INTER BASIN WATER TRANSFERS IN INDIA – A SOLUTION TO HYDROLOGICAL EXTREMITIES

H. Mahabaleshwara[1], H.M. Nagabhushan[2]

[1]*Professor & Former Principal, R.Y.M Engineering College, Bellary*
[2]*Professor & Dean, R.Y.M Engineering College, Bellary*

Abstract

Water is treated as liquid gold since it is sacred and precious natural resource for health and wealth of the humanity. It is one and only the life sustaining elements of nature and second to "air" for survival of mankind and live stock on the earth. Earth is the only planet at present contains liquid water. The spatial and temporal uniformity in rainfall may possibly meet the water requirements for the various sectors such as Agriculture, Power, Industries, Domestic requirements etc., for the overall development of a region or country, If non uniformity is observed it results in the flooding situations in certain areas and drought conditions in some areas which have adverse impacts on the socio economic growth of a developing country. The government of India is spending enormous amount every year to overcome these natural unforeseen calamities. To protect a region or country from floods and droughts, it is inevitable to have a remedy/solution to transfer the water from surplus basin to deficit basins. The concept of Inter basin & Intra basin water transfer can provide unique solution for the dual problems faced by the country like India.

India having geographical area of 328 MHa stands as Seventh largest country in the world. The total water potential of India per annum is 4 x 10^6 Mm^3 (4000 km^3) including snow fall out of which 1.887 x 10^6 Mm^3 (1887 Km^3) flows as river water. At present 1.033 x 10^6 Mm^3 (1033 Km^3) of water is utilized and balances as 0.854 x 10^6 Mm^3 (854 Km^3) flows into sea and oceans. Also India experiences/ blessed with good rainfall in majority of the areas and scanty rainfall in few locations. The magnitude of average rainfall in North Eastern states of India is about 300 cm and less than 15 cm in North Western parts in the arid and semiarid regions. For the effective management of rain water in India the only alternative is to implementing Inter basin & Intra basin concepts.

As per the studies conducted by NWDA(National Water Development Agency) about all river basis of India, it is remarked that Inter basin Water transfer is quite possible. NWDA proposed linking of Indian rivers under two components namely Himalayan and Peninsular components comprising perennial and non perennial rivers. Thus 30 links are proposed for benefiting water deficit basins from surplus basins, thereby flooding situations can be reduced and drought impact may be minimized to uplift for social and economical growth of India. The present paper throws a light on present rainfall and water potential scenario of India pertaining to interlinking of rivers which is on the top agenda of the country.

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1. INTRODUCTION

The concept of the Inter basin water transfer is to be explored and implemented to ensure uniform distribution of available natural water resource and to mitigate the consequences of hydrologic extremes of floods and droughts. The implementation of Inter basin water transfer [1] is the need of the hour for the overall development of a country like India in which population is growing at an alarming rate. Also the Inter basin water transfer helps to prevent the formation of deltas along the coast line and migration of people from drought affected regions.

India has 1/6th of the global population and 1/25th of world's water resources, but the water availability is highly uncertain both in time and space due to its peculiar monsoonal climate. About 70 % of the population directly or indirectly depends on agriculture, in the back drop of economic growth from industrialization. The urban population in the country is increasing at faster rate which requires the establishment of basic infrastructure, amenities and increase in food production. It is essential to convert rain fed crops into irrigation crops. At present the average food production is about 1.4 Ton/Ha which needs to be increased to 3.0 ton/Ha. Out of the net sown area of 140 M Ha, the rain fed area is about 80 M Ha and remaining 60 M Ha is under irrigation. Nearly 78% of water harnessed is being used for irrigation and the balance 22% is used for domestic and Industrial requirements.

The basins of Ganga, Brahmaputra, Meghana and west flowing rivers constitute 27% of the drainage area and receive 72% of total rain fall of India. The important river basins of India are shown in Figure and the detail is presented.

