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IMPACT OF INTERLINKING OF RIVERS: ISSUES & CHALLENGES

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Abstract: India's rivers actually speak for both natural life and the populace, serving as both their vital conduits. The Indian people's life depends heavily on the rivers. The river systems provide us with affordable transportation, electricity, drinkable water, irrigation, and a means of subsistence for our growing population. Several of India's largest cities are located along the banks of revered rivers. It is imperative that river water be managed properly right now. Indian farming is primarily depends on the monsoon, which is erratic by nature. As a result, water logging in some areas and a severe lack of irrigation in others are problems. Drought-related agricultural damage and the poor drainage system could be controlled. Diminishing and dwindling most critical resource issues of the 21st century. The core objectives of the paper are to study issues and challenges in interlinking of rivers in India and to study environmental impact of Inter-River Linking Project (IRL). At the backdrop of this, the present paper is an attempt to study issues and challenges in interlinking of rivers in India from the point of view of society at large.

Keywords: River Interlinking, Water Scarcity, Irrigation, Environmental Impact

1. INTRODUCTION

River interlinking is a complex and multifaceted issue that has garnered significant attention in recent years, particularly in regions where water scarcity and uneven distribution of water resources pose significant challenges to sustainable development and environmental conservation. This research paper aims to provide a comprehensive analysis of the potential benefits and drawbacks of river interlinking projects, drawing on various academic sources to inform the discussion. One of the key potential benefits of river interlinking projects is the ability to address water scarcity and facilitate the redistribution of water resources across different regions. By transferring water from surplus basins to deficit basins, these projects can help mitigate the effects of droughts, ensure more reliable water supplies for agricultural and domestic use, and support the overall water security of a region. However, the success of such projects is largely dependent on the technical feasibility, economic viability, and environmental sustainability of the interventions, as well as the willingness of stakeholders to cooperate and share the benefits and risks involved (Acharya et al., 2019).

Furthermore, the conflict resolution of sharing water at the interstate level has been a persistent challenge, with some disputes being settled while others continue to this day. The interbasin water transfers can further compound these issues, as they involve the intricate confluence of

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interdependency between various sectors and stakeholders. (Gundimeda & Howe, 2008). Another crucial aspect to consider is the potential environmental impact of river interlinking projects.

It is also important to consider the potential environmental impacts of river interlinking projects, which can include disruption of natural ecosystems, changes in water flow patterns, and the introduction of invasive species. Careful planning and environmental impact assessments are crucial to ensure that these projects do not have unintended consequences that undermine their long-term sustainability.

The hydrological cycle will continue to control the availability of freshwater in different parts of the Earth's surface until such time as technologies such as saltwater desalination are applied on a reasonably large scale. Freshwater is becoming increasingly scarce in many regions of the world due to the sharp rise in demand for it brought on by the expansion of the world's economy and population.(Musie & Gonfa, 2023) Because of this, the ratio of people to accessible water resources is getting worse every day. Water makes up around three-quarters of the earth's surface, which is fortunate. For this reason, the planet is aptly named the "blue planet" or "watery planet." The unusable portion of the earth's water resources makes up more than 99% of the total; this includes 2.15% of glaciers and icecaps and 97.2% of oceanic waters; the minuscule portion is less than 0.4% and includes only 0.3% of usable groundwater and even less surface water that is directly consumable. In order to strike a suitable balance between supply and demand as well as availability and usage at the local, regional, and global levels for the sustainability of their ecosystems, careful planning is therefore crucial for the prudent use of this priceless resource. That's where the idea of interlinking or basin transfer originates.(Vyas et al., 2016) There are two parts to the river network: the peninsular and Himalayan components. The goal of all interlinking plans is to elevate water across natural basins or move it from one river system to another. India is listed as a nation whose water scarcity is predicted to worsen significantly over the next several decades in the global picture.(Bhargava, 2018) Furthermore, the unpredictability of the climate and geography contributes to drought conditions, which in many regions of the nation result in significant hardship for people due to a lack of water for both domestic purposes and crop protection. (Dai, 2010). There are now terms for rivers that are water scarce and those that are "surplus" due to the temporal and spatial fluctuations in rainfall over India. The goal of India's political leadership is to permanently address the detrimental effects of drought and water scarcity in these regions, which is why they are pursuing the project to connect the country's rivers. The goal of India's river interconnection project is to move water from basins with surpluses to those with deficits, if any. (Vyas et al., 2016)

Water is a vital resource that is essential for the sustenance of life and the functioning of diverse ecosystems. However, the uneven distribution of water resources across different regions and the increasing demands for water due to population growth, agricultural and industrial development, and climate change have led to water scarcity in many parts of the world.(Lal, 2015) In response to these challenges, the concept of river interlinking has gained traction as a potential solution to redistribute water resources and address water scarcity.

