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Interlinking of River Basins: A Mega Harvesting Plan-A Review

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ABSTRACT

Water availability is becoming dearer and dearer day by day in India due to monsoon vagaries and increasing population propulsion. Linking of basins through canals is not a new concept, but has been in practice since times immemorial. Inter-basin water transfer was primarily envisaged by Rao and Dastur in 1970s. The President of India, Abdul Kalam gave a shot in the arm early in 2003 to the issue of linking of rivers. Ultimately the National Water Development Authority (NWDA) made thorough study, which indicated that Himalayan Rivers, have exceedingly surplus quantum of water and hence, proposed transfer of water from these surplus basins to deficit basins in peninsular region. We opine that the areas of dry land to be converted into a wetland, and the areas of unproductive land to be converted into agriculture land are far more than the land to be lost due to canals and reservoirs. Moreover, increase in the number of crops per year or the cropping intensity also increases along the link canals and the rivers to be linked. It is an environmentally sound and sustainable, technically feasible and socially acceptable measure, also to control inundation and floods through dense afforestation of the river banks. It reduces siltation too. Thus, the economic and ecological benefits far outweigh the feared losses.

INTRODUCTION

Water is one of the two most important natural resources, the other being the air available freely everywhere and at each split of second. In a nutshell, the universal importance of water can be put as the biological, geo-chemical, meteorological component of the environment, indispensable for the origin, existence and perpetuation of the Mother Earth and the biota inhabiting it. Hence, there is an immense demand for this unique renewable single chemical compound. It is a boon that water constitutes more than three fourths of the area of the earth and hence, it is designated, appropriately, as 'watery planet' or 'blue planet'. Of the total water resources of the earth, the un-utilizable component accounts for more than 99%, this includes 97.2% of oceanic waters, 2.15% of glaciers and icecaps and 0.3% of un-utilizable groundwater. In fact, comparatively, a trivial quantity of less than 0.4%, including 0.3% of usable groundwater and even less percentage surface waters, is available for direct consumption. Thus, the utilizable surface waters constitute a very meager percentage in the total global water resources. Hence, proper planning is essential for judicious utilization of this precious commodity for striking an appropriate balance between demand and availability, and availability and utilization at the global, regional and local levels for the sustainability of their ecosystems. The universal fact that land can never be physically transferred, which annotates the present context as, from water surplus region to water deficient region; whereas water can and has to be transferred to form its surplus region to deficit region subjected to its demand in the latter. This is the very concept of linking of rivers. Water status of the region whether it is water –surplus, water- sufficient, water – deficit, constitutes water budget of the region. This is the result in its turn of many dynamic factors, environmental, economic, social and political (?). All these issues are discussed in the present review.

The concept of inter-basin transfer of water

The concept of linking of rivers or inter-basin transfer of water is essentially based on the availability of surplus of water in the donor river especially at the point of diversion to the deficit river basin. The surplus or deficit in a basin is determined on the basis of availability at 75% dependability, import, export, and existing and future needs. A river basin is said to be reasonably in surplus of water, if the surplus water is available after meeting the irrigation needs of at least 60% of the cultivable area in the basin. Only this water from such a basin can be diverted to deficit basins. In the recipient/deficit river basin, it is proposed that, at least, 30% of the cultivable area is covered under irrigation. This is one of the most effective managements of surface water resources, as according to protagonists, it is an economically viable, technically feasible and environmentally sound and viewed as the future main stay for the sustainable development of any region confronting water deficit. On this basis, The National Water Development Authority (NWDA) after a thorough study indicated that Himalayan rivers, especially, Brahmaputra and Ganga have exceedingly surplus quantum of water and hence, proposed transfer of water from these surplus basins to deficit basins in peninsular region (Vidyasagar Rao 2003; Reddy 2003). After assessing the technical and environmental aspects of the project, the people's perceptions and politician's willingness have to be assessed, more so the later, if the surplus river basin and deficit river basin are under two opposition parties.

Historical aspects

Linking of canals is not a new concept, but has been in practice since times immemorial. Human beings started diversion of water from local resources ever since, they started agriculture, by construction of earthen "anicuts" across local streams. The "grand anicut" of the 2nd century over the river Cauvery, recorded to be functioning till mid 19th century providing irrigation to 25,000 hectares resisting the impact of floods for 1600 long years, was the earliest known major diversion undertaken in India. Since historical times irrigation canals were developed by Cholas, Pandyas, rulers of Vizianagarm and Kakatiyas for diverting the waters from Cauvery, Tungbadhra and Vaigai. The western Yamuna Canal and Agra Canal were built during the Mughal reign. The British rulers in India proposed to link Calcutta, when it was the capital, with Karachi and Madras through a link canal combining all the rivers in the peninsula. Later they did not pursue the matter further, probably because the capital was shifted, the expenditure was huge, and their interests were probably more vested than rested on the welfare of India. Sir Arthur Cotton, the pioneer of modern irrigation, constructed anicuts over the rivers Krishna and Godavari for diversion of the waters. The present Telugu Ganga project supplying Krishna river waters to Chennai city, Yeleru reservoir water in East Godavari district to Visakhapatnam Steel Plant, Periyar – Vaigai Buckingham Canal in Tamil Nadu, Nagarjuna Sagar Right Bank Canal and Rajasthan Canal are being successfully implemented. Experts are projecting life-endangering statistics of impending severe water shortage. This crisis must not be allowed to occur. A satisfactory performance of these projects augurs well for undertaking more such inter-basin water transfers at national level.

Status of water resources in India

Our annual water demands for all purposes in 2050 are estimated at 970 –1450 km^3 as against the utilizable quantity of 1122 km^3 from all sources; thus a precarious balance is forecast between demand and the availability of water, if all the utilizable water is used properly, which may not be possible at our present level of awareness conscience and commitment for development of our society/nation. This, we have to confess, is a distressing fact and sad and regrettable commentary on motivation and purposefulness of our people both urban and rural. It is estimated that the utilizable quantum of water can be increased by 250 k m^3 through inter-basin transfer of water. Our National water policy also calls for inter-basin transfer of water from surplus basins to deficit basins depending upon the water status of the basins. It is essential that this giant hydrological issue should be carefully assessed from all the facts before launching.

