsoon season, the total annual demand being 31976 MCM.

iii) Water Availability

According to Table 8.2.2, total water available for use in Bihar in the command of Kosi-Mechi canal is 8703 MCM during monsoon and 12,322 MCM during non-monsoon, total being 21,205 MCM.

Contrary to this, the Committee has considered that all the water available at Dam site left out after utilisation in Nepal will be available for use in Bihar in the command of Kosi-Mechi as a first charge. Accordingly the water availability for the command of Kosi-Mechi Link would be 41,615 MCM as indicated below:

Description	Water available
1. Available water from free Catchments area outside state:	
a. Total water available for use below Kosi dam vide simulation study of NWDA	40,377
b. Use in Chatra canal system considered by the Committee (C.C.A. = 58,000 ha.)	3,916
c. Available water for use in Bihar (a-b)	36,461
2. Available water from catchments within state of Bihar Vide Annexure 2.5	5,154
3. Total water availability for use in Bihar (1c+2)	41,615

Season wise breakup of this available flow has been considered as 29,353 MCM during monsoon season and 12,262 MCM during non-,pnsoon season as explained below:

Total annual flow at the dam site	41615MCM
Live storage capacity of Kosi dam	9000 MCM
Unstored annual flow (41615 - 9000) MCM	32615 MCM
Monsoon flow= 90% 0f 32615 MCM	29353 MCM
Non-monsoon flow=41615 MCM -29353 MCM	12,262 MCM

Considering the availability from Kosi basin and also than from Kamla and Mahananda basin in proportion to their CCA included in the command of Kosi-Mechi Link, the water availability for the entire command area of 11,25,786 ha. has been computed in annexure 8.2.2.5 Accordingly, the Committee has assessed the availability of flow for use in the command of the Kosi- Mechi- Link in Bihar as 31,882 MCM during monsoon and 12545 MCM during non- monsoon, totaling to 44,425 MCM in a year as per details shown at Annexure 8.2.2.5.

iv) **Status of shortage or surplus in the command**

Comparing the water availability with the demand in the basin stated above, it transpires that the command area will face shortage to the tune of 12862 MCM during non-monsoon season, though there is surplus of 25313 MCM during monsoon period. this includes a shortage of 2701 MCM in Mahananda basin (vide Annexure 8.2.2.5) of the Kamla-Balan-Kosi composite basin during non-monsoon. This shortage can be met by MSTG Link. Still the command of Kosi-Mechi Link canal will be left with a shortage of 10162 MCM (12,863 MCM - 2701 MCM) during non-monsoon season, even though there is a surplus of 25313 MCM during monsoon period.

This shortage can be met by conservation of more monsoon flows. This can be possible by constructing additional storages on tributaries like Sun Kosi, Tamur and Arun, wherever possible. These storages will not only increase the availability of flows during non-monsoon but also facilitate silt control in the flows coming down. The silt control in the flows will check the vagrant and erosive tendency of the river lower down.

8.2.2.6 REVIEW OF PROVISION OF FLOOD MODERATION IN THE SCHEME

The proposed Kosi High Dam, a major component of the scheme, is an indispensable and a major component of long term measures for the solution of this problem of flood and irrigation in this belt. As such it is essential to re-assess the provisions made in the reservoir scheme for mitigating the severe problems of flood and irrigation prevailing in the basin. The component wise assessment is mentioned in the succeeding paragraphs.

i) **Provision of Flood Cushion in the Kosi high dam**

The CWINC in the year 1950 had recommended for construction of Kosi High Dam at Barahkshetra to impound 8518 MCM (6.9 million acre ft) of which 3827 MCM (3.10 million acre ft.) was intended for silt storage and the remaining 4691 MCM (3.8 million acre ft.) was intended to moderate flood to a safe maximum discharge of 5663 cumec (2 lakh cusec) along with other allied provisions. A review of the provisions made in the Kosi high dam (as mentioned in para 8.2.1) reveals that there is no provision of flood cushion for moderating the flood to a safe maximum discharge in the river.

While formulating the reservoir capacity of Kosi High Dam, NWDA has considered the probable maximum flood of 42475 cumec (15 lakh cusec). In the CWC report the PMF of 42475 cumecs was routed with flood impinging level at the crest level of spillway (321.50 m) and the routed maximum discharge worked out to be 14300 cumecs (5 lakh cusec), thus accounting for a flood storage of 3208 MCM (2.6 million acre ft) between crest level and MWL (338.30 m)

The gross storage of KHD Project is considered as 13450 MCM upto FRL 335.25 m. But in the feasibility report, it is mentioned that the water level during the flood season is proposed to be maintained below the crest level (321.50 m) by regulating the releases through sluices and spillway gates. These two statements seem to be contradictory and misleading. It seems that conservation storage in the non-monsoon has been considered as 13,450 MCM upto FRL 335.25 m, but in the monsoon period it is up to crest level 321.50 m only.

The maximum peak flood of 9.15 lakh cusec has been observed on 5th Oct. 1968 at Barahkshetra Dam site but the inflow hydrograph is not available. The next highest observed flood peak of 8.55 lakh cusec for which the inflow hydrograph is available.

The same inflow hydrograph has been routed with a flood cushion of 4.75 m, the flood impinging at 330.50 m. The maximum outflow came out to be 7900 cumec with maximum reservoir level 338.39 m. Thus it seems that keeping maximum outflow of 7900 cumec. (2.79 lakh cusec) and impinging level 330.50 m corresponding to flood cushion of 10% of live storage i.e. 937 MCM the maximum reservoir elevation attained during routing remarks just around MWL (338.30 m).

It is worth to be added that as per the Kosi Technical Committee (1965), recommendation, this proposed Kosi High Dam should have provision for 4691 MCM (3.8 MAF) flood cushion so that flood can be moderated to safe maximum discharge of 5660 cumecs (2 lakh cusec). This provision will ensure dependable flood protection and at the same time this will facilitate construction of forward embankments on either side of the defined channel carved out for moderate flood. And by doing so, a vast tract of culturable land can be brought under cultivation for reasonably stable defined channel. The variation between maximum and minimum discharge must be kept within reasonable limit which may be 15:1 This is required for improved morphology and navigation through the river. To maintain the river morphology it is essential to provide at least 200 cumec (i.e. 3629 MCM) water d/s of the Kosi barrage even in non-monsoon period.

ii) Soil conservation to control inflow of sediment load

In view of the heavy sediment load being carried in the Kosi river, it is necessary to adopt soil conservation measures in the upper catchments so that optimum benefit can be assured from the constructed and proposed schemes. As the Tamur tributary having 10 per cent catchments of the Kosi river, contributes 26% of the coarse silt, the Kosi Technical Committee (1965) has suggested that as the first step soil conservation should be done in its catchments.

The plan of soil conservation for the Tamur catchments should include debris (check) dams at suitable points. These dams will help to check the high velocity by controlling gradient. Conservation plans on land, supplemented by Conservation forestry and other coordinated measures on the unfarmed portion of catchments, provide a soil conservation scheme.

Kosi Technical Committee (1965) has referred the extensive work in the direction of Soil Conservation taken up by New-Zealand. The following information are worthwhile to mention:-

" Spelling or retirement from grazing, especially during flowering and seeding revived both native and sown pastures remarkably and generally produced a cover on eroded land that resisted erosion and controlled water much better.

Surface sowing of cloves, and even grasses under some circumstances, resulted in the establishment of surprisingly good pastures on deteriorated sown and native grass lands, particularly when grazing was strictly controlled.

Top dressing with phosphate and trace elements proved to be the biggest factor in promoting the introduction of clovers and the strengthening of grass is on deteriorated hill country soils.

Rational grazing of cattle was more effective than sheep grazing in regenerating poor pastures, and cattle obviated the need to burn native pastures periodically. When burning and rabbits were eliminated the rapid recovery of native pasture under controlled cattle grazing was not promising.

The value of planted trees in healing unstable eroded land, particularly in gullies, was confirmed in all districts, as was the effectiveness of native cover regenerated by complete spelling in areas of higher rainfall.

Pasture furrows were valuable in conserving water and reducing the scour of soil.

Graded banks and broad-base terraces were strictly effective in stopping the loss of soil from cultivated slopes by sheet and rill erosion and in greatly reducing uncontrolled run-off.

Wide and low, grossed waterways, proved effective in harmlessly disposing of run off that could not be retained on the land.

Dam capable of temporarily storing flood waters and regulating their discharge through a pipe demonstrated their merits.

Gully Control Works, such as debris dams and drops, proved effective.

It was found that all the other conservation practices were of limited use until dressing and over sowing not only increased the protective value of the pasture but also increased the cropping capacity of the land and so provided revenue for other improvement and supporting conservation practices. However, top dressing and seeding are difficult and expensive on hill country. The economical solution was found in New Zealand in the serial mechanization of this work".

The effective and profit giving soil conservation thus is very important for the catchments of the dams in the Himalayan region for very effectiveness and effective life of the structure.

8.2.2.7 Navigation System

The proposal of NWDA to remodel Purnea Branch Canal as navigation channel for 8830 MCM water does not appear logical as it will involve numerous additional works. Instead navigation can be well planned and provided without much ado from Nepal to sea port at Kolkata through river route.

8.2.3 RECOMMENDATIONS

1. The proposed Kosi High Dam should have provision of flood cushion for 4691 MCM (3.80 MAF) as recommended by Kosi Technical Committee (1965) so that flood can be moderated to safe maximum discharge of 5660 cumecs (2 Lakh Cusecs)

2. Soil conservation measures in the upper catchments should be included in the Link Schemes to control inflow of sediment load in the Kosi dam reservoir so that optimum benefit can be assured from the proposed dam.

3. The shortage to the extent of 2,701 MCM in Mahananda basin of the Kamala- Balan-Kosi- Mahananda composite basin during non-monsoon period be met by MSTG Link.

4. The remaining shortage of 10,162 MCM during non-monsoon should be met by conservation of more of monsoon flows by constructing storage reservoirs on the tributaries of Kosi viz. Sun Kosi, Tamur and Arun.

5. The proposal of NWDA to remodel Purnea Branch Canal as navigation channel does not appear logical. Instead navigation should be provided through river route itself.

8.3 MANAS-SANKOSH-TISTA-GANGA (M.S.T.G) / JOGIGHOPA--TISTA-FARAKKA (J.T.F) LINK CANAL PROJECT

8.3.1 THE SCHEME AS PREPARED BY NWDA

8.3.1.1 General outline of the scheme

The Manas-Sankosh-Tista-Ganga link canal is a major unit of the Himalayan component of the Interlinking of Rivers of India. The link Canal envisages to transfer water from Brahmaputra to Ganga and comprises the flowing components:-

i. A dam on river Manas, a major tributary of Brahmaputra with live storage of 8750 MCM, located about 4 Km upstream of Indo-Bhutan border.

ii. Another dam with maximum height of 253 m and live storage capacity of 4930 MCM, on river Sankosh, a tributary of Brahmaputra also located in Bhutan about 12 Km up stream of Indo Bhutan border.

iii. A barrage on river Sankosh – 11 Km down stream of proposed dam on river Sankosh.

iv. The MSTG link Canal off takes from the tail race of right bank power house and joins Sankosh barrage. The link Canal utilises the existing Tista and Mahananda barrages to cross these rivers and outfalls into Ganga 60 Km upstream of Farakka.

v. The total length of the link Canal is 457 Km. Component wise particular of the canal is as given in Table 8.3.1

Table 8.3.1

S.N.	Name of Component	Length Km.	Bed Width m.	F.S.D m.	Bed slope	Design discharge
1	2	3	4	5	6	7
i.	Manas-Sankosh Link	114	66	10	1 in 20,000	1370
ii	Sankosh-Tista Link	137	121	10	1 in 20,000	2355
iii	Tista-Ganga Link	206	121	10	1 in 20,000	2355
Total	MSTG Link	457	66 to 121	10	1 in 20,000	1370 to 2355

vi. The length of link canal in Bihar has been reported as 118 Km, which on verification has been found to be 151.2 Km.

vii. There is an alternative Link proposal also called Jogighopa Tista-Farakka (JTF) Link Project which has a barrage at Jogighopa on main river Brahmaputra and 97.53 Km. long link canal joining the barrage with the Sankosh barrage. The link canal from Sankosh barrage to Ganga is common for both the alternatives. The transfer of Brahmaputra water from Jogighopa barrage to Sankosh barrage involves 100 m lift which has been proposed to be achieved through five pumping stage with a total pumping capacity of 1059 MW. There is a scope of generating 300 MW power at Jogighopa barrage. In view of involvement of pumping, the alternative has not been considered viable by NWDA.

