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Chapter

# Interlinking of River: Issues and Challenges

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## Abstract

Climate change events cause erratic spatial and temporal variability in rainfall, temperature, humidity, etc. in long term, and are most severely affecting irrigation, domestic and industrial water supply. At the same time, water availability is also under pressure due to climate change and overexploitation of water resources. In a monsoonal climate that is already erratic and highly seasonal in nature, this increased variability due to climate change will further impact water availability and salt water intrusion. To overcome such problems, one of the most effective ways is interlinking of rivers. It is the interbasin water transfer from the water surplus rivers to water deficit rivers or regions. It will increase water supply, irrigation potential, mitigate floods, and droughts and reduce regional imbalance in the availability of water. Interlinking of rivers will reduce regional imbalances significantly and provide benefits by the way of additional irrigation potential, domestic and industrial water supply, hydropower generation, and transport facilities.

**Keywords:** rainfall, river interlinking, surface water, groundwater, droughts, floods

## 1. Introduction

The rainfall occurrence in India is mainly due to orographic effect, coupled with tropical depressions originating in the Arabian Sea and the Bay of Bengal. It accounts for about 85% of the total rainfall in the country. The uncertainty in rainfall occurrence is a serious problem for the country marked by extended dry spells and fluctuations in seasonal and annual rainfall pattern. Most parts of the country are facing deficit rainfall trend and are subjected to large variations resulting in frequent droughts and floods conditions. Floods cause immense hardship to the population and enormous loss to the country. In the summer seasons as the rivers dry up and the ground water level goes down, the water availability for agricultural, industrial and drinking purposes becomes critical. While, some parts of the country do not have enough water even for raising a single crop due to regional rainfall alteration, on the other hand, surplus rainfall occurs in some parts of the country causing floods or waterlogged situation.

Irrigation has been the prime factor for increasing the food grain production in India from a mere 50 million tons in 1950s to more than 291 million tons in 2019–2020. In 1950–1951, the canal irrigated area was 8.3 million hectares while in 2013–2014 at 17 million hectares. Despite that, the relative importance of canals has fallen from 40% in 1951 to 26% in 2010–2011. On the other hand, in 1950–1951, the well and tube well accounted for 29% of gross irrigated area and they share 64% of the gross irrigated area in 2012–2013. Irrigated area has increased from 22 million

hectares to 66 million hectares in the year 2012–2013 [1]. The population of India, which is around 1.2 billion at present, is expected to increase to 1.5 to 1.8 billion in the year 2050 and that would require about 450 million tons of food grains. The irrigation potential has to be increased to 160 million hectares for all crops for meeting food requirements by 2050. Through conventional sources, the maximum irrigation potential that could be created is about 140 million hectares. Other strategies shall have to be evolved for attaining a potential of 160 million hectares.

The Brahmaputra and Ganga rivers are the main Indian rivers in which almost 60 per cent of the Indian river drain. They also cause recurring floods and hence damages. Flood damages, which were Rs. 520 million in 1953, have gone up to Rs. 957.36 billion in 2018 mostly affecting the States of Assam, Bihar, Uttar Pradesh and West Bengal along with loss of lives. In other side large areas in the States of Andhra Pradesh, Gujarat, Rajasthan, Karnataka and Tamil Nadu face recurring droughts with approximately 85% areas of these states falls under drought prone.

One of the most effective means to enlarge the irrigation potential of river command areas is the Inter Basin Water Transfer (IBWT). It refers to the water transfer from water surplus rivers to the water deficit rivers or regions. Brahmaputra and Ganga rivers particularly their northern tributaries, Godavari, Mahanadi and West Flowing rivers originating from the Western Ghats of India are found to be surplus in surface water resources. If storage reservoirs can be built on these rivers and connected to other parts of the country, regional water imbalances could be reduced and many benefits by way of additional irrigation potential created, industrial and domestic water supply, hydropower generation, waterways facilities, etc. would be ensured.

## 2. History behind interlinking of rivers

The initial plan to interlink India's rivers came in 1858 from a British irrigation engineer, Sir Arthur Thomas Cotton, but the idea of interlinking Indian rivers was revived a few decades ago independently by M. Visveswarayya, K. L. Rao and D. J. Dastur. In 2002, the Supreme Court of India ordered the Indian Government to complete river interlinking project within the next 12–15 years. In response to this order, the Government of India appointed a Task Force and scientists, engineers, ecologists, biologists and policy makers started to deliberate over the technical, economic and eco-friendly feasibility of this gigantic project [2].