India, with rural and agro-based socio-economic structure with more than two thirds of her population of 105 million depending upon agriculture, more than 86% (266 M ha) area being rural out of the total geographical area of 329 M ha, and with the densely populated urban areas reeling under severe shortage of drinking water; cannot afford to neglect development of water resources. Even though our country is said to have adequate water resources, their distribution in time and space does not coincide with water requirements for irrigation and domestic and industrial purposes. Of the 4,000 km^3 of water that occurs as precipitation, snowmelt etc. 1890 km^3 is estimated as available resource. According to Reddy (2003), in-basin utilizable resource, after accounting for flood flows and topographical constraints, is estimated as 690 km^3 of surface flows and 450 km^3 of dynamic groundwater. The balance of 750 km^3 of water should not be allowed to drain into the sea in view of the severe water scarcity in the large regions in the country.

Rao (1973) opined that except the Himalayan river zone of Brahmaputra, Indus and Ganga and the southwestern zone, no other zone in India is self-sufficient in water resources, and hence suggested interlinking of rivers as the main strategy to strike the balance in water distribution in the country. But the hydrological project has since been shelved without any due consideration. So much water had flown through Ganga, since then, till the Constitutional Head, the President of India, Abdul Kalam gave a shot in the arm early in 2003 to the issue of linking of rivers by suggesting to the experts in the related disciplines to look into the feasibility of the huge hydrological issue for equitable distribution of water resources in time and space to meet the perennial problem of water scarcity regions. Reddy (2003) remarked that the year 2003, marked by the UNESCO as International Year of Fresh Water, could well be the year of river linking for India. The comment seems appropriate, as the year witnessed the rejuvenation of the project as many arguments have been put forward for and against the inter-basin transfer of water.

Rivers and their tributaries are the main channels of drainage surface water supply and ground water sources at least up to 20 km width along the banks. India has 13 major and 45 medium river basins. The latter have a basin area of 2,000 -20,000 sq km occupying 8% of the total basin area. The rivers are supposed to be serving 80% of population and contributing to 85% of river discharge. The basin

Table 1. Basin wise water in India (Km^3/yr)

No	Basin	ASW	AMR	EUSW	RGW	SGW
1	Indus	73.3	58.6	46.0	26.5	1338.2
2a	Ganga	525.0	401.3	250.0	171.6	7834.2
2(b+c)	Brahmaputra + Meghna	585.7	477.5	24.0	35.1	1018.5
3	Godavari	111.4	107.1	76.3	40.6	59.4
4	Krishna	78.1	61.0	58.0	26.4	36.0
5	Cauvery	21.6	18.9	19.0	12.3	42.4
6	Pennar	6.7	6.2	6.7	4.9	11.1
7	EF: Between Mahanadi and Pennar	22.5	15.3	13.1	18.8	41.3
8	EF: Between Pennar and K'kumari	16.5	16.0	16.5	18.2	66.0
9	Mahanadi	66.9	60.2	50.0	16.5	119.7
10	Brahmani – Baitarni	33.0	32.6	18.3	4.1	43.4
11	Subarnarekha	12.8	9.7	6.8	1.8	10.8
12	Sabarmati	3.8	3.4	1.9	1.8	10.8
13	Mahi	11.0	10.7	3.1	4.0	12.6
14	WF : Kachchh, S'tra and Luni	15.1	13.6	15.0	11.2	113.2
15	Narmada	46.0	36.9	27.5	10.8	18.4
16	Tapi	16.9	16.2	15.0	8.3	7.5
17	WF: Tapi to Tadri	87.4	80.3	11.9	17.7	11.2
18	WF: Tadri to K'kumari	113.5	97.8	24.3	-	-
19	Inland drainage ; Rajasthan	-	-	-	-	-
20	MR: B'desh and Myanmar	31.0	24.8	-	-	
Total		**1878.3**	**1547.8**	**683.4**	**431.9**	**10,812.0**

ASW,Available surface water; AMR, Average monsoon run-off; EUSW, Estimated utilization surface water ; RGW, Replenishable groundwater , including augmentation from canal irrigation ; SGW, Static reserve of groundwater ; EF, East – Flowing; WF, West – flowing; MR, minor rivers ; K'kumari, Kanyakumari ; S'tra, Surashtra; B'desh, Bangladesh, Source: MOWR-1999.

areas (sq km) of major rivers and their water resource availability are shown in Table-1 (MOWR 1999). The data show that around 58% of the area is under perennial-river basins (Ganga, Brahmaputra, Indus and Mahanadi) with more than adequate water, at least a part of the excess of which can be diverted to the water-deficit basins constituting 42% of the total basin area, to support the agro-based economy of the respective regions, and hence of the country.

Rainfall

Even though India is the second wettest county in the world with an average rain fall of 1170 mm and a total rainfall of 4000 BCM per annum, huge regional differences cause high imbalance in the availability of water; 80% of the rainfall is seasonal occurring during a period of 15-60 days any time from June to September. This rainfall is the source of water for the rivers other than Himalayan rivers and for irrigation in the plains. Delayed or absent monsoon showers can spell disaster in the region to the crops. In many places, the rainfall is erratic; more than half of rainfall occurs not uncommonly over a short duration of few days/hours, causing heavy damage to the life and property. Table-2 shows the distribution of rainfall in time is very uneven and more often it does not coincide with crop requirements. India can be divided four zones depending upon the amount of rainfall received.

- 1600 mm and above: The West Bengal, Assam and the south-west and central-west coastal regions (Konkan in Karnataka and Malabar in Kerala).
- 1000-1500 mm: Central India from the Himalayas down to the river Godavari, eastern coastal area, region between east of the Western Ghats and north and south Gujarat.
- 500-1000 mm: Almost dry area; Tamil Nadu, South side of Deccan plateau, and the north-west of Deccan, Saurashtra in Gujarat.
- Below 500 mm: Desert areas: The Rann of Kutch and the Thar Desert

