Inter – Basin Water Transfer (IBWT) Project of India – An Efficient Water Management Ingrained Planning Concept

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ABSTRACT
Inter-basin water transfer (IBWT) project for optimum utilisation of land and water resources in India has been formulated by Govt. of India in 1980 under the National Perspective Plan (NPP) comprising of two components (i) Peninsular Rivers Development and (ii) Himalayan Rivers Development. The planning studies for firming up the various link proposals under NPP are being carried out by National Water Development Agency (NWDA), a Govt. of India Society under the Ministry of Water Resources since 1982. This multi-purpose and multi-stake holder mega scheme proposes additional utilisation of 170-200 BCM of water to cope with the future food, energy, drinking, industrial and environmental requirements of water across various river basins and regions in the country to the possible extent. Since the scheme is basically for optimum utilisation of water resources in the country, efficient water management is naturally ingrained in the planning of various aspects of the scheme. The scheme encompasses this objective by way of (i) Water Resources Conservation, (ii) Water Use Conservation & (iii) Efficient Use of Water. In the detailed planning of this scheme, further optimization considering adoption of conjunctive use of surface and ground water, drip & sprinkler irrigation systems & other state-of-art technologies etc. for more resilience and effective functioning of the link projects can be studied.

1. THE BASIC PHILOSOPHY & THE NEED:

India's water resources are skewly distributed both in space and time constraining the optimum development of its water as well as land resources. The annual precipitation including snowfall in the country is estimated at 4000 BCM, which is seemingly quite substantial, but for its uncertainly of occurrence only in few spells during monsoon (June to September) and at only a few places in abundance. While some river basins like Ganga, Brahmaputra, Barak and other west flowing rivers in Western Ghats are bestowed with abundant flows (>60 per cent of country's river flows) in excess of their requirements, other rivers in rest of India suffer for want of it in order to meet even their reasonable in-basin needs. Floods are a recurring feature in India particularly in Brahmaputra and Ganga river basins while droughts are frequent in large parts of Peninsular India causing immense hardship to the population and enormous economic loss to the nation. The country has to cope with this reality and come up with a long term strategy encompassing creation of storages (big/small to conserve water when and where available), integrated river basin planning (optimum development of land and water within a basic hydrological unit) and inter – basin water transfer (IBWT-to supplement the needs of water scarce areas in the country). The basic philosophy of the IBWT is to correct the imbalances in the natural availability of water in the country across its land resources in time and space.

The futuristic projections of water requirements of the country (Say by 2050 AD) for various purposes such as irrigation, municipal, industrial, energy & other needs also amplify the need of inter – basin water transfer as a long term option to face these challenges. The population of India is expected to stabilize at about 1500 to 1800 million by the year 2050 requiring about 450 million tonnes of food grains at even the present level of consumption. The existing level of food production is around 200 Million tonnes. The future food requirement necessitates increase in irrigation potential to 160 million hectares for all crops by 2050. The annual renewable water resource for the country is assessed at 1869 BCM. Out of this, about 690 BCM of surface water and 433 BCM of ground water is only utilizable through conventional structures making it to a maximum irrigation potential of about 140 million hectares that could be created.

Many urban centers are unable to cope with the ever increasing water needs of its resident as well as floating population from their local resources and have already been facing irregular, intermittent & inadequate water supplies. Metro cities like Delhi, Mumbai, Chennai etc. bank upon inter-basin water transfer to quench the basic needs of their civilians. Many more towns/villages will also have to depend on distant sources in order to be able to meet their domestic needs in future.

On the energy front too, the situation is not as illuminating as it is hoped to be. The assessed hydropower potential of the country (84000 MW) will grossly fall short of peaking requirement of 3.3 million MW at optimal 40% by 2050 AD. Therefore, the situation warrants that the country plan to harness the huge potential available in Himalayan rivers in Nepal and Bhutan through large storages which inter-alia will pave way for Himalayan links to take-off to extend irrigation, municipal and other benefits in the Himalayan region of India.

