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BRAHMAPUTRA-TISTA-GANGA LINK FOR HYDRO-POWER DEVELOPMENT TO MEET ENERGY REQUIREMENT FOR DESALINATION OF SEA WATER

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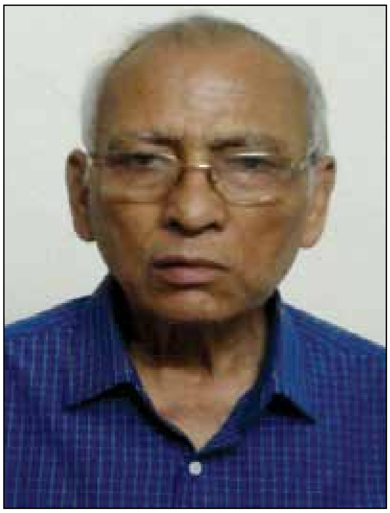

Introduction

India is surrounded by Bay of Bengal on the east, Arabian Sea on the west and Indian Ocean on the south. It is protected by the Himalayas on the north separating India and Tibet/China. Out of a total 1869 billion cubic meter (BCM) of water resources potential of India, water resources potential of Brahmaputra-Ganga basin is 1162 BCM i.e. 62% of the country (IWRS, 2007). Hydro-power potential of Brahmaputra-Ganga basin is 1,12,366 MW i.e. 76% of India's total hydro-power potential of 1,48,701 MW as per Table-1 (CBIP, 2022)). It may be noticed from table-1 that untapped hydro-power in Brahmaputra and Ganga basin are 54,329 MW and 26,859 MW respectively which corresponds to 93.1% and 51.4% of the potential available in the respective zones.

There are no major technical obstacles to desalination as a means of providing an unlimited supply of fresh water from sea, but the high energy requirements of this process pose a major challenge. Theoretically, about 0.86 kWh of energy is needed to desalinate 1 m^3 of salt water at 34,500 ppm (AMTA-2017). This is equivalent to 3 kJ per kg of brine. The present day desalination plants use 5 to 26 times as much as this theoretical minimum depending on the type of process used in desalination. Clearly, it is necessary to make desalination processes as energy-efficient as possible through improvements in technology and economies of scale.

Desalination as currently practiced is driven almost entirely by the combustion of fossil fuels. These fuels are not only in finite supply, they also pollute the air and responsible for global climate change. The whole character of human society in the 20th century in terms of its history, economics and politics has been shaped by energy obtained mostly from oil. Almost all oil produced to date is what is called conventional oil, which can be made to flow freely from wells (excluding oil from tar sands and shale). Of this vast resource, about 1600 billion barrels have so far been discovered and just over 800 billion barrels had been used by the end of 1997. It is estimated that there may be a further 400 billion barrels of conventional oil yet to be found. With current annual global consumption of oil being approximately 25 billion barrels, and rising at 2 per cent per annum, the "business as usual" scenario would suggest that the remaining oil will be exhausted by 2050.

The present paper deals with development of hydro-power potential through linking of Brahmaputra with Ganga via Tista for hydro-power development in order to meet the energy requirement for desalination.

Advantages of Hydro-Power

Power can be generated by different means e.g. thermal power by burning coal and fossil fuels and nuclear power from uranium. But they have several drawbacks and non-sustainable. They cause atmospheric pollution and rise in temperature which is responsible for climatic changes. As per IPCC forecast, a rise in temperature by 1.5^0 C by 2030 will result in severe floods and draughts with rise in sea level causing devastation in many parts of the world. Hydro-power like solar, wind and tidal power are renewable, sustainable and do not cause atmospheric pollution. The greatest advantage of hydro-power is its flexibility in operation. There are countries like Norway and Sweden where entire energy supply comes from hydro-power. As on 31.12.2019, installed capacities of the different power sources in India are as follows (CBIP, 2020):

Sources	Installed Capacity	Percentage
Thermal	2,30,701 MW	62.55%
Hydro-Power	45,399 MW	12.32%
Nuclear Power	6,780 MW	1.84%
Solar & wind	85,908 MW	23.29%
Total Installed Cap.	**3,68,789 MW**	

Hydro-Power Potential of India

Hydro-Power power potential available in different parts of the country is given in table-1 (CBIP, 2022). It may be noticed that the highest hydro-power potential of India lies in the Ganga (53,395 MW) basin in the northern region and Brahmaputra (58,971 MW) in the North - Eastern region (NER) in India. It may also be seen that capacity yet to be developed are 51.39% and 93.10% in Ganga and Brahmaputra basins respectively.