The above data demonstrate variations in rainfall in time and space. Its trend is undependable and unpredictable. The country is a revelation climatologic antagonism, as the country has the region with the highest total annual rainfall in the world (10,600 mm), Chirapunji in Meghalaya and one of the lowest annual rainfall regions (126 mm), the Thar Desert in Rajasthan. The isohyets and the annual precipitation indicate that nearly one third (1, 06,83,90 km) of the total geographical area (3,28,77,80 km) of the country is drought prone, whereas the floods occur more often than not in the perennial rivers like Brahmaputra , Ganga and others like Mahanadi rivers. Deficiency of water is prevalent mainly due to the inequitable distribution of rainfall. It is common that while one part of the country or even of a state suffers from acute drought, the other region is in the grip of storms and floods due to heavy rains. The 2nd and the 3rd regions often are subjected to drought conditions. The Ganga-Brahmaputra-Meghua basins with an area of 33 % in the total river basin area in the country, contribute 62% of water resources, (Patel 2003). These basins, rich in both groundwater and surface water resources are the potential water resource-donor basins to the water resource deficit basins. In 2003 while floods caused devastation in Orissa, starvation due to acute drought was reported in Karnataka. In Karnataka and Andhra Pradesh, while the monsoon played havoc in coastal districts because of heavy downpour over a short period, the interior districts (Rayala Seema and Telangana in Andhra Pradesh, and Raichur, Bellary and Konkan region in Karnartaka) were reeling under relentless drought. According to the Central Water Commission Report (1982) Karnataka has the highest percentage of drought prone area of 79% of its geographical area with concentration of urban agglomeration and agriculture in Krishna and Cauvery

Table 2. Seasonal Distribution of Rainfall in India

Months	% Rainfall	Monsoon
January to February	2.6	Post-Northeast monsoon
March to May	10.4	Southwest monsoon
June to September	73.7	Southwest monsoon
October to December	13.3	Northeast monsoon

basins. *The southern peninsula, which is drought-prone, is yet to be made drought-proof.* This huge gap in rainfall resulting in wide variations in the availability of utilizable water has to be bridged.

The hydrological estimates of National commission of agriculture reveal that our country experiences an average annual precipitation of 400 M ha. M. it is estimated that more than half of it is unutilizable. The current utilization is 65 M ha. M which is bound to increase three fold by 2025 because of increase in population and possibly also of irrigated area and industries. But the annual average precipitation does not increase, on the contrary may decrease owing to deforestation and environmental degradation. Do we have at present any sustainable hydrological mechanism for increasing the utilization of the available resources? Our country, except Kerala northeastern states and Kashmir, experiences severe drought every alternate year. In Andhra Pradesh, the total annual rainfall recorded in 2004 is 612 mm against average annual rainfall of 900 mm; some districts reeled under 50% deficit in rainfall. In the current year (2009) the rainfall is quite erratic and recorded only 30% of annual rainfall in 280 districts in India. The recurrence of drought almost every year has resulted in severe scarcity of drinking and irrigation water leading to starvation deaths and suicides of nearly 1500 farmers. The situation was no better during the last three years The farmer suicides are 100 for the last three months in Andhra Pradesh during current year. The drought affected areas in various states are 45% in Andhra Pradesh, 64% in Tamil Nadu , 79% in Karnataka , 63% in Rajasthan , 62% in Gujarat , and 40% in Maharashtra. At the national level, it is estimated at 32%, (Bhavanisankar & Raman 2003). This area is common to all the years, in addition drought affects one area or the other every year, thus the drought-affected area would be nearly 50% in the country every year.

The total population of the drought affected states and a region in the country is estimated at around 400 million constituting nearly 40% of the total population. For a country like India with agriculture as the main livelihood, failure of monsoon, not an un-frequent phenomenon, critically upsets the socioeconomic and political setup and would lead to an uncontrollable chain of reactions culminating possibly in chaos at national level. The agricultural drought is declared in 280 districts out of 593 in India in the current year, 2009. The situation demands an efficient and judicious management of available water resources for optimum utilization and their sustainability for the food and observed security of posterity.

Rainfall and floods being natural phenomena, their occurrence cannot be changed, linking of frequently flood-prone high rainfall and surplus river basins with the seasonal rivers in the drought prone areas is to be considered from all aspects, hydrological, economic environmental, socioeconomic and political, predicting and weighing the individual and integrated impacts. As the issue is gigantic involving the whole nation in terms of population, land area and water, all the available options should be considered with an open mind at national, regional and local levels.

Water Demands

The river systems in India possesses an average annual surface flow of 1953 km^3 (excluding groundwater) of which utilizable quantity is only 690 km^3 constituting only 37% of the total annual flow. This precious quantum should be judiciously to the fullest advantage to prevent starvation and drought, and for the sustenance of economy of the nation. So far, India has built over 600 storage dams with an aggregate capacity of 130 million-acre feet (Bhavanishankar & Raman 2003). Even though it is a commendable achievement, it does not fulfill the demands either in controlling the floods or in the transfer of water to the needy areas. These dams could conserve only one seventh of surface water available in the country (Bhavanishankar & Raman 2003). Therefore, we need to undertake inter-basin transfer of water and construction of more dams and reservoirs at diversion points.

The per capita availability of water (PCA) in India is only 2200 m^3/year as against 17500 m^3/year in Russia. As per international standards, a country with less than 1700 cu m of PCA is considered water-stressed, when the PCA drops to 1000 m^3, it is said to be water-scarce. Demographic projections indicate that by the year 2050, the country's population would be stabilized at around 1640 million; at that time, the PCA would be precariously placed at 1100 m^3; but the situation, it is feared, may escalate to a higher figure (MOWR 1999). If the population increases further, which is likely, the PCA would sink to less than 1000 m^3 (Patel 2003). It does not constitute even 10% of the corresponding value in the developed countries. The current usage of 600 BCM of water by the country has to be increased to 1200 BCM by 2050 to keep abreast of the needs of the increasing population. According to world demographists, by the year 2050 India's population will be more than China's and the total population of both countries together will be more than half of the world population. It indicates that the population of India would be more than one fourth of the total population of the world. The biggest problem we would be confronting then is to meet food and water needs of the steaming millions. Whether we can feed them with the present "stabilized" agricultural area of 185 M ha and at the present rate of creation of irrigation for 2 lakh ha/year, which is exceedingly lower than the expected 18 lakh ha/year. But Bandyopadhyay & Perveen (2003) question justifiability of the assumption of an arithmetic expansion of irrigated land as the possible solution towards maintaining India's' food security. However, it is found on the field that an increase in irrigated land after the linking of canals in local area has increase the productivity of land in Tribal areas (Vasudeva Rao 2004). Even if we achieve the dream figure of 18 lakh ha/year, the ultimate irrigation potential is expected to be around 140 M ha. The situation warrants not only the expansion of the total agricultural area but also the potential irrigated area. But the latest demand for irrigated area has increased to 160 M ha, which can possibly be met through increase in the water resources in the water scarcity areas, possibly through inter-basin linking. Cultivable area in India is 184 M ha and the net sown area is around 140 M ha. Irrigation facilities created by 1996-97 are supposed to be meeting the water requirements of about 89.56 M ha from 22.6 M ha in 1950-51 revealing the very slow rate of increase in irrigation potential. As against the planned and decided supply of irrigation to additional 35 lakh hectares annually by 1995, Government of India could achieve the supply to only 18 lakh hectares by 2003. *Diversion of floodwaters from the perennial–river basins, which almost experience heavy rains every year, to the water deficit regions not only solves the problem of non-availability of surface waters during the rainy season, but also builds up the groundwater table, which would enable the farmers to raise at least dry land crops of commercial value.*