Thus, the IBWT scheme with a potential of 35 Mha & scope for additional utilization to the extent of 170-200 BCM is an inevitable option for the country for increasing the irrigated area and for catering to various other needs. It is evident that this multipurpose, multi – stake holder(the States within India, the neighboring countries of Nepal and Bhutan) scheme of IBWT is going to play a pivotal role in the nation’s water resources planning for future. Since the scheme is basically for optimum utilization of water resources in the country, efficient water management is naturally ingrained in the planning of various aspects of the scheme.

2. THE PANNING OF THE SCHEME IN INDIA:

The inter-basin water transfer scheme is being pursued in the country as a ‘National Perspective Plan (NPP) for Water Resources Development’. The NPP comprising of Himalayan and Peninsular rivers development components was formulated by Government of India in 1980.

Peninsular Rivers Development Component
The scheme is divided into four major parts:

(i) Linking Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai rivers and building storages at potential sites in these basins, popularly known as ‘Southern Water Grid’.
(ii) Networking west flowing rivers, north of Bombay and south of Tapi.
(iii) Connecting the southern tributaries of Yamuna (Ken-Chambal Rivers)
(iv) Diverting west-flowing rivers of Kerala and Karnataka to the east.

The Peninsular rivers development is expected to provide additional irrigation of about 13 Mha and generate about 4 million KW of hydropower.

Himalayan Rivers Development Component
The Himalayan Rivers Component envisages construction of storages on the principal tributaries of Ganga and the Brahmaputra in India and Nepal, along with interlinking canal systems to transfer surplus flows of the eastern tributaries of the Ganga to the West, apart from linking the main Brahmaputra and its tributaries with the Ganga and Ganga with Mahanadi. This component is expected to provide additional irrigation of about 22 million ha and generation of about 30 million KW of hydropower.

Thus, the implementation of NPP would benefit 25 million ha of area with irrigation from surface waters, 10 million ha by increased use of ground waters, raising the ultimate irrigation potential from 140 million ha to 175 million ha and generation of 34 million KW of power, apart from the incidental benefits of flood control, navigation, water supply, fisheries, salinity and pollution control etc.

The NPP envisages three major interlinking systems and a no. of Independent links.

(i) Linking Manas, Sankosh and other tributaries of Brahmaputra with Ganga, Damodar,Subarnarekha and Mahanadi
(ii) Linking system to transfer surplus flows of the eastern tributaries of the Ganga such as Ghagra, Sarda to the West (upto Sabarmati)
(iii) Linking Mahanadi with Godavari, Krishna, Pennar, Cauvery and Vaigai rivers

In the planning of NPP, a no of water conservation & management aspects have been incorporated. A few more such aspects as felt relevant have been included in the course of detailed studies carried out on the NPP. These would be discussed in detail in the foregoing paragraphs.

3. THE AGENCY:

Govt. of India, set up an Autonomous body – 'National Water Development Agency' (NWDA) in 1982 under the Ministry of Water Resources to conduct detailed studies required to firm up the NPP. Since then, over the last 30 years, NWDA has been conducting various studies as listed below in accordance with its assigned tasks from time to time and came up with 30 feasible link proposals, 16 under Peninsular and 14 under Himalayan components as indicated in Figure-1.

1. Water balance studies of river basins/sub-basins and at diversion points.
2. Toposheet and storage capacity studies of reservoirs.
3. Toposheet studies of link alignments.
4. Pre-feasibility studies of link alignments.
5. Feasibility studies of link projects.
6. Detailed Project Reports (DPR) of link projects.

While continuing the above studies for NPP, NWDA has also taken up the pre-feasibility/feasibility/DPR studies, for the Intra-state link proposals as proposed by various States. In all these studies, efficient water management aspects have been duly considered to prevail and incorporated as such in the planning of links for future.

