A Scientific Analysis of the Justifications Extended for the Proposed Interlinking of Rivers in India

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The Background of Inter-basin Water Transfers

In the past few centuries there has been a great escalation in the global freshwater requirements while its per capita availability has declined drastically. Search for ways to overcome freshwater scarcities had been taken up by communities, national governments and international organisations. Heavy investments in engineering structures have opened the possibilities of withdrawing more and more water from the natural sources like lakes, rivers and the groundwater aquifers. More than half of all accessible global freshwater runoff is currently withdrawn for human uses. The consequence is that drastic reductions have taken place in the amount of water remaining instream causing degradation of the aquatic ecosystems and affecting negatively the various services provided by the ecosystems. The Nile in Egypt, the Ganges in South Asia, the Amu Darya and Syr Darya in Central Asia, the Yellow river in China, the Colorado river in North America, etc. are among the major watercourses whose flows have been obstructed and diverted – to such an extent that for parts of the year, little or none of their freshwater flow reaches the sea (Postel, 2000).

Transfer of water from one river basin to another has been practised as an exemplary engineering response for meeting the growing water requirements. Water resource engineering has traditionally been fixed on providing supply augmentations as the solutions, ignoring the 'soft' demand-side management options (Biswas, 1979). This has resulted in plans for several interregional water transfers (IWT) in many parts of the world. One of the earliest examples of IWT is found in Egypt where, in the Pharaonic era, engineering efforts had been made to moderate the flow of the river Nile. King Mina, a ruler of Egypt in the First Dynasty, had constructed large number of canals and bridges to carry the Nile water to lower lands (Abu-Zeid, 1983). Another example can be given from Japan, where water transfers have been in practice for over several hundred years. Though initially started on a small scale, primarily to serve the purpose of rice cultivation, the expansion and development of cities and industries in recent decades (especially after the World War II), forced Japan to take up large-scale IWT projects (Greer, 1983).

Several proposals for major inter-basin water transfers were made in the decade of the 1960s. A new generation of plans was put forward in North America in 1964, headlined by the much talked-about and grandiose North American Water and Power Alliance (NAWAPA) scheme. It included numerous plans for the distribution of water from areas with high precipitation in the North-Western part of North America to less water endowed areas of Canada, United States and Mexico (Biswas, 1978). The immensity of the plan stirred the imagination of many engineers and economists and within 5 years of NAWAPA being proposed, a whole series of IWT schemes was put forward for the redistribution of water of North America

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(Golubev and Biswas, 1978). Similarly, in the erstwhile Soviet Union new engineering proposals were put forward for large scale transfer of water from the more humid to the less humid regions of the continent (Micklin, 1977; *Soviet Geography*, 1972). Before the 1960s, the Soviet Union depended mostly on traditional irrigation techniques. The 'integrated method of development of desert lands' (Gujja and Shaik, 2004) exemplifies the immediate realisations of engineering capability created by the alterations of the natural flows in the rivers on a very large scale and its impact on economic growth. Golubev and Vasiliev (1978) have pointed out that, "Interregional water transfers are appealing because of the great amount of water produced, which drastically changes the water situation".

The same concepts of engineering generated the proposal for the South to North Water Transfer Project in China. The Yangtze basin, well-endowed with water, as well as other southern river basins benefiting from the ample summer monsoon precipitations, contribute about 80 percent of the total annual run-off in China. However, the water from these rivers are available to only 40 percent of the arable land. On the other hand, the drier regions in the North and North East of China, the Huang he (Yellow), the Huai he, the Hai he basins and the Northwest inland region together have more than half of the geographic area with 45 percent of the arable land and nearly 36 percent of the population. They, however, have direct access to only 12 percent of the water resources of the country (Gujja and Shaik, 2004). The Chinese Academy of Sciences conducted field investigations of the water transfer in the upper reaches of the Chang Jiang (Yangtze). When fully developed, the scheme has been proposed to divert 40-50 cu km of water per year from the Yangtze basin to the North China plain, alleviating water scarcity for 300–325 million people living in what even then would be a highly water-stressed region (Berkoff, 2003). In India too, projects such as the Periyar-Vaigai system, Indira Gandhi Canal and Telegu Ganga stand as classic examples of IWT. In the 1970s, Rao (1975) proposed the Ganga-Cauvery link canal that still guides the imagination of the governmental engineers in India, though this proposal did not find support for its being followed up.

Opposition to Large Inter-basin Transfers

Water requirements have traditionally been assessed by planners and developers on the basis of projections of population growth, irrigational needs, industrial production and the change in consumption patterns based on economic development. Engineering designs for projects were accordingly made to provide the appropriate supplies. However, over the past few decades, this traditional approach of engineering has been jolted and perceptible changes are taking place in the way water systems are being perceived or managed. Some of the projects undertaken earlier have started to be seen as sources of further problems, water systems management is seen to be facing a crisis. Need for a fundamental shift away from the present reductionist engineering paradigm to a holistic and interdisciplinary one has been recognized by many water management professionals. As Wolff and Gleick (2002:1) have noted, "The world is in the midst of a major transition in the way we think about – and manage - our vital and limited freshwater resources". Such a statement exemplifies fundamental changes that are taking place in water systems management (Postel, 1997; Reddy, 2002; Seckler, 1996).

As a result of such changes, a more cautious approach towards the design of the IWTs was observed during the 1970s. Subsequently, it led to the rethinking on some of the earlier plans for water transfers. For example, in North America itself, implementation of several projects had been abandoned, modified or at least slowed down. The change in the original proposal for the Texas Water System made in 1968, consisting of a large diversion from the Mississippi river into the state of Texas, is a clear indication of this new trend. The earlier plan for the Texas Water System has been modified so much that it now serves as a negative example of IWTs and inter basin transfers. The entire attention was focussed on narrow aspects of engineering and economics, while scant perfunctory attention was accorded to the associated ecological-economic aspects (Greer, 1983). What were the reasons for such a change in the professional view of IWT projects? Firstly, there were strong opposition to the transfer from the basins from which water is being taken out. Secondly, the economic feasibility of many such large transfers was not established in a convincing manner. Thirdly, and most importantly, the cumulative environmental impacts, that got little attention in the initial assessment of the feasibility of the projects, started to be conspicuous by their impacts over time. In short, the decade of 1970s was also the time when, “New approaches to complex river development were according greater recognition to its environmental limits and consequences” (White, 1977).

Availability of extra amount of water in water scarce areas generates great economic values. For the agrarian societies, water provides the road to prosperity. However, there are also negative economic, social and environmental impacts of large water projects. In the past, these have not been observed so conspicuously. With the passage of time, however, such factors start to become conspicuous and the doubts over their justifications and feasibility have led to intense policy debates. Shao and Wang (2003) suggest that, “Interbasin water transfer projects are prone to problems and controversies, and may challenge the established basin management, legal system and policy making procedure which are taken for granted until such projects are put under consideration.” Howe and Easter (1971) additionally caution that IWT projects are likely to prove expensive to nations, except under certain “rescue operation” type of cases (to replenish the groundwater, for instance). On the other hand, Wells (1971) pointing out the case of Texas Water Systems, notes that water imports to the high plains of Texas are not only economically feasible but also obligatory for the state. Such statements clearly point to the need for a comprehensive feasibility study and options assessment as decision support for large water projects.