The summer of 2005 was a saddest example of severe water scarcity especially in Andhra Pradesh. The Telangana and Rayala Seema regions had already had the foretaste of the imminent severe drought, as even drinking water was not available. This has resulted already in migration of nearly two lack people from Kadapa and Kurnool districts and over 68 thousand from Karimnagar district. The migrants almost all are men who have left their families, to feed them. The situation is even more severe in the present year 2009 with unprecedented agriculture drought (900 mandals of 21 districts) in Andhra Pradesh. However, at the fag end of September 2009, unprecedented floods of Krishna river devastated Karnool, Krishna and Guntur districts, which has been named as historical devastation due to floods in 1000 years.

Alternative methods of conservation of water

1. **Conjunctive use of groundwater and surface waters**: Utilizable ground water which constitutes 0.3% of the total global water resources and 0.4% of the utilizable water resources, is one of the most treasured water resources available round the year, irrespective of the seasons, if properly managed. It should be pointed out that ground water table would be augmented at least up to 30 km width on either side of the link, more so if the links are at higher level. This would lead automatically lead to conjunctive use of both the sources.

2**. Water Harvesting**: Of late rainwater harvesting has duly been acclaimed as a sustainable method of water conservation. By 'rain water harvesting', the water conservationists mean, a feasible technique to utilize rainwater that would otherwise go unutilized. Actually, utilization of water from any source that would otherwise go waste is '*water harvesting*'. The Himalayan Rivers, because of the melting of ice at the place of their origin, commonly have surplus water even during summer; which can be diverted to the deficit regions for utilization for drinking and irrigation for second crop. Strictly speaking inter-basin transfer of water is, basically, a method of harvesting of surplus water/ rainwater/flood water. Here the floodwater or the excess rainwater of one region or the water- surplus basin is 'harvested' or transported to water-deficit basin in the other region. Thus inter-basin transfer of water is essentially water harvesting on a larger scale.

3. **Effective Techniques of Irrigation**: Comparatively effective techniques of irrigation like drip irrigation, sprinkler irrigation, contour bunding/ trenching, etc. and cropping techniques involving crop rotation, inter-cropping, mulching, adoption of dry crops depending upon the season etc. are to be followed depending upon the location-specific demand.

4**. Cloud Seeding**: Cloud seeding with silver iodide has been tried in foreign countries and recently in India (Andhra Pradesh) too. The expertise currently available in our country for cloud seeding has to be improved to meet the demands. The recent attempt in Karimnagar district Rayala -seema in Andhra Pradesh was only an excuse during the last three years. The time selected was found to be inappropriate, as the rainfall did not meet the demands of the crop either in time or in space. It also may not be possible to extract the required amount of rainfall for required time period from the cloud seeding. Moreover, not all types of clouds respond to cloud seeding, it requires specific type of rain bearing clouds at a specific time and over specific region. Thus, rainfall due to cloud seeding depends upon many contingencies, which may not be operating simultaneously. Therefore, cloud seeding is not a feasible proposition for water conservation. Cloud seeding in India is currently at research level and hence, further investigations are to be carried out on trial and error basis to apply the technique with assured advantage on large scale.

Present Status of River Linking and Political and Social Implications

There is an immense pressure to share river waters among the countries, states and regions. The political and social issues are very important as they may decide the fate of this kind of projects of national importance. Mondal (2004) opined that the linking of rivers is more problematic for socio-economic-cultural relations of the society. In South-East Asia, the Himalayan river waters are of interest, as the Himalayan region has some of the world's most underdeveloped/developing countries, Bangladesah, Nepal, India, Bhutan, Pakistan, Tibet, and China. Construction of dams across the Himalayan rivers Brahmaputra and Ganga and their main tributaries in India and Nepal and interlinking of their canal system and transfer of surplus flows of the eastern tributaries of the Ganga to the west in addition to linking of Ganga and Brahmaputra constitute implementation aspects of the main concept of inter-basin transfer of water between the countries. While providing irrigation to additional 22 million hectares, it generates pollution free hydro-power and will provide flood control in the Ganga- Brahmaputra basin. Thus, Ganga- Brahmaputra basin, and Nepal and Bangladesh would have advantage from the project. But the initiation, completion and success of the scheme are contingent upon the cooperation and political environment in the countries, states and regions involved. It is easier said than done to advise the politicians to bury the hatchet for the welfare of the people. According to Narseen Jahan et al. (2003) of Bangladesh, the issue of the Himalayan Rivers is to be viewed in terms of geopolitical, sociopolitical, temporal, functional requirement and operational modes. They cite the conflicts regarding Farakka dam between India and Bangladesh. They emphasize that as India is the stronger party and geographically placed at a strategic position, she has a more important role to solve the regional conflicts and strive for the riparian agreements between the countries. As India is inherently liberal and ready to cooperate with neighbors and more so in the context of the important problem of water sharing, it can be a role model and pioneer for such riparian agreements

The interlinking of rivers planned on the basis of studies of National Water Development Agency (NWDA-2003) of India envisages transfer of excess flood waters from Himalayan river component of Ganga and Brahmaputra, from Ganga to the parched lands of western India and from tributaries of Brahmaputra, Manas and Sankhosh (the sources of flood-misery to Assam and Bangladsesh), to the east and southeastern parts of India. Water balance studies indicate availability of sufficient floodwaters for diversion. However, the links are still at the conceptual stage of planning (Fig.1). As per the reports, Bangladesh has fears and is creating disinformation in the world forum, that the mega projects, to be undertaken in India for diversion of waters from Ganga, would cause water scarcity in Bangladesh. But the flow data in Ganga and the quantum of water to be diverted reveal that Bangladesh has unnecessary fears. At least the transfer of water from Ganga to peninsular component does not affect the water status of Bangladesh. However, this has become a bone of contention for river-sharing between the countries.