4. WATER CONSERVATION IN THE PLANNING OF IBWT:

The scheme encompasses this objective of water conservation in all its three dimensions (IWRS-2007):

(i) Water Resources Conservation - efficient management of rainwater through storage, allocation and transfer for use and preservation of the quality of the resource including its supporting eco-system.
(ii) Water Use Conservation – water supply and distribution with minimum losses and consumption through prevention of wastage and
(iii) Efficient Use of Water - through adoption of water saving technologies and cropping patterns

4.1 Water Resources Conservation:

Obviously, the IBWT scheme involves storages for effecting the envisaged water transfers in accordance with allocations & priorities among various demands at each project viz. the mandatory releases for preserving river ecology, committed downstream releases, project's own requirement and water transfers to other basins/sites.

4.1.1 Storages:

Storage reservoirs are vital to the exploitation of water resources for the sustained development of the country. But, the storages created, under construction and planned put together workout to just above 57% of utilizable surface water. It is of utmost importance that the task of completing the capacity under construction and creation of the capacity identified for future are taken up on priority and completed within a fixed time frame. However, construction of large storages is going to be increasingly difficult in future owing to the problems of resettlement and rehabilitation of project affected people and other environmental concerns.

Taking due cognizance of this situation, the scheme of IBWT proposes to first integrate the existing and ongoing projects like Nagarjunasagar, Srisailam & Almatti on river Krishna, Somasila on river Pennar etc in its fold for optimum use of their available capacities to the extent feasible. Further, since the scheme is being planned for the ultimate development of water resources in the country by 2050 AD, all the presently planned projects are presumed to be in place by then. Therefore, the scheme also considers the proposed projects of various States/neighboring countries for inclusion in order to harness their capacity for water transfer, as possible. Thus, mostly, the proposed water transfer is planned by integrating the existing, ongoing and proposed projects of Indian States or neighbouring countries of Nepal and Bhutan. Only where there is no scope for such integration, exclusive storages (not so large) for the link projects as per the requirement are proposed. Not a single major dam is specifically proposed under Himalayan Component (barring a few regulating dams/barrages), while about 17 dams are proposed in respect of 6 links under Peninsular Component (Table-1).

Table -1: Dams proposed by NWDA under Peninsular Component (www.nwda.gov.in)

Sl. No.	Link Project	Quantum of Diversion (Mm^3)	Proposed Dams	Live Storage (Mm^3)
1	Parbati – Kalisindh – Chambal	1360	1.Patanpur 2. Mohanpura 3. Kundaliya	110.00 87.50 959.00
2	Damanganga-Pinjal #	909	1. Bhugad 2. Khaargihill	400.00 420.50
3	Par-Tapi-Narmada*	1350	1. Jheri 2.Mohankavchali 3. Paikhed 4. Chasmandva	187.34 179.94 218.00 75.08
4	Pamba-Achankovil-Vaippar	634	1.Punnamedu 2.Achankovil Kal Ar 3. Achankovil	27.80 184.90 118.50
5	Bedti-Varda	242	1.Pattanadahalla 2.Shalmalahalla	13.00 72.50
6	Netravati-Hemavati	188	1. Yattin hole 2. Keri hole 3. Hongadhallad	30.20 17.00 45.80
Grand Total		**4683**	**17**	**3147**

* The link involves 3 more storages proposed by Govt. of Gujarat (Live storage: 593 Mm^3)
# The link involves Pinjal storage proposed by Govt. of Maharashtra(Live storage: 402 Mm^3)

It is of significance to note that in the major link system of Peninsular component which involves nine links viz.. Mahanadi – Godavari – Krishna – Pennar – Cauvery – Vaigai, not even a single new dam is proposed exclusively for the scheme. This link system envisages water use of about 27 BCM with just optimization of existing, ongoing and proposed storages in these river basins in addition to fulfilling their own requirements (Table-2).