The available storage in all reservoirs and tanks is only 55% of available surface water, considering 1.5 times filling. Hence it

is required to utilize remaining 45% of surface water by creating the additional storage. The irrigation commission in 1972 has identified 67 drought prone districts comprising 326 taluks located in 8 states having an area of 49.73 M Ha. Subsequently the national commission on agriculture in 1976 identified few more drought prone areas with slightly different criteria. The state wise drought affected areas are shown in the Table

The Criteria adopted to declare drought occurrence in an area are
1. When the annual rainfall is less than 75% of the normal in 20% of the years examined.
2. When less than 30% of the culturable area is irrigated.

The revised study made by Central Water Commission (CWC) in 2006 reveals that 51.12 M Ha area is drought affected in 74 districts. Thus in comparison to total geographical area of the country about 1/6th is drought prone area, Figure 1.2 shows location of drought prone areas of India.

Table 1: Drought affected States

SNo	State	Area (Ha)	Drought area (Ha)	%
1	Karnataka	19177000	15240095	79
2	Andhra Pradesh	27662000	12562382	45
3	Maharastra	30776000	12418056	49
4	Tamil Nadu	13007000	8327617	64
5	Rajasthan	34222000	21408800	63
6	Gujarat	19598000	12091618	62
7	Orissa	15578000	2290000	15

As per international standards per capita water requirement is 1700 m3 per year. If the availability is less than 1000 m3, it is considered as water scarcity. If it ranges between 1000-1700 m3 it is treated as water stressed. India with present availability of about 1600 m3 is under water stress condition. The North East river systems namely Ganga and Brahmaputra contribute 60% to nation's water resources where as 3 major southern river systems viz Godavari, Krishna and Cauvery contribute 6%, 4% and 1% respectively. The annual rainfall over the country is ranging from 10cm in Rajasthan to 1100 cm at Chirapunji in Assam.

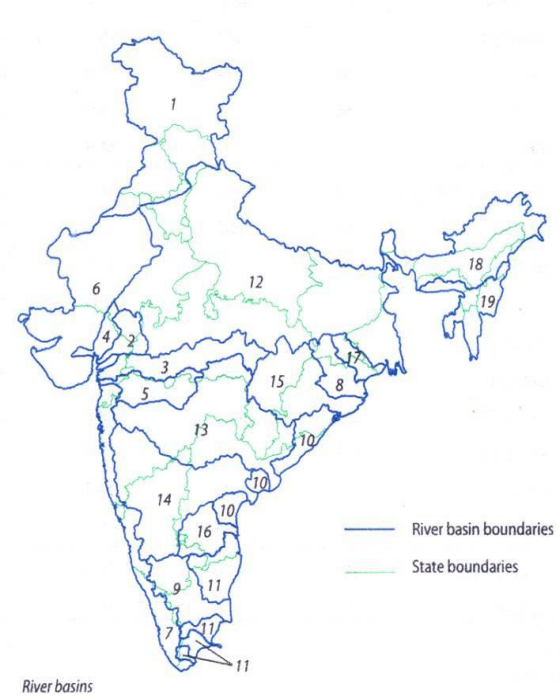

Fig -1: River basin map of India

1. Indus
2. Mahi
3. Narmada
4. Sabarmati
5. Tapi
6. WFR1
7. WFR2
8. Brahmani & Baitarani
9. Cauvery
10. EFR1
11. EFR2
12. Ganga
13. Godavari
14. Krishna
15. Mahanadi
16. Pennar
17. Subernareka
18. Brahmaputra
19. Meghana

Table 2: Water Resources Of Indian River Basins

SNo	Name of Basin	TRWR Km3	PUWR Km3			Water resources available per capita m3	
			Surface Water	Ground Water	Total	TRWR	PUWR
1	Indus	73.3	46	14.3	60.3	1501	1235
2	Mahi	11	3.1	3.5	6.6	1649	990
3	Narmada	45.6	34.5	9.4	43.9	2542	2448
4	Sabarmathi	3.8	1.9	2.9	4.8	631	797
5	Tapi	14.9	14.5	6.7	21.2	831	1183
6	WFR1	15.1	15	9.1	24.1	257	409
7	WFR2	200.9	36.2	15.6	51.8	3871	998
8	Brahmani & Baitarani	28.5	18.3	3.4	21.7	1703	1296
9	Cauvery	21.4	19	8.8	27.8	656	852
10	EFR1	22.5	13.1	12.8	25.9	1169	1346
11	EFR2	16.5	16.7	12.7	29.4	423	753
12	Ganga	525	250	136.5	386.5	1418	1044
13	Godavari	110.5	76.3	33.5	109.8	1441	1431
14	Krishna	78.1	58	19.9	77.9	1133	1130
15	Mahanadi	66.9	50	13.6	63.6	2463	2341
16	Pennar	6.3	6.3	4.04	10.9	440	762
17	Subernarekha	12.4	6.8	1.7	8.5	829	568
18	Brahmaputra	585.6	24.3	25.7	48	17661	1448
19	Meghana	48.4	1.7	8.5	10.2	4830	1018