The Almatti dam over Cauvery river in Karnataka is matter of controversy between Andhra Pradesh and Karnataka. Controversies may also arise between the regions within the state like the supply of Godavari waters to Telangana region. In this scenario, where people are regional and linguistic conscious in India, inter-state and intra-state water conflicts are not un-common (Ali 2004). In, fact whenever inter-basin transfer of water is proposed, it always met with strong resistance from the donor river basin, even though it has surplus water. Even intra-basin transfer of waters across the states and construction of dams are always the centers of controversy between the states as between Haryana and Punjab, Karnataka and Tamil Nadu. Karnataka and Andhra Pradesh etc. Already Bihar, West Bengal, Maharashtra, Kerala, Assam, Punjab and Rajasthan have opposed the inter-basin transfer of waters.

Another social issue of great importance is the displacement of the people from the region of linking. *Forced displacement from the homeland is always painful and serious issue. The problem would be magnified and indiscriminately exploited by the*

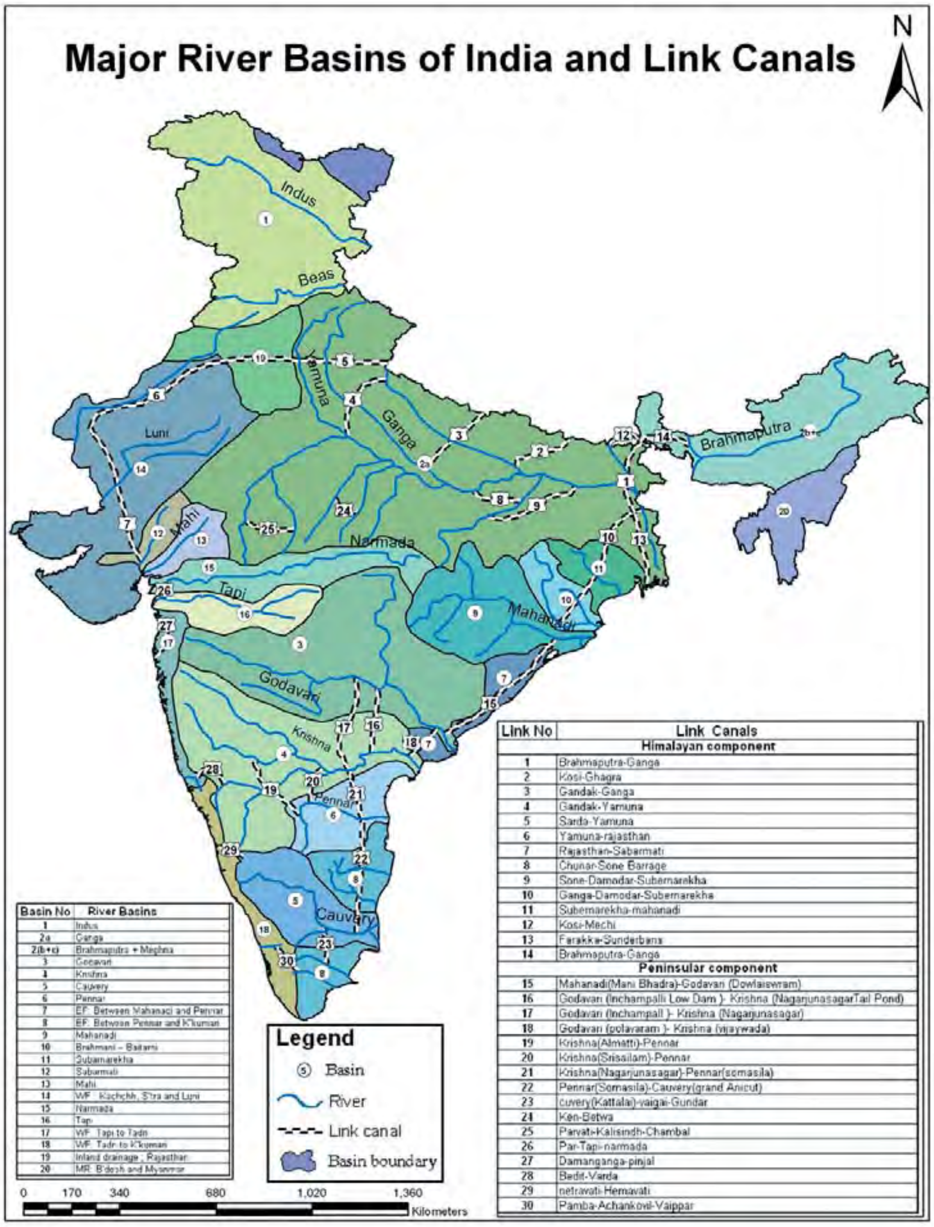

Figure 1. Major River Basins of India and Link Canals

politicians with their vested interests who instigate the people, especially the susceptible rural and tribal communities, who are likely to be displaced. There are many cases of non-settlement of issue of lands to the persons displaced from the link canal areas. When the proposed canals transfer water through other states or other regions in the same state, they are bound to claim water from the canal. If the claim is not acceded to, they try to thwart the project resulting in mutual distrust and more often in violent conflicts. Recently, when Government of Andhra Pradesh has proposed the construction of a dam over the river Vamsadhara at the Orissa-Andhra Pradesh border, the Government of Orissa has strongly objected, as it may inundate fields and forests on their side and that Andhra Pradesh may also extract more water from the Vamsadhara river basin. The Orissa Government has proposed and even given a go-ahead order for construction of 7or 8 dams over the river Vamsadhara, which would create severe water scarcity in the Srikakulam district. This kind of mutual distrust, and antagonism and conflicts, more due to vested interests and selfish mottos are to be tackled and an atmosphere of trust and belief is to be created before undertaking the projects like river linking. An example at intra-state conflict is the resistance offered by farmers of West Godavari district to dig Polavaram Right canal through their district for transfer of water to the Krishna River. Thus, violent opposition may occur and gather momentum between the states and also between the regions even within the same state. By its own admission, the Central Government recognizes, as a major hurdle, the managing a political consensus for this ambitious but all-important project. On the construction of Sutlej–Yamuna canal, which was to be completed by January 2003 by the Central Government, under the directive of the Supreme Court, had to be abandoned in 1990 after spending about Rs.450 crores, at the height of militancy in the Punjab. In the Cauvery dispute also, the Apex Court directed the Karnataka Government to release water into Mettur reservoir in Tamil Nadu to save the standing crop. No agreement could be reached between the states even in the hour of crisis and the then and also now impending starvation. Similarly no agreement could be reached, notwithstanding, the directive from the Supreme Court in case of Sardar Sarovar, Tehri and Bansagar projects, which have been languishing for 20 years, still are nowhere near completion, because the people could not be satisfactorily rehabilitated.