An index map showing layout of both the Schemes is enclosed vide Plate No. 6&7.

8.3..1.2 Benefits

The Scheme envisages to provide the following benefits :

i. Irrigation benefits in 6.536 lakh ha out of which 2.64 lakh ha will be in Bihar.

ii. The releases from Manas and Sankosh will be utilised for power generation and the installed capacity of power houses will be 1400 MW. A power house having installed capacity of 125 MW is also proposed in Second Stage at Sankosh. There will be seven power stations on the Tista-Ganga link canal with total installed capacity of 805 MW, out of which four numbers of power stations with installed capacity of 393 MW will be in Bihar.

iii. This will augment the flow of Ganga at Farakka for preserving the Calcutta port and other purposes. The balance water will be further diverted to Mahanadi, Godavari, Krishna, Pennar, Cauvery to serve water short areas in south.

iv. Navigational facilities will be provided throughout the link canal.

8.3.1.3 Water balance study by NWDA

The surface water balance at Manas Dam & Sankosh Dam sites have been worked out by NWDA as below : Unit MCM

Sl. No	Particulars	Water Balance at	
		Manas Dam	Sankosh Dam
1	Availability		
a	Gross Annual Yield		
i)	At 75% dependability	27578	14745
ii)	At 50% dependability	35867	16356
b	Surface Water import	Nil	Nil
c	Surface Water export	Nil	Nil
d	**Overall availability**		
i)	At 75% dependability	27578	14745
ii)	At 50% dependability	35867	16356
2	**Surface Water Requirement for**		
i)	Irrigation	1696	211
ii)	Domestic Use	157	30
iii)	Industrial use	307	56
iv)	Hydropower use (Evaporation Loss)	96	68
v)	Provision for U/s utilization in Bhutan	2181	1183
	Sub Total	4438	1548
3	**Regeneration**	Nil	Nil
4	**Surface Water Balance**		
i)	At 75% dependability	23140	13197
ii)	At 50% dependability	31429	14808

Source : NWDA Technical Study No PFR (H)/2/94 on MSTG Link Report.

As worked out above the balance flows available at Manas and Sankosh dam sites at 75% dependability are 23140 MCM & 13197 MCM respectively. But based on simulation studies at Annexure2.7 &2.8 of NWDA Report, it is seen feasible to divert only 22560 MCM for Manas and 12433 MCM from Sankosh reservoirs through MSTG Link. In addition to this, half of 75% monthly dependable flows of four major intermediate virgin streams, totalling to about 8215 MCM, is also proposed to be contributed into the link canal at the respective crossing points of the link with these streams. Thus a total of 22560 +12433+8215 = 43208 MCM would be available for diversion through the links.

8.3.1.4 Water transfer through the link canal

Out of available water of 43208 MCM the en-route demand for annual irrigation in 6.536 lakh ha. which includes 2.64 lakh ha in Bihar, has been worked out as 4027 MCM while transmission loss has been assessed as 1268 MCM i.e. total en-route demand is 4027+1268=5295 MCM.

This leaves a balance of 43208 - 5295 = 37913 MCM for transfer into Ganga for fulfilling the fast growing needs at Farraka and further diversion to South. It has been estimated that 15000 MCM of water will be utilized for augmentation of flow of Ganga at Farraka during lean period of January to May and balance flow of 22913 MCM will be diverted to further South towards Mahanadi for meeting requirement of the water short areas in the region of Ganga to Mahanadi and also beyond Mahanadi.

8.3.2 OBSERVATIONS & FINDINGS OF THE COMMITTEE

8.3.2.1 Water requirement for irrigation in Bihar, as assessed by the committee:-

As discussed earlier, the proposed command area in Bihar falls under agro-climatic sub-zone- IV-5 for which an overall irrigation intensity of 250% has been considered appropriate. The total water requirement for agricultural use as assessed by the Committee works out to 1288 MCM during monsoon and 3614 MCM during non-monsoon, annual irrigation demand being 4902 MCM vide Annexure 8.3.2.1. Besides, this there is non-irrigation demand in this basin within Bihar to the tune of 869 MCM, the break up being 289 MCM during monsoon and 580 MCM during non-monsoon. Thus the total demand in the basin (Bihar State) would be 5771 MCM per annum, the monsoon and non-monsoon break up being 1577 MCM and 4194 MCM respectively. The water available from existing and proposed Schemes, in the basin, has been assessed as 2822 MCM during monsoon and 1338 during non- monsoon. There is, therefore, surplus of 1245 MCM during monsoon and shortage of 2856 MCM during non- monsoon period as will be evident from Annexure 8.3.2.1

8.3.2.2 Problems apprehended

The perusal of the Index map shows that the link canal crosses river Mahananda through existing barrage and river Mechi through new existing barrage and then flows parallel to the course of river Mahananda. The following points are very relevant in this scheme.

i. The area is very thickly populated. Due to high density of population, there is very heavy pressure on land.

ii. According to the report, the requirement of land for the construction of link canal in Bihar is 3480 ha. But on verification this calculation has been found to be erroneous.

The requirement of land works out to about 7000 ha.

iii. The link canal is in deep cutting and several places the cutting is more than 10m. The ground water in this area is very high. The construction of such deep lined canal will be very problematic. Even after constructions, the maintenance of lined canal in such a zone of high water table will remain a constant source of problem.

iv. The large area of land in thickly populated. The acquisition of such vast area of land in this thickly populated area will be very difficult. This will also create a big problem of rehabilitation.

v. The area is in lower reach of Ganga basin and there is problem of flood and drainage congestion of surface water. It is apprehended that these problems will be further aggravated.

8.3.2.3 Proposal foe meeting the shortage in the basin

The part of Mahananda basin (CCA = 264137 ha.) being commanded of MSTG link has a shortage of 2856 MCM during non-monsoon period (vide Annexure 8.3.2.1). The adjacent part of this very basin(i.e. 1,81,00 ha) falling in the command of Kosi-Mechi Link canal has also got a shortage of 2701 MCM and that too during non-monsoon (refer Annexure 8.2.2.5). Thus the Mahananda basin has a total shortage of 5557 MCM (i.e. 2856 MCM+ 2701 MCM). This shortage can very well be met by diversion of Brahmaputra water through MSTG Link at Mechi barrage shown at Plate No. 6a

Total needed diversion to Mahananda basin for this purpose would be 6642 MCM during non-monsoon period against the presently envisaged diversion of 1627 MCM as per NWDA proposal of MSTG Link. The basis and distribution of the desired water i.e. 6642 MCM is as shown in Table 8.3.2 given below:

TABLE 8.3.2

(Unit MCM)

S.N	Particulars	Monsoon	Non-monsoon	Total
1.	Demand in MSTG Link canal in Bihar vide s.n.1 of annexure 8.3.2.1	1577	4194	5771
2	Flow available from free catchments of Mahananda basin (4160-1627=2533)	2280 (90%)	253 (10%)	2533
3	Flow required to be released through MSTG Link for use in Bihar (1-2)	nIL	3941	3941
4	Demand in Mahananda basin in the command of Kosi- Mechi Link canal (vide annexure 8.2.2.5)	1081	2874	3955
5	Flow available from free catchments of Mahananda basin (Vide Annexure 8.2.2.5)	1562 (90%)	173 (10%)	1735
6	Flow required to be released through MSTG Link for use in Bihar in the Mahananda basin, falling in the command of Kosi- Mechi Link (4-5)	Nil	2701	2701
7	Total water proposed to be released for Bihar through MSTG Link (3+6)	-	6642	6642

This enhanced diversion during the period is quite possible as the MSTG Link system is supported by storages of 13,680 MCM (i.e.8750 MCM in Manas basin + 4930 MCM in Sankosh basin). It is also to be added that even after diversion of 6647 MCM, of water for Bihar , the system will be capable of diversion of 15000 MCM of water for Farraka during the lean season (as stipulated by the NWDA in their report) and 17898 MCM for its diversion to further south towards Mahanadi.

8.3.3 RECOMMENDATIONS

MSTG and JTF link canals while passing through Bihar are of similar nature. These are unrealistic in as much as, it is impractical to excavate 10.0 m deep canal having about 121.0 m wide bed and lining it in this zone and running for more than 150.0 Km side by side the rivers Mechi and Mahanada. In view of the problems discussed above and in light of the situation that the alignment of the proposed link canal runs parallel to the course of river Mahananda, it is considered advisable to utilise the course of River Mahananda for diversion of Brahmaputra water to Ganga. With this end in view the following alternative is recommended:

1) MSTG Link canal may be carried on its fixed alignment till it crosses river Mechi near village Bairagi as proposed by NWDA. A barrage may be constructed and the discharge needed for Bihar may be diverted through canals on both the sides while the discharge to be transferred through Ganga and partly to be used in Bihar on left bank of Mahananda be dropped into Mechi itself .The conveyance of imported water to be transferred into Ganga may be done through river route viz. through Mechi and then Mahananda river instead of having a big canal parallel to the rivers. The river will have to be improved to accommodate the additional discharge, straightened and the Mahananda embankment be duly improved, fortified and riveted wherever required.

For this purpose additional structure needed will be as follows:

i. A barrage in river Mechi at junction of the MSTG Link canal with head regulator on both sides.
ii. Another barrage with H/R at the off-take point of Barsoi channel. This will facilitate irrigation as well as regulate the flow into the Barsoi channel vide Index Map attached.
iii The drops in Link canal as well as drops on additional structures just d/s of Mechi and Mahananda confluence in Bihar and other control/ diversion structures may be so designed that they can have hydel power generation units to provide constant source of renewable energy.
iv. A diversion structure across river Mahananda upstream of confluence with Ganga , with a power channel to utilise the drop at the outfall into Ganga for power generation especially, during lean flow when Ganga water will be at low level vide Index Map attached.
v. If required to accommodate the additional discharge, the course of river may be improved by dredging, straightening and even bank protection. Small short-cut for straightening the river Mahananda within existing embankments may also be done to facilitate navigation. This improvement may need rehabilitation of few villages lying within embankments, if affected by higher discharge in Mahananda.

2) In order to safeguard the interest of Bihar it is recommended to increase the diversion of Brahmaputra water to this state to the tune of 6642 MCM (vide Table 8.3.2) and that too, only during non-monsoon against the present allocation of 1627 MCM in a year. This will meet the shortage of 2856 MCM in the command of MSTG link and also of2701 MCM in the command of Kosi- Mechi Link (ref. Annexure 8.3.2.1 & 8.2.2.5) in Mahananda basin.

This enhanced diversion during the period is quite possible as the MSTG Link system is supported by storages of 13,680 MCM (i.e.8750 MCM in Manas basin + 4930 MCM in Sankosh basin). It is also to be added that even after diversion of 6647 MCM, of water for Bihar , the system will be capable of diversion of 15000 MCM of water for Farraka during the lean season (as stipulated by the NWDA in their report) and 17898 MCM for its diversion to further south towards Mahanadi.

8.4 IMPACT OF THE SCHEMES OF INTERLINKING OF RIVERS

8.4.1 Impact on drainage .

Since all the proposed link canals mostly pass through Nepalese territory except that from Sankosh-Tista-Ganga Canal and part of Kosi-Ghaghra and all are proposed to be lined, adverse effect of drainage congestion in this State on account of seepage from them will not be significant. The canals, however, specially, Kosi-Mechi & Kosi-Ghaghra and Gandak- Ganga Link Canal are more or less contour canals, and pass through cutting many rivulets and rivers. Obstruction to flow of water straight from Nepal to Bihar will be partially obstructed causing drainage congestion in Nepal and may, in case of pressure on the link canal, cause breaches which may be affecting the territory of Nepal and Bihar lower down in some cases. The main problem of drainage in Bihar is obstruction caused by development works without providing proper waterway by various agencies and adverse outfall condition. The first one is an internal problem and does not depend on any way on the proposed link canals. The effect of works on the outfall conditions, i.e. the level of the Master drain the Ganga, may however, affect the drainage in Bihar. Since Ganga from Allahabad to Farakka has been declared as National Inland Waterway, it is expected that the GOI will improve this part of the Ganga by concentrating its flow into only one channel and deepening it, thus improving its discharge and sediment carrying capacity. It is expected that out-fall conditions of the rivers of Bihar into the Ganga will improve, having good effect on drainage.