TRWRTotal Renewable Water Resources
PUWRPotentially Utilizable Water Resources

Table 3: Area Liable To Floods

SNo	State	Geographical area (M Ha)	Area liable to flood (M Ha)	%	Area protected (M Ha)
1	Andhra Pradesh	27.51	1.39	5.05	0.70
2	Assam	7.84	3.15	40.18	1.305
3	Bihar	17.39	4.26	24.50	1.566
4	Gujarat	19.60	1.39	7.09	0.362
5	Haryana	4.42	2.35	53.17	1.095
6	Himachal Pradesh	5.57	0.23	4.13	-----
7	Jammu and Kashmir	22.22	0.08	0.36	0.012
8	Karnataka	19.18	0.02	0.10	0.001
9	Kerala	3.89	0.87	22.37	0.011
10	Madhya Pradesh	44.34	0.26	0.59	-----
11	Maharastra	30.77	0.23	0.75	0.110

12	Manipur	2.23	0.08	3.59	0.073
13	Meghalaya	2.24	0.02	0.89	0.075
14	Orissa	15.57	1.40	8.99	0.351
15	Punjab	5.04	3.70	73.41	2.407
16	Rajasthan	34.22	3.26	9.53	0.016
17	Tamil Nadu	13.01	0.45	3.46	0.029
18	Tripura	1.05	0.33	31.43	0.009
19	Utter Pradesh	29.44	7.34	44.93	0.739
20	West Bengal	8.88	2.65	29.84	1.001
21	Delhi	0.15	0.05	33.33	0.023
22	Pondicherry	0.05	0.01	20.00	----
	Total		33.52		9.776

2. WATER CRISIS SCENARIO IN INDIA

The estimated drought prone area is 51.12 M Ha and flood prone area is 33.52 M Ha. By 2025 the estimated per capita availability of water may go down to 1340 m3/year, thus nearly 60% of Indian population will be living in water stress conditions. India produces about 200 Million Tons of food grains to feed the population of about 110 crores. In next 50 years the population is expected to grow to 160 crores, necessitating food production of 450 Million Tons. The country is to gear up to achieve it with proper perspective and vision. The culturable command area in the country is about 184 M Ha and the net sown area is about 140 M Ha.

3. NECESSITY OF THE STUDY

As long as spatial and temporal uniformity in occurrence of rainfall is present, the water deficit and excess conditions do not arise. If not, the available water must be utilized properly by storage and transfer so as to satisfy the various needs uniformly over the entire country. In India the monsoons are highly orographic causing floods in North and North Eastern region and drought in other areas. The solution for storage and transfer lies in much talked about interlinking of rivers or inter basin water transfer.[11,12] As the Govt. of India is spending huge amount of money every year towards the relief of floods and drought, it is worthwhile to spend on inter basin and intra basin water transfer schemes keeping long term benefits in view. Moreover the inter basin water transfer is the only solution to maintain regional balance in all sectors like Agricultural, Industrial, Power generation, Domestic, Navigation etc.

4. EXISTING INTER BASIN WATER TRANSFER PROJECTS IN INDIA AND OTHER COUNTRIES

The concept of Inter basin water transfer is not new. In fact it was practiced in India and other countries long back and most of the projects of water transfer are still functioning well. Consequently many projects of large scale water transfer have been planned and some of them are implemented.