Of course, the central Government is empowered by the Supreme Court to go ahead with the project of linking of rivers and to complete it within 10 years. It should be mentioned that the Apex Court, realizing the importance of the project, has compressed the proposed 30-years project into 10-years one. But, as experts feel, this is an impossible task, more so, in the current social atmosphere and political instability in the country and the huge expenditure. *Practically considering, people's emotions and voice have more weight and say than the Supreme Court's directive in this kind of issues*. Thus, the project will not be a reality by 2016. All these hurdles are to be expected after assessing the water balance in the donor and the recipient river basins, hence proper strategies are to be evolved with emphasis on political and social and environmental issues. It is but natural whenever any project is proposed antagonists are more vociferous or even violent and tend to undertake mass protests, satyagrahas, which have become a way of life in India. This is not to undermine the people's voices and rights, but only reviewing/ assessing the current situation and the event-prediction for future security. In the present scenario of coalition politics, interstate and interregional conflicts, can we expect the situation to improve for people's welfare schemes like the inter-basin transfer of waters, or sharing of waters from the same river by different states? Consensus has to be achieved for this project, which would create a hunger- and thirst- free sound environment. But the present generation has to pay heavy price for the canal-reticulum through water cess and irrigation cost on the basis of per quantum utilization during the process of the realization of the project.

Views and Proofs

Suggestions for a National Water Grid for transferring surplus flood water available in some regions to water deficit areas have been made from time to time. Two such proposals put forth earlier in the seventies, which attracted considerable attention, were National Water Grid envisaging Ganga-Cauvery link by Rao (1973) and Garland Canal by Dastur (1974) but could not be acted upon due to certain deficiencies. The continued interest shown by many people gave impetus to study inter-basin water transfer proposals on a systematic basis. A National Perspective Plan (NPP) for water resources development was formulated by the Union Ministry of Water Resources, envisaging interlinking of rivers by transfer of water from surplus basins to deficit basins/areas with a view to minimize the regional imbalances and optimally utilise the available water resources in the country. National Water Development Agency is studying the proposals of NPP in order to give concrete shape to it.

Shivaji Rao (2003) strongly recommends that interlinking of rivers is inevitable to prevent the water and food famines by 2025. Gurjar (2003) suggested a holistic and transparent impact assessment of the project before grounding. Kesava Rao (2003) also appealed for a careful full-length study by engineers and scientists put together before implementing the river linking project. According to Radhakrishna (2004) there is no unanimity of opinion regarding the identification of water surplus basins; state and central Govt. disagree with each other regarding the surplus of water from Mahanadi and Godavari. But officials favor large projects involving huge amount of money.

According to Bandyopadhyay & Perveen (2003) the proposal of linking of river basins claims to package an uncertain and questionable idea. This statement appears to be rather biased as the Yeleru canal to bring Godavari water to the Visakhapatnam steel plant city and the Telugu Ganga, to supply water from Krishna River to the Chennai city are not large scale projects and found to be performing satisfactorily. Supply of Godavari waters for drinking of Viskhapatnam is being implemented successfully. These three link projects are in force with least controversy.

According to Subhash Chandra (2004) the Himalayan water flow and diverting it up to river Cauvery by spending cores of rupees do not make any sense. He holds that the canal irrigation , if brought at such mega levels by over-looking the highly variable climatic, geological, soil, and other related conditions of the country, is bound to result in the conversion of fertile and potential agricultural land into perpetual non-productive, water logged, saline insipid barren land. *Such statements look farfetched, because they are made without taking into consideration the valuable results obtained with the already existing projects.*

"What we need in India is an effective plan to deal with drought and inter linking of rivers is no solution. It is smoke screen to deluge the people". With all the respect for his experience and knowledge, the above statement of Radhakrishna (2003) appears as one sided. The latter part of the statement may be modified as "is not the only solution". In fact it may be one of the good solutions as the link canals pass through absolutely water scarcity regions, hence these regions may latter attract habitation and civilization, as civilizations start and flourish with development of water resources. Therefore linking of rivers when implemented effectively may not be a "smoke screen to deluge the people", but provides water source to quench the thirst of the land and people.

Digging canals and distributaries is being implemented for diversion of Godavari river waters to Visakhapatnam city to meet the domestic and industrial water needs, as the Godavari River is the largest reliable water source nearest to the city. Reddy (2003) advocates Integrated Water Resources Management (IWRM) for the sustainable development of water resources in a river basin. He feels that such plan can bring out the need for import or transfer of water to/from a basin. Thus inter basin transfer of waters has to be considered as the main strategy to meet the water scarcity in drought regions along with other techniques mentioned below. Vaidyanathan (2003) expressed that this project has been designed with the concept that it will improve the living status of people in India, with growth in our country. The completion of this project would result in constant water supply for domestic use, agriculture and industries along with the flood control, improvement in water flow, navigation and food security. The construction of dams, canals etc. and their maintenance would create jobs, which would check the migration of people form villages to cities. Ali (2004) expressed concern for the ecological problems to be taken care off before implementing such mega projects. Gupta & Deshpande (2004) indicated that priority should be given to rainwater harvesting, renovation and reuse of wastewater and then inter-basin transfer to meet the water demands of our country. Interlinking of rivers will affect, besides other aquatic life, fish diversity throughout the project area and beyond, by changing the depth, flow and turbidity of water, creating barriers to those species that migrate upstream to spawn, encouraging the spread of alien invasive species such as *Oreochromis mossambica*, permitting the invasion of the hardier species of carps from the northern rivers that tend to out-compete the endemic ones or even hybridize with them (Ranjit Daniels 2004).

Sainudeen Sahib (2005) strongly felt that the inter-linking of all rivers within the Indian Territory is essential for overall development. Shashikumar (2005) stated that mega ventures like inter-linking of rivers is a welcome step for our nation provided they are for the betterment of humankind rather than demonstration of political will.

Rajamani et al. (2006) presented a new hypothesis which states that implementation of inter-linking of rivers would change the quantity and fresh water flow into Bay of Bengal , which result in a set of events that would adversely affect the monsoon rainfall and would also convert the Bay of Bengal into a producer of CO_2 and N_2O. Thatte & Chetan Pandit (2006) contradicted the above concept of adverse of rainfall due to the river-linking but proposed a detailed study on the subject on the mammoth project. Sharma (2006) stated that the apprehensions raised by a group of scientists on adverse impacts on monsoon activity due to diversion of waters through various links seem to be misplaced and misinformed. Govindaswamy Agormoorty (2007) opined that unlike big dams, small check dams neither displace people nor destroy natural resources.