The proposed link canal, Manas-Sankosh-Tista-Ganga link canal into Bihar, if at all constructed as proposed will, however badly affect drainage of that area. It cuts many local drainage channels and rivers which join Mahananda and their outfall into Mahananda will be badly disturbed and adverse drainage problem will be created in Araria, Kisanganj, Purnea, & Katihar districts. The modification suggested by this Committee will obviate this problem as the river itself will become carrier of the Manas-Sankosh-Tista Link Canal's water and will not necessitate so may cross drainage works, and will not obstruct the rivers joining Mahananda in Bihar.

The part of Kosi-Ghaghra Link Canal in Bihar will also cut the distribution system of Gandak canals, Ghorasahan & Tribeni and is bound to adversely affect the drainage.

8.4.2 Impact on Ecology and Environment

Ecology as per Oxford dictionary means study of effect of Environment on living being, whereas Environment means surroundings. The earth which was inhabited by hardly hundred crore
people prior to the past century, is now inhabited by more than six hundred crore. The earth, naturally is having impact of this fast growing population and its connected activities. In this background human effort to utilise the water resources to the optimum to meet the populations' need, connected agricultural activities and irrigational efforts are bound to affect the ecology and change the surroundings.

Main environmental aspect in Reservoir backed Irrigation Projects are on

a. Catchments Area

b. Reservoir - including resettlement and rehabilitation - removal, forest clearance, wild life, drawdown slip, cultural interests, climatic changes, sedimentation, tourism and recreation, health hazard and ground water profile.

c. The Dam-induced seismicity, dam safety measures Regulation and consideration for upstream flow downstream and pollution control.

d. River Regime Downstream - bank and bed erosion, flood damage, navigation pisciculture, water quality etc.

e. Command Area - Water logging and salinity, Effect of fertilisers and pesticides, health hazard, soil fertility, change in land use water pattern.

f. Socio-economic system - ranging from command economy with dominance of public ownership of means of production, participatory irrigation management etc.

The link canal schemes, hence, do affect Bihar also, even though the Dams and Reservoirs are located in Nepal except that on Sone & others proposed by this Committee. The study by this Committee hence, has strongly advocated for catchments treatment, the aspect which has been totally ignored in these schemes.

The Reservoirs will in Committee's view improve tourism recreational activities and will thus help economy of Nepal apart from enormous gain from power generation. It is not expected to, in any way, adversely affect Nepal, rather will help by increasing activities like fisheries, tourism etc.

The phenomenon of so called "Reservoir induced seismicity" is subject matter of considerable debate and opinions have differed. A study showed that out of 425 dams in the world, which could be termed large dams, only 15 dams had shown an increase in seismic activities after impoundment. Studies indicated that it cannot be attributed entirely to the formation of reservoir even in there cases. Thus the existing state of knowledge about seismicity does not enable a precise evaluation of the seismic consequences that follow the impoundment in a large reservoir. The proposed reservoir on Gandak is a small one.

Safety - measures of dam must form part right from the very beginning.

The Reservoir Regulation and gate operation must be properly defined and documented to obviate any hazard or mishap. Bihar being the main state to be affected must have say in this right from very beginning and throughout its operational life. The operation has to be linked with uniform flow down so far flood control, as well as reduction of peak flow and enhancing lean water discharge, making the river pollution free, navigable all through the years and improving the morphology of the river.

The Command area in this case which lie mostly in Bihar may not have any adverse effect as already it is experiencing the irrigation. Only its intensity will have to be optimised. This zone since lies in zone having less evaporation and more monsoon precipitation, salination of surface is not experienced in any significant amount. It is not expected that salinity will ever increase as the monsoon rains leach out any salt even if it surfaces. Only the surface drainage of the command area has to be improved gradually to the full extent.

Land use pattern in the background of availability of irrigation water and with a view to optimising production and productivity has to be suitably oriented in this regards. The steps being taken by Bihar towards participatory management of irrigation is laudable step, but it must be accomplished along with consolidation of land holdings and proper OFD work. Proper On Farm Development should consolidate land holdings of each land holder at one place and each land holder should have proper approach at his farm, has irrigation channel on one side of his farm, and field drain on the other side, well laid considering contour of the area. Such steps will help in developing suitable cropping pattern, and timely doses of water supplies just in right quantity, without causing over irrigation, or under irrigation. Aforesaid, measures would also help in obviating chances of water logging and salinity, and will enthuse farmers to invest more labour and money for optimising production. Need to educate the farmers to use right type of and doze of fertiliser and pesticide cannot be over emphasised. Agriculture extension services can ensure preventing any hazard on account of chemical fertilisers, insecticide and pesticides.

Environmental management plan of the region involves multi-disciplinary endeavour in a wide spectrum explained above. This will need co-ordinated and concerted efforts from various departments of the State Government and active support and assistance from the Government of India.

Annexure 8.1.3.3

Assessment of water requirement in proposed **Gandak-Ganga link canal** for irrigation & Non-irrigation needs in Bihar

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA in GGLC command to be irrigated (ha)	Total area to be irrigated in ha				Water demand irrigation (MCM)			
1	2	3	4	5	6	7	8	9	10	11	12
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
			Intensity	**0.8**	**0.95**	**0.75**	**Delta**	**0.65**	**0.473**	**1.01**	
1	Ghaghara-Mahi Western Gandak Composite	519154	519154	415323	493196	389366	1297885	2700	2333	3933	8965
							Delta	0.65	0.35	1.01	
2	Upper Eastern Gandak Upper Burhi Gandak Composite	599034	599034	479227	569082	449276	1497585	3115	1992	4538	9644
							Delta	0.65	0.441	1.01	
3	Lower Eastern Gandak-Baya Lower-Burhi Gandak Composite	493648	493648	394918	468966	370236	1234120	2567	2068	3739	8374
							Delta	0.65	0.473	1.01	
4	Ganga stem	56899	56899	45519	54054	42674	142248	296	256	431	983
5	Total	1668735	1668735	1334988	1585298	1251551	4171838	8677	6648	12641	27967

	Non-irrigation Demand (MCM)				Total demand seasonwise MCM)			
	13	14	15	16	17	18	19	20
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
Ghaghara-Mahi Western Gandak Composite	881	881	881	2643	3581	3214	4814	11608
Upper Eastern Gandak Upper Burhi Gandak Composite	642	3617	3617	7876	3757	5609	8155	17521
Lower Eastern Gandak-Baya Lower-Burhi Gandak Composite	881	881	881	2642	3448	2949	4620	11016
Ganga stem	100	100	100	300	396	356	531	1283
Total	2504	5479	5479	13462	11181	12127	18120	41428

	Water available (MCM)				Water Deficit/Surplus (MCM)		
	21	22	23	24	25	26	27
	Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.
Ghaghara-Mahi Western Gandak Composite	14891	827.5	827.5	16546	11310	-2386	-3986
Upper Eastern Gandak Lower Burhi Gandak Composite	17474	971	971	19416	13717	-4638	-7184
Lower Eastern Gandak-Baya Lower-Burhi Gandak Composite	15360	853.5	853.5	17067	11912	-2095	-3767
Ganga stem	386	21.5	21.5	429	-10	-334	-510
Total	48111	2673.5	2673.5	53458	36930	-9454	-15446

Annexure 8.2.2.5

Assesment of water requirement in proposed Kosi-Mechi Link Canal for Irrigation and Non-Irrigation Needs

Sl.No.	Name of Basin	Total CCA (Ha)	Part of CCA in KMLC command to be Irrigated (Ha)	Total area to Be Irrigated (Ha)				water demand for Irrigation (MCM)			
				Kharif	Rabi	HW	Total	Kharif	Rabi	HW	Total
1	2	3	4	5	6	7	8	9	10	11	12
			intensity	**75%**	**95%**	**80%**	**Delta**	**0.5**	**0.44**	**1.01**	
1	Kamala-Balan	322318	106686	80015	101352	85349	266715	400	446	862	1708
			intensity	**75%**	**95%**	**80%**	**Delta**	**0.65**	**0.55**	**1.01**	
2	Kosi	838100	838100	628575	796195	670480	2095250	4086	4379	6772	15237
			intensity	**75%**	**95%**	**80%**	**Delta**	**0.65**	**0.59**	**1.01**	
3	Mahananda	445137	181000	135750	171950	144800	452500	882	1015	1462	3359
4	Total	1605555	1125786	844340	1069497	900629	2814465	5368	5840	9096	20304

	Non Irrigation Demand (MCM)				Total Demand Season Wise (MCM)			
	13	14	15	16	17	18	19	20
	Kharif	Rabi	HW	Total	Kharif	Rabi	HW	Total
Kamala-Balan	170	170	170	510	570	616	1032	2218
Kosi	832	4867	4867	10565	4918	9246	11638	25802
Mahananda	199	199	199	596	1081	1213	1661	3955
Total	1201	5235	5235	11671	6569	11075	14332	31975

	Water Available (MCM)				Water Deficit/Surplus		
	21	22	23	24	25	26	27
	Kharif	Rabi	HW	Total	Kharif	Rabi	HW
Kamala-Balan(90:10)	967	54	54	1075	397	-562	-978
Kosi	29353	6132	6132	41615	24435	-3114	-5506
Mahananda	1562	87	86	1735	481	-1126	-1575
Total	31882	6273	6272	44425	25313	-4802	-8060

Annexure 8.3.2.1

Assessment of water requirement in proposed Manas-Sankosh-Tista-Ganga Link Canal for Irrigation & Non-Irrigation needs

Sl. No.	Name of basin	Total CCA (Ha)	Part of CCA in MSTG command to be irrigated (Ha)	Total area to be irrigated in ha				water demand for Irrigation (MCM)			
				Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
1	2	3	4	5	6	7	8	9	10	11	12
			Intensity	**75%**	**95%**	**80%**	**Delta**	**0.65**	**0.59**	**1.01**	
1	Mahananda	445137	264137	198103	250930	211310	660343	1288	1480	2134	4902

Sl. No.	Name of basin	Non Irrigation Demand (MCM)				Total Season wise Demand (MCM)			
		Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
		13	14	15	16	20	21	22	23
1	Mahananda	289	290	290	869	1577	1770	2424	5771

Sl. No.	Name of basin	Water Available Seasonwise				Water Deficit/surplus			
		Kharif	Rabi	H.W.	Total	Kharif	Rabi	H.W.	Total
		24	25	26	27	28	29	30	31
1	Mahananda	2822	669	669	4160	1245	-1101	-1755	-1611

CHAPTER-IX

SUMMARY OF RECOMMENDATIONS

CHAPTER IX

SUMMARY OF RECOMMENDATIONS

9.1 General

9.1.1 The scheme for interlinking of major rivers of India, which is very bold, ambitious, imaginative and which has been planned on hitherto unprecedented scale is considered the biggest project of the country and one of the biggest in the world in the field of water resources. It has raised high hopes in all parts of the country. Bihar is also expected to be benefited in a significant way. The scheme is in very initial stage. Though the Himalayan component from where water is envisaged to be transferred is lagging behind, the Peninsular component where water is envisaged to be transferred is in slightly advanced stage. However a detailed study of the different link canals proposed under the Himalayan component and related to Bihar suggests that there is need for improvements and modifications on following accounts to suit the needs of and to make it more beneficial to Bihar.