Since 2015, Indian Government has implemented river interlinking projects in several segments such as the Godavari-Krishna river interlining in Andhra Pradesh and the Ken-Betwa rivers interlink in Madhya Pradesh. These projects are built with aims that it will enhance annual per capita water availability for increasing population of the country. The Godavari-Krishna rivers interlinking projects also envisions an area more than twice the size of Andhra Pradesh receiving extra water for irrigation and to even out the unwarranted swings between droughts and floods. Yet even as the project moves forward there is a large possibility that it could dislocate nearly 1.5 million countries population due to the flooding of 27.66 lakh hectares of land [3].

## 3. Proposals for interlinking of rivers (ILR) in India

### 3.1 Earlier proposals

Transferring surplus water available in some regions to water deficit areas have been made suggested through formation of a National Water Grid from time to time. The two such proposals which attracted considerable attention put forth in the 1970s were:

### *3.1.1 National Water Grid by Dr. K.L. Rao (1972)*

In 1972, Dr. K.L. Rao presents a 2640 km long Ganga—Cauvery river interlinking project. Its major component includes a large scale pumping of water over a head of 550 m. The power requirement for water lifting from the head was estimated to be 5000–7000 MW, used for irrigating an additional culturable area of 4 million hectares. This project had not any flood control benefits. It had estimated that the overall cost of the project was about Rs. 12,500 crores.

### *3.1.2 Garland Canal by Capt. Dastur (1977)*

In 1977, Capt. Dastur presented a proposal for construction of two canals in Himalayan regions of India. The first proposed canal was 4200 km long Himalayan Canal run along the foothills of the Himalayas from the Ravi river to the Brahmaputra river near Chittagong. The second proposed canal is 9300 km long Garland Canal covering the Central Deccan and Southern Plateau region of the country. Both of the canals integrated with numerous lakes/reservoirs and interconnected with water pipelines at two points such as Delhi and Patna. The total estimated cost of the projects was Rs. 24,095 crores.

## 3.2 Existing proposals

Many large scale water transfer projects have been planned and few of them implemented and constructed as a landmark for the overall development of the water scarce regions. A few successfully implemented projects are briefly explained here.

- Periyar river project

The project was started in 1895 with the aim to provide irrigation facility to water deficit Vaigai river basin. This river project is one of the most outstanding endeavors of the nineteenth century in trans-basin diversion. The project envisages the transfer of water from Periyar river basin to Vaigai river basin. A masonry gravity dam at Periyar river has been constructed across a gorge on west flowing. Its height is about 47.28 m. A 1740 m long tunnel across the mountain with a discharge capacity of 40.75 cumecs has been driven to supply the water to Vaigai river basin. Initially, it provided irrigation to 57,923 ha culturable land, which has been extended to 81,069 ha. There is also a hydropower station of 140 MW capacities.

- Parambikulam Aliyar river project

It is an interstate multipurpose project completed in late 1960s and functioning based on an agreement between the states of Tamil Nadu and Kerala. Nine dams and two weirs had been constructed and their reservoirs interlinked by tunnels. The project envisages transfer of water from Chelakudi basin to Bharatapuzha and Cauvery basins. This project transfer water from the basins of three west flowing rivers originating from the western ghats of India along the Kerala-Tamil Nadu border such as Bharathapuzha Chalakkudipuzha Periyar river. These rivers are mainly dependent on the southwest monsoon and northeast monsoon rainfall. The water released to the east is mainly used for irrigation purpose. The water is being delivered to drought prone areas in Coimbatore district of Tamil Nadu and the Chittur area of Kerala states. The gross command area for irrigation is about 1,62,000 ha. There are four hydropower stations with an overall capacity of 185 MW.

- Kurnool Cudappah Canal project

A private company started this scheme in 1863. The project envisages transfer of water from Krishna basin to Pennar basin.

It takes off from right flank of Anicut constructed across Tungabhadra River near Sunkesula Village in Kurnool District. The total length of canal is 306 km i.e. from Sunkesula Anicut up to 235 km in Kurnool district and the remaining length of 71 km in Cuddapah district. The canal has total storage capacity of 84.9 cumecs which extends from Krishna to Pennar basin and irrigates area of about 52,746 ha.

