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Long Distance Water Transfer: The Chinese Plans

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Abstract: The demand for water has been increasing steadily with increases in population and standard of living. The food and energy crises of the Seventies have made water resources development a priority issue in many countries. Agriculture currently accounts for 80 % of all global water consumption but hydroelectric generation does not consume any water. Since irrigation and hydropower generation are compatible uses of water, most recent water developments include both these uses.

Quantity of water available to any country is limited, but demands are continually rising. Accordingly, water use has to be made more efficient and options like interregional water transfers have to be explored. The paper outlines the problems and prospects associated with long distance water transfer projects and discusses the latest plans for this type of development in the People's Republic of China.

Introduction

Water, said the Greek philosopher Pindar in the 5th Century BC, is the best of all things. It may have been an overstatement but the fact remains that water plays an essential part in the overall development process of countries. It has become an even more important issue during the last decade due to several events, some natural and others manmade. First, severe droughts and floods in many parts of the world during the early Seventies seriously disrupted agricultural production and contributed to a major food crisis. During the World Food Conference, convened in Rome in 1974 to propose solutions to such a major global crisis (Biswas and Biswas 1975), it became quite evident during the deliberations that proper control and management of water is absolutely essential not only for further horizontal expansion of agriculture but also for increasing the overall yield from existing cultivated land. Second, steadily increasing prices of fossil fuels, especially oil, focussed national attention on development of hydroelectric power, a renewable source, as a viable source of additional electric power generation. This was a departure from the general practices of the Fifties and Sixties, when many countries preferred to construct fossil-fuelled power plants because of the economic advantages they offered and also easy availability of oil and coal. Third, the Lima declaration of the United Nations Industrial Development Organization recommended that by the year 2000, 25 % of global industrial production should take place in developing countries. If this is to be achieved, more water will be required for further industrial development. Fourth, the UN Conferences on the Human Settlements (M.R. Biswas 1978) and on Water (M.R. Biswas 1977) emphasized the plight of people of developing countries, especially in rural areas, who do not have access to safe drinking water. At the recommendation of the Water Conference, the decade 1981–90 was officially declared to be the International Drinking Water Supply and Sanitation Decade by the General Assembly of the United Nations (Biswas 1981a). Finally, pollution of inland and coastal water bodies and the oceans became an increasing focus of national and international concern, partly through the work of the United Nations Environment Programme, which itself was created in the early Seventies by the UN Conference on the Human Environment held at Stockholm in 1972. All these events, individually and cumulatively, clearly indicate the urgent necessity of sustainable water development which would ensure optimal utilization of available water for various purposes as well as maintenance of its quality.

Of all types of water use, agriculture is the largest user of water: currently accounting for some 80 % of the total global consumption. Much of this water is used for irrigation, even though rainfall still is the primary source of water for crop production in many different parts of the world.

If the total agricultural production in developing countries is to be doubled between 1980 and 2000, the total irrigated area has to be expanded by more than 40 %, from 105.3 million ha in 1980 to 148 million ha by 2000. Even then, however, the total irrigated area as a percentage of all arable area will increase only moderately, from about 14 % in 1980 to only 16 % two decades later. The average rate of expansion will be 1.7 % per annum, a rate that is slightly lower than developments in the recent past. Even though 84 % of the area will still be non-irrigated, irrigated areas will account for 41 % of total crop production. This clearly indicates the role and importance of irrigation to increase total agricultural production (FAO 1981).

A noteworthy aspect of this potential expansion is the wide variation in regional expansion patterns. For example, in Africa, the total irrigated area will increase from 3.7 million ha in 1980 to only 6 million ha by 2000. In contrast, the Far East will account for nearly three-quarters of the total irrigation expansion during this period, from 67.5 million ha, with India alone accounting for nearly three-quarters of this increase.