The interconnections between the environmental and economic systems become more evident in the background of a widely acknowledged discernible shift in water resource sector from supply to demand side management (ADB, 1999). Hashimoto et al. (1982) have identified three criteria for evaluating the performance of water resources systems, viz., how likely a system is to fail (reliability), how quickly it recovers from failure (resilience) and how severe are the consequences of failure (vulnerability). It is suggested that these criteria assist in the evaluation and selection of alternative design and operating policies for a wide variety of water resource projects (Jain, Reddy and Chaube, 2005). The present period is a very dynamic one for conceptual development in water resource management, as a result the older ideas about IWT are getting replaced by newer ones. A great deal of new work is needed to establish a new paradigm and to provide a more penetrating and overarching policy framework.

The interlinking of rivers in India is being proposed in this important juncture when a shift in the paradigm of water resource management is taking place worldwide. In this background the proposal for such a heavy investment needs to be assessed in a very comprehensive and participatory manner.

The Proposed Interlinking of Rivers in India

The distribution of precipitation in India is characterised by wide spatial and temporal variations. This is a direct result of the domination of the Monsoon in the making of the weather of South Asia. While some parts of the region receive very large monsoon precipitation and rivers inundate wide areas in the floodplains, other parts receive much less precipitation and often face scarcity of water. On the basis of the public statements of the political leaders, the proposed Interlinking of Rivers (ILR) seems to be justified as the win-win solution to the dual problems of floods and droughts in the various parts of the country. In view of the fact that the proposal is billed as the largest engineering project in the world, such a proposal, which appears to offer a simple solution to a complex problem, need to be assessed with a high level of transparency and professionalism.

India occupies about 2.45 percent of the terrestrial surface and 72% of the geographical area of South Asia. When viewed in terms of precipitation per unit area of the land, the country receiving 4 percent of the total global precipitation, seems to be well above the global average. Nonetheless, with over 17 percent of the world's population living in the country, its position in terms of per capita water availability is seen to be quite difficult. The spatial and temporal variations in the precipitation lead to regional inequities in water availability in India (Figure 1). About 71 percent of the available water resources of India is localized in 36 percent of the geographical area of the country, primarily in the Ganges-Brahmaputra-Meghna basin and all the west flowing rivers from the Western Ghats.

Following the priority given to irrigation in the official policy, and the availability of the green revolution packages, the demand on the country's water resources from the irrigation sector has substantially grown. Irrigation potential has grown from about 22 Mha during the early 1950s to about 105 Mha by the turn of the century. For both agriculture and industry, every additional volume of water opens up scope for increased financial return. In many parts of the country, the greater purchasing power of the industry has caused either overexploitation of groundwater resources or diversion of water from sources traditionally used for irrigation. These conflicting demands for transfer of water from various regions for the provisioning of domestic supplies, for promoting commercial agriculture or industries have started becoming potential basis for intense conflicts over the available resources.

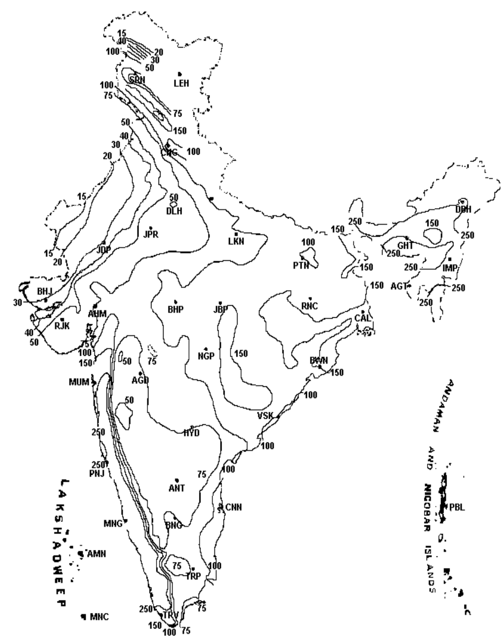

Figure 1: Spatial Variation in Precipitation Pattern over the Country
Source:http://www.imd.ernet.in/section/climate/annual-rainfall.htm

About a century ago, mainly for improving navigational access, proposals for several interlinking canals were made by Arthur Cotton. With the availability of greater engineering capabilities, the idea of transferring large quantities of water from river basins with higher rainfall to the drier basins with the objective of irrigation started to encourage policy makers to think on IWTs. In this line, Rao (1975) proposed three link canals between Brahmaputra and Ganga, between Ganga and Cauvery, and between Narmada and parts of Rajasthan with the purpose of transferring water to the drier areas in southern and western India. Such a proposal was not favoured by the Central Water Commission of India on various grounds, including the cost.

The main idea of transferring water from the Ganga-Brahmaputra river system to the less water endowed areas in southern and western parts of India by linking canals, nevertheless, remained alive in the minds of the officials in India's Ministry of Water Resource and the Central Water Commission. With the formation of National Water Development Agency (NWDA) in 1982, it got into circulation again. The NWDA was, subsequently, entrusted with the task of developing plans for inter-basin transfers of water to examine the possible storage sites and interconnecting links in details. After detailed studies, it proposed 30 links in the Himalayan and Peninsular components which are now important parts of the recent proposal for ILR in the country (TFILR, 2003). The justification presented for the proposed ILR by the TFILR (2003:22) is based on addressing three types of need:

1. The paramount need for national self-sufficiency in food and energy with sustainability
2. The need for regional equity in regard to poverty alleviation and means of livelihood for the rural agricultural based population in low rainfall areas
3. The need for promoting greater cooperation amongst the States in management of interstate river systems, thus avoiding water disputes, which have held up development or caused ill will amongst them.

Assessment of the Justifications for the Proposed ILR

The proposal for ILR in India has been widely publicised since October 2002. However, what is available in the public domain does not contain any technical information on the project, like those on the various storage dams and link canals that are being proposed. In the absence of open technical information on the project, any serious professional assessment of the justifications for it cannot be made. Nevertheless, on the basis of the available information, Bandyopadhyay and Perveen (2004) and Iyer (2003a) have drawn attention to why an open professional review of the proposed ILR is very much needed. After years of repeated public demand from many professional quarters to the Ministry of Water Resources, some details of only one link, the Ken-Betwa link, has recently been put up in the public domain. The National Civil Society Committee on Interlinking of Rivers (NCSCILR) has arranged for a review of the Feasibility Report for this proposed link, which indicates that there are major professional gaps in such official documents. In addition, significant questions have been raised by many on the conceptual framework, justifications and options assessment, as given in favour of the proposal (Iyer, 2004, Vaidyanathan, 2003). Proper study of these critical comments and transparency in addressing them is of utmost importance. Otherwise, the poor people will be investing in the world's largest construction project, which may only benefit politicians and contractors.