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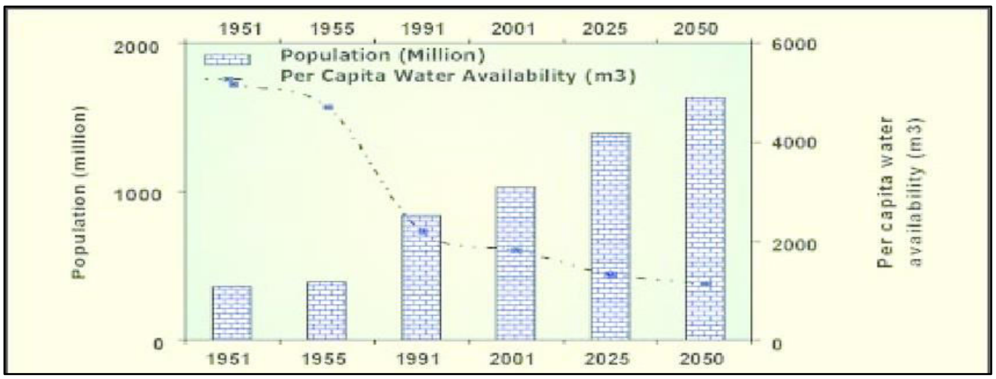
River interlinking projects involve the transfer of water from surplus river basins to deficit river basins, with the goal of improving water availability and mitigating the effects of droughts and other water-related challenges. These projects can involve the construction of dams, canals, and other infrastructure to facilitate the movement of water across different river systems.

According to an article on the India Water Portal, the country's total agricultural area is 159.7 million hectares, and its annual surface water requirement is estimated to be 690 km3. This is despite the fact that India's water needs will increase significantly as shown in **Fig 1** in the coming years due to our limited agricultural area (Khajuria et al., 2013). As more companies emerge these days, the amount of available agricultural land decreases as well. Water is a key component needed by agricultural areas in order to meet demand and other requirements. Every component demonstrates how important it is for rivers to be connected. The option exists of moving water from excess regions to deficit and drought-prone places.

Fig 1. Variation of water availability with population growth.
Source: (http://www.indiastat.com)



1.1. BACKGROUND & HISTORY

River linking has always been in the debate in India, though historically most plans were deemed unfeasible. Sir Arthur Cotton's plan in colonial times to link the southern rivers in 1839 was abandoned as railways took priority (Interlinking of rivers in India, 2013). The National Water Grid project by Dr. K.L. Rao, an eminent water engineer who later became water resources minister, to link the Ganges and Cauvery with a 2,640 km canal to pump 25 billion cubic meters at a height of 450 m to irrigate 4 million ha in the southern states was eventually scrapped as it was very costly and lower cost alternatives were available. A third plan, the 'Garland canal', was proposed by the retired Captain Dastur. A grandiose project, which though prima facie impractical, persisted in national discussions. So linking rivers at a grand scale to solve India's water problems has been proposed for more than 150 years but was impractical on both technical and financial grounds. Recently, these megaprojects are again coming into the national agenda, as the cost of these projects and the technology become within the means of the nation (Mevada & Devkar, 2017).

The central and state governments of India are again contemplating large water infrastructure projects as a part of their solution to the growing water crisis in India and the increased water demand from all the sectors. The recent economic growth, largely centered in cities, has added pressure on the government to invest in the agriculture sector (Bhargava, 2018).

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The history of river interlinking in India illustrates a persistent effort to tackle critical water resource challenges through large-scale engineering projects. While these initiatives hold promise for improving water security and agricultural productivity, they also raise significant environmental and social concerns that must be carefully managed to ensure sustainable outcomes (Shah et al., 2020).

1.2. OBJECTIVES

The Inter Linking of River aims to equitably distribute water and to resolve water scarcity for drinking and irrigation purposes by linking various water channels

The basic objectives of the river connectivity initiative are to:

1. Divert water from water surplus areas to arid and semi-arid parts of the district.

2. Increase the efficiency of different water storage structures.

3. Conserve water by channeling it through canals ducts, drains, natural drains etc. into drought-prone areas.

4. Identify the inter-relationships of recharge areas with geology and geomorphology practices to examine the soils and structure of the area.

5. Detect land use changes over time and determine their relationship with changes in the area of connectivity.

6. Carry out qualitative and quantitative assessment of water resources.

7. Suggest suitable sites and methods for artificial recharge to augment ground water recharge in the area.

8. Establish and evaluate long-term research on monitoring, measuring and planning for sustainable development in the area under benefit.

9. Assess the socio-economic impact of the river connectivity initiative.

These objectives highlight the multifaceted approach of the river interlinking project, which aims to address water scarcity, improve water management, and promote sustainable development in water-stressed regions of India (Vyas et al., 2016) (Desai et al., 2005).

1.3. National Water Development Agency (NWDA)

Many suggestions have been made from time to time for interlinking the Indian rivers. After carefully examining all such suggestions for transferring water for irrigation and other purposes from surplus areas to deficit areas in the country for the optimum development of water resources, the Ministry of Water Resources and the Central Water Commission formulated in 1980 a National Perspective Plan (NPP) for water development keeping existing uses undisturbed and tribunal awards in view and providing for the reasonable needs of the basin for the foreseeable future.(Desai et al., 2005) The perspective plan comprises two components – Himalayan Rivers Development and Peninsular Rivers Development. NWDA has been set up in July 1982 by the Government are shown in **Fig 2**.