- **widening the objectives to include all problems related to water resources development like flood moderation, ensuring adequate flow during lean period in master drain i.e. river Ganga instead of focusing only on transfer of water to south and west.**
- **conceptual change to envisage equitable distribution of water resources in different regions and sub-regions of the state sub-basins of major river basin along with the different parts of the country.**
- **adopt approaches about the assessment of demand for shortage and surplus basins, assumptions about cropping / irrigation intensities and potential of development of agriculture as recommended by the National Commission for Integrated Water Resources Development (1999), the Second Irrigation Commission (GOI, 1972), Committee on Agricultural Productivity in Eastern India (RBI, 1984).**

The study and review of the Reports on link canals of the Himalayan components related to Bihar dispel the following general beliefs:

i. That huge quantity of surplus surface water is available which can be transferred to Southern &Western parts of the country. On the contrary the study reveals that there is surplus water only during monsoon period and that, too when the proposed import to Bihar from Bharmhaputra 1627 MCM and from Chunar 5566 MCM is considered to be available. But overall picture is that there is shortage of 70,879 MCM considering need of non- monsoon water (Vide Annexure 9.1). Thus surplus of 63571 MCM in monsoon, may be stored by reservoirs on all the rivers and their tributaries coming into Bihar, and also stored as ground water so that they can reduce the deficit of non-monsoon period.

ii. That the scheme envisages to transfer flood water to water short basins of Southern and Western India. On the contrary, most of the transfer of water is envisaged

from the storage though transfer of water from run-off- the river during monsoon is proposed. But such transfer of water will not have significant impact on the flood moderation. **The scheme should consider the option of transferring water during flood only and provide storage in the deficit basins, along with providing the same in the surplus basins.**

9.1.2 Objective of the River Interlinking Schemes of India is transfer of surface water flow to a water short area/basin from water surplus area/basin after meeting the water requirements of the latter.

i. This objective is acceptable. However it seems proper that it should also address the burning problems like flood, drainage congestion and diminishing lean season flow in Ganga which have been restricting not only the development of water resources of Bihar but have also shattered all its agro economic development.

ii For working out irrigation water requirement, the NWDA has considered the cropping intensity of the region of basin as the presently achieved cropping intensity or 100% whichever higher. This principle puts a barrier on the regions / basins which are lagging behind in the field of water resource development and its utilisation on account of reasons other than the availability of water. In Bihar, the development of irrigation potential is not up to the mark, not because of lack of water resources on annual basis but due to the following reason:-

- Un even distribution of surface runoff
- Lack of adequate and suitable storage site within the state.
- Predominance of flood and water logging.
- Diminishing lean water flow in the tributaries rivers and even in river Ganga.
- Inter state and international issues involving water resources development
- Economic backwardness
- Poor financial condition of the state.

iii. Considering the awareness of water utilisation in the nation and future economic requirement of the state, the Committee, keeping into consideration the agro-climatic conditions of the state, considers the cropping intensity of 230% to 250% which is likely to be achieved in the situation in which all or many of the constraints mentioned in (ii) above are removed.

9.1.3 Resource profile

Geographical area of the state is 93.80 Lakh ha and its culturable area is 64.42 Lakh ha. According to Land use utilisation/classification of land data pertaining to 1999-2000, the net sown area and total crop area are 56.68 Lakh ha and 79.95 Lakh ha., indicating thereby cropping intensity of 141%.

The 75% dependable annual inflow yield assessed by the SBSIC, 1994 was 3,15,893 MCM, of which 2,83,655 being from the catchments area outside the state and 32,238 MCM being from the catchments area within the catchments. The Committee has re-assessed this resource as 132,175 MCM in a year (vide Annexure 9.2) The breakup being 100726 MCM from catchment area outside state and 31,449 MCM being from the catchment area within the state. The latter assessment is on the following consideration:

a The inflow yield of river Ghaghra and Ganga from catchments area outside state(i.e. 68,015 MCM and 85,000 MCM respectively) are not available for use in Bihar.

b The inflow yield of river Gandak and Kosi from catchments area outside state has been modified according to the study of NWDA.

c The inflow yield of river Mahanada from catchments area outside state has kept as that proposed to be made available from MSTG Link i.e. 1627 MCM.

d The inflow yield of river Sone and Karmnasa outside state has been limited to 7,709 MCM (i.e. 6.25 MAF) and 308 MCM(0.25 MCM) in light of the Bansagar agreement. In addition about 64 MCM is to be made available as per Musakhand Dam agreement, but is hardly available even though cost has been shared equally.

The study of water availability in different river basins / sub-basins of Bihar reveals the following startling facts :

9.1.4 Disparity in use of Ganga water to the gross dis-advantage of Bihar has been indicated by N.W.D.A., while stating at Page 13, Table 2.3 in the report on Chunar-Sone Barrage Link Canal, that out of 1.08 Lakh MCM, which is 75% dependable yield of river Ganga at Chunar (Banaras), 1.25 Lakh MCM is the requirement of U.P. itself. It means that 17,000 MCM of water, which is not assured and comes down occasionally is also used up by the command area falling within U.P., and whatever water comes down in Ganga is coming from Ground water recharge (not at all from Uttaranchal) and rivers joining Ganga downstream. This water too is reserved for W.B. and Bangladesh in non-monsoon period. Even in such a scenario water from tributaries of Ganga has been and are proposed to be diverted westward by

(a) Sarda Yamuna Link Canal
(b) Ghaghra-Yamuna Link Canal
(c) Yamuna Rajasthan Link canal and
(d) Rajasthan-Sabarmati Link Canal

This scenario must change, and the full requirement of Bihar be fully assured before diverting Ganga-Basin's water to west and transferring Brahmputra Basin's water entirely to south.

The concept of Inter-linking of Rivers and principles enunciated by the report of the National Commission for Integrated Water Resources Development must be accepted to fulfill the needs of North-Indian States (being taken as surplus States) also.

9.1.5 Focus on flood

The N.W.D.A schemes do not at all show concern over the flood- problem and sufferings of Bihar, which must be given full- priority. This has been discussed in Chapter V as per in TOR-2. These may be done by the following measures.

(a) Allowing Flood-cushion on all the reservoirs in Himalayan Rivers especially in those on Kosi and Gandak at least to the extent of 10 to 15 % of the live storage in them.

(b) Providing reservoirs on all the tributaries of Kosi, Gandak and on Bagmati, Kamla etc. to store flood water.

(c) Undertaking effective, economical and beneficial soil-conservation steps in the catchment area of these reservoirs with a view to
   (i) Minimising siltation in them and
   (ii) Thus enhancing the useful life of these reservoirs and reducing Dead Storages, and
   (iii) For making the scheme beneficial to people of Nepal.

(d) Diverting flood water of Kamla, Bagmati etc in Ghaghra basin and

(e) Examining possibility of evacuating water of waterlogged area on the confluence of Bagmati, Kamala etc with Kosi by linking directly into the Ganga near Badlaghat/ Mansi.

9.1.6 Water requirement in Bihar correctly assessed on projected and realistic need (coverage area and intensity of irrigation) in the back-ground of reservoirs backing and enhanced flow in rivers, is given season-wise for all the climatic zones in the Annexure 9.1, which must be fully met before transferring water to other regions. It is possible to meet this requirement by storage, judicious diversions in this process, and allowing use of Ganga water.

9.1.7 To achieve optimum utilisation and benefits, the enhanced coverage of irrigation, modification of its distribution system as well as the structures, head-works and allied work involved in these should also form part of the NWDA scheme.

9.1.8 Bihar must be associated from the very beginning with the planning, execution and operation of Reservoirs on the rivers flowing through Bihar. Bihar has its major interest over the flow, morphological upkeep, for ecological balance of these river systems. The State's very existence is dependent on these rivers and consequently any provision, alteration and operation over these river systems must be fully monitored by the State of Bihar.

9.1.9 Similarly, Bihar must be associated and empowered to control channels leading into Bihar either by flow or by lift.

9.2 SURFACE WATER BALANCE STUDY (TOR 1)

1. Assumptions made by N.W.D.A. for arriving at water requirement are not acceptable. The actual culturable area, intensity of irrigated agriculture as well as need of projected population have not been assessed properly.

2. The surface water balance study done by the Committee with water need assessed as per actual CCA and projected intensity of irrigation shows a net deficit of 7307 MCM (vide annexure 9.1).

3. Season wise water balance has also been worked out at Annexure 9.1 which will reveal that water need assessed by NWDA for various Link Canals schemes affecting Bihar is much less than that assessed by the committee. This is because of following two reasons

a. CCA adopted by NWDA is much less than that assessed by SBSIC for these Basins
b. The crop intensity limited to existing or 100% whichever is more adopted by NWDA is too inadequate in comparison to 230% -250% projected by the committee to assess the 2050 AD needs.

4. The season wise surface water balance at Annexure 9.1 also shows that while there is surplus of 63,571 MCM of water during monsoon period (Kharif Season) there is a deficit of 70,880 MCM during non-monsoon period (Rabi and HW season). This indicates that there is urgent need to store the monsoon water in reservoir to prevent it from going to waste and utilise it in non-monsoon. If possible the reservoir should be over the year storage capacity.

5. This study also reveals that water is short in both monsoon and non-monsoon period for the South Bihar basins whereas there is surplus component in monsoon period and a deficit in non-monsoon period in North Bihar basins.

6. Overall surplus or deficit of water in the state does not at all reflect the correct and real picture. Surplus in monsoon only highlights the fact that 63,571 MCM of water though available is not utilisable on account of total absence of facility of storage and transfer for later use in other season or even in other region. Overall deficit in the present study has increased because high rural population density, trend of rise in population and surplus labour force necessitates optimum use of land and also highest possible irrigated agriculture.

7. Even if ground water, which has not been considered in the study, is utilised, the deficit shall still remain.

8. Some urgent steps may be necessary to even partially store the monsoon surplus water to reduce the deficit, since planning of optimum irrigation intensity cannot be reduced. These steps may be:-

a. Transferring surplus monsoon water to other parts, on condition of getting the same in non- monsoon period in south Bihar.

b. Constructing maximum number of reservoirs to store the same in Nepal, South Bihar and Jharkhand with maximum capacity

c. Storing partially monsoon surplus as ground water to the extent possible.

d. Keeping South Bihar reservoirs existing / under construction / proposed as full for Rabi and Hot weather irrigation by pumping monsoon surplus of upper catchments and North Bihar through Ganga

e. Adapting improved agricultural practices and knowledge of modern science for saving water's need for crops & preventing wastages.

(Para 4.4)

9.3 FOCUS ON FLOOD MODERATION- KOSI-GHAGHRA LINK SCHEME (TOR-2)

1. The Kosi Ghaghra Link Canal as proposed by NWDA may be accepted with a proviso that it should cater for irrigation intensity of 250% for both un-irrigated area and area under existing/ongoing/proposed Irrigation Schemes falling in the en-route command. Water demand should be worked out accordingly.

2. To offset the shortage of water in the non-monsoon period and for flood moderation, provision of storage reservoir on Kamla at Chisapani and on Bagmati at Noonthore and Masan dam in Burhi-Gandak basin should be incorporated in the scheme.

3. Suitable structure on its crossing with a.) Ghorashan Branch Canal, b.) Triveni Canal and c.) Trihut Main Canal. which are missing in the proposal should be provided.

4. The Link Canal can be utilised for diversion of flood of river Kamla and Bagmati with some alteration and additions in the scheme as suggested in Para 5.6.5.4.

   NWDA should consider these proposals and carry out detailed survey and investigation for this purpose.

5. The feasibility of Kosi-Ganga link at Mansi to mitigate flood problem in Bagmati-Adhwara group of rivers and drainage congestion at the confluence of Bagmati, Kamla and Kosi needs to be examined in depth after detailed survey and investigation and model tests

(Para 5.7)

9.4 CHUNAR-SONE BARRAGE AND STG-LINK SCHEME AS WELL AS PUMP CANALS FOR SOUTH EASTERN PARTS OF BIHAR (TOR-3 & 4)

9.4.1 Recommendations on Providing Assured irrigation in South Bihar through Chunar-Sone-Barrage (C-SB) Link and Sone Dam-Southern Tributaries of Ganga (SD-STG) Link Canals. (TOR-3)

1. In order to substitute Sone water at Kadwan (7117) MCM for diversion to cover area east of river Punpun and to meet deficit in Sone-Karmanasa command (11,153 MCM), a quantity of 18,270 MCM would be required to be diverted from river Ganga at Chunar which should be made available to Bihar at Chunar through the proposed River-Interlinking Schemes viz. Kosi-Ghaghra Link, Gandak-Ganga Link, Ghaghra Link and Sarda(Karnali)-Yamuna Link, before transferring any water to other basins from Bihar.