- Telugu Ganga river Project

This project has been implemented primarily to meet the pressing need of water supply to Chennai metropolitan area as well as to irrigate 5.75 lakh acres in drought prone areas of Rayalaseema and uplands of Nellore District in Andhra Pradesh. It brings Krishna water from Srisailam reservoir through an open canal, first to Somasila reservoir in Pennar valley. The scheme consists of 408 km long canal from Srisailam Reservoir to Andhra Pradesh. From Somasila, water is capture to Kandaleru through a 45 km long canal and then to Poondi reservoir in Tamil Nadu through another 200 km long constructed canal. By mutual agreement, 12 TMC of water is to be delivered to Tamil Nadu at the border from Krishna basin. This greatly augments the water supply to Chennai city. The canal also irrigates 2.33 lakh hectares in Andhra Pradesh.

- Ravi-Beas-Sutlej-Indira Gandhi Nahar Project

This project presents an excellent example of the way the big inter basin water transfers initiatives added all round socio-economic improvement with typical enhancement inside the ecological and environmental factors of the vicinity. As per the Indus Water Treaty (1960) water of three eastern rivers viz. Beas, Sutlej and Ravi have been issued to India. As the land to be benefited from this interlinking river project in India, lies mainly to the east and south of these rivers basins, the rivers needed to be interlinked and the water transfer to canal systems for serving large tracts in India. Bhakra garage is the principal water garage on Sutlej river while Pong garage is the principal water garage on Beas river. Bhakra basin system provides irrigation to about 26.3 lakh hectares of new culturable area except stabilization of present irrigation facility to 9 lakh hectares. The gross hydropower generation capacity of Bhakra Nangal Project is 1379 MW. A Pondoh diversion dam is situated 140 km upstream of Pong reservoir on Beas which transfer water from Beas to Bhakra reservoir and generates hydropower of 165 MW. The Beas-Sutlej link is 37.25 km long of which 25.45 km is in tunnel through difficult hard rock formations. The overall discharge potential of the tunnel is 254.70 cumecs. Ranjit Sagar dam is also constructed at Ravi river that gives additional water to Beas and additionally generate a big block of hydropower.

## 4. Inter Basin water transfers in other countries

Many large-scale water transfer schemes have been planned and implemented in other countries also.

- South-north water transfer project, China

An ambitious plan to link Yangtze river basin in the south with the yellow river basin in the north, construction of the South-north water transfer project (SNWTP) began on 2002. Two third of the country's water is in the south, while half its people and nearly 65% of its agricultural land are in north. The project is set to cost nearly $80 billion and has necessitated the relocation of 330,000 people. He will transfer 45 billion cubic meter (BCM) of water through 3000 km long tunnels and canals.

- Tagus-Segura transfer project, Spain

This project was completed in 1978 that connects four river basins Tagus, Jucar, Segura and Guadiana, to irrigate 1.7 lakh hectares and provide water to 76 municipalities in south eastern Spain. The project has resulted in reduced in flows in Tagus.

- Lesotho highlands water projects, South Africa

This project was started in 1950 and completed in 1986 by South Africa and its neighbor Lesotho, the project involves transferring water from the upper reaches of the Orange river in Lesotho to the Vaal river in south Africa, and also generate hydel power. This project transferred 750 million cubic meter water (MCM) annually.

- California's State Water Project, United States

The 1st phase of the project was completed in the year 1973. The California State Water Project is a water storage and delivery system of reservoirs, aqueducts, power plants and pumping plants. The major purpose of the project was water supply. It diverts 4 $km^3$ of water from excess watered northern California to the drier central and southern parts. The conveyance system consists of 715 km long aqueduct, a complex system of lined and unlined canals, siphons, tunnels and pumping stations, etc. The water also irrigates about 750,000 acres of farmland, mainly in the San Joaquin Valley.

Similarly, importantly major under construction and existing inter basin water diverted in Canada include Kemano, Churchill Diversion, Well and Canal, Bay d' Espoir, James Bay, Churchill Falls, etc. Proposed river inter basin transfers in Canada include Long Lake, Ogoki (for transfer within Canada) and North American Water and Power Alliance (NAWAPA), Canadian Water, Grand Canal Concept, Central North American Water Project (CNAWP), Magnum Plan, Smith Plan etc. for transfer from Canada to USA.