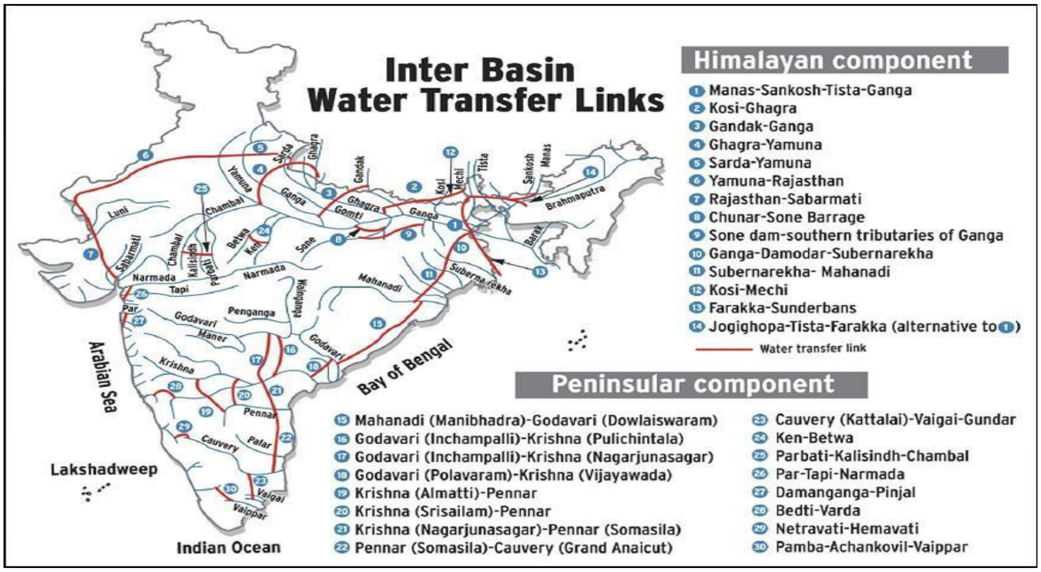

Fig 2: Proposed inter-basin water transfer links in India. (**Source:** National Water Development Agency (NWDA)

1.3.1 Himalayan Rivers Development

In the Himalayan Component, many dams are slated for construction on tributaries of the Ganga and Brahmaputra in India, Nepal, and Bhutan. So as to conserve monsoon flows for irrigation and hydro-
Power generation, besides flood control. Links will transfer surplus flows of the Kosi, Gadak and Ghagra to the west. Ganga with the Mahanadi River to transfer surplus water from east to west. In addition, the Brahmaputra-Ganga link will augment dry-weather flow of the Ganga. Surplus flows that will become available on account of interlinking of the Ganga and Yamuna are proposed to be transferred to the drought-prone areas of Haryana, Rajasthan and Gujrat. It will also provide flood moderation in the Ganga-Brahmaputra system. Fourteen links are proposed in the Himalayan component.

Links Identified in Himalayan Component

1. Manas - Sankosh - Tista – Ganga
2. Kosi - Ghagra
3. Gandak - Ganga
4. Ghagra - Yamuna

5. Sarda - Yamuna
6. Yamuna - Rajasthan
7. Rajasthan - Sabarmati
8. Chunar - Sone barrage
9. Sone dam - Southern tributaries of Ganga
10. Farakka - Damodar - Subarnrkha
11. Subernarekha – Mahanadi
12. Kosi - Mechi
13. Farakka - Sunderbans
14. Jogigopa - Tista – Farakka

1.3.2 Peninsular River Development

The main component of Peninsular Rivers Development is popularly known as the Southern water grid, which is envisaged to link Mahanadi, Godavari, Krishna,Pennar and Cauvery rivers. The scheme was prima facie found to be technically feasible and economically viable. (River linking project: a solution or problem to India's water woes?, 2016). The link system is conceived on the basis of substitution and exchange to avoid unnecessary lifts. Substitution envisages that the surplus water is delivered at the downstream use points in the basins facing water deficit, substituting for the existing committed releases from the upstream location in the deficit basin. In exchange, whole or part quantum of the water will be drawn from the upper reservoir to cover the needy upland areas, wherever feasible. This arrangement obviates the need for large lifts, thereby reducing the energy requirement as well as unit cost of the scheme. The main links proposed under the Peninsular Components are:

1. Mahanadi (Manibhadra) - Godavari (Dowlaiswaram)
2. Godavari (Inchampalii) - Krishna (Pulichintal)
3. Godavari (Inchampalii Low dam) - Krishna (Nagarjunasagar),
4. Godavari (Polavaram) - Krishna (Vijayawada),
5. Krishna (Almatti) – Pennar,
6. Krishna (Srisailam) - Pennar (Prodattur),
7. Krishna (Nagarjunasagar) - Pennar (Somasila),
8. Pennar (Sornasila)-Cauvery (Grand Arnicut),
9. Cauvery (Kattaiai) - Vaigai – Gundur,
10. Ken – Betwa,
11. Parbati - Kalisindh – Chambal,
12. Par - Tapi – Narmada,
13. Damanganga – Pinjal,
14. Bedti – Varda,
15. Netravati – Hemavati,
16. Pamba - Achankovil - Vappar.