Table-1 Hydro-Power Potential of India (Above 25 MW only) as on 30.9.2020

Region/State	Identified Capacity as per reassessment study		Capacity In Operation		Capacity Under Construction		Capacity In Operation + Under Construction		Capacity yet to be taken up under construction	
	Total (MW)	Above 25 MW (MW)	(MW)	%	(MW)	(%)	(MW)	(%)	(MW)	%
NORTHERN										
Jammu & Kashmir	11769	11497	3360	29.23	2559.5	22.26	5919.5	51.49	5577.5	48.51
Ladakh	2377	2046	89.0	4.35	0.0	0.0	89.0	4.35	1957.0	95.65
Himachal Pradesh	18820	18540	9809.00	52.91	2125.00	11.46	11934.00	64.37	6606.00	35.63
Punjab	971	971	1096.30	112.90	206.00	21.22	1302.30	134.12	0.00	0.00
Haryana#	64.00	64.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rajasthan##	496.00	483.00	411.00	85.09	0.00	0.00	411.00	85.09	0.00	0.00
Uttarakhand	18175	17998	3756.40	20.87	1490.0	8.28	5246.4	29.15	12751.6	70.85
Uttar Pradesh*	723	664	501.60	75.54	0.00	0.00	501.60	75.54	162.40	24.46
Sub Total(NR)	53395	52263	19023.30	36.40	6380.50	12.21	25403.8	48.61	26859.20	51.39
WESTERN										
Madhya Pradesh	2243	1970	2235.0	100	400.0	20.30	2635.0	100.00	0.0	0.00
Chhattisgarh	2242	2202	120.0	5.45	0.0	0.00	120.0	5.45	2082.0	94.55
Gujarat###	619	590	550.0	100	0.0	0.00	550.0	100.00	0.0	0.00
Maharashtra	3769	3314	2647.0	79.87	0.0	0.00	2647.0	79.87	667.0	20.13
Goa	55	55	0.0	0.00	0.0	0.00	0.0	0.00	55.0	100.00
Sub total(WR)	8928	8131	5552.0	68.28	400.0	4.92	5952.0	73.20	2179.0	26.80
SOUTHERN										
Andhra Pradesh	2366	2341	1610.0	68.77	960.0	41.01	2570.0	109.78	0.0	0.00
Telangana	2058	2019	800.0	39.62	0.0	0.00	800.0	39.62	1219.0	60.38
Karnataka	6602	6459	3644.2	56.42	0.0	0.00	3644.2	56.42	2814.8	43.58
Kerala	3514	3378	1856.5	54.96	100.0	2.96	1956.5	57.92	1421.5	42.08
Tamilnadu	1918	1693	1778.2	100	0.0	0.00	1778.2	100.00	0.0	0.00
Sub Total(SR)	16458	15890	9688.9	60.97	1060.0	6.67	10748.9	67.65	5141.1	32.35
EASTERN										
Jharkhand	753	582	170.0	29.21	0.0	0.00	170.0	29.21	412.0	70.79
Bihar####	70	40	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Odisha	2999	2981	2142.3	71.86	0.0	0.00	2142.3	71.86	838.8	28.14
West Bengal	2841	2829	441.2	15.60	120.0	4.24	561.2	19.84	2267.8	80.16
Sikkim	4286	4248	2169.0	51.06	1133.0	26.67	3302.0	77.73	946.0	22.27
Sub Total(ER)	10949	10680	4922.5	46.09	1253.0	11.73	6175.5	57.82	4504.6	42.18
NORTH EASTERN										
Meghalaya	2394	2298	322.0	14.01	0.0	0.00	322.0	14.01	1976.0	85.99
Tripura	15	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Manipur	1784	1761	105.0	5.96	0.0	0.00	105.0	5.96	1656.0	94.04
Assam	680	650	350.0	53.85	0.0	0.00	350.0	53.85	300.0	46.15
Nagaland	1574	1452	75.0	5.17	0.0	0.00	75.0	5.17	1377.0	94.83
Arunachal Pradesh	50328	50064	815.0	1.63	2300.0	4.59	3115.0	6.22	46949.0	93.78
Mizoram	2196	2131	60.0	2.82	0.0	0.00	60.0	2.82	2071.0	97.18
Sub Total(NER)	58971	58356	1727.0	2.96	2300.0	3.94	4027.0	6.90	54329.0	93.10
ALL INDIA	148701	145320	40913.7	28.15	11393.5	7.84	52307.2	35.99	93012.9	64.01