## 5. Need for Inter Basin water transfers (IBWT)

Inter Basin Water Transfers is necessarily required to overcome the water scarcity situations in the regions/basins. These are needed to enhance water utility and reduce water wastage of water surplus areas in the following manner:

- Large variation in rainfall and available water resources in space and time
- Diversion of water from water surplus basins to water deficit basins/regions
- Use of the surplus water which is otherwise flowing into the sea unutilized
- To mitigate likely adverse impact of climate change, short term and long term

### 5.1 Indian National Water Policy (2012)

National water policy (NWP) considered water as economic goods for promoting its conservation and efficient use. NWP was formulated to govern the planning and development of water resources and their optimum utilization. The NWP was adopted in September, 1987. It was reviewed and updated in 2002 and later in 2012. It stated that Inter basin water transfers are not only for increasing production but also for meeting basic requirement of human need and achieving equity and social justice [4]. Inter-basin transfers of water should be considered after evaluating the environmental, economic and social impacts of such transfers.

## 6. Issues: interlinking of Indian rivers

In case of water disputes, Article 262 of the constitution of India provides "Parliament may by law provide for the adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter-State river or river valley."

According to the National Water Policy (NWP), water is a prime natural resource for human's beings as well as animals and, for this reason, a valuable countrywide asset. These days, it is difficult to explore freshwater due to boom in population, agricultural and industrial sectors, and contamination of water assets. By 2020, the world human population is expected to reach up to 7.9 billion and the world may face to great severity for freshwater. The India's annually receives about 4000 $km^3$ of water from precipitation, but due to exclusive rainfall patterns and their mismanagement, leads to wastage of water. By the way of considering this interlinking of Indian rivers, a highly formidable and big project is planned, that is under debate.

In 1990, the Government of India appointed a high level Commission to have a look at the approach of water resource development in India, together with the possibility of interlinking rivers. The concept of canals linking is to divert surplus waters from some identified rivers basins to the water deficit river basins and regions [5].

In 2015, the Supreme Court of India directed the Government of India to draw up and put in force a program to interlink principal rivers of India. Subsequently, the Prime Minister of India announced its decision to work on the court directive and appointed a task force to ensure the implementation of the project by the same year [6].

The appeal of interlinking rivers is primarily based on the expertise that a huge quantity of water of the country rivers flows into the ocean and that if only this is prevented, and water transferred from water surplus rivers to water deficit rivers, there may be good enough supply of water for anyone throughout the country. At another level, the project is seen as promoting national integration and a fair & equitable sharing of the country's water wealth. Whether or not the linking of rivers will promote integration or generate greater disputes is a moot question. The expert belief that the river interlinking is essential to make sure adequate and safe water delivery to all people and anywhere. Domestic water use currently accounts for about 5% of the total water use extracted through wells, tube-wells, tanks and canals.

The requirements of water in different sectors growing rapidly but will still are relatively small compared to those of other uses. To meet the requirement under limited conditions, river interlinking is the only solution for this problem. Even if interlinking were justified for other reasons, it will be difficult to reach water

to the entire livelihood without huge investments in a centralized water distribution network. Through approaches of decentralized local rainwater harvesting, by renovating and improving traditional water storage structure can meet the essential demands of water for domestic requirement more effectively and at a low input cost.

By far, agriculture is the largest water user and more than 85% of water from wells, tube-wells, tanks and canals are used for irrigation purposes. The water demand is increasing and will continue to be, by far, the biggest claimant on available water supplies. There is much scope for enhancing the water use efficiency of irrigation systems by reducing wastage of water such as runoff, seepage, evaporation, interflow and so on, and through efficient on-farm water management practices.

The water demand for irrigation arises when rainfall is not sufficient to meet the water demand for raising crops and obtaining optimum crop yields. The annual rainfall is sufficient to meet the water requirements in the *kharif* in the country. Irrigation is required essentially to tide over insufficient soil moisture during dry spells within the season. In the states Haryana, parts of Gujarat, Punjab, Rajasthan and Tamil Nadu agricultural acreage which required irrigation during the *kharif*. Practically in the whole country, especially the northwest, irrigation is essential between the month of November and June. So far, these water imbalances have been met by water capturing technologies such as constructing water harvesting structures to store excess rainy water during monsoon for use in the dry season and by exploring groundwater. Some areas, such as Tamil Nadu, have exhausted the water potential for harnessing the surface flows. In several other part of the country, the possibilities for constructing water storage structure are limited. In these areas groundwater resources are already overexploiting to meet the water demands of different sector, so under these conditions the scope for exploring water is limited. In many areas, the problem is to check expansion and contain the rate of exploitation of surface and sub-surface water resources. Considering this river interlinking is seen as a way out to solve the problem of water deficit of the country.