Conceptual Gaps in the Proposed ILR

The main conceptual framework that is used to design the proposed ILR is based on an identification of the various river basins of India under broad categories of surplus, marginally surplus, marginally deficit and deficit. Though the World Water Assessment Program (WWAP, 2001) describes 'water scarcity' as "the condition of insufficient water of satisfactory quality and quantity to meet human and environmental needs", no clear and peer-accepted methodology for classification of river basins as naturally 'surplus' or 'deficit' is available in the scientific literature on water resource. The Available Water Resources (AWR) per capita consequently measured the ratio of the renewable water in the hydrological cycle to the number of people (Falkenmark et al. 1989; Gleick, 2000). But the term 'renewable water' was later replaced with 'water withdrawals' since it was felt renewable water might also include floods and more generally all the renewable water resources, which are not controlled. Water withdrawals referred to the total amount of water diverted/abstracted from the natural water systems (Raskin et al. 1997). This concept was further refined when the hydrologists found it important to distinguish between 'water withdrawals' and 'water use'. Defined as the amount of water physically removed, water withdrawal as a concept is less useful in a discussion of limits on the total amount of water, since much of the withdrawn water is later returned to the water cycle (IWMI, 2000:24). Seckler et al. (1998) have pointed out that half of the diverted water in some basins returns to the river and goes to the sea; in others, no more than 5 percent of the total runoff reaches the downstream end of the basin. 'Water use' was consequently considered a more useful measure of water consumption (Molle and Mollinga, 2003).

Adopting a slightly different approach for analysis, Salameh (2000) has focused on the amount of water needed for domestic needs and for the demand of food production in relation to population size. However, while the indicator does provide a useful means of estimating water stress in relation to food self-sufficiency, the focus on food/population ratio does not yet consider environmental needs. It also disregards the concept of virtual water – the latter adjusting domestic shortfalls in water against the virtual water in food imports (Postel, 1999:130; Allan, 2002). Feitelson and Chenoweth (2002) however, take the view that the provision of water for domestic use as well as environmental services has been considered.

The above review makes it clear that deficiency in water supply or 'scarcity' is not just a natural phenomenon. It is also dependent largely on the indicators we use to assess them, the nature of demand in a particular basin, social customs and institutions and government policies. Any measure to manage demand for water can therefore be truly effective if they are based upon an understanding of the water demand situation in a region — that is, where water is going, where it is being lost, where savings can be made (or maximized) and the attitudes of water users. The intrinsic variability in water endowment rules out any possibility for making a straightforward assessment of a river basin as 'surplus' or 'deficit'. If such an arithmetic view is nonetheless followed, as probably is the case for the proposed ILR, it would be presupposing an unhindered mobility of water within the geographical area of the basins with uniform access (Bandyopadhay, 2004). With such a simplistic methodological approach to the proposed ILR, it is very likely that serious differences of opinion between a recipient and the donor basin may erupt on whether the basin is so called 'surplus' and water can be transferred away from it without causing harm to the downstream areas or its future uses. This has already started to be the case for the Mahanadi.

The assessment and approval of water projects in India have traditionally been based on consideration of the direct cost of construction and operation of the engineering structures. The intrinsic social, economic and environmental costs therefore, become a *sine qua non* for a more informed decision making. The incompleteness of such practices invariably generated popular discontents and has brought considerable public disgrace for large water-related projects. With the recent advances in scientific knowledge on water systems and in ecological economics, assessment of the environmental impacts of water diversion projects has become somewhat possible. When environmental flows and ecosystem services offered by water systems are brought under consideration, fundamental alterations in the framework for policy making on large water projects could take place.

On the basis of the very general description of the proposal for ILR as available in the public domain, it is not possible to undertake any detailed professional assessment of its technical dimension. What can be undertaken however is an assessment of the justifications and examination of other options available for addressing the same objectives. This section examines the important justifications, on which the very costly proposal for interlinking of the rivers in India is being put forward. In this background, the following conceptual questions are raised and analysed:

Can the ILR control floods in high rainfall areas and provide domestic water security in the water scarce areas?

Does India's food security depend on irrigation from the proposed ILR?

Is there a comprehensive knowledge base for the Himalayan component?

ILR vis-à-vis control of floods and water supply in scarcity areas

Secured supply of the domestic water needs is a basic human right and should receive the top priority in policy. For this, water may be transferred across river basins at all costs. In terms of quantity, the domestic requirements are small and transferring such quantities across basins will not be costly. In the official assessment of total water requirements in India, the high priority for domestic supplies gets lost with the clubbing together of the water requirements of industry and agriculture. Water demands from the irrigation and industry sectors have a lower priority and should be treated separately. In order to have an assessment of the feasibility of domestic supplies, the status of water availability and domestic requirements in specific river basins or watersheds is needed. This data is not available over the various parts of the country.

Nigam et al. (1997) had undertaken water availability studies in a few water scarce areas of India and their study made it clear that if the precipitation available within the concerned watersheds or sub-basins is harvested and conserved properly, supply of domestic water needs would not pose a serious problem in most parts of the country. For promoting domestic water security in the drier areas of India, local level water harvesting and conservation has been a proven technology. It is a cheap and socially acceptable technological option even today when compared with large storage and long distance diversion facilities, which often carry high financial, social and ecological costs (WCD, 2000). This observation is completely in consonance with the results of numerous community initiatives for water harvesting in India, whether in Maharashtra, Gujarat, Rajasthan, Tamil Nadu, Uttaranchal or anywhere else in the country (Agarwal et al. 2001).

A scientific understanding of scarcity gets further compounded in India by the tendency among politicians to somehow get their electoral areas declared as affected by 'natural disasters' like 'droughts' or 'floods'. Due to the monsoon and dry season cycles, periods of water stress and regular inundations can be expected as natural events in different parts of India (Bandyopadhyay, 1989) and agricultural practices had evolved with concerns for protection against such extreme events. Moreover, there are many other human induced reasons for water scarcity occurring in an area, including unsustainable use of groundwater and land management practices. The distinctions of diverse forms of drought get reconfirmed by Kelkar (*Businessworld,* 2001), when he warns that: "If the rainfall over a given region is more than 25% below normal, meteorologists call it a drought. However, this does not always bring out the true picture since crops could still survive if they get enough rain at the critical growth stages. On the other hand, a statistically normal rainfall but with a few spells of very heavy rain interspersed with long dry spells can cause agricultural drought as opposed to a meteorological drought."

An impression has got created that if the proposed ILR is achieved, it will bring an end to all the problems of water scarcity in the water scarce parts of India. People have started to believe that there is 'enough' water in the 'surplus' river basins to cater to all the needs of all the people in the water scarce regions. Whether this is a credible position or not is another matter, but the idea has attracted a great deal of public attention in the drier parts of India. The result has been a general lack of interest of the people in taking up local initiatives for harvesting and conservation of local rainwater. Among these people, the impression is taking root that there is no need to do anything locally except supporting this mega-project of ILR. The rest will be done by the government, the donors, the engineers and the contractors. Such impressions negate the reality of water security in the drier areas extended by many local level non-governmental initiatives. Pointing out to the need for looking beyond the grandiose proposal only, Verghese (2003) wrote that: "The interlinking project is not a single stand-alone panacea for the country's water problems but the apex of a progression of integrated micro to mega measures in an overall but unarticulated national water strategy."