Brahamaputra-Tista-Ganga Link

Indira Gandhi set up the National Water Development Agency (NWDA) in 1982 to study the possibility of water transfer from surplus basins in the Ganga-Brahmaputra basins to deficit basins in the south and west of India. NWDA, under the Ministry of Water Resources, River Development and Ganga Rejuvenation (now Ministry of Jalshakti), Govt. of India, proposed the National Perspective Plan (NPP) consisting of 14 river links under the Himalayan component and 16 river links under the peninsular component (IWRS, 1996; Mazumder, 2011; Parashar, R.K., 1999). National Commission of Integrated Water Resources Development was of the opinion that long distance river links may be taken up later (due to exorbitant costs) and suggested that execution of short links like, Ganga-Brahmaputra Link-1 be taken up initially on priority basis. (NCIWRD, 1999).

India advocated inter-basin water transfer from the Brahmaputra basin to the Ganga basin through a link canal to augment the dry season flow in the Ganga basin downstream of Farakka barrage in order to address the grievances of Bangladesh. India's 1978 proposal consisted of a barrage 2,460 m long across the Brahmaputra river at Jogigopa (Fig. 1) in Assam with a link canal 324 km long, 274 metre wide and 9 metre deep passing mostly through Bangladesh up to a point upstream of Farakka barrage in West Bengal as shown in Fig.1in dotted green Line. This proposal was the shortest link between Brahmaputra and Ganga. It had no lift component and the flow was entirely through gravity. However, the proposal was rejected by the Bangladesh Government due to political reasons. (Crow et al, 1995).

In its revised proposal, Govt. of India decided to connect Jogigopa barrage with Tista and Ganga by-passing Manas and Sankosh rivers as shown in Fig. 1 in full green line NWDA, 2005). The proposal envisages the construction of three storage reservoirs (Subansiri, Dihang and Tipaimukh dams) in the eastern foothills of the Himalayas to supplement the dry season flow of the Brahmaputra at Jogigopa. The idea is to divert water from these storages to the Ganges basin in the months of February to April when water is abundant in Brahmaputra and scarce in the Ganges basin due to late arrival of Monsoon in Ganga basin as compared to Brahmaputra basin. The Dihang and Subansiri reservoirs are estimated to lower the flood peak in Bangladesh by 1.3 m while the Tipaimukh dam will reduce the flood in the Meghna basin in Bangladesh, especially in Dhaka (Rahman, 2009).The new link is exclusively within Indian territory and passes through a 32 km narrow belt (Known as Chicken Neck) separating India from Nepal and Bangladesh as shown in Fig. 1 in green full line.