Examples of Inter basin water transfer in India

- Periyar - Vaigai project (Kerala state 1985)
- Kurnool – - Cuddapah Canal (Andhra Pradesh 1863-1870)
- Parambikulam - Aliyar project (1962-82)
- Telugu – - Ganga project
- Beas – - Sutlej Link (1983)
- Indira Gandhi Nahar project (Rajasthan canal, 1958)
- Sarada - Sahayak Project (1960)
- Ramganga – - Ganga Link (1978)
- Tungabhadra – - Pennar project
- Mahi project
- Tehri Multipurpose project

Other Countries

CANADA: In Canada 16 inter basin water transfer schemes have been implemented for hydropower development.
USA: In United States, the California state water project, first phase of which was completed in 1973, provides for the diversion of 4 Km3 of flow from surplus Northern California to the deficit central and southern parts of the state.
CHINA: In China there are schemes existing from ancient times which are recently supplemented by modern construction techniques. Now China is also planning for transfer of 48 BCM of water from South to North through a Grand Canal close to Eastern coast. Recently completed projects in China include Biliuha-Dalian inter basin water supply system.
U.S.S.R: Among the Inter basin water transfer projects planned and implemented in USSR, the notable scheme executed in the central Kazakistana is Irtysh Karganda scheme

5. NEW PROPOSALS FOR INTER BASIN WATER TRANSFER IN INDIA

The concept of Interlinking of rivers was initially proposed by Sir Arthur Cotton in the year 1850 for Inland navigation purpose. Later in 1972 the then Central Irrigation Minister Dr

K.L.Rao proposed Ganga-Cauvery link. In 1977 Captain Dastur proposed Garland of canal around the Himalayan, Central and Peninsular India. Later, Ministry of Water Resources and Central Water Commission formulated a National Perspective Plan (NPP) in 1980 to study water resources development in the country and transfer of water from surplus basin to deficit one [3] to minimize regional imbalance. NWDA (National Water Development Agency) was formed under NPP to further investigate and explore the possibilities of interlinking of rivers [6]. The broad objectives of NWDA [2] are

1. To promote systematic and scientific study of interlinking of rivers.
2. To carryout detailed study, survey, investigations of Peninsular and Himalayan rivers.
3. To identify possible water transfer projects/links to carry water from surplus basin to deficit one after meeting the existing and proposed needs.
4. To prepare feasibility reports of various components of Himalayan and Peninsular rivers.

After thorough investigations NWDA proposed to transfer 173 BCM of water through 12,500 Km length of canal. As per NWDA, Inter basin water transfer is proposed in two components namely (1) Himalayan component and (2) Peninsular component. The proposed national water grid is given in Figure below. In this figure numbers 1-30 refer to the links considered under Himalayan (1-14) and Peninsular (15-30) components as listed below.

5.1 Himalayan Component

This component mainly proposes to link Brahmaputra and its tributaries with the river Ganga and Ganga with Mahanadi. In addition it also proposes to transfer surplus flows of the Eastern tributaries of Ganga to the West. This component envisages construction of canal systems and storage reservoirs on the principal tributaries of Ganga and Brahmaputra rivers in India, Nepal and Bhutan. This component would provide additional irrigation to about 22 MHa and power generation of about 30000 MW besides flood control in Brahmaputra and Ganga basins. The 14 links of Himalayan component are

Table 4: Himalayan Component

1 Brahmaputra-Ganga	6 Yamuna-Rajastana
2 kosi-Ghagra	7 Rajastana-Sabaramati
3 Gandak-Ganga	8 Chemar- Sone barrage link
4 Ghagra- Yamuna	9 Sone dam-southern Ganga
5 Sarada-Yamuna	10 Ganga –Damodar – Subernarekha
11Subernarekha-Mahanadi	13 Farakka-Sunderban
12 Kosi-Mechi	14 Brahmaputra-Ganga(Jogighopa-Tista-Farakka)