Let us now examine the key considerations and debates around the river interlinking project. NWDA had conducted feasibility studies and found it possible to connect the six rivers namely The Mahanadi, the Godavari, the Krishna, the Pennar, Cauvery and Vaigai to provide a long term solutions to the problem of water scarcity being faced by the farmers in South India namely Andhra Pradesh, Karnataka Tamil Nadu & Pondicherry States (Mazumder, 2014). However, the project has faced significant opposition from various stakeholders due to concerns over environmental, social, and economic impacts.

2. River Linking Project in India

The River Linking Project (RLP) is designed to ease water shortages in western and southern India while mitigating the impacts of recurrent floods in the eastern parts of the Ganga basin. The RLP, if and when implemented, will be one of the biggest inter-basin water transfer projects in the world. However, the true cost can be known only when the detailed project reports of the 30 river link projects are drawn up. It will connect the rivers in the north with those of the south through a network of canals. Water from the Brahmaputra will flow into the Ganga, which in turn will be connected to the Mahanadi and Godavari. Godavari will be linked to Krishna, then to Pennar and Cauvery (Kumar, 2018). Similarly, Narmada will flow into the Tapi and Yamuna into the Sabarmati. This grand inter-basin transfer is slated to be completed by 2016.

Coping with annual floods and droughts, both occurring at the same time indifferent parts, has been a major concern for India over the years. These concerns are more acute today as the growing population and the resultant increase in water demand place a heavy burden on the unevenly distributed water resources, and also cause huge economic losses to the financially vulnerable groups of the population (Shaban & Sattar, 2011). Additionally, there is a huge demand to enhance and diversify food production. Designed to address these issues, the National River Linking Project proposes to transfer water from the potentially water surplus Himalayan rivers to the water-scarce river basins of western and peninsular India. The RLP will build 30 river links and approximately 3000 storages to connect 37 Himalayan and peninsular rivers to form a gigantic south Asian water grid. Environmentalists questioned the ecological cost of large dams, while the civil society probed the social cost of people displacement. However, much of the arguments for and against the project have little analytical rigor. 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 (Kumar, 2018).

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 (Vyas et al., 2016). 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 (Sinha et al., 2012).

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. A pragmatic expert opined in 2004 that the linking of rivers is more problematic for socio-economic-cultural relations of the society (Mazumder, 2014). However, we need to go ahead with the project due to various compulsions. 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, Bangladesh, 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 (Banerji, 1999). As per the opponents of this project, it will have severe environmental and ecological costs.

2.1. Need for Interlinking of Rivers in India.

2.1.1 Regional Rainfall Variation

The rainfall over the country is primarily orographic, associated with tropical depressions originating in the Arabian Sea and the Bay of Bengal. The summer monsoon accounts for more than 85 percent of the precipitation. The uncertainly of Occurrence of rainfall marked by prolonged dry spells and fluctuations in seasonal and annual rainfall is serious problem for country. Large parts of Haryana, Maharashtra & A.P., Rajasthan, Gujarat, M.P. and Tamil Nadu are not only deficient in rainfall but also subjected to large variations, resulting in frequent droughts and causing immense hardship to the population and enormous loss to the nation (Dey & Mujumdar, 2019). The water availability even for drinking purposes becomes critical, particularly in the summer months as the rivers dry up and ground water recedes. Regional variations in rainfall lead to situations when some parts of the country do not have enough water even for raising a single crop. In the other hand excess rainfall occurring in some parts of the country creates havoc due to floods.(Pragnya et al., 2018)

2.1.2 Control of Flood Damages

Floods are recurring features particularly in Ganga and Brahmaputra rivers, which has almost 60% water flows of the country. Flood damages, which were 52 Crores in 1953. have gone up to 5846 Crores in 1998, with annual average being 1343 Crores affecting the state of Assam, Bihar, West Bengal, U.P. along with human sufferings.(Dhar & Nandargi, 2000). On the other hand large areas in A.P., Rajasthan, Gujarat, Karnataka, and Tamilnadu face recurring droughts. As much as 85% of drought prone area falls in these states (Mishra & Nagarajan, 2012). The National Water Development Authority has already identified the feasibility of 14 inter-link projects involving the transfer of about 175 Billion Cubic Meters of water annually from the surplus river basins to the deficit river basins.(Vyas et al., 2016)

2.1.3 The Futuristic Demand for Irrigation

At present estimate the "ultimate" irrigation potential of the country being stated as 113 million Ha.(Vyas et al., 2016). The ground water component of the ultimate potential has been recently reassessed from about 40 million hectares to about 64 million hectares mainly due to additional recharge. The ultimate potential through conventional sources is likely to be hiked up to around 140 million hectares (Margat & Gun, 2013).