Table -2: Existing, Ongoing and Proposed Storages in Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai Link (www.nwda.gov.in)

S. No.	Link Project	Quantum of diversion (Mm^3)	Name of Dam	Live Storage (Mm^3)
1	Mahanadi (Manibhadra) – Godavari (Dowlaiswaram)	12165	1. Manibhadra (P)	6608
2	Godavari (Polavaram) – Krishna (Vijayawada)	5325	Polavaram (P)	2130
3	Godavari (Inchampalli) – Krishna (Pulichintala)	4370	1. Inchampalli(P)	4285
			2. Pulichintala(P)	1026
4	Godavari (Inchampalli) – Krishna (Nagarjunasagar)	16426	1. Inchampalli(P)	
			2. Nagarajuna Sagar (E)	
5	Krishna (Nagarjunasagar) – Pennar (Somasila)	12146	1. Nagarajuna Sagar (E)	5733
			2. Somasila (E)	
6	Krishna (Srisailam) – Pennar	2310	1. Srisailam (E)	7078

7	Krishna (Almatti) – Pennar	1980	1. Almatti (O)	3105
			2. Kalvapalli (P)	73
8	Pennar (Somasila) – Cauvery (Grand Anicut)	8565	Somasila (E)	1994
9	Cauvery (Kattalai) – Vaigai – Gundar	2252	----	----

E- Existing; O-Ongoing; P-Proposed;

Thus, in the planning of the scheme, every effort has been made to optimize the utilization of the presently available & already planned storages first and only in exceptional cases additional/new storages specifically for the scheme are proposed.

4.1.2 Allocation & transfer for use:
Certainly, the projects which are integrated in IBWT scheme, do have their own demands & commitments to be met in preference. Therefore, in the operational planning (Simulation) of the IBWT scheme, at each reservoir, allocations to the project's own demands and downstream committed releases are made on priority. After fulfilling such demands only, the link requirements for water transfer are proposed to be met from the reservoir. For instance, at Srisailam reservoir on river Krishna, committed releases for Nagarjunasagar/Krishna delta, irrigation releases for its left & right bank canals & Telugu ganga canal are accorded priority in that order and only after satisfying these demands, the proposed diversion to Pennar is considered from the reservoir. This way, meeting the project's own requirements is ensured before proposing to utilize its storage space for the water transfer to the needy areas.

4.1.3 Preservation of the river ecosystem:
Provision for certain minimum flow in the rivers is a mandatory requirement in a planning process in order to maintain water quality, river regime, river ecosystem and other downstream public necessities such as bathing, drinking, cattle use etc. Therefore, in the planning of IBWT scheme, The preservation of d/s river eco-system is taken care of with due provision for a minimum lean season flow of 10% of the inflow at diversion structures after meeting the downstream requirements and with storages at 10% of average lean season natural flow downstream the storage prior to contemplating water diversion through link canals elsewhere. In addition, special provision towards flushing, desilting, leaching etc. has also been made, where necessary. For instance, the Ganga (Farakka)-Sunderbans link proposal envisages releases for (i) flushing of Kolkata port (ii) augmentation of dry weather flows in the rivers of Jamuna & Ichhamati for desilting purposes and (iii) leaching water requirement of Sunderbans area during dry season (N.S.R.K.Reddy etal., 2007). Thus, the water transfer to a needy basin is proposed as a last priority demand on the storage to further optimize its capacity utilization as possible, after meeting the other project demands in precedence including the mandatory releases for the d/s eco-system.

4.2 Water Use Conservation:

4.2.1 Minimizing losses & saving energy:
The IBWT scheme involves long distance water transfer mostly through open canals. In order to ensure the delivery of water at the receiving end with higher conveyance efficiency (minimum losses) so as to meet the reasonable needs of the water short areas all the link canals are proposed to be lined throughout their length. This also reduces the need for lifting the seeped water and effectively functions as an energy saving mechanism.

4.2.2 Principle of substitution and exchange:
In many cases, the surplus water in a river basin is available at the terminal storage, which is obviously situated at a low elevation, where as the needy areas requiring water supply are usually upland areas located at higher level. So, the basic water transfer from surplus to deficit areas involves pumping the water, which renders it energy and cost expensive. Therefore, in order to accomplish transfer of water by gravity to the extent possible/ or with minimum pumping in short reaches, 'Principle of Substitution and Exchange' is envisaged in the planning of IBWT scheme. The concept implies taking over the commands/requirements of downstream existing projects in the water short basins from the link canals and the waters meant for these commands from upstream projects in the respective basins are tapped in exchange at higher level for diversion to needy upland areas. This concept significantly reduces the pumping which otherwise would have been involved in transporting the surplus water directly to such upland areas, thus helps in optimizing the energy requirement.