15.Mahanadi (Manibhadra) - Godavari (Dowleswaram) Link	23.Cauvery (Kattalai) - Vaigai - Gundar Link
16.Godavari (Inchampalli) - Krishna (Nagarjunasagar) Link	24.Ken - Betwa Link
17.Godavari (Inchampalli Low Dam) - Krishna (Nagarjunasagar Tail pond) Link	25.Parbathi - kalisindh Link
18.Godavari (Polavaram) - Krishna (Vijayawada Link)	26.Par - Tapi - Narmada
19.Krishna (Almatti) - Pennar (Bukkapatnam) Link	27.Damanganga - Pinjal Link
20.Krishna (Srisailam) - Pennar (Mylavaram)Link	28.Bedti - Varda Link
21.Krishna (Nagarjunasagar) - Pennar (Somasila)Link	29.Netravathi - Hemavathi Link
22.Pennar (Somasila) - Cauvery (Grand Anicut) Link	30.Pamba-Achankovil - Vaippar Link

5.2 Peninsular Component

In this component a network of interconnected river basins of Peninsular India is considered. NWDA carried out water balance studies of all the major river basins such as Mahanadi , Godavari , Krishna ,Pennar , Cauvery , Vaigai, West flowing rivers of Kerala , Karnataka , North of Bombay and South of Tapi and Southern tributaries of Yamuna to find out water surplus and deficit basins. The 16 links of Peninsular component are given below.

From Peninsular Component it is possible to irrigate about 13 M Ha and about 4000 MW of Hydropower can be generated. The Peninsular component utilizes 69.6 TMCum of water. This component involves the construction of storage reservoirs at potential sites in addition to the existing /ongoing reservoirs and a network of canals for water transfer. The following Table gives the details of proposed Interlinking of rivers

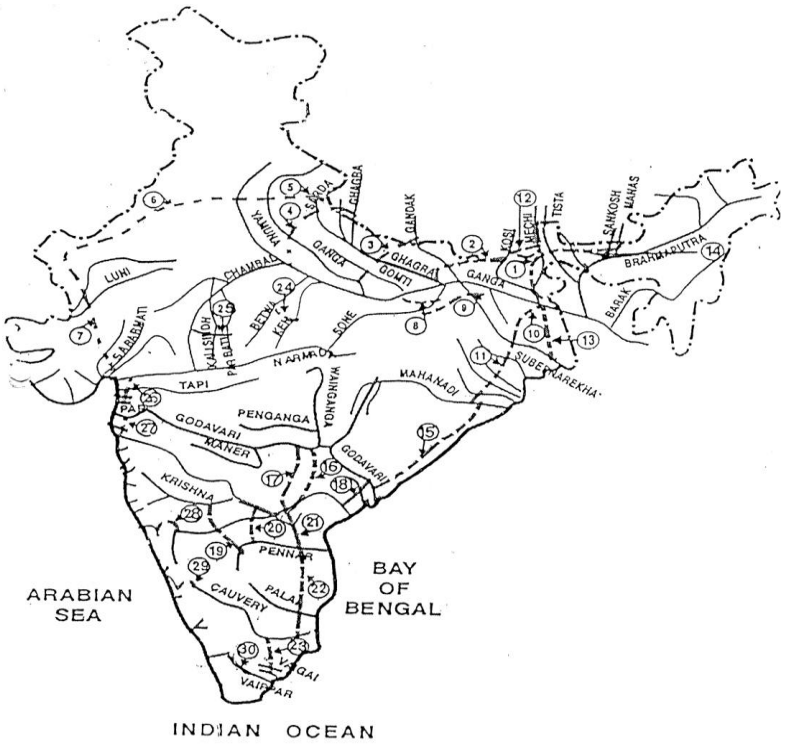

Fig.2: Proposed National Water Grid(NWDA)

Table 5: Details of Interlinking of Rivers

Sl. No	Particulars	Himalayan Component	Peninsular Component	Total
1	Link Canal	14	16	30
2	Major Reservoirs	9	27	36
3	Total Length of Link Canals (Km)	6100	4780	10880
4	Transferable Water (Km3)	33	141	174
5	Power Generation (MW)	30000	4000	34000
6	Project Cost of Irrigation unit (Crores)	185000	106000	291000
7	Project cost of Hydropower Unit (Crores)	--------	--------	269000
8	Additional Irrigation Area (MHa)	13	22	35