Fig.1 Brahmaputra-Tista-Ganga Link-1 (Under NPP by NWDA)

Benefits of India and Bangladesh from Brahmaputra-Tista-Ganga Link

Primary objective of the proposed Brahmaputra-Tista-Ganga link-1 is to transfer excess water of Brahmaputra basin to Ganga basin for augmenting dry weather flow of Tista and Ganga rivers for hydro power, irrigation, water supply, navigation and flood moderation(Verghese,1999). Tista barrage project has an irrigation potential of 9.22 lakh ha-m in six northern districts of West Bengal, namely, Cooch bihar, Darjeeling, Jalpaiguri, Uttar Dinajpur, Dakshin Dinajpur and Malda. Apart from the proposed storages in Subansiri, Dihang and Tipaimukh, water stored in three storage dams on Teesta river in Sikkim will be diverted from barrages on Teesta, Mahananda and Douk rivers. The dams and the barrages on Tista are already completed and the construction of distribution canals are in progress. First part of the proposed Brahmaputra-Tista link will be of immense benefit for both India and Bangladesh ensuring firm water supply during lean season. Tista project started in 1975 is yet to be completed partly due to land acquisition problem and partly due to inadequate lean season flow from Tista to meet water demand of a huge command of 9.22 lakh ha in West Bengal on a firm basis.

Second part of the link canal connecting Tista with Ganga upstream of Farakka barrage on Ganga river will bring excess water of Brahmaputra basin to Ganga basin to augment dry weather flow at Farakka for transmission to Bhagirathi-Hoogly river system for survival of Kolkata port, navigation (National Waterway-1 and 2), industrial use and water supply to Kolkata Metropolitan city and other innumerable towns on either side of Bhagirathi-Hoogly river. Link no.1 is proposed to be connected with other links downstream of Farakka for transfer of water from surplus basins of Brahmaputra and Ganga and other eastern rivers to the water deficit basins through links 21 and 22 as proposed under NPP to address the severe water crisis in Cauvery and Pennar Basins in the south.

Besides sharing of Ganga water in the lean season, Bangladesh wants agreement for sharing of Brahmaputra and Tista river water too. Construction of dams on Subansiri, Dihang, Lohit rivers and a dam at Tipaimukh will be highly useful for water storage for firm water supply for hydro-power, irrigation and navigation. It will help tapping the huge hydro-power potential remaining unutilized so far in NER. It will resolve the dispute between India and Bangladesh about water sharing of Ganga, Tista and Brahmaputra rivers and possible sharing of hydro-power also to Bangladesh. At the 36th JRC meeting, India assured Bangladesh that it would implement the Brahmaputra-Ganga link and storage dams on Subansiri, Dihang and other tributaries of Brahmaputra river after consultation with Bangladesh (Daily Star, 2005).India, however, rejected the Bangladesh proposal to have a trilateral agreement between India, Bangladesh and China (Uppermost Riparian Country of river Brahmaputra) who has constructed large numbers of high dams on river Brahmaputra called Yarlung Zangbo and its tributaries in Tibet (Fig.1) without any agreement with either India or Bangladesh.

Share of hydro-power in the hydro-thermal mix is only19% today against an ideal share of 40%. It is only 12% of India's total installed capacity consisting of thermal, hydro, nuclear and other renewable powers (like solar, tidal and wind power).The NER states in the Himalayas is attractive for hydro-power generation because the rivers in this region descend an elevation around 3,500 m to 500 m in a short distance of 200-km stretch. The water wealth and terrain head in NER are nature's gift and a bounty for the relatively underdeveloped states in the NER. Some of the tributaries of Brahmaputra river are indicated in Fig. 2 showing average annual run-off of Brahmaputra and its tributaries (Mahanta, 2016). Needless to mention that apart from the main Brahmaputra and its tributaries, there are innumerable sub-tributaries in the Brahmaputra catchments (lying in Arunachal Pradesh and Assam states of India) where available water and terrain heads can be utilized for hydro-power development either by storage type or run-off the river type schemes for feeding the National Power Grid.