Since demand for water is rising continually, and the stock of water available is fixed, there is already a water crisis in many parts of the world. The major question then arises: how can enough water be made available to sustain all necessary human activities. This can be done in two fundamental ways. First is to make existing water patterns more efficient so that the same quantity of water can be used to satisfy more demands. The second is to bring additional water to the water-deficient regions from water-surplus areas. The two alternatives are not mutually exclusive.

Interregional Water Transfer

One of the major means of transferring water to water-deficit regions from water-surplus areas is interregional water transfer, which has been receiving increasing attention in recent years (Biswas 1981b, Biswas et al. 1982, Golubev and Biswas 1978).

Conceptually it can be argued that all water development projects involve transfer of water over some distances. Part of rain or snow that falls in one region ultimately finds its way, as surface and ground-water, to a river, which often flows through several regions. At certain locations water can be stored in reservoirs by damming the river. The water stored in reservoirs can be released as and when required. In other words, water is always in motion and is being continually transferred from one region to another by both natural artificial means.

Within the present context, however, the emphasis is not on this type of "normal" water transfer: the main focus is on large-scale artificial mass transfer of water over long distances – from a water-surplus to a water-deficient region – in order to further the economic development of the latter, mainly through agricultural and industrial developments. This could be achieved by diverting the course of a river, or by constructing a large canal which could carry significant portion of available water. Both these alternatives invariably have important economic, social and environmental implications which need to be carefully analysed and evalued before final decisions can be made for their construction.

Before long distance mass transfer of water can be seriously investigated as a viable policy option, it is essential to carry out a comprehensive assessment of available water resources, both surface and groundwater, in terms of quantity as well as quality. It is a fundamental fact of hydrology that availability of water in a river is both a function of space and time. Thus, static assessment is not a viable option: time-series data of hydrological variables – either real or reconstructed – is an important prerequisite for any analysis. In order that reliable forecasts of water availability can be made it is necessary to have adequate data over a reasonable period of time. Based on such data, long-term water management plans can be prepared. However, in many parts of the world, such data are not available or, if available, they are for a rather limited time period. Furthermore, very rarely is any information available on their reliability and accuracy. This is unfortunately the case for most developing countries. This is basically the situation on data on water quantity: information on water quality is even more scarce and seldom available. Accordingly very little is known on the quality of available water. Quality of water determines its possible uses, and hence data on water quality is necessary to develop rational management plans. Much progress has to be made in this field.

Other problems associated on data on water quantity and quality, in addition to data scarcity, are non-representativeness of monitoring sites, unavailability of trained technicians to collect data and maintain data collection instruments and monitoring networks, and lack of experienced professionals to analyse the data collected, and facilities to store and retrieve data. The situation is further complicated by the presence of different agencies at federal, state and local levels who collect water-related data. Cooperation between these agencies is generally poor and sometimes even non-existent. Accordingly, exchange of data is not always feasible. In the United States alone, at least 20 federal agencies are associated only with water quality monitoring programmes. Proliferation of data collection agencies often makes the system complicated and in a few cases even unmanageable.

Second important consideration is the assessment of water demands for different purposes. It should be noted that the term "demand", in the context of water resources management, generally means requirements, and is very rarely used in its traditional economic sense. Indeed, very rarely is the concept of demand elasticity explicitly considered within the water planning process *per se*. Consequently very little is known about constructing realistic demand functions under varying socio-economic conditions. Expressed differently, it means that emphasis so far has been on supply management – that is, increase in supply is considered to be virtually the only management alternative – rather than consideration of demand management. As the water requirements for various purposes continue to increase and available sources become more and more exploited and polluted, it is highly likely that emphasis will gradually shift from supply to demand management.