There is another question that has been raised on the physical ability of the proposed ILR to address the issue of domestic water security in all the drier areas of India. A look at the map of the link canals will show that the main north-south link is proposed along the east coast of the country, while the main east-west link connects eastern Uttaranchal with Saurashtra, across Rajasthan. Some smaller proposed links get scattered in other parts of the country. A scrutiny of the map will surely raise the question — what can the proposed ILR do to offer to the vast water scarce rural areas in the central and south-central parts of the country? Domestic water supply in these dry and relatively upland areas will have to depend on local-level harvesting and promotion of greater recharge of groundwater from local precipitation.

Further, in the case of the coastal areas, all the way from the Sunderbans in the east down to Kanyakumari to the Kutchh in the west, the technology of coastal water supply through desalination will prove to be a cheaper and more dependable technological option for domestic supplies than ILR. Large cities near the coast, like London, have already made massive plans for future water supply based on this technology. As it stands, there is no clear case made for the role of the proposed ILR in providing domestic water security in either the coastal areas or the heartland of India, because cheaper and more dependable technological options are clearly available. Large inland urban areas and industrial towns would, nevertheless, need a lot of water for domestic supplies. For addressing such requirements, a clear national plan, that keeps inter-basin transfers as a possible option, is needed. However, priorities of such proposals for domestic supplies should not be mixed up with the demands from the irrigation and industry sectors since such utilizations have lower priority than domestic supplies.

Food security and ILR

During the 1960s when India was facing serious problems with food self-sufficiency, the package of green revolution technologies of high yielding varieties of seeds, fertilizers, pesticides and irrigation helped the country immensely in enhancing the production of food. The irrigation potential created in the country has grown in the last 50 years from 22.6 Mha to 106.6 Mha, an increase of about 500 percent. India has the largest irrigation network and second largest arable area in the world. According to the available projections, the population in India will continue to grow for a few decades.

Satisfaction of the paramount need for national self-sufficiency in food and energy with sustainability has been shown as a very strong reason for the proposed ILR. Food self-sufficiency is a very important and sensitive factor and makes a politically attractive justification for any investment. Assessment of future food grain requirement can be made from per capita consumption and the population. Per capita food grains production has been a common indicator of food security. Recent agricultural statistics reveal that with improvements in farming technologies and plant genetics, India has achieved a record food grain production of 211.32 million tonnes in 2001-2, which is 15.40 million tonnes more than that of the previous year (MOA, 2003). Between 1950 and 2000 annual cereal production per capita rose from 121.5 to 191.0 kg (Hanchate and Dyson, 2004:229).

Based on population projections, socio-economic and demographic changes and assumed changes in the pattern of food consumption, several projections for future food grain productions have been made. The NCIWRDP had estimated the total food grain demand for 2010, 2026 and 2050 at high and low growth rates. These projections were made on the basis of an unpublished work of Ravi (1998), probably based on income-demand elasticity. According to the estimates of the NCIWRDP, the food grain demand for India (direct and indirect) for 2010 under the low and high demand scenario have been shown as 245 and 247 million tons. Hanchate and Dyson (2004:241) in a systematic review of the past work say that: "…this analysis suggests that in 2026 direct cereal demand will be roughly 220 mmt, with another 30 mmt being needed for other uses, giving a 'ball- park' total of 250 mmt"

The TFILR has, however, projected that "considering both internal consumption and exports the country has to plan for 550 million tonnes of foodgrain production by 2050 AD". It is necessary to examine the validity of this figure of 550 MT of foodgrain requirement. The drastic increase in the declared food production target conflicts with the field level data like those of the National Sample Survey (NSS). According to the Asian Productivity Organisation (APO, 1996) for India, "in the last 20 years, there have been no significant changes in average daily food consumption." In this way, the estimates of food requirement by the NCIWRDP for 2010, is similar to what is projected for 2026 by Hanchate and Dyson (2004).

It is quite relevant to point out that the basis for such a drastic increase in the annual food grain requirement is probably rooted less in reality and more in two factors. First, a mechanical calculation is based on income demand elasticity for estimating future food grain demands. Hanchate and Dyson (2004:233-5) does not indicate any large changes as projected above: "According to the NSS annual consumption of all cereals combined fell from 175 kg per person during 1972-3 to about 147 kg during 1999-2000. The FBS (FAO) figures, however, suggest that consumption rose slightly from around 153 kg in 1972-3 to about 157 kg in 1993-4, before increasing to 164 kg in 1999-2000……The NSS data on per capita food consumption underpin the projections because they provide the only state level figures."

While projecting cereal demand for India in 2026, Hanchate and Dyson (2004:237) accept that: "Accordingly, here we have simply assumed that for the rural and urban populations of each state, levels of per capita consumption will remain constant, as in 1993-4. For all India, this corresponds to annual consumption of 154 kg per person – a figure which is almost identical to the average of the NSS and FBS estimates for 1999-2000. ”

The second factor for the very inflated target figure of 550 MT comes from the linking of agricultural exports with the internal food grain requirements as is clear from the TFILR (2003:11) statement below:

“Attempts, therefore, need to be made not only to be satisfied with producing enough to eat, but the strategy needs to be to produce surpluses for export to achieve a commanding position. Therefore, considering both internal consumption and exports, the country has to plan for 550 million tonnes of food grain production by 2050 AD.”

Indeed, the above position of the TFILR puts the scenario for water management in exactly the opposite setting to what existed in India in the 1960s. At that time, the country did not have enough food in stock and was on the verge of importing food grains. International trade was without a framework like the WTO. The present food grain scenario in India is quite different. There is a large buffer stock of food grains in India and exports, not imports of agricultural products are envisaged in the coming decades. International trade is in a vastly different stage, with the WTO in place. In between the lines, the proposal starts to get more clearly connected with the growth of export oriented farming and water intensive industries in the drier parts of the country, which is being threatened by the present scarcities. It is indeed good to promote new forms of farming and industries. However, the question is whether there is any great justification for India making such a heavy public investment of funds and opportunities, for the promotion of a few big farmers, agro-companies or industries to earn dollars or euros. Investments in providing water for export oriented farming or industries need to be seen in the context of the investors getting a share in the profit of such activities. There is nothing wrong in economic development based on the export market, as long as the people are fully informed. Economic development needs to be shared among all the stakeholders and not be enjoyed by one group at the cost of sacrifices made by many others, especially with respect to involuntary displacement and rehabilitation. The past records of widespread displacement and unsatisfactory rehabilitation related to large water resource projects in India make it a necessary step before decision making.

Food self-sufficiency through improvement in yields

One important factor related to the total food production is indeed the yield. Mechanical expansion of irrigated areas is only one factor for increasing the total agricultural production. In spite of the availability of good water and land, the yield in our agriculture stands at quite a low level when compared with other countries of the world. Options for improvement in the yield under these conditions offers an alternative to the mechanical expansion of irrigation potential. This may be elaborated with the example of China, which faces challenges similar to India in terms of population and food production and has a larger population to feed with much less arable land, the yield levels are almost double of that of India. As Swaminathan (1999:73) has pointed out, China produces 13 percent more food grains per capita than India. Data from the FAO (CWC, 1998:223-4) indicates that while the cereal yield for India stood at 2134 Kg per ha in 1995, the same for China was 4664 Kg per ha (Figure 2).