An examination of the river interlinking raises numerous questions: (1) it is primarily based at the presumption that there are large surplus flows in some basins and that the physical transfer is possible in terms of physical engineering, and can be performed economically without growing any adverse environmental, social and economic impact.

It is the fact that the most of the difficulty arises practically in all Indian rivers during the southwest monsoon. About 90% of south Indian rivers flow takes place in the month of May to November. Being perennial Indo-Gangetic and Brahmaputra river basins, the percentage of the total flow occurring during months between May and November may be somewhat smaller but not all that much smaller flow rate. More than 80% of the yearly flow in the Kosi river occurs in the month between May and November and almost three-fourth in the month between June and October.

The prevalence of monsoon refers to the season when aggregate rainfall is sufficient for plant growth. In some parts of India, such as Rajasthan, parts of Gujarat and the Deccan, even the *kharif* rain is far too low and variable for productive agriculture. In some others parts, excessive water could assist transfer to more productive cropping patterns. Those deficit regions are far from those taken into consideration surplus water are required to transfer over very water harsh terrain.

## 7. Hashim commission report (2004–2005)

The commission report highlighted that which rivers and at which locations water surpluses could be transfer and to which rivers, and at what factors in these

rivers the transfer water could be taken. There may be no records at the large quantity of water to be transferred via different canals link, the location and extent of the region to be strengthen on the receiving side and the water distribution system via which water is to be allocated in the region.

## 8. Interlinking of rivers to get new push during the year 1999–2004

An ambitious project on interlinking of river got new impetus during the year 1999–2004. It focuses mainly on rivers linking of sub-basins within a larger basin or nearby basins instead of going on for distant inter-basin river linkages.

Government of India considered those rivers basin for interlinking which are adjacent to each other, keeping in the mind its feasibility and utility to larger beneficiaries/stakeholders. It has done the interlinking of rivers in a manner that it simultaneously looks after irrigation and drinking water needs of human beings and ecological concerns.

The International Water Management Institute (IWMI), Sri Lanka and the Challenge Program on Water and Food (CPWF) have designed a 3 year project on "Strategic Analysis of India's River Linking Project" to qualitatively improve the troubles and route of the prevailing NRLP debate [7].

## 9. Challenges: interlinking of Indian rivers

### 9.1 River linking should adjust rainfall, hit monsoons

Criticizing the interlinking of rivers (ILR) mission of the Government of India, a leading geologist and environmental expert warned the move ought to disrupt rainfall pattern which could be a major problem in respect of climate change. The formidable ILR initiative which received a boost via the Prime Minister of India has 30 river linking initiatives under its ambit and consists of each peninsular and Himalayan Rivers.

V. Rajamani (Emeritus Professor, Jawaharlal Nehru University, New Delhi) reported that there is a major disruption of ecosystem. In respect of climate change there is a possibility of change in rainfall pattern. The marine ecosystem will be disturbed and the physical process for the rainfall will be affected. You could no longer dependent upon the monsoon. Under changing rainfall pattern, it is not possible to meet water requirement of the ecosystem. So, there is need to link water bodies of those areas with water surplus areas to enhance the water flow to meet the water necessities.

There is not enough water to interlink rivers across India: IIT study.

A study of Indian Institutes of Technology, Mumbai and Indian Institutes of Technology, Chennai reported that rainfall of the country has decreased over the years 1901–2004, reducing water storage even in the river basins that have surplus water. It also reported that a significant fall in rainfall (i.e., more than 10% in each basin) in the major water surplus river basins of the Godavari, the Mahanadi, the Mahi, the Brahmani, the Meghna and the many small rivers in the Western Ghats, and east flowing river basins of the country. Only the Brahmaputra river basin showed that there is no deficit in rainfall [8]. Rivers linking project will have an ecological effect while building a network of dams, reservoirs and canals. It should be reanalyzed and reevaluated through considering changes in climatic patterns of the river basins. In such manner a decrease in surplus river basin contradicts the conventional perception that climate change phenomenon resulting wet areas to turn out to be wetter and dry areas to turn out to be drier over Indian conditions.