Table 6: salient features of inter basin water transfers in india

1.	Additional Irrigation	:	35 M Ha
2.	Hydropower generation	:	34000 to 40000 MW
3.	The Cost of the project	:	Rs 5,60,000 crores (as per 2002 estimate)
4.	Water utilization	:	20.96 MHa m
5.	Execution period	:	40 years
6.	Agricultural production	:	250 to 450 Million Tons

7.	Total length of canals	:	10880 Km
8.	Cost per Ha	:	Rs 75000
9.	Water availability	:	1122 m3 / capita / year
10.	Flood control		
	Area can be protected	:	About 40 M Ha
	Population protected	:	About 260 Million
	Financial savings	:	About 1200 crores per year
11.	Drought protection		
	Population benefited	:	About 86 Million
	States benefited	:	14
	Districts benefited	:	116
	Financial benefit	:	About 1200 crores per year
12.	Rivers involved	:	37
13.	Reservoirs involved	:	60

6. MERITS AND DEMERITS OF INTER BASIN WATER TRANSFER MERITS

6.1 Merits

1. Possible to utilize the water resources uniformly and economically to yield Significant output.
2. Enhancement in Irrigation potential and power generation
3. Provides ample surface water to meet the growing needs of Domestic and Industries.
4. Scopes for Inland Navigation which reduces stress on existing communication system.
5. It minimizes the intensity of drought and floods.
6. It helps to increase per capita income.
7. Reduces the exploitation of ground water as surface water is made available in abundant.
8. Huge employment generation
9. Development of fisheries
10. Salinity control
11. Recreation facility
12. Infrastructural development
13. Socio economic development
14. Considerable improvement in ground water potential
15. Control in migration
16. Conversion of barren land into culturable land
17. Reduction in formation of further deltas in coastal zones.
18. Minimization of the relief expenditure towards floods and droughts.

6.2 Demerits

1. Large area liable for submersion due to construction of reservoirs and canals
2. Adverse effects over ecological system
3. Difficult to solve Interstate or International water disputes
4. Legal problem in sharing the water
5. Cost of the project and recurring expenditure for maintenance are high
6. Water pollution in conveyance
7. Loss of water in conveyance through the canals
8. Land acquisition and rehabilitation problems
9. Requires afforestation to compensate for loss in green
10. It is a long term project which may cause large variation in estimation
11. Serving for high altitude areas needs pumping of water which requires huge power and maintenance.
12. Needs huge debate at micro level and macro level on the issue to convince the public.
13. Problems of soil erosion and sedimentation
14. In undulated zones it may required to construct large number of cross drainage works.

7. ESSENTIAL STUDIES AND ANALYSES

To prepare a project report of water transfer scheme between two basins, the following studies and analyses are essential.

1. Water balance studies
2. Toposheet studies
3. Ecology and environmental impact assessment
4. Existing utilization and surplus of surface and sub surface water
5. Existing Irrigation, Industrial, domestic, power generation and other usages
6. Making International treaty and bilateral agreement between related states regarding water sharing.
7. Survey and Investigations
8. Water resources and hydrology
9. Preparations of plans, designs and estimates
10. Benefit cost ratio and financial returns.
11. Optimization studies for managing water resources

8. CONCLUSIONS

The hydrological extremes of floods and droughts will have adverse effects on social and economical development of a country or region. The unique and long term solution for dual problem is inter basin water transfer. The study proves to be an authentic reference and resource for the planners, field engineers, administrators, researchers and the general public dealing with water resource exploitation, utilization and transfer. The following conclusions are drawn out of this work.

The next 50 years in India would witness a very large growth of urban centers. Many large urban centers would grow into metropolitan centers and meeting their water requirements would pose new challenges. The food production has to grow proportionally necessitating more allocation of water for irrigation. The inter basin water transfer proves to be the best option for the policy planners, administrators, professionals, media, NGO's and public to meet the challenges of the future. The entire surface water resource of the country is to be treated as national property so as to make its development and utilization uniform for the overall development of the country. Remote sensing and GIS tools can be utilized to carry out the hydrological, drainage, seepage and socio-economic analysis and the environmental impact assessment of the proposed water transfer projects. The basins of the water transfer scheme can be studied by developing digital elevation models (DEM) which help to generate the stream networks map, slope and aspect ratios of the basins.

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