2.1.4 Increasing Population and Food Demand

Population of India is expected to stabilize at 1500 to 1800 million by 2050. It is a well-known fact that with increasing population, the food demand and agricultural production would go up. As per the experts, to meet the food requirement for the projected population of 1.6 billion, the food production needs to be enhanced from the present level of 280 million tonnes to 450 million tonnes by the year 2050. A.D.(Byrnes & Bumb, 1998) and that would require about 450 million tons of food grain annually at present rate of consumption. By 2050 we have to plan for production not less than 500 million tons of food grains.

2.1.5 The Hydropower Demand and Increasing Demand of Energy

The ministry of power has projected the peak demand of energy at the rate of over 9% annually. So projected demands are 2.65 Lakhs MW and 8.53 million MW of about 44000 billion units, in the years 2010 & 2050 respectively (Dudhani et al., 2006). India has limited sources of petroleum, so Bulk of this power has to come from coal based thermal power plants and peaking power has to come from Hydel Sources. At 40% requirement of power from hydel sources for peaking, peaking requirement will be around 3.3 million MW which is by far higher than the 84000 MW of estimated hydel power potential of the country. In such scenario the large potential available in Nepal & Bhutan would become attractive and perhaps inescapable.(Sharma & Awal, 2013)

2.1.6 Metropolitan water supply

Most of the mega cities or the urban centers are already water short in spite of Priority given to urban centers and industrial water requirement. Part of requirement can be met by recycling wastewater (Saravanane et al., 2014). Balance requirement will have to be met throughout long distant transfers. "Small is beautiful" may sound pleasing to ears, but it is impossible to fully utilize water resources of India, through small tanks.(Tewari, 2011) Firstly it is not possible to construct in hilly regions and forest area from where major flows enter the rivers. Secondly very big submersion area is needed.

2.1.7 Decreasing Ground Water Level

From the data collected and the actual experience in taking bore well, the ground water level is going down and down every year. So the irrigation experts have come to the conclusion that the entire Deccan plateau has to be supplemented by some new schemes says like Ganga-Cauvery river link project. Groundwater over-exploitation has resulted in falling water tables and deterioration of water quality in many parts of the country.

2.1.8 The Hydropower Demand and Increasing Demand of Energy

The ministry of power has projected the peak demand of energy at the rate of over 9% annually. Connecting Brahmaputra to Ganga or any such scheme decided by planning commission, further also for,

a. To minimize the number and size of dams to be constructed.

b. To provide cheaper inland waterway transport

c. To reduce ecological damage

d. To increase forest cover.

2.1.9 Need For Inter Basin Transfers

Though river basin could be a basic unit for water resource planning, this may not lead to the optimal, utilization of the surplus-water resource in various pans of the country. There are many basins in the country which are surplus in water resources even in the ultimate stage of development while other basin are already facing situation of water shortages (Shrivastava et al., 2018). For meeting these shortages in deficit regions, long distance inter basin transfers of water may be necessary. This will lead to equitable distribution and optimum utilization of water resources (Tockner et al., 2015).

3. Status of Water Resources of India

The average annual rainfall in India is about 119 cm. This is considerable variation in rain both temporarily and spatially. Most rain falls in the monsoon season (June-September), necessitating the creation of large storages for maximum utilization of the surface run-off (Patel et al., n.d).

ISSN PRINT 2319 1775 Online 2320 7876
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Within any given year, it is possible to have both situations of drought and of floods in the same region. Regional varieties are also extreme, ranging from a low value of 100 mm in Western Rajasthan to over 11,000 mm in Meghalaya in North-Eastern India. Possible changes in rainfall patterns in the context of climate change is a major cause of concern. Global warming and climate change and other predicted or observed long-term trends on water availability could affect India's water resources. The Table 1 gives about the land and water resources availability in India.

Table 1: Land and Water Resources of India

Particulars	Quantity
Geographical Area	329 M-ha
Flood Prone Area	40 M-ha
Total Cultivable Land Area	184 M-ha
Net Irrigated Area	50 M-ha
Natural Runoff (Surface Water and Ground Water)	1869 km^3
Estimated Utilizable Surface Water Potential	690 km^3
Groundwater Resource	432 km^3
Available Groundwater resource for Irrigation	361 km^3
Net utilizable Groundwater resource for irrigation	325 km^3

Source: National Institute of Hydrology: www.nih.ernet.in

4. Importance of Interlinking of rivers

The need to conserve water arises from its wide applications. Water is absolutely important to sustain flora, fauna and human life. This highlights its first importance. But other than this primary use of water there is a wide application of freshwater as enlisted below.

4.1. Agriculture

The most important use of water in agriculture is for irrigation, which is a key component to produce enough food. Irrigation takes up to 90% of water withdrawn in some developing countries. By linking of rivers vast amount of land areas which are not used for agriculture can be converted into fertile.

4.2 Drinking

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The human body contains from 55% to 78% water, depending on body size. To function properly, the body requires between one and seven liters of water per day to avoid dehydration; the precise amount depends on the level of activity, temperature, humidity, and other factors.

4.3 Washing

The propensity of water to form solutions and emulsions is useful in various washing processes. Many industrial processes rely on reactions using chemicals dissolved in water, suspension of solids in water slurries or using water to dissolve and extract substances. Washing is also an important component of several aspects of personal body hygiene.