2. The water of 18,270 MCM so available at Ganga may then be diverted by constructing:

i. A Barrage across river Ganga at Chunar with proposed Chunar-Sone Gravity Canal, taking off the barrage, to divert 7,939 MCM of Ganga water annually.
ii Chunar-Sone Barrage Link Canal as proposed by the NWDA with modification to increase its capacity to divert 10,331 MCM annually instead of 5566 MCM for Bihar as envisaged in the present C-SB Link scheme.
iii. Sone-Dam Southern Tributaries of Ganga (SD-STG) Link canal as proposed by NWDA, to divert 7117 MCM of Sone water from proposed Kadwan dam instead of only 2512 MCM of water as envisaged in the present SD-STG Link canal Scheme as proposed by NWDA.
iv. As SD-STG Link will cover only 3,87,378 ha. of CCA between Punpun and Kiul, the balance CCA of 5,81,145 ha. should be covered through Barh(Ganga) Nawada multipurpose pump Scheme proposed by the Committee by diverting 5664 MCM of Ganga water at Barh during the non-monsoon period. The water demand in this command during the monsoon period will be met by its own resources.
v. All identified reservoir schemes in the command of Punpun (part) -Harohar-Kiul (part) composite basin and Kiul(part)-Badua-Bilasi-Beharna-Chandan-Chir river basin may be constructed with priority to utilise all possible runoff.
vi. Further reservoirs on rivers like Suara, Kao, and Awsane in Karmnasa-sone-basin; Jagarnath, Bulandhi, and Madar in Punpun river basin; Dhadhar, Tilaya, dhanarjai, sarkri, Lilajan and Mohane in Kiul-Harohar river basin be investigated and constructed to supplement the water requirement in the basin.

3. The Sone dam project at Kadwan, proposed by the government of Bihar, should not be allowed to be modified at all as has been proposed by the NWDA, since it will not only reduce the storage capacity but will also reduce the power generation drastically from 450 MW to 90 MW only, which will not be in the interest of Bihar.

(Para 6.4.1)

9.4.2 Recommendation on Pump Canal schemes to cater for the South Eastern part of Bihar (TOR-4)

1. **Pump Canal Scheme on right bank of river Ganga**

All the existing, on-going and proposed pump canal schemes on right bank of Ganga, be modernised / implemented to meet the demand of water in the command of south Bihar in the east of river kiul, falling below 60.0 m contour, as proposed by the NWDA. The Ganga water required to be pumped through these scheme is 810 MCM during monsoon and 4534 MCM (refer Para 6.3.4.3.1) during non-monsoon.

This can be achieved by:

i Meeting entire need of Bangla desh and west Bengal from proposed diversion of Bhamaputra basin water into Ganga and allowing free use of Ganga water in Bihar in both monsoon and non monsoon seasons

ii. Giving preference to Ganga basin itself for utilisation of water of this basin before transferring to other basin.

iii. The water to be transferred by Gandak-Ganga Link and Kosi-Ghaghra Link etc. in monsoon , be allowed to flow down in the Ganga in non-monsoon period, from reservoirs on Ganga basin including those on its tributaries. (Para 6.3.4.3.1)

2. **Construction of reservoirs**

Reservoirs like Sindhwarni and Amhara in Badua , Belharna river basin as well as Kudar in Bilasi-Chandan Chir river basin may be constructed as quickly as possible. Besides these identified reservoir, attempt should be made to explore further reservoir schemes and be constructed as quickly as possible.

(Para 6.4.2)

9.4.3 General recommendations

1. **Over utilisation of Sone water in UP and MP at Kadwan**

According to Bansagar agreement, entitlement of MP and UP for utilisation of sone water is 6476 MCM and 1542 MCM respectively, all being in the upstream of Kadwan. Against this, the total utilisation in these two states, as indicated in the NWDA report, is 12470 MCM (refer Para. 6.2.2.1). This is utter violation of provision of Bansagar agreement. This may be protested strongly for protecting the rights of people in Bihar and Jharkhand on use of Sone water.

2. **Requirement of Ganga water at Chunar.**

The NWDA and GOI may be impressed upon to make sufficient water available at Chunar, so that without causing any adverse effect on the ecology and environment of the river Ganga below Chunar, it may be possible to divert 18270 MCM of Ganga water at this site.

3. **First charge on use of Bhramaputra water.**

The first charge on the additional water, thus transported from Barmaputra's tributaries into Ganga must be, to fulfill the shortage of water in the Mahanada basin in Bihar and the commitment of water made to Bangla Desh and West Bengal below Farakka, and thereby removing restriction on Bihar from using Ganga water to meet its requirement.

4. **Utilisation of water diverted through Gandak-Ganga and Kosi-Ghaghra etc.**

The water to be transferred by Gandak-Ganga and Kosi-Ghaghra etc. in monsoon, be allowed to flow down in the Ganga in non-monsoon period from the reservoirs in the Ganga basin including those on its tributaries for utilisation in Bihar.

5. **Storing of surplus monsoon flow in ground water through wells**

Additional wells be dug all along the geographical area of the state with the aim of increasing storage of ground water specially in south Bihar, and to the extent of raising depth of ground water aquifer in north Bihar.

This will facilitate storing of surplus monsoon flow. The surcharged ground water will result into increase in base flow of the rivers, which can be used during the lean period. At the same time, the water percolated below the ground will reduce the surface flow, thereby providing relief to the surface water drainage congestion in lower valleys.

According to Annexure 4.4, total surplus water during monsoon period is 68,260 MCM in North Bihar. If by any means, only 25% of this is allowed to be stored in ground water, it will hardly cause an increase of 40 cm in the ground water. Thus the area where minimum depth of ground water is below 3 m to 4 m, this technique can very safely be applied.

6. **Research Work**

The bare truth and fact, considering the ever growing population on the planet and the geographical compulsion, is that in future, grave situation of extreme shortage of fresh water specially in non monsoon season is growing to mount. In order to overcome this situation it is suggested that in addition to all efforts suggested above, research must begin to have control on

i) Evaporation of sea water at selected places

ii) Formation of cloud

iii) Convection of cloud in selected direction and upto prefixed locality and

iv) Precipitation of the same to the extent desired

The rate at which the Science and Technology has advanced in the last century, such an achievement seems to be quite possible. Only concerted effort must be started and the entire residents of this planet must co-operate not only for achieving such technology but also for operating the same.

(Para 6.4.3)

9.5 PER CAPITA WATER AVAILABILITY IN BIHAR (TOR-5)

1. In the scenario of 1991 the Ganga river basin stands in the 10^{th} position so far as per capita water availability is concerned. This is as high as 16617 M^3 for the Bramhaputra-Barak river basin, which stands at the highest position whereas only 1471 M^3 per capita is available for Ganga river basin ranking at the 10^{th} from the top vide Annexure 9.4.

2. The Per Capita water availability in all the rivers in south Bihar excepting Sone Karmanasa Composite basin and even in the Kamla river basin in the north Bihar, is less than that in Krishna, Cauvery and Pennar basins which are being considered as shortage basins and where water is proposed to be transferred.

As such diversion of Ganga waters to any other river basins of South India does not appear justified.

3. With rate of fast growing population in the Ganga river basin, this basin is expected to come into the category of water scarce river basin by the year 2025. Hence it would be proper that before diversion of Brahmaputra waters to Southern India, its water must be diverted in sufficient quantity to Ganga river basin, being adjacent one.

4. Bihar is situated in this very Ganga river basin and the scenario of water availability per capita in this state is shown in table 7.4.This table indicates that the availability of water in various river basins of the state is very poor. By the year 2050, all the river basins of the state excepting Kosi, Gandak and Sone-Kao-Gangi basin will fall in the category of severe -water scarce basin. This means about 55% of the total population will face the situation in which water availability becomes primary constraint to health.

About 35% of the state population (i.e. population living in Gandak basin and Sone - Kao- Gangi basin) will have to survive in water scarcity condition (water availability per capita being in the range of 500 M^3 to 1000 M^3 per capita per year. Only 10% of the state population (i.e. population of Kosi basin only) will be in ease situation.

The above situation obviously indicates that the future of about 90% of the state population in the year 2050 is very grim as far as water availability is concerned.

5. In order to provide availability of expected ultimate utilisable water at the level of national figure of 421 M^3 in the year 2050, the state will require 87,469.76 MCM of utilisable water. Attempt may be made to utilise all available water in non-monsoon & enhance storage capacity of monsoon surplus to the maximum extent. This can then be just achieved.

6. Simultaneous attempt must be made to reduce the rapid rate of growth of population, trying to keep it static i.e no growth which has unfortunately been 28% as against 11% of Kerala.

7. The fact remains that Bihar being almost at tail end of Ganga, will have no authority or control over Ganga water which will definitely be used up and lifted by upper riparian state, and in non-monsoon month there will be extreme scarcity. Unless Nepal & U.P. co-operate in storing monsoon water and making it available to Bihar. South Bihar will need help of Jharkhand for storage and self help for augmenting ground water by pumping monsoon flow from the Ganga.

(Para 7.4)

9.6 COMMENTS ON OTHER SCHEMES OF NWDA AFFECTING BIHAR AND THEIR IMPACT ON DRAINAGE AND ENVIRONMENT (TOR-6)

a) GANDAK-GANGA LINK PROJECT

1. Since Gandak river is a life line for major part of North-West Bihar comprising six very populous districts on which irrigation system has been planned and executed and is one of the major source through which water can be transferred to river Ganga for utilisation in South Bihar, any work intended to reduce flow of water in this river is not at all acceptable to Bihar.

2 In order to increase the utilisable flow in the basin during the non-monsoon season it is recommended that:

i. All reservoir schemes on Gandak and its tributaries (having storage capacity upto 15,553 MCM) already identified by the NWDA viz. Kali Gandaki, Burhi Gandaki, Marshyandi, seti and Gandak reservoirs may be implemented at priority.

ii Further reservoir schemes for storing 7,707 MCM may be explored and implemented simultaneously.

iii. Proposals in (i) and (ii) may be treated and constructed as a part of NWDA River Interlinking Schemes.

3. In succinct, not a single drop of Gandak water is surplus for diversion during non-monsoon and diversion of monsoon flow only from Gandak-Ganga Link canal, that too only to the extent of 9,654 MCM, can be agreed, provided the same amount of water is made available to Bihar at Chunar during non-monsoon period.

(Para 8.1.4)

b) Kosi-Mechi Link Project

1. The proposed Kosi High Dam should have provision of flood cushion for 4691 MCM (3.80 MAF) as recommended by Kosi Technical Committee (1965) so that flood can be moderated to safe maximum discharge of 5660 cumecs (2 Lakh Cusecs)

2. Soil conservation measures in the upper catchments should be included in the Link Schemes to control inflow of sediment load in the Kosi dam reservoir so that optimum benefit can be assured from the proposed dam.

3. The shortage to the extent of 2,701 MCM in Mahananda basin of the Kamala- Balan-Kosi- Mahananda composite basin during non-monsoon period be met by MSTG Link.

4. The remaining shortage of 10,162 MCM during non-monsoon should be met by conservation of more of monsoon flows by constructing storage reservoirs on the tributaries of Kosi viz. Sun Kosi, Tamur and Arun.

5. The proposal of NWDA to remodel Purnea Branch Canal as navigation channel does not appear logical. Instead navigation should be provided through river route itself.

(Para 8.2.3)

c) **Manas-Sankosh-Tista-Ganga / Jogighopa-Tista-Farakka Link Canal**

These link canals while passing through Bihar are of similar nature. These are unrealistic in as much as, it is impractical to excavate 10.0 m deep canal having about 121.0 m wide bed and lining it in this zone and running for more than 150.0 Km side by side the rivers Mechi and Mahanada. In view of the problems discussed above and in light of the situation that the alignment of the proposed link canal runs parallel to the course of river Mahananda, it is considered advisable to utilise the course of River Mahananda for diversion of Brahmaputra water to Ganga. With this end in view the following alternative is recommended:

1) MSTG Link canal may be carried on its fixed alignment till it crosses river Mechi near village Bairagi as proposed by NWDA. A barrage may be constructed and the discharge needed for Bihar may be diverted through canals on both the sides while the discharge to be transferred through Ganga and partly to be used in Bihar on left bank of Mahananda be dropped into Mechi itself .The conveyance of imported water to be transferred into Ganga may be done through river route viz. through Mechi and then Mahananda river instead of having a big canal parallel to the rivers. The river will have to be improved to accommodate the additional discharge, straightened and the Mahananda embankment be duly improved, fortified and riveted wherever required.