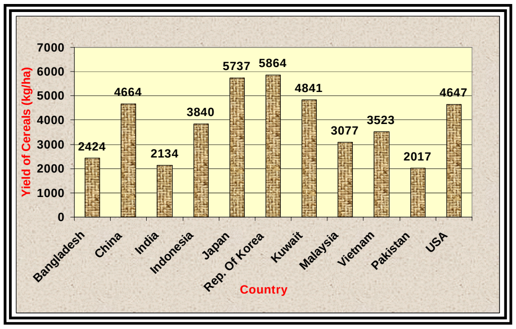

Figure 2: Country Wise Yield of Cereals (in Kg/Ha) (Source: *Water and Related Statistics* (New Delhi, Central Water Commission) 1998]

As far as agricultural science in India is concerned, great technological breakthroughs that can push agricultural productivity very much upwards in the coming years already exist. The NCIWRDP (1999a:57) has pointed out that the yield of wheat in experimental farms in India has already exceeded 6000 kg per hectare. If a level of yield somewhere close to this is achieved even after half a century, food self-sufficiency without the ILR will not be a problem.

This has been the view of many experts on inter-basin transfers, like Bharat Singh (2003), who take the view that India is "already producing enough food; production can be further increased by at least 25 percent from existing irrigated area itself by improved inputs and agricultural technology." Similarly, in the rain fed land, NCIWRDP has projected that the food crop yield is expected to grow from the present 1000 kg per ha to 1500 kg per ha only in half a century. However,. Carruthers and Morrison (1994) reiterate this view, when they say that: "We do not anticipate or call for an increased rate of capital intensive investment in irrigation infrastructure but we do need to see that more is achieved with what is presently developed."

It is important to note that China, with only half as much arable land per capita as India, today is not thinking in terms of drastically increasing the volume of water in agriculture but increasing the water use efficiency in the existing irrigated areas. Wang (2002:15,110), the Water Resource Minister of China, writes that: "Irrigation is no longer 'watering the land' but supplying water for growth of crops ...At present, the average agricultural water use efficiency is 0.43 in China. If water saving irrigation is extended to raise the figure up to 0.55 (some experts consider 0.6), food security can be guaranteed when the population increases to 1.6 billion in 2030 without increase of total agricultural water use."

In the case of India, blessed with more arable land and more irrigation potential, while similar figures for the improvement in the efficiency of the use of irrigation water (from 0.35 at present to 0.60 in 2050) have been projected on paper (NCIWRDP, 1999a:58), there is no clear policy perspective for achieving higher water use efficiency and reach the declared targets. The lack of interest in end-use efficiency in irrigation will push the farmers to the soft but costly solution offered by the interlinking of rivers. Swaminathan (1999:93) has thus cautioned that: "The inefficient and negligent use of water in agriculture is one of the most serious barriers to sustainable expansion of agricultural production. Public policy regarding the cost of water supplied by major irrigation projects and low-cost or free distribution of power for pumping underground water aggravate the problem……Water consumption can be reduced radically, by as much as five-to-ten fold, at the same time as significantly increasing crop yields."

Vaidyanathan (2003), who has examined the methodology and estimates in the NCIWRDP Report, questions the very concept of this efficiency underlying the measures. He says that: "The present available efficiency of surface irrigation, according to the figures cited in the report, ranges between 30 and 50 percent…….The concept of efficiency not being specified, their relation to projections cannot be verified without comparable estimates of current and future water balances and irrigation efficiencies overall for the two major sources separately.” The World Bank Irrigation Sector Report on India takes a similar view on irrigation and takes the position that "from the past heavy emphasis on physical expansion, effort now needs to turn to a much greater emphasis on productivity enhancement" (World Bank, 1999:11). It is clear that the further physical expansion of irrigation is neither needed nor is it the most cost-effective option for maintaining India’s food security.

There is another side to all this. The proposed ILR, if implemented, would nevertheless transfer a significant amount of additional water to the drier areas, at great public expense. The question arises about what will be the use of this water. The better options are related to more fundamental changes in agriculture by addressing many other factors, in particular those of sustainability. Otherwise, as Postel (1999) has cautioned: “It is not enough to meet a short-term goal of feeding the global population. If we do so by consuming so much land and water that ecosystems cease to function, we will have, not a claim to victory, but a recipe for economic and social decline.”

The above analysis makes it clear that there is really no convincing link of the proposed ILR with the production of food that will ensure food self-sufficiency. The more likely object is to use the diverted water for the growing water intensive commercial crops in the dry areas, particularly for export oriented production by agro-business companies or big farmers and for the industries. Under such conditions, the question will emerge whether the case is fit for the application of the Land Acquisition Act 1984. However, unless the proposal is openly assessed on the question - what is the urgent need for transferring such large quantities of water to the drier areas, the political stunt associated with the word ‘food-self-sufficiency’ may overtake scientific decision making.

Is there a Comprehensive Knowledge Base for the Himalayan Component?

In the whole country, the Himalayan river system of Ganga-Brahmaputra alone has a very large share of the country’s water availability. Though the proposed ILR has two separate components, one Himalayan, and the other Peninsular, in terms of the availability of water, the potential of the Peninsular rivers is quite small. Mohile has noted that “Among the Peninsular rivers, Mahanadi and Godavari are considered to have sizeable surplus ….The proposal of Peninsular river development will enable additional use of about 84 Cu km of water to benefit the states of Orissa, Andhra Pradesh, Madhya Pradesh etc.”

However, whether there is any such ‘surplus’ water in Mahanadi or Godavari, has become an object of debate among the states involved. Since in the available knowledge on the proposed ILR no detailed technical data on what is going to be transferred, from where, to where and at what point of time, etc. are made available in the public domain, only an intelligent guess may be taken recourse to in this regard. Such a guess is that the proposed interlinking of rivers will not have any significant water transfer capability without using the so called ‘surplus’ water in the Himalayan rivers of Brahmaputra and Ganga. Only the ‘Himalayan Component’ of the ILR can make available good amounts of water and the ‘Peninsular Component’ by itself, offers very little.

The idea of transferring water from the two Himalayan rivers of Ganga and Brahmaputra is quite old. The engineering interventions of embankments and dams on the various Himalayan rivers, in both Nepal and India, are seen as parts of proposed ILR and a great problem lies here. In spite of a good amount of research work published on the very complex nature of the ecology of these

Himalayan rivers (Ives and Messerli, 1989; Bandyopadhyay and Gyawali, 1994), official policies and decisions on these rivers are still being guided by the mechanical and traditional view (Blaikie and Muldavin, 2004). A very important gap in the present knowledge is the uncertainty on the sediment dynamics (Vance et al. 2003) of such river basins (Vance et al., 2003; Bruijnzeel, 2004). However, based on the traditional and reductionist engineering and inspite of the great gap in scientific knowledge on the ecology of the Himalayan rivers, several dams have already been planned on the various tributaries to the Ganga, while more recently, attention of the governmental engineers have been focussed on the various tributaries of the Brahmaputra. Decisions concerning rivers are seldom taken in India in consultation with specialists in hydrography. Engineers most often produce what the men in power ask them to do.