In 1982, National Water Development Agency (NWDA) was set up as an autonomous organization under the Ministry of Irrigation with the aim to carry out detailed studies, surveys and investigations of the water balance and feasibility studies of the river interlinking projects.

In 2002, the President of India point out the river linking project in the course of a speech. He proposed that it as a solution to India's water problem after which an application requesting an order from the Supreme Court of India on river linking matter was submitted. Finally, in 2002 the Government of India declared a substantial plan for an IBWT program involving 30 links of different river basins of peninsular and the Himalayan parts of India [9].

The interlinking of river (ILR) was introduced in 1982; it was actively taken up during Atal Bihari Vajpayee's tenure as Prime Minister during 1999–2004. The ILR project has two components the peninsular and the Himalayan. Both the components together have 30 river-linking projects.

The peninsular part of the India covers the rivers in southern India envisaged developing a "Southern Water Grid" with 16 important river linkages in different states. This part included diversion of the excess waters of Godavari and Mahanadi to the Krishna, Cauvery, Pennar and Vaigai rivers. The inter basin water transfer network in peninsular part of the India is shown in **Figure 1**.

The peninsular part of the India has 16 major canals and 4 sub-components: (1) Network of Mahanadi-Godavari-Krishna-Cauvery-Vaigai rivers; (2) Network of west flowing rivers lies between south of Tapi and north of Bombay; (3) Network of Parbati-Kalisindh-Chambal and Ken-Betwa rivers and (4) diverting the flow in some of the west flowing rivers to the eastern side of the country. As per NRLP the enroute irrigation under the peninsular part of the country is expected to irrigate substantial areas. The amount of water diverted in the peninsular part may be 141 $km^3$. The area to be irrigated is situated in arid and semi-arid western and peninsular part of India. The overall project cost includes three components in the peninsular part of the India may be Rs.1,06,000 crore and the hydroelectric power component may be Rs. 2,69,000 crore. The gross hydroelectric power generated may be 4 to 34 GW [10]. The Himalayan part of the India was conceived for building storage reservoirs on the Ganga and the Brahmaputra and their main tributaries