For this purpose additional structure needed will be as follows:

i. A barrage in river Mechi at junction of the MSTG Link canal with head regulator on both sides.
ii. Another barrage with H/R at the off-take point of Barsoi channel. This will facilitate irrigation as well as regulate the flow into the Barsoi channel vide Index Map attached.
iii The drops in Link canal as well as drops on additional structures just d/s of Mechi and Mahananda confluence in Bihar and other control/ diversion structures may be so designed that they can have hydel power generation units to provide constant source of renewable energy.
iv. A diversion structure across river Mahananda upstream of confluence with Ganga , with a power channel to utilise the drop at the outfall into Ganga for power generation especially, during lean flow when Ganga water will be at low level vide Index Map attached.
v. If required to accommodate the additional discharge, the course of river may be improved by dredging, straightening and even bank protection. Small short-cut for straightening the river Mahananda within existing embankments may also be done to facilitate navigation. This improvement may need rehabilitation of few villages lying within embankments, if affected by higher discharge in Mahananda.

2) In order to safeguard the interest of Bihar it is recommended to increase the diversion of Brahmaputra water to this state to the tune of 6642 MCM (vide Table 8.3.2) and that too, only during non-monsoon against the present allocation of 1627 MCM in a year. This will meet the shortage of 2856 MCM in the command of MSTG link and also of2701 MCM in the command of Kosi- Mechi Link (ref. Annexure 8.3.2.1 & 8.2.2.5) in Mahananda basin.

This enhanced diversion during the period is quite possible as the MSTG Link system is supported by storages of 13,680 MCM (i.e.8750 MCM in Manas basin + 4930 MCM in Sankosh basin). It is also to be added that even after diversion of 6647 MCM, of water for Bihar , the system will be capable of diversion of 15000 MCM of water for Farraka during the lean season (as stipulated by the NWDA in their report) and 17898 MCM for its diversion to further south towards Mahanadi.

(Para 8.3.3)

d) IMPACT OF THE SCHEMES OF INTERLINKING OF RIVERS

i. Impact on drainage .

Since all the proposed link canals mostly pass through Nepalese territory except that from Sankosh-Tista-Ganga Canal and part of Kosi-Ghaghra and all are proposed to be lined, adverse effect of drainage congestion in this State on account of seepage from them will not be significant. The canals, however, specially, Kosi-Mechi & Kosi-Ghaghra and Gandak- Ganga Link Canal are more or less contour canals, and pass through cutting many rivulets and rivers. Obstruction to flow of water straight from Nepal to Bihar will be partially obstructed causing drainage congestion in Nepal and may, in case of pressure on the link canal, cause breaches which may be affecting the territory of Nepal and Bihar lower down in some cases. The main problem of drainage in Bihar is obstruction caused by development works without providing proper waterway by various agencies and adverse outfall condition. The first one is an internal problem and does not depend on any way on the proposed link canals. The effect of works on the outfall conditions, i.e. the level of the Master drain the Ganga, may however, affect the drainage in Bihar. Since Ganga from Allahabad to Farakka has been declared as National Inland Waterway, it is expected that the GOI will improve this part of the Ganga by concentrating its flow into only one channel and deepening it, thus improving its discharge and sediment carrying capacity. It is expected that out-fall conditions of the rivers of Bihar into the Ganga will improve, having good effect on drainage.

The proposed link canal, Manas-Sankosh-Tista-Ganga link canal into Bihar, if at all constructed as proposed will, however badly affect drainage of that area. It cuts many local drainage channels and rivers which join Mahananda and their outfall into Mahananda will be badly disturbed and adverse drainage problem will be created in Araria, Kisanganj, Purnea, & Katihar districts. The modification suggested by this Committee will obviate this problem as the river itself will become carrier of the Manas-Sankosh-Tista Link Canal's water and will not necessitate so may cross drainage works, and will not obstruct the rivers joining Mahananda in Bihar.

The part of Kosi-Ghaghra Link Canal in Bihar will also cut the distribution system of Gandak canals, Ghorasahan & Tribeni and is bound to adversely affect the drainage.

(Para 8.4.1)

ii Impact on Ecology and Environment

Ecology as per Oxford dictionary means study of effect of Environment on living being, whereas Environment means surroundings. The earth which was inhabited by hardly hundred crore people prior to the past century, is now inhabited by more than six hundred crore. The earth, naturally is having impact of this fast growing population and its connected

activities. In this background human effort to utilise the water resources to the optimum to meet the populations' need, connected agricultural activities and irrigational efforts are bound to affect the ecology and change the surroundings.

Main environmental aspect in Reservoir backed Irrigation Projects are on

a. Catchments Area

b. Reservoir - including resettlement and rehabilitation - removal, forest clearance, wild life, drawdown slip, cultural interests, climatic changes, sedimentation, tourism and recreation, health hazard and ground water profile.

c. The Dam-induced seismicity, dam safety measures Regulation and consideration for upstream flow downstream and pollution control.

d. River Regime Downstream - bank and bed erosion, flood damage, navigation pisciculture, water quality etc.

e. Command Area - Water logging and salinity, Effect of fertilisers and pesticides, health hazard, soil fertility, change in land use water pattern.

f. Socio-economic system - ranging from command economy with dominance of public ownership of means of production, participatory irrigation management etc.

The link canal schemes, hence, do affect Bihar also, even though the Dams and Reservoirs are located in Nepal except that on Sone & others proposed by this Committee. The study by this Committee hence, has strongly advocated for catchments treatment, the aspect which has been totally ignored in these schemes.

The Reservoirs will in Committee's view improve tourism recreational activities and will thus help economy of Nepal apart from enormous gain from power generation. It is not expected to, in any way, adversely affect Nepal, rather will help by increasing activities like fisheries, tourism etc.

The phenomenon of so called "Reservoir induced seismicity" is subject matter of considerable debate and opinions have differed. A study showed that out of 425 dams in the world, which could be termed large dams, only 15 dams had shown an increase in seismic activities after impoundment. Studies indicated that it cannot be attributed entirely to the formation of reservoir even in these cases. Thus the existing state of knowledge about seismicity does not enable a precise evaluation of the seismic consequences that follow the impoundment in a large reservoir. The proposed reservoir on Gandak is a small one.

Safety - measures of dam must form part right from the very beginning.

The Reservoir Regulation and gate operation must be properly defined and documented to obviate any hazard or mishap. Bihar being the main state to be affected must have say in this right from very beginning and throughout its operational life. The operation has to be linked with uniform flow down so far flood control, as well as reduction of peak flow and enhancing lean water discharge, making the river pollution free, navigable all through the years and improving the morphology of the river.

The Command area in this case which lie mostly in Bihar may not have any adverse effect as already it is experiencing the irrigation. Only its intensity will have to be optimised. This zone since lies in zone having less evaporation and more monsoon precipitation, salination of surface is not experienced in any significant amount. It is not expected that salinity will ever increase as the monsoon rains leach out any salt even if it surfaces. Only the surface drainage of the command area has to be improved gradually to the full extent.

Land use pattern in the background of availability of irrigation water and with a view to optimising production and productivity has to be suitably oriented in this regards. The steps being taken by Bihar towards participatory management of irrigation is laudable step, but it must be accomplished along with consolidation of land holdings and proper OFD work. Proper On Farm Development should consolidate land holdings of each land holder at one place and each land holder should have proper approach at his farm, has irrigation channel on one side of his farm, and field drain on the other side, well laid considering contour of the area. Such steps will help in developing suitable cropping pattern, and timely doses of water supplies just in right quantity, without causing over irrigation, or under irrigation. Aforesaid, measures would also help in obviating chances of water logging and salinity, and will enthuse farmers to invest more labour and money for optimising production. Need to educate the farmers to use right type of and doze of fertiliser and pesticide cannot be over emphasised. Agriculture extension services can ensure preventing any hazard on account of chemical fertilisers, insecticide and pesticides.

Environmental management plan of the region involves multi-disciplinary endeavour in a wide spectrum explained above. This will need co-ordinated and concerted efforts from various departments of the State Government and active support and assistance from the Government of India.

(Para 8.4.2)

9.7 Intra State Linking to be given priority

North Bihar:- The rivers Kosi, Panar, Mechi, Kankai, Mahananda should be inter linked (joined) by canals with level crossings on all of them. Similarly the rivers Kamala, Adhawara groups, Bagmati, Lalbekaya, Masan, & Gandak should be interlinked as already proposed by NWDA, in Kosi-Ghaghra Link canal project. This may also be used for diverting flood water as and when required.

A dam on Adhawara Pathar at or near about Chhaya on Karmnasa & another on Suara, near Bhagwanpur and Kao near Sasaram should be constructed as part of NWDA Scheme, and as Intra -state Interlinking these with Bharari dam, Kohira Dam, Suara , Karmnasa- after joining Suara, Durgawati and Kao should be interlinked to meet the deficit in one and utilizing water and preventing flooding in other.

The existing capacities of reservoirs such as those on Kiul, Badua, Chandan, may be increased by remodeling and arrangements may be made to keep them full from excess monsoon water of North Bihar by pump canals to the extent possible to conserve surplus monsoon flow and reduce deficit of South Bihar especially that in Rabi and HW period, to enable meeting increased irrigated agriculture intensity.

Storage of surplus monsoon water can also be tried in ground water aquifer by well designed intake wells at suitable places in South Bihar where possibility exist to store as a aquifer levels (Ground water levels) are low. Ground water has got to be utilized and augmented by artificial methods if the State has to survive.

(R.R.Prasad)	(S.C.sinha)	(S.K.Sinha)	(K.N.Lal)
Member	**Member (till 21.9.2004)**	**Member**	**Chairman**

SURFACE WATER BALANCE

Annexure-9.1

Sl. No	Name of project	Assessed by NWDA			Assessed by the Committee								
		CCA (ha.)	Water need (MCM)	Name of Basin	CCA (ha.)	Water need (MCM)			Water available from existing & proposed schemes (MCM)			Shortage (-ve) / Surplus (MCM)	
						Monsoon	Non Monsoon	Total	Monsoon	Non Monsoon	Total	Monsoon	Non-Monsoon
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Manas-Sankosh-Tista-Ganga Link	2,64,000	1,627	Mahananda	**2,64,137**	**1,577**	**4,194**	**5,771**	**2,822**	**1,338**	**4,160*** **	**1,245**	**-2,856**
2	(a) Kosi-Mechi Link	8,74,500	21,025*	Kamla-Balan	1,06,686	570	1,648	2,218	967	108	1,075	397	-1,540
				Kosi	8,38,100	4,918	20,884	25,802	29,353	12,262	41,615	24,435	-8622
				Mahananda	1,81,000	1,081	2,874	3,955	1,562	173	1,735	481	-2,701
				Sub-Total	**11,25,786**	**6,569**	**25,406**	**31,975**	**31,882**	**12,543**	**44,425**	**25,313**	**-11,863**
	(b) Kosi-Ghaghra Link	8,17,281	6,250**	Bagmati	4,82,367	2,543	7,382	9,925	6,538	727	7,265	3,995	-6,655
				Kamla-Balan	2,15,632	1,152	3,331	4,483	1,957	217	2,174	805	-3,114
				Ganga Stem	154623	1,076	2,410	3,486	1,049	117	1,166	-27	-2293
				Sub-Total	**8,52,622**	**4,771**	**13,123**	**17,894**	**9,544**	**1,061**	**10,605**	**4,773**	**-12,062**
				Total (2a+2b)	**19,78,408**	**11,340**	**38,529**	**49,869**	**41,426**	**13,604**	**55,030**	**30,086**	**-24,925**
3	Gandak-Ganga Link	13,63,790	15,272**	Ghaghra-Mahi-Western Gandak	5,19,154	3,581	8,027	11,608	14,891	1,655	16,546	11,310	-6,372
				Upper Eastern Gandak-Upper Burhi Gandak	5,99,034	3,757	13,764	17,521	17,474	1,942	19,416	13,717	-11,822
				Lower-Eastern Gandak- Baya-Lower Burhi-Gandak	4,93,648	3,448	7,568	11,016	15,360	1,707	17,067	11,912	-5,861
				Ganga-stem	56,899	396	887	1,283	386	43	429	-10	-844
				Total	**16,68,735**	**11,182**	**30,246**	**41428**	**48,111**	**5,347**	**53,458**	**36,929**	**-24899**
		33,19,571	44,174	Total North Bihar	**39,11,280**	**24,099**	**72,969**	**97,068**	**92,359**	**20,289**	**1,12,648**	**68,260**	**-52,680**