Owing to the official confidentiality imposed on the hydrological data on the Himalayan rivers, the technical and economic feasibility of these projects, in all probability, will not see any open professional scrutiny. The National Commission for Integrated Water Resource Development Plan (NCIWRDP, 1999:370) observed that "the secrecy maintained about water resources data for some of the basins is not only highly detrimental but is also counter-productive. Hydrological data of all the basins need to be made available to the public on demand.

From the various documents that are open, it is clear that the ecological complexity and the geomorphological peculiarities of the Ganga-Brahmaputra river system have not received the due attention. The potential for earthquakes at the plate boundary all along the Himalayan foothills is well known and widely accepted (Khattri, 1987). Verticality and the fragility of the seismicity-prone foothills of the Himalaya will subject these structures to high level risk of instability. Unfortunately, the knowledge-base required for making professionally comprehensive assessment of such projects is in a state of infancy. To any professional informed of the complexity of the eco-hydrology of the Himalayan rivers, it is well known that systematic knowledge needed for making credible impact assessment of the proposed dams and canals would need extensive field observations spread over decades. In that background, the period of 12 years given by the Supreme Court (SC) as the time limit for the completion of the proposed interlinking may be followed only at the cost of science. When, at a later date, such a comprehensive knowledge base becomes available in an open and professional manner, several of the proposed projects may prove to be technically and economically unfeasible. Recognising the seriousness of the gaps in the knowledge about the Himalayan rivers, the NCIWRDP (1999a:187-8) took the wise view that "The Himalayan component would require more detailed study using systems analysis techniques. Actual implementation is unlikely to be undertaken in the immediate coming decades."

As an example of the great need for filling this knowledge gap, one can consider the common belief (and justification in the public mind) that the proposed ILR will be able to 'control' floods in the Himalayan rivers. Floods in the Himalayan foothills and the adjoining plains are the result of an enormously intense monsoon precipitation and the complex ecological processes associated with its movement downstream. The flows in these rivers have a very large peak to lean ratio and regular inundation of the floodplain during the monsoon period is an obviously expected natural event. But in these areas a false belief is circulated that embankments would protect the floodplains from being inundated. This has encouraged the people to invade the floodplains in large numbers. Politicians are unable to reverse the trend even if they wish to do so. Engineers are unwilling to make the bitter scientific truths clear to the politicians. Thus, in tune with the politicians, the traditional and reductionist engineering makes claims that the embankments and dams are needed to control floods in the Himalayan rivers. Such claims are not new, and continue to be made over decades in spite of a great deal of research to the contrary and open examples of failures (Mishra, 2003). It is thus clear, that an adequate knowledge base does not exist on the basis of which the Himalayan Component of the ILR can be addressed to. Furthermore, the process of the generation of new interdisciplinary knowledge base is seriously restricted by the confidentiality of data. What first needs to be done is the making of the knowledge base, rather than executing engineering projects with traditional and largely outdated common sense knowledge.

Conclusions

The proposal for the ILR has been in public circulation for quite a few years. The feasibility of the project has not yet been publicly established by an open scientific process. The main element of the ILR is the transfer of water from the Brahmaputra to the Ganga above Farakka, and onwards up to Tamil Nadu in the South and Gujarat in the west. There are no documents that openly establish the economic, social and environmental justifiability of the proposal for ILR. Critical hydrological data remain unavailable or inaccessible due to official confidentiality. The justifications and presumed benefits of the ILR proposal are being circulated without documentary basis, though they continue to excite the power-crazy politicians as much as the uninformed people. The present analysis establishes the inherent need for introspectively revisiting the whole conceptual basis for the proposed ILR and the nature of the use of the transferred water. *This article stresses that in hydrological science there is no differentiation of river basins as 'surplus' or 'deficit'.* Through an analysis of whatever is available in the open, this article questions whether (a) the ILR can control floods in high rainfall areas and provide water security in the water scarce areas of India, (b) India's food self-sufficiency depends on irrigation from the proposed ILR, and (c) a comprehensive knowledge base for the Himalayan component is available.

The official documents are not found to be able to convincingly answer any of these questions in the affirmative. We therefore conclude that unless the proposed ILR is discussed in all details with all the stakeholders, the wisdom of going ahead with the proposal, in parts or as a whole, will remain questionable.

References:

Abu-Zeid, M. (1983) 'The river Nile: main water transfer projects in Egypt and impacts on Egyptian agriculture' in Biswas, A.K et al (Eds) (1983) *Long-Distance Water Transfer - A Chinese Case Study and International Experiences* (Dublin, International Publishing)

Agarwal, A., S. Narain and I. Khurana (2001) *Making Water Everybody's Business: Practice and Policy of Water Harvesting* (New Delhi, Centre for Science and Environment).

Alcamo, J., T. Henrichs and T. Rosch (2000) 'World Water in 2025: Global Modeling and Scenario Analysis' in F. Rijsberman (Eds) *World Water Scenarios Analyses* (London: Earthscan)

Allan, J. A. (2002) 'Water resources in semi-arid regions: Real deficits and economically invisible and politically silent solutions' in A. Turton, and R. Henwood (Eds.) *Hydropolitics in the Developing World: a Southern African Perspective* (Pretoria: African Water Issues Research Unit)

Anon (2003) 'Sustainable Development in a Dynamic World: Transforming Institutions, Growth and Quality of Life' *World Development Report* (New York: World Bank and OUP).

Anon (2002) 'National Water Policy' (New Delhi, Ministry of Water Resources)

Anon (2000) *Water in the 21st Century* www.adb.org/Documents/Reports/Water/default.asp)

Bandyopadhyay, J. (2002) 'A critical look at the Report of the World Commission on Dams in the context of the debate on large dams on the Himalayan rivers' *International Journal of Water Resource Development* 18(1):127-45 March

Bandyopadhyay, J. (2004) 'Adoption of a New and Holistic Paradigm is a Pre-condition for Integrated Water Management in India' in G. N. Saha (ed) *Water Security and Management of Water Resources* (Kolkata: National Atlas and Thematic Mapping Organisation, Government of India)

Bandyopadhyay, J. and B. Mallik (2003) 'Ecology and Economics in Sustainable Water Resource Development in India' in K. Chopra, C H Hanumantha Rao and R. Sengupta (Eds) *Water: Resources, Sustainable Livelihoods and Eco-Systems Services* (New Delhi, Concept Publishing)

Bandyopadhyay, J. and D. Gyawali (1994/95) 'Himalayan Water Resources: Ecological and Political Aspects of Management' *Mountain Research and Development* 14 (1):1-24

Bandyopadhyay, J. and S. Perveen (2004) 'Interlinking of Rivers in India: Assessing the Justifications' *Economic and Political Weekly* 39(50):5307-16

Bandyopadhyay, S. and M. K. Bandyopadhyay (1996) 'Retrogration of the Western Ganga-Brahmaputra Delta (India and Bangladesh): Possible Reasons' *National Geographer* 31(1-2):105-128.

Bauer, C. J. (1997) 'Bringing Water Markets Down to Earth: The Political Economy of Water Rights in Chile, 1976-95' *World Development* 25(5): 639-656.