Case (a) Gravity: For instance, the surplus water that would be available at Polavaram (FRL 45.72 m) in Godavari basin are proposed for transfer to Prakasam barrage on Krishna river by gravity. The waters that were to be released for the barrage from Nagarjunasagar (FRL 179.83 m) are proposed for transfer to Pennar basin and beyond in exchange**.**

Case (b) Min. pumping: Like wise, the surplus waters available at Inchampally (FRL 112.77 m) on Godavari are planned to be transferred through a lift of 116 m to Nagarjunasagar. The waters meant for meeting the requirements of Nagarjunasagar command from the upstream projects are tapped in exchange at Almatti (FRL 519.6 m) and Srisailam (FRL 269.75 m) for transfer to the needy areas in Pennar basin and beyond.

4.2.3 Integrated operation of reservoirs:

The major link systems of IBWT scheme involve operation of a number of storage and diversion structures in integration. The storages are planned to be so operated that the in-basin needs are first met on priority before contemplating diversion outside. Also, the water transfer shall be effected in accordance with the actual requirements of the water short areas and thus minimize unwarranted spills/wastage of the transferred water.

In the context of IBWT, four possible situations can be visualized in a particular time period (P.R.Rao & N.S.R.K. Reddy, 2007).

1. Both river basins surplus - no need for any water transfer
2. Both river basins water short - no scope for any water transfer
3. Surplus basin water short and deficit basin water surplus – no need for any water transfer
4. Surplus basin surplus and deficit basin water short –water transfer required & possible

In the IBWT scheme, the real requirement of the water short basin on both time and quantity scale is first assessed in order to arrive at the time period wise actual supplementation required from surplus basin (Case-4). Then, possibility of meeting such requirements from water surplus basin through a link project apart from meeting the enroute needs is studied through simulation considering integrated operation of off-take, tail end and enroute balancing/feeding reservoirs in a single link project or a chain of reservoirs in a link system, as the case may be.

4.3 Efficient Water Use:

4.3.1 Extensive Irrigation:

The motto of the IBWT scheme is equitable distribution of water resources across various river basins/regions in the country. In tune with this objective, extensive irrigation (instead of intensive irrigation in a confined area) with 100% cropping intensity is proposed in the new commands planned to be brought under irrigation from the link canal. The aim is to extend the irrigation and other benefits from the link to as much large area & population as possible, thus bringing the hitherto unirrigated and mostly drought prone areas into the irrigation fold.

4.3.2 Irrigation Efficiencies:

There is a vast scope for improving the water use efficiency in irrigation sector in terms of per unit of land and water, which is as low as 40% at present. If the efficiency could be improved by even 10 percent, it will be equivalent to adding substantially to new potential(IWRS-1995). This scope has to be explored on priority, more so because with increasing demand from other sectors, availability of water for irrigated agriculture is being progressively reduced. With an hopeful expectation of adoption of better management practices and water saving technologies in future towards this end, improved irrigation efficiencies of 55% in respect of major & medium projects and 70% in case of minor projects are considered in assessing the requirements of water surplus as well as water short basins and link commands in the IBWT scheme.

4.3.3 Cropping Pattern:

Crop diversification is very essential as water intensive crops like paddy and sugarcane can not be increased beyond a certain limit as the future crop water requirements (say 2050 AD) have to be managed within the imminent reduced allocation for irrigation sector. Therefore, in IBWT scheme, while the water use in respect of completed and ongoing projects has been considered as originally envisaged by the respective States, in respect of the proposed projects and in the link commands, an appropriate cropping pattern for improved water management is evolved in conformity with the local soil and climatic conditions, food habits, existing crops being grown, marketability of the produce etc. in order to assess the water requirements realistically. While in respect of future major, medium and minor projects, 150%, 125% & 100% cropping intensities are considered, in case of new commands under the link, mostly 100% cropping intensity is proposed.