Linking of Rivers in India, The Present Commonly Agreed Proposal by the Protagonists

A National Perspective for Water Resources Development proposed by Central Water Commission envisages two constituents for linking the rivers in India, The Himalayan River development and the peninsular river development (Vidyasagar Rao 2003). The former, expected to irrigate an additional 22 M ha in the Brahmaputra and Ganga basins, would be a control measure and is expected to increase the inland navigation through the discharge of water. The latter would supply irrigation to an additional 13 M ha in the southern states and Maharashtra, Gujarat, Madhya Pradesh, Orissa etc.

The most important aspect of the proposal is the gravitational water flow in the proposed inter- and intra-basin transfers. This would save an otherwise huge expenditure on power.

Korse (2004) rightly emphasizes the need for case-specific approach and strategy for river linking. The problems that confront the program of river linking vary with the links of various rivers in the various regions, and even for the same link in different regions. This is true as the each links in the west, east and south have specific and different environmental and social issues at stake, which should be considered on the basis of location specific approach, which is a more micro-level approach than the case specific or link specific approach. It is also better if a typical river link of medium size, mentioned in the proposal, is undertaken to assess the overall impact. It is proposed that 20 major rivers in India would be linked during the next decade through canals of 12,500 km length requiring the construction of nearly 400 reservoirs, altogether, at a mammoth cost of US $100 billion. The initial investment, of course is huge, but the environmental, social, and economic benefits are invaluable and recur every year for sustainability for generations together (Ranjit Daniels 2004). Kumar & Jain (2007) expressed that it may not be correct to say that the state governments oppose water transfer; what they may be opposing is free transfer of raw water. For instance all the state governments encourage the setting up o f industries (even though they consume large amount of water) to produce goods which may be shipped outside the state. Jain, Vijaykumar & Panigrahi (2008) visualized that decidedly it will be the most ambitious scheme in the history of India. Successful completion will rapidly wipe out many curses of poverty. On the other hand any serious delay will lock large resources in non-productive investment and negate the benefits of growth in many sectors that end country has tasted recently.

Ecology and Economy

Water is the main controlling agent of ecology, i.e., environment and economy, the two main pillars of the sustainable development. It is an unfortunate fact no developing country at present, including India, is able to survive and progress without the aid of the World Bank or Western countries. It is essential that we should try to break the clutches of the continued debt and dependence and to create self-confidence and dignity of the individual and nation as a whole. For achieving this objective of self-sufficiency, adequate water supply for irrigation, domestic and industrial purposes is the main key. It is true that water conflicts do occur among the member states and even among the member district of a state regarding the sharing of river waters. But this issue can be tackled through negotiations/ nationalization of river waters. One of the main reasons for the low agricultural yields in water deficit regions especially during last five years is the scarce availability of ground water because of the gradually depleting ground water source, attributable to low rainfall and shortage of surface water sources as in Rayalaseema and Telangana regions in Andhra Pradesh Satara and Vidharbha regions in Maharashtra, Saurashtra, Kutch and Mehsana regions in Gujarat, eastern and southern regions of Tamilnadu, such other regions in the country Data should be collected regarding the dislocation of villages and flooding of agricultural lands for construction of dams and canals. Rehabilitation measures should be planned and suitable locations are to be identified prior to undertaking this kind of projects. Ecology and economy should be considered from two important aspects - the donor rover basin and the recipient river basin.

The Donor River basin

The diversion of floodwaters from the donor river has no negative impact either, economic or ecologic, on its command area; on the contrary the dangerous environmental degradation in the river basin likely to be caused by inundation due to floods could be mitigated. Construction of dams and reservoirs on the link aspects will reduce the sediment and the silt load downstream. When the excess of water during floods is diverted to water scarcity regions (for example from Ganga to Peninsular rivers), the danger, due to change in river morphology and the shape of the delta that might be caused by the floods, will be mitigated. The normal ecological functions of the river will be disturbed during floods causing inundation, loss of property and life. These dangerous changes in river ecology will be reduced after diverting at least part of the floodwaters from the water-excess basins to water-deficit basins for a better cause. Thus, through river water transfer in the donor river basin, at least some dangerous impacts can be mitigated and transformed into conduciveness. *Water gets harvested in this process from high rainfall region to the low rainfall region.*

Interlinking of peninsular rivers with Ganga is expected to support irrigation to 34 M ha using 173 billion cm of water (to be diverted/harvested) in the project. According to Alam (2003, citation of MS

Reddy lecture) water will be transferred at a rate of 1500 m cm/s during flood season from Ganga to Cauvery through a network of canals. As per Reddy, the normal flow rate during flood period in the Ganga is 30,000-60,000 m^3/s. Thus, the rate of transfer accounts for only 5 to 10% of the flood waters. This variation in water transfer in the huge amount of floodwater flow affects the least river morphology and the ecology of delta during flood time. Diversion of 10% of floodwaters would have an appreciable positive impact on the downstream of the donor river basin. It should be pointed out that the total expected 30,000-60,000 m^3/s of floodwaters is the result of floods occurring at some places along the whole length of the river covering the regions upstream and downstream of Ganga with reference to location of the reservoir at the site of the linking. Hence, diversion of 1500 cm/s of floodwater from the upstream, into the reservoir during floods will possibly mitigate the impact of floods in the downstream region. Any large-scale change in their course due to floods definitely would change the normal course of environmental events, especially in the donor river region of the donor river basin. The river water flow may modify local micro-climates, (soil nutrients and minerals) temperature and humidity especially during flood period. It is, therefore, essential thorough investigations must be carried out for management of the resources and the events to prevent untoward dangers and aiming at long-term improvement. Bhavanishankar & Raman (2003) suggest that huge deposits of silt and debris at the outfall, which are the result of their transportation by the river and causing aggregation at the river mouth that may lead to the inundation and flooding of the delta area during heavy rains, may be pushed into the Bay of Bengal. As this is an operation of gigantic magnitude involving technical environmental aspects and high investment, it is essential to take up to carry out initially as a pilot project for proper assessment of all the issues. An environmentally sound and sustainable and socially acceptable measure to control inundation and floods is the dense afforestation of the riverbanks that would mitigate the impact of floods and reduce siltation too.