1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	Chunar-Sone Barrage Link	5,26,033	5,566	Karmnasa	3,26,709	2,249	3,557	5,806	657	588	1,245	-1,592	-2,969
				Sone-Kao-Gangi	4,93,121	3,661	6,902	10,563	5,040	8,527	13,567◆	1,379	1,625
				Punpun 40%	2,19,643	1,579	2,525	4,104	0	592	592	-1,579	-1,933
				Ganga stem	38,655	307	502	809	262	29	291	-45	-473
				Total	**10,78,128**	**7,796**	**13,486**	**21,282**	**5,959**	**9,736**	**15,695**	**-1,837**	**-3,750**
5	Sone Dam (a) Harohar Zone	2,98,846	2,512	Punpun 60%	3,29,464	2,368	3,788	6,156	2,073	180	2,253	-295	-3,608
				Harohar	5,90,676	4,501	6,300	10,801	2,914	386	3,300	-1,587	-5,914
				Kiul 40%	48,383	353	484	837	193	91	284	-160	-393
				Total	**9,68,523**	**7,222**	**10,572**	**17,794**	**5,180**	**657**	**5837**	**-2,042**	**-9,915**
	-STG Link (b) Badua-Chandan			Kiul 60%	72,574	529	726	1,255	300	126	426	-229	-600
				Badua-Belharna	1,32,530	953	1,340	2,293	427	310	737	-526	-1,030
				Bilasi-Chandan-chir	1,58,513	1,243	1,801	3,044	1,326	165	1,491	83	-1,636
				Ganga stem	1,20,272	954	1,359	2,313	816	91	907	-138	-1,268
				Total	4,83,889	3,679	5,226	8,905	2,869	692	3,561	-810	-4,534
		8,24,879	8,078	Total south Bihar	**25,30,540**	**18,697**	**29,284**	**47,981**	**14,008**	**11,085**	**25,093**	**-4,689**	**-18,199**
6	GrandTotal	40,86,669	52,252		**64,41,820**	**42,796**	**1,02,253**	**1,45,049**	**1,06,367**	**31,374**	**1,37,741◆◆**	**63,571**	**-70,879**

* Total diversion through Kosi-Mechi Link 23702 MCM, less for Nepal use (-) 1737 Tr. loss (-57) Export to Mahananda (-883) = 21,025 MCM

** Total diversion through Kosi-Ghaghra Link = 7482 MCM, less for Nepal use (-) 1232 = 6250 MCM

*** This study includes import from Bhramaputra's tributaries through MSTG Link (1627 MCM)

◆ This includes import from Ganga through C-SB Link 5,566 MCM

◆◆ Details of water availability i. vide Annexure 9.4 1,32,175 MCM

ii import from Ganga 5,566 MCM(Through C-SB Link)

Total 1,37,741 MCM

Water Availability Seasonwise & Schemewise in different river basin refer table attached next page

Water avaiability seasonwise & Schemewise in different river basin of Bihar

Sl No.	Name of Scheme	Name of Basin	Part of CCA	Total Water	Monsoon	Non Monsoon
1	2	3	4	5	6	7
1	MSTG	Mahananda	264137	4160	90% of (4160 -1627) + 1627/3 = 2822	4160-2280 = 1338
2	Kosi-Mechi	"	181000	1735	90% of 1735 = 1562	1735 - 1562 = 173
		Total	**445137**	**5895**		
3	Kosi Mechi	Kosi	**838100**	**41615**	90% of (41615-9000) =29353 (9000 kosi dam water used in non-monsoon)	41615-29353 = 12262
4	"	Kamla-Balan	106686	1075	90% of 1075 = 967	1075-967 = 108
	Kosi-Ghaghra	"	215632	2174	90% of 2174 = 1957	2174-1957 =217
		Total	**322318**	**3249**		
5	Kosi-Ghaghra	Bagmati	482367	7265	90% of 7265 = 6538	7265-6538 = 727
6	Gandak-Ganga	Ghaghra -Mahi-Western Gandak Composite	519154	16546	90% of 16546 = 14891	16546-14891 = 1655
7	"	Upper Eastern Gandak Upper Burhi Gandak Composite	599034	19416	90% of 19416 = 17474	19416-17474 = 1942
8	"	Lower Eastern Gandak-baya-Lower Burhi Gandak Composite	493648	17067	90% of 17067 = 15360	17067-15360= 1707
9	"	Ganga Stem Zone -4	56899	429	90% of 429 = 386	429-386 = 43
	Kosi-Ghaghra	Ganga Stem Zone -5	154623	1166	90% of 1166 = 1049	1166-1049 = 117
10	Chunar-Sone Barrage	Ganga Stem Zone-6a	38655	291	90% of 291 = 262	291-262=29
11	STG Link	Ganga Stem Zone-6b	120272	907	90% of 907 = 816	907-816=91
		Total	**370449**	**2793**		
12	Chunar-Sone Barrage	Karmnasa	326709	1245	308/3 (jamania)+ 95%of 583(runoff of karmnasa)= 657 [(937-354){354 in reservoir}) {1245-308=937-354= 583}	1245-657= 588
13	"	Sone-KaoGangi	493121	13567	5566/3 (ganga water via chunar) +7117/3 + 92% of 884 (runoff of Kao river)= 5040	13567-5040=8527
14	"	Punpun (40%)	219643	592	0	reservoir water =592
15	STG Link	Punpun (60%)	329464	2253	92% of 2253 = 2073	2253-2073 =180
		Total	**549107**			
16	"	Harohar	590676	3300	100 % of (3300-386)= 2914	reservoir water =386
17	"	Kiul (60%)	48383	284	100% of (284 - 91)=193	reservoir water =91
18	"	Kiul (40%)	72574	426	100% of (426 -126)=300	reservoir water =126
		Total	**120957**	**710**		
19	"	Badua-Belharna	132530	737	92% of (737-273)= 427	737-427=310
20	"	Bilasi-Chandan-Chir	158513	1491	100% of (1491-165) =1326	reservoir water =165
		Grand-Total	**6441820**	**137741**		

Surface Water Resources in river Basins of Bihar **Annexure- 9.2**

Sl. No.	Name of Basin	Catchment Area (Sq. Km.)			75% Dependable water availabilty in MCM					
					As assessed by SBSIC			As assessed by the Committee		
		Outside state	Within State	Total	Outside state	Within State	Total	Outside state	Within State	Total
1	2	3	4	5	6	7	8	9	8	10
1	Ghaghra	124955	2995.4	127950	68015	839.7	68855		840	840
	Mahi		2507.8	2507.8	0	799.1	799.1		799	799
2	Gandak	36610	4187.7	40798	50810	1179.9	51990	45109	1174	46283
	Baya		2775.7	2775.7	0	1067.2	1067.2		1067	1067
3	Burhi-Gandak	2420	9601.4	12021	813.3	3226.7	4040	813	3227	4040
2	Bagmati-Adhwara	7884	6499.9	14384	5080.9	2184.4	7265.3	5081	2184	7265
3	Kamla Balan	2744	4487.7	7231.7	1741.3	1508.1	3249.4	1741	1508	3249
4	Kosi	62615	11410.2	74025	47065	5154	52219	36461	5154	41615
5	Mahananda	7157.7	6150.1	13308	5612.4	4267.9	9880.3	1627	4268	5895
	Total North Bihar	244385	50615.9	295001	179138	20221	199359	90832	20221	111053
III	Karmnasa	2665.2	5126.9	7792.1	487.1	937	1424.1	308	937	1245
6	Sone	67163	3064.8	70228	17600	335	17935	7709		7709
7	Kao-Gangi		4128.8	4128.8	0	884.4	884.4		884	884
8	Punpun	979	8046.7	9025.7	244.4	2009.1	2253.5	244	2009	2253
9	Kiul	421	2629.5	3050.5	98	612.3	710.3	98	612	710
10	Harohar	4272.3	9900.7	14173	994.7	2305.3	3300	995	2305	3300
11	Badua-Belharna		2215	2215	0	736.8	736.8	0	737	737
12	Bilasi Chandan Chir	1483.3	2609.7	4093	540.4	950.7	1491.1	540	951	1491
	Total South Bihar	76984	37722.1	114706	19965	8770.6	28735	9894	8435	18329
	Ganga Stem		5473.3	5473.3	85000	2793	87793		2793	2793
	Grand Total	321369	93811.3	415180	284102	31785	3158887	100726	31449	132175

Annexure 9.3

Water Availability (Per Capita Per Year for different river Basins for Bihar)

Sl. No.	Name of Basin	water available in MCM	Population in Lakh				Per Capita in m3			
1	2	3	4	5	6	7	8	9	10	11
I	NORTH BIHAR		1991	2001	2025	2050	1991	2001	2025	2050
1A	Ghaghra-Mahi Western Gandak Composite	16546	66.38	85.25	135.04	213.91	2492.62	1940.78	1225.24	773.51
1B	Upper Eastern Gandak Lower Burhi-Gandak Composite	19416	51.34	65.94	104.45	165.44	3781.85	2944.58	1858.95	1173.58
1C	Lower Eastern Gandak Baya Lower Burhi Gandak composite	17067	66.36	85.23	135.00	213.84	2571.88	2002.49	1264.20	798.11
2	Bagmati-Adhwara	7265	55.30	71.02	112.50	178.20	1313.74	1022.89	645.77	407.68
3	Kamla Balan	3249	38.70	49.70	78.73	124.71	839.53	653.67	412.67	260.52
4	Kosi	41615	66.55	85.47	135.39	214.46	6253.19	4868.80	3073.74	1940.49
5	Mahananda	5895	36.79	47.25	74.85	118.56	1602.34	1247.60	787.62	497.24
	Total North Bihar	111053	381.42	489.87	775.96	1229.1	2911.57	2266.98	1431.17	903.52
6	Ganga Stem									
	Ganga Stem in Sub-Zone 4	429	7.54	9.68	15.34	24.30	568.97	443.18	279.66	176.54
	Ganga Stem in Sub-Zone 5	1166	20.49	26.32	41.68	66.03	569.06	443.01	279.75	176.59
	Ganga Stem in Sub-Zone 6a	291	5.12	6.58	10.42	16.50	568.36	442.25	279.27	176.36
	Ganga Stem in Sub-Zone 6b	907	15.94	20.47	32.43	51.37	569.01	443.09	279.68	176.56
	Sub-Total Ganga Stem	2793	49.09	63.05	99.87	158.2	568.95	442.98	279.66	176.55
	South Bihar									
7	Karmnasa	1245	17.44	22.40	35.48	56.20	713.88	555.83	350.90	221.53
8	Sone & Kao Gangi composite	8593	49.24	63.24	100.17	158.67	1745.13	1358.77	857.81	541.55
9	Punpun	2253	41.94	53.87	85.32	135.15	537.20	418.27	264.06	166.70
10	Harohar	3300	64.32	82.61	130.85	207.27	513.06	399.47	252.19	159.21
11	Kiul	710	10.16	13.05	20.67	32.74	698.82	544.11	343.50	216.86
12	Badua-Belharna	737	10.78	13.85	21.93	34.74	683.67	532.32	336.06	212.16
13	Bilasi Chandan Chir	1491	20.90	26.84	42.52	67.35	713.40	555.46	350.67	221.38
	Total South Bihar	18329	214.78	275.85	436.95	692.12	853.38	664.45	419.48	264.82
	Total Bihar	132175	645.29	828.77	1312.78	2079.44	2048.30	1594.83	1006.84	635.63