4.4 Transportation

The use of water for transportation of materials through rivers and canals as well as the international shipping lanes is an important part of the world economy.

4.5 Chemical Uses

Water is widely used in chemical reactions as a solvent or reactant and less commonly as a solute or catalyst.

4.6 Heat Exchange

Water and steam are used as heat transfer fluids in diverse heat exchange systems, due to its availability and high heat capacity, both as a coolant and for heating. Cool water may even be naturally available from a lake or the sea. Condensing steam is a particularly efficient heating fluid because of the large heat of vaporization.

4.7 Fire Extinction

Water is used for fighting wildfires. Water has a high heat of vaporization and is relatively inert, which makes it a good fire extinguishing fluid. The evaporation of water carries heat away from the fire.

4.8 Recreation

Humans use water for many recreational purposes, as well as for exercising and for sports. Some of these include swimming, waterskiing, boating, surfing and diving. In addition, some sports, like ice hockey and ice skating, are played on ice. Lakesides, beaches and water parks are popular places for people to go to relax and enjoy recreation. Many find the sound and appearance of flowing water to be calming, and fountains and other water features are popular decorations. Some keep fish and other life in aquariums or ponds for show, fun, and companionship. Humans also use water for snow sports i.e. skiing, sledding, snowmobiling or snowboarding, which require the water to be frozen.

4.9 Flood prevention

During heavy rainy seasons some areas can experience heavy floods while other areas might be experiencing drought like situations. With network of rivers this problem can be greatly avoided by channeling excess water to areas that are not experiencing a flood or are dry.

4.10 Generation of electricity

With new canals built, feasibility of new DAMS to generate hydroelectric power becomes a possibility. It expects to add 34,000 MW of hydro power to the national grid. This turn will create employment and boost crop output and farm income.

4.11 Navigation

Newly created network of canals opens up new routes and ways and routes of water navigation, which is generally more efficient and cheaper compared to road transport.

4.12 Industrial Applications

Water is used in power generation. Hydroelectricity is electricity obtained from hydropower. Hydroelectric power comes from water driving a water turbine connected to a generator. Hydroelectricity is a low-cost, non-polluting, renewable energy source. The energy is supplied by the motion of water. Typically a dam is constructed on a river, creating an artificial lake behind it. Water flowing out of the lake is forced through turbines that turn generators.

Pressurized water is used in water blasting and water jet cutters. Also, very high pressure water guns are used for precise cutting. It works very well, is relatively safe, and is not harmful to the environment. It is also used in the cooling of machinery to prevent overheating, or prevent saw blades from overheating.

The availability of water resources and their judicious management is crucial for the overall socioeconomic development of a country (Dixit, 2019).

Water is also used in many industrial processes and machines, such as the steam turbine and heat exchanger, in addition to its use as a chemical solvent. Discharge of untreated water from industrial uses is pollution. Pollution includes discharged solutes (chemical pollution) and discharged coolant water (thermal pollution). Industry requires pure water for many applications and utilizes a variety of purification techniques both in water supply and discharge.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 03, 2021

4.13 Food Processing

Water can be used to cook foods, boiling, steaming, and simmering are popular cooking methods that often require immersing food in water or its gaseous state.

Water is also used for dishwashing. Water also plays many critical roles within the field of food science. It is important for a food scientist to understand the roles that water plays within food processing to ensure the success of their products.

This calls for a need to preserve as much freshwater as possible to meet our pressing needs. The prime advantage of interlinking rivers is that excess flood water from basins having surplus rain is redirected to basins having scarce rainfall. This puts forth a dual advantage that is it protects flood prone areas from flood and supplies drought prone areas with a source of water. An extensive plan has been chalked out by the National Water Development Authority (**NWDA**) under the motivation of our late Prime Minister Mrs. Indira Gandhi (1982) to interconnect the major rivers of India (Bhattacharya, 2015).

5. Dimensions of Social Impacts

There are many kinds of social impacts of a typical large river valley project like a dam or a hydropower project. The social impacts are experienced in the upstream, downstream and the command areas of the projects. The reservoirs behind the dams bring displacement for the upstream communities. Those affected up to the Full Reservoir Level (FRL) are generally considered when talking about Resettlement and Rehabilitation (R&R). However, the impact due to the reservoir is higher considering the fact that water level is expected to go to Maximum water level and there is also the backwater effect as the water flows in sloping profile. The dam and the related structures also require colonies, roads, fine aggregates, coarse aggregates, steel and cement and each of which would bring its own impacts.

In the downstream areas, there are many dimensions of social impacts. Firstly, since the dams divert or stop all the water in the river at least in the non-monsoon months, the river is taken away from the downstream people. Their source of drinking water, irrigation water and water for other needs is taken away. Secondly, the groundwater is also affected as the recharge function of the river for the downstream areas is destroyed. Thirdly, fisheries and other bio diversity in the downstream river is destroyed. Fourthly, the concentration of pollution in the downstream stream increases due to stoppage/diversion of freshwater flow (Jia et al., 2012). Fifthly, in absence of freshwater flows, the river no longer can act for navigation for the downstream communities. Sixthly, the construction of the dam changes the character of floods in the downstream areas and the floods becomes sudden and many times more destructive. Seventhly, the geomorphological behavior of the river changes as the silt in the river water gets trapped in the upstream dam. The eroding capacity of the silt free water flows increases significantly, which can bring fresh social impacts for the downstream (Zhang et al., 2016).

ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , UGC CARE Listed (Group -I) Journal Volume 10, Iss 03, 2021

Communities. Lastly, with the drastic reduction in freshwater flows at the mouths of the rivers, the salinity ingress increases, which can affect the remaining freshwater in the river, the groundwater in the coastal zones, and also the soil in the coastal areas. All these impacts need to be appraised and estimated for each of the links. None of this has been done for any of the links.(Fakouri et al., 2018)

The whole canal networks include the main canals, the branch canals, the distributaries, the minor, sub minors and the field channels. Moreover, the impacts due to the structures along the canals, the drainage network required to compensate for the drainage congestion and the additional capacity required to drain away the water added in the area by the canals, and also the land required for the coarse and the fine aggregates and the earth required for the canals should be included in the social impact assessment (Haque et al., 2013). However, the National Water Development Agency (NWDA) has not included these impacts in the feasibility studies for the 14 links that it have made public.

5.1 Lack of Information

Like in case of all water resources development projects, very little information has been made public by the govt. in case of ILR. It was a struggle to get the report of the National Commission for Integrated Water Resources Development, which was set up by the Govt. of India and which submitted the report in Sept 1999. After a lot of struggle, the first volume of the report could be made available only in 2002. The NCIWRD report said that interlinking of rivers is feasible and its benefits would outweigh the costs. However, neither the costs nor the detailed benefits have been spelt out.

Then following repeated orders from the Supreme Court of India, the feasibility reports of only the 14 peninsular links were made public in 2005. However, this still leaves out the remaining 16 links, about which NWDA has not made any of its reports public. Moreover, the reports of the 14 peninsular links is far from complete. To illustrate, the Ken Betwa link is supposed to involve at least five big dams, but the feasibility report of the link includes detailed information about only one of these. Similarly, the Parbati-Kalisindh- Chamal link is to include ten large dams, but the feasibility report includes some detailed information only.(Vyas et al., 2016)

5.2 Available Information

As mentioned earlier, sufficient information is not available to arrive at accurate estimates of likely displacement due to ILR. We have relied mostly on officialReports for this paper, where available. Thus, we have relied on the feasibility reports of the 14 peninsular river links that have been made public by the NWDA following orders of the Supreme Court of India. For the Himalayan links, we have relied on the reports of the Bihar Govt. and papers by officials of the W Bengal govt., where available. The available relevant information about the Himalayan links is described in the following sections.

5.3 Broad contours of ILR

The Table 2 below gives broad contours of the Himalayan and the Peninsular Components of the ILR in terms of number of links, number of reservoirs, cost, water transfer, claimed benefits and etc.

Table 2. Broad Contours of ILR

	Himalayan Component	Peninsular component	Total
Links	14	16	30
Reservoirs	16	58	74
Power Installed	30 000 MW	4 000 MW	34 000 MW
Cost in crores	454 000	106 000	560 000
Water Transfer	141.3 BCM	33 BCM	174 BCM
Additional I	22 M-ha	13 M-ha	35 M-ha
Link Canal	6100 km	4777 km	10877
Drought mitigation	1.7 M-ha	0.85 M-ha	2.55 M-ha

Source: NWDA 2005-I (183) and II (173)

5.4 Budget and Cost Estimates

The estimated cost (in 2002) of interlinking rivers stands at Rs. 5,60,000 crores with an annual outlay over thirty-five years of Rs. 16,000 crores. Another estimate puts it close to 5,56,000 crores , out of which Rs. 3,30,000 crores is earmarked for linking the Himalayan rivers with the various peninsular rivers. The Central Government is estimated to need Rs. 20,000 crores a year to execute the project. Gujja (2003) estimates Rs. 5, 50,000 crores as the cost of completing what would be the largest civil engineering project ever in India. As a long term project, the actual inflation and potential cost increases during such a long span are anybody's guess. Long term planning and a sound financial simulation are required to meet the standard of due diligence for such proposals.

6. Issues and Concerns

6.1 Ecological issues

Major concern being the argument that rivers change their course in 70–100 years and once they are linked, future change of course can create huge practical problems for the project.(Shaw, 2003)

6.2 Environment

There is likely to be opposition to the ILR scheme from environmentalists. Views have been expressed that the ILR may cause environmental impacts much different from those caused by general water resources development projects. However, this eventuality will arise only if the scheme is not properly designed, constructed and managed. If properly executed, this proposal has the potential to significantly improve the ecosystem in the receiving basins without degrading the same in the donor basins. However, the project should be undertaken with full rec- ognition of the ecological damages that may be caused and that the benefits should far outweigh these costs.(Davies et al., n.d)