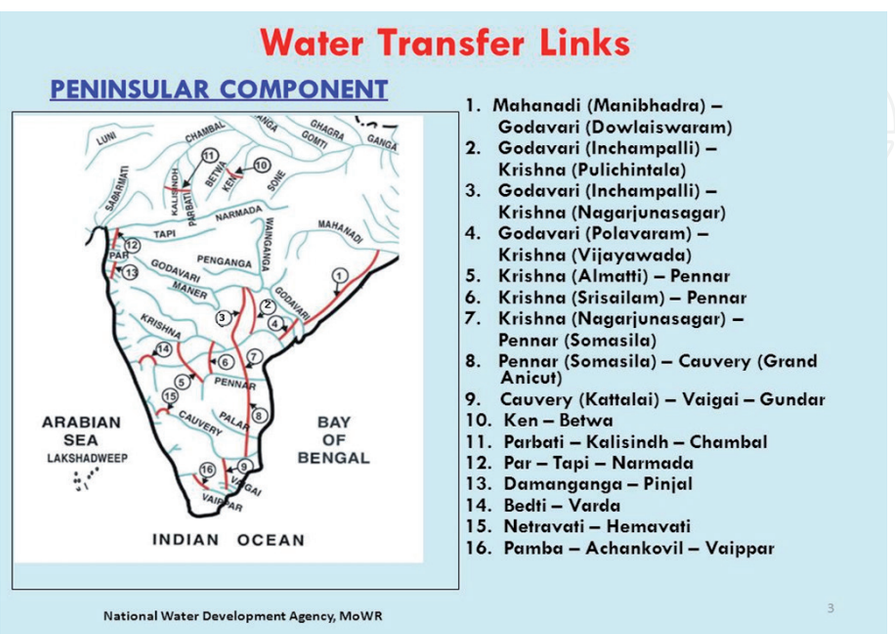



**Figure 1.**
*Inter Basin water transfer network in peninsular India.*

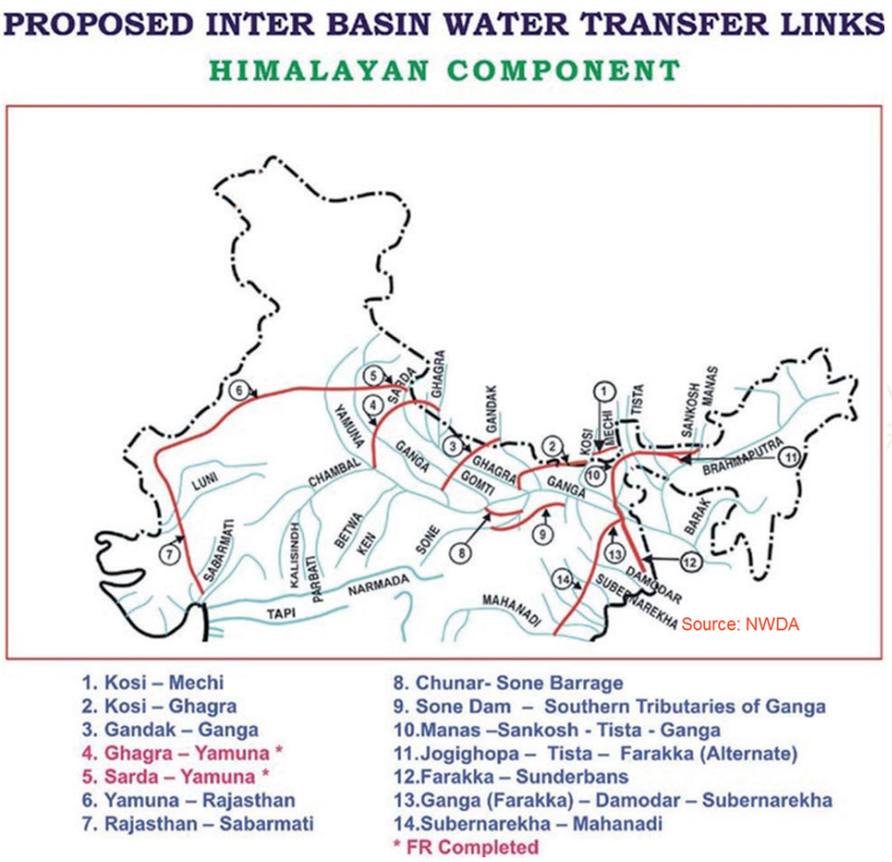



**Figure 2.**
*Inter Basin water transfer network in Himalayan India.*

both in India and Nepal in order to conserve water during the monsoon season for irrigation and hydro-power generation, besides checking floods. The Himalayan part of the India is comprised of 14 inter basin water transfer network including Brahmaputra-Ganga, Kosi-Mech, Kosi-Ghagra, Gandak-Ganga, Ghagra-Yamuna, Sarda-Yamuna, Ganga-Damodar-Subernarekha, Subernarekha-Mahanadi and Farakka-Sunderbans. The Inter basin water transfer network in Himalayan part of the India is shown in **Figure 2**.

The Himalayan part of the India has 16 important river networks, has two sub-components: (1) Transfer of Ganga and Brahmaputra rivers surplus waters to the Mahanadi Basin and from Mahanadi to Godavari, Godavari to Krishna, Krishna to Pennar and Pennar to the Cauvery river basins. (2) Transfer of water from the Eastern Ganga tributaries to the western sects of the Ganga and the Sabarmati river basins. Altogether, those river water transfers network will mitigate the floods issues within the eastern sects of the Ganga Basin and gives irrigation water delivery to the western sects of the Ganga. The Himalayan sects needed large number of dams in Bhutan and Nepal to capture and divert flood waters from the tributaries of the Brahmaputra and Ganga rivers, and also within India to divert the surplus waters of the Godavari and Mahanadi rivers. The amount of water diverted in the Himalayan part may be 33 $km^3$. The overall project cost of the Himalayan part is to be Rs.1,85,000 crore. The gross hydroelectric power generated may be 30 GW [11].

## 10. Successfully interlinking Indian rivers projects

There are many river linking projects are successfully completed or operated by the Govt. of India is explained below:

### 10.1 Polavaram project

It is also called Indira Sagar project. It is a multipurpose project built on Godavari river in the state of Andhra Pradesh. It has assessed culturable command area (CCA) of 2.91 lakh hectares and hydropower generation capacity of 960 Mega Watt (MW). It additionally has a carrying capacity of drinking water supply of 23.44 thousand Million Cubic Feet (TMC) to Vishakhapatnam Steel Plant. Its' inter-basin annual water carrying capacity is 80 TMC to Krishna river basin [12].