Note:	Range(m^3/Capita/Year)	Descriptive Feature
1.	>1700	Water surplus
2.	1000-1700	Water stressed local & rare shortage
3.	500-1000	Water scarce, begins to hamper health, economic development and human well being
4.	<500	Water supply becomes primary constraint to life

Annexure 9.4

Per Capita Water Availability in The River Basins of India

S N	Name of the River Basin	Per Capita Available Surface Water (M^3)	Rank
1	Indus (upto Border)	1750	IX
2	(a) Ganga	1471	X
	(b) Brahmaputra,Barak & Others	16617	I
3	Godavari	2048	VIII
4	Krishna	1285	
5	Cauvery	728	
6	Pennar	652	
7	East flowing rivers between Mahanadi & Pennar	954	
8	East flowing rivers between Pennar & Kanyakumari	364	
9	Mahanadi	2514	VII
10	Brahmani & Baitarni	2915	VI
11	Subarnarekha	1308	
12	Sabarmati	360	
13	Mahi	1052	
14	West flowing rivers of Kutch, Saurashtra including Luni	683	
15	Narmada	3105	V
16	Tapi	1005	
17	West flowing rivers from Tapi to Tadri	3388	IV
18	West flowing rivers from Tadri to Kanyakumari	3483	III
19	Area of Inland Drainage in Rajasthan desert		
20	Minor river Basins draining into Bangladesh & Burma	14762	II

Source: Theme Paper on "Water Vision 2050".water resources day '99, Indian water resources Society,(Table 1.1)

बिहार सरकार
जल संसाधन विभाग

अधिसूचना

संचिका संख्या 5/पी.एम.सी. ———— पटना, दिनांक--------/04

विषय : राष्ट्रीय नदियों को जोड़कर जलान्तरण कार्यक्रम के तहत परियोजनाओं का अध्ययन करने एवं तदनुसार सरकार को अनुकूल परामर्श देने हेतु अवकाश प्राप्त अभियन्ता प्रमुख श्री के0एन0लाल की अध्यक्षता में गठित समिति के प्रतिवेदन को संशोधित करने हेतु समिति का गठन ।

1. राष्ट्रीय जल विकास अभिकरण द्वारा हिमालीय अवयव के अन्तर्गत प्रस्तावित कुल 14 सम्पर्क नहर परियोजनाओं में से निम्नलिखित 7 सम्पर्क नहर योजनाएं प्रत्यक्ष या परोक्ष रूप से बिहार राज्य से संबंधित है

1. चुनार-सोन बराज सम्पर्क नहर
2. सोन-गंगा की दक्षिणी उप-सहायक नदियों का संपर्क नहर
3. कोशी-मेची संपर्क नहर
4. कोशी-घाघरा संपर्क नहर
5. गंडक-गंगा संपर्क नहर
6. ब्रह्मपुत्र-गंगा सम्पर्क नहर(मानस-संकोश-तिस्ता-गंगा)
7. ब्रह्मपुत्र-गंगा सम्पर्क नहर (वैकल्पिक)(जोगीघोपा-तिस्ता-फरक्का)

2. पूर्व में विभाग द्वारा गठित विशेषज्ञ समिति ने अपना प्रतिवेदन जनवरी 2004 में राज्य सरकार को समर्पित किया है । उपर्युक्त प्रतिवेदन की विभाग में समीक्षा के उपरान्त निम्नांकित विन्दुओं पर भी अध्ययन कराने एवं तदनुसार यथोचित संशोधन करते हुए एक अन्य प्रतिवेदन बनाने का निर्णय लिया गया ।

(i) जल संतुलन अध्ययन (Water Balance Study) सिर्फ सतही जल के आधार पर ही किया जाय जैसा कि राष्ट्रीय जल विकास अभिकरण (NWDA) द्वारा उनके अध्ययन में किया जा रहा है । भू-गर्भ जल का भी विचार नही किया जाय ।

(ii) बाढ़ की समस्या का निदान अध्ययन-प्रतिवेदन का फोकस (focus) हो तथा कोशी-घाघरा सम्पर्क नहर को सम्पूर्ण लम्बाई में रखते हुए इस योजना के अन्तर्गत कमला, अधवारा-समूह, वागमती और बूढ़ी गंडक नदियां को आपस में जोड़ने की संभाव्यता पर विचार किया जाय ।

(iii) चुनार-सोन बराज सम्पर्क नहर योजना के अतिरिक्त चुनार में बराज निर्माण कर ग्रैविटी-नहर (gravity canal) द्वारा अधिक से अधिक क्षेत्र में सिंचाई उपलब्ध कराने की संभावना एवं सोन (कदवन) डैम-एस0टी0जी0 सम्पर्क नहर को अधिक से अधिक जल उपलब्ध कराकर सम्पूर्ण क्षेत्र में सुनिश्चित सिंचाई सुविधा उपलब्ध कराने हेतु अध्ययन एवं सुझाव ।

(iv) बिहार के पूर्वी भाग में सिंचाई के लिये पम्प नहर योजनाओं की उपयोगिता तथा गैर मानसून अवधि में गंगा-जल अनुपलब्धता की समस्या के निदान हेतु आवश्यक अध्ययन एवं सुझाव ।

(v) प्रति व्यक्ति जल उपलब्धता के दृष्टिकोण से बिहार के बेसिनों में जल उपलब्धता की विवेचना/ समीक्षा ।

(vi) अन्य कोई विषय जो उपयुक्त विन्दुओं के संदर्भ में समिति द्वारा आवश्यक समझा जाय ।

3. इस अध्ययन कार्य के लिए निम्नांकित समिति गठित की जाती है:-

(i) इ0 के0 एन0 लाल, सेवा निवृत अभियंता प्रमुख- अध्यक्ष
(ii) इ0 एस0 के0 सिन्हा, सेवा निवृत अभियंता प्रमुख- सदस्य
(iii) इ0 सुरेश चन्द्र सिन्हा, सेवा निवृत मुख्य अभियंता- सदस्य
(vi) इ0 राम रतन प्रसाद, सेवा निवृत मुख्य अभियंता- सदस्य

पूर्व की भांति अवकाश प्राप्त अभियंता प्रमुख ई0 के0 एन0 लाल इस समिति के अध्यक्ष रहेगें एवं समिति के संयोजक, मुख्य अभियंता, जल विज्ञान एवं योजना आयोजन, पटना होंगे ।

4. समिति का गठन निम्नांकित शर्त्तो के साथ किया जाता है :-

(i). इस समिति का कार्यकाल कार्यारम्भ की तिथि से अधिकतम 3 महीने का होगा, जिसके अन्तर्गत समिति अधिकाधिक कुल 20 बैठक कर अपना प्रतिवेदन प्रस्तुत करेगी ।

(ii). समिति के प्रत्येक सदस्य को 800 रू0 प्रति बैठक की दर से मानदेय दिया जायगा ।समिति के सदस्य सुनिश्चित करेंगे कि यदि वे किन्हीं अन्य समिति में भी कार्यरत हों तो उनके कार्य-दिवस अलग-अलग हो ताकि एक हीं समय में किए गए कार्य के लिए दो बार मानदेय का भुगतान न हो ।

(iii). समिति का कार्यालय कमरा संख्या-211, प्रथम तल, सिंचाई भवन, पटना में होगा ।

(iv). समिति को साज सज्जा सहित कार्यालय, एक स्टाफ कार, अनुसचिवीय कर्मचारियों एवं पदाधिकारियों की व्यवस्था विभाग द्वारा की जायेगी एवं इसके लिये अतिरिक्त पदों का सृजन नहीं होगा या दैनिक वेतन पर कोई नियुक्तियां नहीं की जायेगी ।

(v). अधीक्षण अभियंता योजना एवं मोनिटरिंग अंचल-5 तथा निदेशक (अ0 अभि0) जल विज्ञान निदेशालय-अनीसाबाद समिति को यथा आवश्यक अभिलेख उपलब्ध करायेगें ।

(vi). समिति पर होने वाला सम्पूर्ण व्यय जल संसाधन विभाग के योजना बजट मुख्य शीर्ष 2701 वृहद और मध्यम सिंचाई, उप मुख्य शीर्ष-80 सामान्य लघु शीर्ष 005-सर्वेक्षण और अन्वेषण, उप शीर्ष-सर्वेक्षण तथा खोज मद में प्रावधानित राशि के अन्तर्गत भारित होगा ।

(vii). समिति पर होने वाला व्यय मुख्य अभियंता जल संसाधन विभाग, पटना के माध्यम से होगा एवं इसके निकासी एवं व्ययन पदाधिकारी कार्यपालक अभियंता, सोन नहर प्रमंडल, खगौल, पटना होगें ।

(viii). समिति कार्यारम्भ करने की सूचना के साथ-साथ अपना कार्यक्रम प्रस्तुत करेगी एवं 10 बैठकों के बाद प्रगति प्रतिवेदन आयुक्त एवं सचिव जल संसाधन को समर्पित करेगी ।

(ix). समिति अपने दायित्वों के निवर्हन हेतु वॉछित पदाधिकारियों एवं कर्मचारियों की अधियाचना विभागीय आयुक्त को समर्पित करेगी ।

5. यह आदेश तुरंत लागू होगा ।

आदेश :- आदेश दिया जाता है कि इसे सर्वसाधारण की जानकारी के लिये बिहार राजपत्र में प्रकाशित किया जाय तथा इसकी प्रति सभी संबंधित पदाधिकारियों को दी जाय ।

बिहार राज्यपाल के आदेश से,

(श्यामनन्दन प्रसाद)
सरकार के संयुक्त सचिव

ज्ञाप संख्या 921. पटना, दिनांक 4/9/04.

प्रतिलिपि अधीक्षक, राजकीय मुद्रणालय, गुलजारबाग, पटना-7 को बिहार राजपत्र के अगले अंक में प्रकाशनार्थ प्रेषित ।

(श्यामनन्दन प्रसाद)
सरकार के संयुक्त सचिव

ज्ञाप संख्या 921. पटना, दिनांक:- 4/9/04

प्रतिलिपि श्री के0 एन0 लाल, सेवा निबृत अभियन्ता प्रमुख, जल संसाधन विभाग / श्री एस0 के0 सिन्हा, सेवा निबृत अभियन्ता प्रमुख, जल संसाधन विभाग / श्री सुरेश चन्द्र सिन्हा, सेवा निबृत मुख्य अभियन्ता, जल संसाधन विभाग / श्री राम रतन प्रसाद, सेवा निबृत मुख्य अभियन्ता, जल संसाधन विभाग को सूचनार्थ एवं आवश्यक कार्रवाई हेतु अग्रसारित ।

(श्यामनन्दन प्रसाद)
सरकार के संयुक्त सचिव

ज्ञाप संख्या 921 पटना, दिनांक 4/9/04

प्रतिलिपि आयुक्त, वित्त विभाग, बिहार सरकार को सूचनार्थ एवं आवश्यक कार्रवाई हेतु प्रेषित ।

(श्यामनन्दन प्रसाद)
सरकार के संयुक्त सचिव

ज्ञाप संख्या 921. पटना, दिनांक 4/9/04.

प्रतिलिपि मंत्री / राज्य मंत्री, जल संसाधन विभाग के आप्त सचिव/ आयुक्त एवं सचिव, जल संसाधन विभाग / विशेष सचिव, जल संसाधन विभाग / अभियन्ता प्रमुख, जल संसाधन विभाग / मुख्य अभियन्ता, जल संसाधन विभाग, पटना / मुख्य अभियन्ता, जल विज्ञान एवं योजना आयोजन, पटना / मुख्य अभियन्ता, योजना एवं मोनिटरिंग, पटना / निदेशक, जल विज्ञान निदेशालय, पटना / संयुक्त सचिव, प्रबंधन कोषांग, जल संसाधन विभाग / अधीक्षण अभियन्ता, योजना एवं मोनिटरिंग अंचल-5, पटना/ कार्यपालक अभियन्ता, सोन नहर प्रमंढल, खगौल, पटना को सूचना एवं आवश्यक कार्रवाई हेतु प्रेषित ।

(श्यामनन्दन प्रसाद)
सरकार के संयुक्त सचिव

C:My Doc.1-mod-report-ex-comm