The Recipient River basin

The main purpose of linking of rivers is to overcome the water deficit in the recipient river basin. Construction of dams and reservoirs at the diversion site will reduce the sediment and the silt load downstream of donor and recipient river basins. Regarding the dislocation of villages and flooding of agricultural lands for construction of dams and canals, data are being collected and appropriate rehabilitation measures are being / to be planned and suitable locations are to be identified prior to undertaking this kind of projects. The problem of rehabilitation is not as easy as one visualizes and has to be tackled sociologically weighing the sentiments of the people with utmost care. Flooding and occasional water logging may inundate large areas of hectares of agricultural land. *The areas of dry land expected to be converted into a wetland, the areas of unproductive land to be converted into agriculture land are for more than the land that may be lost due to canals and reservoirs*. Moreover, increase in the number of crops per year or the cropping intensity also increases along the link canals and rivers to be linked. Thus, the economic ecological benefits far outweigh the feared losses. However, the conclusion regarding the assumed impending environmental ozone depletion due to chemical fertilization of the soil when adequate water is available from the linking of rivers appears rather biased hazy and hasty contra-argument against linking of rivers. However, the modern trend of utilization of organic fertilizers, which is ecologically beneficial, not only increases soil fertility but may also prevent the dangers of chemical fertilizer cycle in the soil-crop-human agencies and circumvent the supposed grave danger of ozone depletion. Another positive impact of interlinking of river is the generation of hydroelectric power.

According to the antagonists of river linking, the proposed links at present would possibly connect the lower end of the rivers, with no positive impact on the drought prone areas of the upper catchment. In this context it is essential to have another look on the proposed path of linking, despite the long time required to chart out the plans. It must be said that the lands along both sides en route the link would be benefited, through the distributaries from the link canals for irrigation and domestic purposes. The ground water table will definitely built up vertically and horizontally. This would increase the agriculture area and irrigated area and would also meet the domestic water needs.

Environmentalism

The environmentalists are no less fastidious. Probably they have reason that forests would be destroyed, even the ecologically valuable biosphere reserves would have to be devolved or would be affected and some endemic and rare species would become extinct. It is true that environment would be affected and some deforestation may occur. But should we be so environmental conscious as to leave the land and people thirsty and starving for ages, and give priority to save a few hectares of forest? Let us go into the logic of the issue. Our country has thousands of hectares of land prone to erosion which has to be and can be alternatively developed to ensure environmentally sound percentage of 33-40% of the area under forest. *Let the environmentalists concentrate on this aspect and give a shot in the arm for the implementation of the mammoth project of inter-basin transfer of water.* Even otherwise the project in all probability is expected to be environmental friendly, as along the regions of the links, which are dry during the pre-linking period would turn into cultivable land where crops and forests can be raised, flood control at least to some extent can be achieved, and pollution free hydropower can be generated to meet the power demand in the next fifty years, when population is hopefully expected to be stabilized. Prakasa Rao et al., (2008) studied the southern links using remote sensing WiFS data and concluded that most of the area traversed by the river-links in southern peninsula comes under waste/gullied land. The study so far conducted (Prakasa Rao 2009) on the proposed links connecting Mahanadi with Andhra Pradesh and Tamilnadu shows the possibility of bringing nearly 7000 sq.Km area of an un-irrigated, wasteland under irrigation in Andhra Pradesh alone. As the proposal encompasses links from Orissa to Andhra Pradesh and Andhra Pradesh to Tamilnadu, it is certain that more land can be brought into irrigation for food security.

Interlinking of rivers would not affect birds or their migration in coastal areas or river mouths, as nor even 10% of the water would flow into the canals from water surplus rivers. On the same account the estuarine ecology or river mouth ecology would be little affected. On the contrary, the would-be-erstwhile dry or semi-dry regions along the links and their distributaries would be probably haven for wild life and birds after they become green because of linking. In these modern days of arboriculture and herbal culture where even exotic species are being raised or even domesticated, 'the likely to be extinct and endemic species' can be grown elsewhere, as our country is blessed with wide regional climatologic and geographic variations, possibly more so because of the increasing awareness regarding tissue-culture real operation. In this kind of versatile climate in time and space, it would not be difficult, hopefully, to find a home for such species. Thus in all probability, the project is environmental friendly. *The environmentalists should view the project not with the view of "development without destruction", but with a view of "development with least destruction", as no development is possible without effecting the 'oikos' or the ecosystem or the home of the original inhabitants including animals and plants as has happened in the establishment of industries in the country, which have provided employment to millions constituting more than half of the present population of employees*. It is but natural that environmentalists out of their anxiety and moral commitment to the cause of the environment and the people raise hue and cry. They tend to view every problem under magnifying lens and project an unduly fearful picture to the people. *They are aware that there is no industry in the country without polluting the atmosphere, but the industries are warned that they should keep the levels of pollution below tolerable limit. Similarly, one should look at the linking of rivers also from broader perspective, as expected gains far out weigh the feared losses or disadvantages*. This project is estimated to produce huge among of environmentally sound energy 34 GW (Jayaraman 2003) which can replace fossil fuels especially in the transport system, as it is using huge amount of energy. Not only this reduces dependence upon Gulf countries for fossil fuels and reducing the pressure on the foreign exchange but also improves the environment by decreasing the particulate and chemical pollution. So increase in agriculture and forest area and plant productivity creates an efficient carbon sink which removes carbon dioxide from air. Carbon sink capacity with in India will be increased.

CONCLUSIONS

The best solution for the implementation of the project is the nationalization of rivers and to have National River Authority under National Water Task Force consisting of expertise from various relevant disciplines, such as policy-makers, planners, engineers, hydrologists, economists', agricultural scientists, environmentalists, social scientists and farmers from various regions of the country. Many earlier reviewers (Radhakrishna 2003, 2004; Reddy 2003; Ranjit Daniels 2004; Rajamani 2005 & Govindaswamy Agoramoorty 2007) have discussed the pros and cons of linking of river basins in India. Even though the problem seems to raise many controversies, the country is now going ahead at intra-state level with projects like Buckingham canal in Taminadu and Eleru in Andhra Pradesh and inter-state project like Almatti and Telugu Ganga which are in successful operation. It shows the interstate and intrastate rivers can be linked after techno-economic feasibility established. The foregoing unbiased reappraisal reveals that interlinking of river basins is essential for sustainable development of a region. Such projects can be implemented after proper planning of ecological conservation, social acceptance and settlement of political controversies.

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