6.3 Impact of climate change

Analysis of measured hydro-meteorological data suggests that the climate of the earth may be undergoing significant long-term changes. For a water planner, the changes may manifest in altered spatial and temporal patterns of precipitation, evapotranspiration and stream flow. Such changes, if at all they take place, might adversely influence the reliability of the project. Some of the components may fail to perform up to the mark and others may become redundant.(Thomas et al., 2017)

According to the Intergovernmental Panel on Climate Change, the major impacts of global warming in temperate Asia will be large northward shifts of subtropical crop areas. Large increases in surface run-off leading to soil erosion and degradation, frequent waterlogging in the South, and spring droughts in the North will ultimately affect agricultural productivity.(Hernández-Ochoa & Asseng, 2018)

In monsoon Asia, the issue of sensitivity of physical and natural systems to the hydrological cycle is linked to major stresses caused by the projected climate change on agricultural production and increased exposure of social and economic systems to impacts of extreme events, in eluding forest die-back and increased fire risk; typhoons and tropical storms; floods and landslides, and human disease impacts. These stresses on physical systems translate into key social vulnerabilities, particularly in combination with unsustainable utilization of resources. For example, the excessive withdrawal of groundwater has in- creased the rate of sea-water intrusion near many major coastal cities of Asia.(Ray & Shaw, 2018). The ecological security of man-groves and coral reefs may be put at risk by climate change. Sea-level rise could cause large-scale inundation along the coastline and recession of flat, sandy beaches of South and Southeast Asia. Monsoons in tropical Asia could become more variable if ENSO events become stronger and more frequent in a warmer atmosphere.(Putra et al., 2019)

6.4 Excess water during monsoons

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 03, 2021

Sunita Narain of the Centre for Science and Environment says, Monsoons happen all over India at the same time. When there is excess water in the Brahmaputra, there'll be excess water in Ganga and Mahanadi too. Interlinking can cause storages to overflow and cause flooding.(Kale, 2003)

6.5 Aqua life

A number of leading environmentalists are of the opinion that the project could be an ecological disaster. There would be a decrease in downstream flows resulting in reduction of fresh water inflows into the seas seriously jeopardizing aquatic life. Even though arresting the river flow into sea to meet inland needs could be excused if the environmental degradation is avoided while designing and executing the storage and distribution facilities, we need to keep in mind the probable influence of such an exercise in the long run on the coastal and ocean ecosystems.(Yang et al., 2013) The upstream and downstream impacts of the river linkage project on the ecosystems and on the lives of the dependent communities need to be carefully studied and the project be designed accordingly.

6.6 Deforestation

Creation of canals would need large areas of land resulting in large scale deforestation in certain areas (Paiva, 1988).

6.7 Areas getting submerged

Possibility of new dams comes with the threat of large habitable or reserved land getting submerged under water. In summary, there are several concerns over the River Interlinking project in India, including ecological issues, environmental impacts, the effect of climate change, excess water during monsoons, impacts on aquatic life, and defore

6.8 Displacement of people

As large strips of land might have to be converted to canals, a considerable population living in these areas must need to be rehabilitated to new areas. Such rehabilitation is fraught with many problems, especially when tribal segments are involved. Any misunderstanding or absence of a proper mechanism in rebuilding new dwellings can lead to catastrophic results, and could be used by extremists in destabilizing peace and tranquility.(Jaysawal, 2013)

6.9 Global Resume

Even as India has been procrastinating, the rest of the world has gone about inter-basin water transfer (IBT) projects at a brisk pace during the past 50 years or so. Global and local opposition now withstanding. Elsewhere in the world many IBT projects have faced a variety of problems and produced some unwanted side effects; however, in overall terms, most have turned out to be beneficial. Even a wary global environmental review of IBTs - which advocates using precautionary principle, concluded that: "In many parts of the world, water transfers have become the lifeblood of developing and extant human settlements, for which no alternative is currently perceived to be available" (Davies et al., n.d).

CONCLUSION

India's ambitious River Interlinking project merits a cautious and comprehensive approach. Successful implementation of this project largely depends upon timely release of water from the surplus basin to the deficit basin. The problem of providing domestic water supplies in ar-eas away from the rivers will largely remain unsolved, even if the interlinking project is completed. Inter-linking of Rivers Project may not have much effect on improving the supply situations in the vast dry areas that are in the higher parts of the basins and away from the rivers to be interlinked, and therefore most critically water scarce areas will have to depend on local rain water.

Interlinking of Rivers alone will not solve water related problems of the country. Concepts such as water conservation, optimal regulation of existing facilities, rainwater harvesting, watershed management, water reuse etc. will continue to be highly relevant and this grand scheme will be an important supplement to these. A holistic view of the scenario is always important and necessary.

Interlinking of rivers projects is one of the major challenges and opportunities to address the water-related issues arising from drought, flooding, climate change and so on. The long-term solution to the water shortage problem is to make the interlinking of rivers challenges through the construction of dams, reservoirs, barrage, hydroelectric power structures and canals across the geographical areas of the country.

While Interlinking of Rivers is certainly a good solution to the shortage of water, it must be done after a thorough survey and detailed study to ensure that the interlinking process does not harm the environment and aquatic life.

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