4.3.4 Water Conservation in Domestic and Industrial Water Use:
The National Water Policy accords the highest priority for domestic water supply in the water allocation. The Policy recommends that in all water resources development projects, provision for drinking water should be of primary consideration and that irrigation and multi-purpose projects should invariably include a drinking water component wherever there is no alternative source of water (IWRS-1995). Further, with the increase in population and rapid industrialization in the country, water demands for industries are also increasing considerably. Therefore, in the planning of IBWT scheme, projected domestic and industrial water requirements (2050 AD) in the river basins as well as enroute commands of the link projects are duly provided for.

But, at the same time, it is of utmost importance that wastage of potable water shall have to be reduced through simple measures like proper maintenance of pipes and fittings to prevent leakages. Industries also need to ensure better water management adopting 3-R principle ie. Reduce. Recycle and Reuse. Alternate production processes and technologies for reducing water use coupled with sound plant maintenance practices are required to be employed to conserve and optimally use the supplied water. In expectation of such efficient water distribution, use and recollection system to prevail in future in both domestic and industrial sectors, 80% of the provision for domestic and industrial use is accounted for as return flows in the planning IBWT scheme.

5.0 CONCLUSIONS:

The declining per capita water availability, growing regional imbalances owing to temporal and spatial variations in rainfall, skewed development of water resources projects resulting in inequitable water distribution, Impending food, energy and other challenges, rising multi-sectoral water demand, low irrigation efficiency, deteriorating water quality are some of the major issues that India has to address on priority. Therefore, the country has to come up with a comprehensive frame work for optimal development of its water and land resources in a time horizon of 4 to 5 decades to be able to meet the projected basic needs of its growing population. IBWT can be an integral part of such development strategy to effectively deal with future food, energy, drinking, industrial and other demands that the country is poised to tackle.

The planning of the IBWT scheme in India encompasses various water conservation and management strategies as illustrated in this paper for optimum utilization of land and water resources in the country. The Govt. constituted a Committee of environmentalists, social scientists and other experts on interlinking of rivers with a view to make the process of proceeding on Interlinking of Rivers (ILR) consultative under the chairmanship of Secretary (WR). The Committee shall advise the Government on various aspects of the proposed ILR project and one among them is 'Adoption of appropriate measures for optimum utilization of transferred water especially in the water short basins while preparing the various DPRs' (NSRK Reddy etal., 2007).

In the detailed planning of the IBWT scheme, some such measures could be conjunctive use of surface and ground water, adoption of drip & sprinkler irrigation systems & state–of–art technologies for more resilience and effective functioning of the link project. Conjunctive use is a planned inter-mix of irrigation water supply by surface and ground water resources so that such supplies dovetail in improving the area under irrigation , both in terms of quality of irrigation supply as well as its areal extent (IWRS-1995). Considerable savings in water can also be achieved by adoption of sprinkler/drip irrigation in water scarcity areas, having conditions conducive to their application (IWRS-2003). State of art technologies such as Global Positioning System (GPS), Geographic Information System(GIS), Remote sensing, Relational Data Base Management System (RDBMS), canal automation etc. will certainly help improve the planning and operation of the IBWT projects. With inclusion of such effective measures in its planning, the IBWT scheme will further evolve as a water conservation and efficient management ingrained scheme for the country.