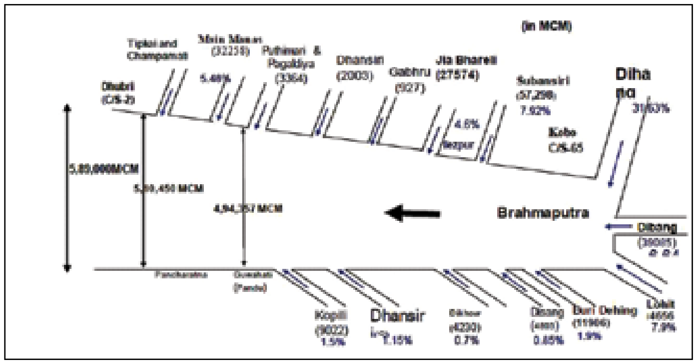

Fig. 2 Average Annual Runoff of the Brahmaputra and its Tributaries (NDMA, 2012)

Conclusions

Desalination of sea water either by reverse osmosis or other means require huge energy. Conventional methods of energy generation by thermal, oil and nuclear plants are not sustainable and cause atmospheric pollution, climate change and global rise of temperature resulting in disasters like floods, draughts and submergence of coastal areas due to rise in sea level. Hydro-power is a renewable source of energy like solar, wind and tidal powers. India has an enormous source of hydro-power potential in the northern and north-eastern regions. The potential yet to bed developed are 53,395 MW and 58,971 MW in the Ganga and Brahmaputra basins respectively. Govt. of India has an ambitious plan of water transfer from the surplus basins of Ganga and Brahmaputra to water deficit basins in the south and north-west for development of irrigation, hydro-power, navigation and municipal supply. Brahmaputra-Tista-Ganga rivers (Link-1 under NPP) should be executed on priority basis to satisfy the water and power need of both West Bengal and Bangladesh. The Proposed link with storage reservoirs as well as numerous other storage and run-off the river type hydro-power schemes will help in augmenting dry weather flow and tapping of huge hydro-power potential of the region in particular and the country in general.

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Born in 1938, **Prof. S.K. Mazumder** graduated in Civil Engineering in 1959 from B.E. College, Shibpur, Calcutta University (now IIEST, Shibpur). He was Assistant Engineer, (Irrigation & Waterways Dte), Govt. of West Bengal, during 1959-62. He obtained his M.Tech. and Ph.d. in Civil Engg (Dam &Hydro-power Engg) from IIT, Kharagpur where he was a lecturer during 1962-67. He was Assistant professor in Civil Engineering at R.E.C. (now NIT), Durgapur, during 1967-75 and Professor of Civil Engineering (Hydraulics & Flood Control) at Delhi College of Engineering (now Delhi Technology University), during 1975-98. He was AICTE Emeritus Fellow during 1998-2000. During Feb-Nov, 1991, he was a visiting professor at EPFL, Switzerland. He was Head of Civil Engg. and Dean of Faculty of Technology, University of Delhi. He is Fellows of CBIP, IE (I), ISH &IWRS and members of IAHR, IRC, ISCA, IPHE, CDC, CEAI. He was principal Investigator of several research schemes sponsored by a number of Govt. and Pvt. Organizations.

Prof. Mazumder has published/presented more than 210 technical papers in National and International journals and conferences, written two books, editor in chief of the proc. of a national conference, contributed a chapter in two books by Kluwer and Springer publications. He got several awards for his papers from the Institution of Engineers (India) and Indian Roads Congress. He received life time achievement award in 2009 and best Reviewer Award in 2019 - 20 from Indian Society for Hydraulics for his immense contribution in hydraulics and water resources engineering.

After retirement, Prof. Mazumder served several consulting companies in Delhi e.g. ICT Pvt. Ltd., Aquagreen Engg. Pvt. Ltd, Scott- Wilson-India Pvt. Ltd., Mahendra Raj Consultants, B&S Consultants, NOIDA, Rambol India, Infinite Civil Solutions, Ahmedabad and currently retained by Maccaferri India, Gurgaon in the area of his specialization i.e. Hydraulics and Water Resources Engineering. He is currently, a faculty member of Indian Academy of Highway Engineers (IAHE), NOIDA. He is Member/convener of several committees of IRC and BIS, Govt. of India. For three years, he was an expert member of EAC (Hydro & Irrigation group), Min. of Env. & Forests, Govt. of India. He was a member of NIH Society, Roorkee, as a nominee of the Minister of Water Resources, Govt. of India. He is a reviewer of several journals published by several societies e.g. Institution of Engineers (India), Indian Society for Hydraulics, ASCE, IRC etc.

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