Berkoff, J. (2003) 'China: The South-North Water Transfer Project - is it justified?' *Water Policy* 5(1):1-28

Bhushan, P. (2003) 'The River Linkages Payoff' available online (http://indiatogether.org/2003/jun/opi-rivers.htm)

Biswas, A. K. (1978) 'North American Water Transfers: An Overview' *Interegional Water Transfers: Problems and Prospects* Vol. 6 (Oxford: Pergamon Press)

Biswas, M. R. (1979) *Agriculture and Environment* Technical Memoir No. 3 (New Delhi, International Commission on Irrigation and Drainage), pp. 225-255

Blaikie, P. M. and J. S. S. Muldavin 'Upstream, downstream, China, India: the Politics of Environment in the Himalayan Region' *Annals of the Americal Association of Geographers* 94(3):520-548

Bruijnzeel, L. A. (2004) 'Hydrological function of tropical forests: not seeing the soil for the trees?' *Agriculture, Ecosystem and Environment* 104:185-228.

Chalise, S. R. and N. R. Khanal (1996) *Extended Abstracts: International Conference on Ecohydrology of High Mountain Areas* (Kathmandu:ICIMOD)

Chitale, M. A. (1995) 'Institutional Characteristics for International Cooperation in Water Resources' in *Water Resources Development* 11(2):113-123

Cosgrove, W. and F. R. Rijsberman (2000) *World Water Vision: Making Water Everybody's Business* (London: Earthscan)

Dunbar M.J and M. C. Acreman (2001) 'Applied hydro-ecological science for the twenty-first century' in M. C. Acreman (Ed.) *Hydro-ecology: linking hydrology and aquatic ecology* IAHS No. 266, (Wallingford: IAHS Press, Centre for Ecology and Hydrology),162 pp.

Falkenmark, M.; J. Lundqvist and C. Widstrand (1989) 'Macro-scale water scarcity requires micro-scale approaches: Aspects of vulnerability in semi-arid development' *Natural Resources Forum* Nov: 258-267

Falkenmark, M. and J. Lundqvist, (1995) 'Looming water crisis: new approaches are inevitable' in L. Ohlsson (Ed) *Hydropolitics* (London: Zed Books) pp. 178 -212

Feitelson, E. and J. Chenoweth (2002) 'Water poverty: Towards a meaningful indicator' *Water Policy,* 4(3):263-281

Fisher, F. M. (1995) 'The Economics of Water Dispute Resolution, Project Evaluation and Management: An Application to the Middle East' in *Water Resources Development* 11(2):377-390

Gaur, V. K. (ed.) (1993) *Earthquake Hazard and Large Dams in the Himalaya* (New Delhi: Indian National Trust for Art and Cultural Heritage).

GEF (1995) *Scope and Preliminary Operational Strategy for International Waters* (Washington DC: Global Environment Facility) pp. 1-3

Gleick, P. H. (2000) *The World's Water 2000-2001: The Biennial Report on Freshwater Resources* (Washington DC: Island Press)

Golubev, G. and A. K. Biswas (1978) 'Interregional Water Transfers' in *Interegional Water Transfers: Problems and Prospects* Vol. 6 (Oxford: Pergamon Press)

Golubev, G. and O. Vasiliev (1978) 'Interegional Water Transfers as an Interdisciplinary Problem' in Biswas, A.K et al (Eds) (1983) *Long-Distance Water Transfer - A Chinese Case Study and International Experiences* (UNU: Tycooly)

Greer, R. (1983) 'The Texas water system: implications for environmental assessment in planning for interbasin water transfers' in Biswas, A.K et al (Eds) (1983) *Long-Distance Water Transfer - A Chinese Case Study and International Experiences* (UNU: Tycooly)

Gujja, B. and H. Shaik (2004) 'Linking of Rivers: Lessons from the Past' in M. Patkar (Ed.) *River Linking: A Millennium Folly?* (Mumbai: NAPM)

Haddad, Brent M (2000) *Rivers of Gold: Designing Markets to Allocate Water in California* (Washington DC: Island Press)

Hanchate, A. and T. Dyson (2004) 'Prospects for Food Demand and Supply' in Dyson, T., R. Cassen and L. Visaria (Eds.) *Twenty-first Century India: Population, Economy, Human Development and the Environment* (New Delhi: OUP)

Helming, S. and J. Kuylenstierna (2001) 'Water–A Key to Sustainable Development' Issue paper for the International Conference on Freshwater, Bonn, 03-07 Dec.

Homer-Dixon, T. (1994) 'Environmental scarcities and violent conflict' *International Security* 19(I):5-40

Howe, C. W., and Easter K. W (1971) *Interbasin Transfers of Water: Economic Issues and Impacts* (Baltimore: Johns Hopkins Press)

Hukka, J. J. and T.S. Katko (2003) *Water Privatisation Revisited: Panacea or Pancake?*(The Netherlands: IRC International Water and Sanitation Centre Delft)

IWMI (2000) *World Water Supply and Demand:1995 to 2025* (Colombo: IWMI)

Iyer, R. R. (2004) 'River-Linking Project: Many Questions' in M. Patkar (Ed) *River Linking: A Millennium Folly* (Mumbai, NAPM)

Iyer, R. R. (2003a) `Linking Rivers…A Chimera of a Project' *The Hindu Survey of the Environment*

Iyer, R.R. (2003b*) Water Perspective, Issues, Concerns* (New Delhi, Sage) pp. 368.

Khattri, K. N. (1987) 'Great earthquake seismicity gaps and potential for earthquake disaster along the Himalayan plate boundary' *Techno-physics,* 138:79-82

Landry, C. J. (1998) 'Saving Our Streams Through Water Markets: A Practical Guide' Political Economy Research Center, Bozeman, Montana.

Lipton, M; J. Litchfield and J. M. Faurès (2003) 'The effects of irrigation on poverty: A framework for analysis' *Water Policy,* 5(5-6):413-427

Mallik, B. and S. Perveen (2004) 'A Scientific and Economic Assessment of the River Link Project in India' in proceedings of the *Workshop on Interlinking of Rivers: Doable and Desirable?* (Kolkata: West Bengal Academy of Science and Technology)

Martin, B. (1996) 'From the many to the few. Privatisation and globalisation' in *The Ecologist* 26(4):145-155.

Micklin, P.P. (1977) 'NAWAPA and Two Siberian Water-Diversion Proposals: A Geographical Comparison and Appraisal' *Soviet Geography: Review and Translation,* 18(2):81-99.

Mishra, D. K. (2003) 'Life within the Kosi embankments' *Water Nepal* 9-10(1-2):277-301.