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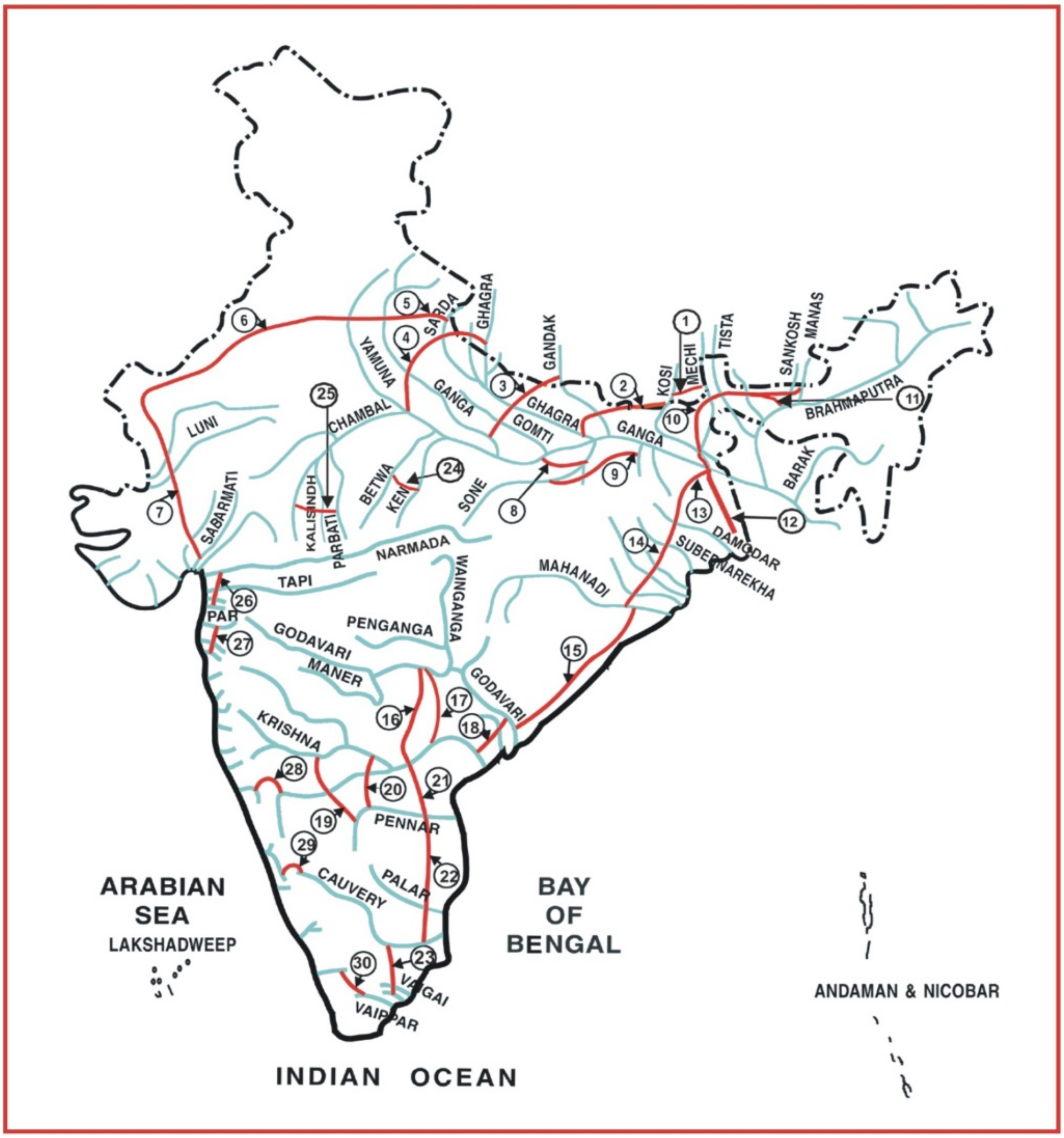
PROPOSED INTER BASIN WATER TRANSFER LINKS



HIMALAYAN COMPONENT

1. Kosi – Mechi
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. Manas –Sankosh - Tista - Ganga
11. Jogighopa – Tista – Farakka (Alternate)
12. Farakka – Sunderbans
13. Ganga (Farakka) – Damodar – Subernarekha
14. Subernarekha – Mahanadi

* FR Completed

PENINSULAR COMPONENT

15. Mahanadi (Manibhadra) – Godavari (Dowlaiswaram) *
16. Godavari (Inchampalli) – Krishna (Nagarjunasagar) *
17. Godavari (Inchampalli) – Krishna (Pulichintala) *
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 *

Figure-1