### 10.2 Ken-Betwa link project

- The main aim of Ken-Betwa link Project provides 6.35 lakh ha irrigation and 49 MCM drinking water supply in the drought prone and backward Bundelkhand region of Madhya Pradesh and Uttar Pradesh.
- It will transfer surplus water of Ken basin to water deficit Betwa basin besides power generation of 78 MW.
- Estimated Cost Rs. 17,700 Crores
- 77 m high, 2031 m long Daudhan Dam on Ken river in Chhatarpur district of M.P 221 km long link canal.

### 10.3 Damanganga-Pinjal link project

- The project envisages to provide 579 MCM of water of Damanganga basin for domestic and industrial water supply to Mumbai city
- Project benefits
  - Domestic and industrial water supply to Mumbai city—579 MCM
  - Hydropower—5 MCM
- Total estimated cost—Rs. 2746.61 crore
- Benefit cost ratio—1.95

### 10.4 Par-Tapi-Narmada link project

- The main aim of this project is to provide irrigation for 2.30 lakh hectares by transferring 1330 MCM of water from Par, Auranga, Ambika and Purna rivers to water short north Gujarat Kutch region besides enroute irrigation and hydropower generation 21 MW.
- Project benefits
  - Annual irrigation—2.3 lakh ha
  - Hydropower—21 MW
- Total cost estimated—Rs. 9279 crore
- Benefit cost ratio—1.95

### 10.5 Mahanadi-Godavari link project

- NWDA reported that Godavari and Mahanadi river basins are water surplus basins. The joint surpluses water of these basins after accounting in basin uses in closing stage of improvement can be transferred to fulfill the water requirement of water deficit basins in South upto river Gundar via Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai-Gundar river linkages. According to the Government of Odisha surveys, the proposed dam turned into having submergence of 59,400 ha.

- Government of Odisha has proposed a dam at Barmul 14 km upstream of Manibhadra village on Mahanadi river. The Barmul dam with full reservoir level (FRL) of 80 m, height of 25 m can have a total storage capacity of 1216 MCM and water diversion of 9182 MCM. Out of which, 4046 MCM water can be diverted to Godavari river.

- Projected Benefits

  - Annual irrigation—5.03 lakh ha.

  - Drinking water supply—125 MCM

  - Hydro power generation—240 MW

### 10.6 Manas-Sankosh-Teesta-Ganga (M-S-T-G) link project

Manas-Sankosh-Teesta-Ganga (MSTG) link is proposed under the Himalayan Component of national Perspective Plan (NPP). MSTG link canal envisages diversion of the surplus waters of Manas and Sankosh rivers to Ganga at Farakka and further transfer to water shortage areas of Krishna, Pennar and Cauvery basins and providing irrigation facilities to the enroute canal command areas.

### 10.7 Kosi Mechi link project

- The main aim of this project is to provide irrigation benefits to the water scarce Mahananda basin command in the districts of Araria, Kishanganj, Purnea and Katihar during kharif season depending upon the pondage available in Hanuman Nagar barrage.

- Projected Benefits

  - Annual irrigation: 2.15 lakh ha

- Benefit cost ratio—3.66

### 10.8 Burhi Gandak Noon Baya Ganga link project

- The main purpose of this project is to diversion of flood water from river Burhi Gandak to river Baya/Ganga for flood moderation. Irrigation to the tune of 1.26 lakh ha during kharif season in Samastipur, Begusarai and Khagaria districts.

- Projected Benefits
  - Annual irrigation—1.25 lakh ha
- Total estimated cost—4214 crore
- Benefit cost ratio—1.54

## 11. Conclusion

The interlinking of rivers project is a major challenge and an opportunity to deal with the water related problems springing up drought, floods, climate change and so on. The long term strategy to water deficit problem lies in making the interlinking of rivers challenges by building a network of dams, reservoir, barrage, hydropower structures and canals throughout the geographical regions of the country. However, Interlinking of rivers is definitely a good solution for the shortage of water, but interlinking has to take place after a reconnaissance survey and detailed study so that does not cause any trouble to the environment or aquatic life.

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