Mohanty, N. and S. Gupta (2002) *Breaking the Gridlock in Water Reforms through Water Markets: International Experience and Implementation Issues for India*

Working paper Series, Julian L. Simon Centre for Policy Research

Molden, D. and C. de Fraiture (2004) 'Investing in Water for Food, Ecosystems and Livelihood' Blue paper, Stockholm, CGIAR

Molle, F. and P. Mollinga (2003) 'Water Poverty Indicators: Conceptual Problems and Policy Issues', *Water Policy,* 5(5-6):529-44

NCIWRDP (1999) *Integrated Water Resource Development: A Plan for Action* (New Delhi, MOWR)

NCIWRDP (1999a) *Report of the Working Group on Interbasin Transfer of Water* (New Delhi, MOWR)

OED (1995) *Learning from Narmada* OED Precis No 88 (Washington DC: The World Bank)

Patkar, M., L. C. Jain, K. Nayar, S.G.Vombatkere, H. Thakkar and R. R. Iyer (2005) 'President Kalam, Please Listen' Available online <http://indiatogether.org/2005/may/env-kalamletr.htm>

Polak (2004) 'Water and the Other Three Revolutions Needed to End Rural Poverty'. Prepared For the Stockholm Water Symposium.

Postel, S. (2000) 'Troubled Waters' *Science* March

Postel, S. (1999) *Pillar of Sand: Can the Irrigation Miracle Last?* (New York: WW Norton)

Postel, S. (1997) *The Last Oasis: Facing Water Scarcity* (New York: WW Norton).

Rao, K. L. (1975) *India's Water Wealth* (New Delhi: Orient Longman)

Reddy, V. Ratna (2002) 'Water Security and Management: Lessons from South Africa' *Economic and Political Weekly* 37(28):2878-81, 13 July

Rajagopal, A (2002) *Aquaculture 'Prosperity' – Some Reflections from India* (Hyderabad: South Asian Consortium for Interdisciplinary Water Resources Studies)

Rasinmäki, J (1997) *The privatisation of the administration of local government: A judical study of the background, provisions, restrictions, forms and effects of privatisation.* Kauppakaari Oy. Helsinki. 512 p.

Raskin, P; P. Gleick; P. Kirshen; G. Pontius and K. Strzepek (1997) *Water futures: Assessment of long-range patterns and problems* (Stockholm: SEI) 77 pp.

Rath, N. (2003) 'Linking Rivers: Some Elementary Arithmatic' *Economic and Political Weekly* 38(29):3033

Rijsberman, F. (2003) 'Can development of water resources reduce poverty?' *Water Policy* 5(5-6):399-412.

Rosegrant, M., X. Cai and S. Cline (2002) *World Water and Food to 2025. Dealing with scarcity* (Washington DC: International Food Policy Research Institute)

Salameh, E. (2000) 'Redefining the water poverty index' *Water International* 25(3):469-473.

Saejis, H. L and M. Van Berkel (1995) 'Global Water Crisis: Major Issues of the 21st Century, a Growing and Explosive Problem' *European Water Pollution Control* 5(4):26-40

Salman, M. A. and K. Uprety (2002) *Conflict and Cooperation on South Asia's International Rivers: A Legal Perspective* (Washington DC: The World Bank) pp. 217

Seckler, D. (1996) *The New Era of Water Resource Management: From Dry to Wet Water Savings* Research Reports No. 1 (Colombo, IIMI)

Seckler, D. (1992) 'The Sardar Sarovar Project in India: A Commentary on the Report of the Independent Review' Winrock International, Water Resources and Irrigation Division. (Discussion Paper 8)

Seckler, D., D. Molden, U. Amarasinghe, C. de Fraiture (2000) 'Water issues for 2025: A research perspective' IWMI's contribution to the 2nd World Water Forum

Seckler, D; U. Amarasinghe; D. Molden; R. De Silva and R. Barker (1998) *World Water Demand and Supply, 1990 to 2025: Scenarios and issues* (Colombo: IIMI)

Shah T., M. Alam, D. Kumar, R.K. Nagar and M. Singh (2000) 'Pedaling out of poverty: social impact of a manual irrigation technology in South Asia' Report No. 45 (Colombo: IWMI)

Shah, T. and O. P. Singh (2003) *Can Irrigation Eradicate Rural Poverty in Gujarat?* Water Policy Research Highlight 10 (Anand, IWMI-TATA Water Policy Program).

Shao, X. and Wang, Z. (2003) 'Interbasin transfer projects and their implications: A China case study' in *International Journal of River Basin Management*, 1(1):5-14

Sharma, S. (2003) 'Budgeting Interlinking of Rivers' Countercurrents. Org, Online edition (http://www.countercurrents.org/en-sharma.htm)

Shiklomanov, I (2000) 'Appraisal and assessment of world water resources' *Water International* 25(1): 11-32.

Smakthin, V., C. Revenga and P. Döll (2004) 'Taking into account environmental water requirements in global-scale water resources assessments' *Comprehensive Assessment Research Report* No. 2 (Colombo: International Water Management Institute)

Small, L. and I. Carruthers (1993) *Farmer Financed Irrigation: the Economics of Reform* (Cambridge: Cambridge University Press)

Snaddon, C. D., M. J. Wishart and B. R. Davies (1998) 'Some implications of inter-basin water transfer for river ecosystem functioning and water resources management in Southern Africa' *Aquatic Ecosystem Health and Management* 1(2):159–182.

Soviet Geography: Review and Translation (1972) Vol 8, November

Starr, Joyce. (1991) 'Water Wars' *Foreign Policy* No.82

TFILR (2003) *Interbasin Water Transfer Proposals* (New Delhi: MOWR)

Vaidyanathan, A. (2003) 'Interlinking of Rivers' *The Hindu* (Chennai) 26 March

Valdiya, K. S. (1992) 'Must We Have High Dams in the Geo-Dynamically Active Himalayan Domain' *Current Science* 63(6):289-296

Vance, S., M. Bickle, S. Ivy-Ochs and P. W. Kubik (2003) 'Erosion and exhumation in the Himalayas from Cosmogenic Isotopic Inventories of River Sediments' *Earth Planetary Science Letters*, 206, 273-288.

Verghese, B. G. et al (1994) *Converting Water into Wealth* (New Delhi: Konark)

Vidal, J. (2003) 'India's Dream Bangladesh's Disaster' *The Guardian* 24 July (http://www.countercurrents.org/en-vidal240703.htm)

Wells, D. M. (1971) 'High Plains Irrigation and Texas Water Plan' *Journal of Irrigation and Drainage Division* American Society of Civil Engineers pp, 123- 130.

Westing, A. H. (Ed.) (1986) *Global Resources and International Conflict: Environmental Factors in Strategic Policy and Action* (New York: Oxford University Press)

White, G. (1977) 'Comparative Analysis of Complex River Development' in Gilbert F. White (ed.) *Environmental Effects of Complex River Development* (Boulder: Westview Press)

Wolf, A. (1998) 'Conflict and co-operation along international waterways' *Water Policy*, 1 (2): 251–265

Wolff, G. and P. Gleick (2002) 'The Soft Path for Water' in Peter Gleick (Ed) *The World's Water: 2002-2003* (Washington DC: Island Press)

World Commission on Dams (WCD) (2000) *Dams and Development – A New Framework for Decision Making* (London: Earthscan)

World Bank (1999) *India: Water Resource Management - The Irrigation Sector* (New Delhi: Allied Publishers)

World Water Assessment Program (WWAP) (2001) 'Indicators for the World Water Development Report: from water-related stress to sustainable water use' Tech Note 1