Efficiently of existing water use is the third important consideration. Undoubtedly, the agricultural sector is one of the most inefficient users of water, and where significant improvements could be made. Existing efficiencies of irrigation systems are so low that they do not by any means reflect the actual water requirements of crops being irrigated. It was estimated that in 1975, on a global basis, 1.3 million million m^3 of water was used for irrigating crops, but for this 3 million million m^3 of water had to be withdrawn. In other words 57 % of total water withdrawn was lost in the process. This, however, should not be construed to mean that 43 % of water reaching irrigated fields was efficiently used. Over-irrigation is endemic and not exactly an uncommon practice in both developed and developing countries. It not only means that water is wastefully used but also contributes to development of adverse environmental problems, like increase in ground water table and salinity levels (M.R. Biswas 1979a, 1979b).

One of the most inefficient parts of the irrigation system often is the section where water is transferred from canal outlets to farms. It has become a no-man's land due to undefined responsibility, which in turn contributes to improper design and unsatisfactory operation and maintenance. While such research has been carried out on losses from canals, very little work has been done on losses from such sections. Studies carried out on 40 such sections in the Indus Basin during 1975 and 1976 indicated losses ranging from 33 to 65 %, with an average of 47 %. Another investigation on 60 sections carried out in 1977 and 1978 by Water and Power Development Authority of Pakistan indicated similar losses. The magnitude of this problem can be best realised by considering the case of good lined canals, which are expensive to construct and have operating efficiencies of 70 to 80 %. When the efficiency of the total system is considered, that is lined canals in conjunction with the inefficient section from canal outlets to farms, the total efficiency is of the order of 20 to 50 %, which means that even for expensive, lined and well-maintained canal systems, in many cases only one-fifth of water released from a reservoir reaches the crops being irrigated.

A major result of this sad state of affairs is that engineers and planners have accepted this inefficient system, at least implicitly. During planning of irrigation projects, total water requirements are generally calculated by multiplying area to be irrigated by water required per hectare. The water requirement per hectare is often estimated on the basis of existing systems, where major portions of water released from reservoirs are lost. Accordingly, overall estimates of irrigation water requirements are invariably high – certainly much higher than necessary – and the inefficient system is condoned and perpetuated. In other words, most irrigation systems designed so far are inefficient and use far more water than necessary. Unfortunately, instead of attempting to make irrigation systems more efficient and then maintain them at such levels, engineers are constantly looking for new sources of water to irrigate with. They often look for costly alternatives, like interbasin water transfer, when such major and expensive projects are not essential (Biswas 1981b), and cheaper alternatives are available – which can be implemented within a significantly less timeframe with indigenous labour and expertise – by simply improving the existing systems. Furthermore, even if new projects are developed, unless special efforts are made to maintain their efficiencies at high levels, their effectiveness will decline with time and thus the vicious circle would continue to be perpetuated.

Interregional Water Transfer in China

In 1980, Professor Walther Manshard, the then Vice-Rector of the United Nations University, invited the author to lead an international group of experts to review the various alternative plans proposed for a massive interregional water transfer project in the People's Republic of China. Specifically our mandate was to review potential social and environmental implications of the proposed plans, in close collaboration with the Institute of Geography of Academia Sinica and appropriate water development agencies in China. The information presented herein stems primarily from this visit. More detailed information on the Chinese proposals *per se*, and experiences on interregional water transfer projects from different parts of the world can be obtained from a forthcoming book (Biswas et al. 1982).

China is a vast country with a total population of 980 million, making it the most highly populated country in the world. As to be expected in such a large territory, the rainfall is not uniform all over. Annual rainfall generally decreases from S to N and from SW to NW. For example, in the NW part of the country – Gansu and Qinghai Provinces, and Xinjiang Uygur, Inner Mongolian and Ningxia Hui Autonomous Regions – the average annual rainfall is mostly below 150–250 mm level. In contrast, average annual rainfall in the middle and lower reaches of the Chang Jiang (Yangtze River) is around 1100 mm.

Rainfall thus not only varies tremendously from one part of China to another, it is also extremely uneven during the year. Heaviest rainfalls normally occur in summer, which accounts for 60–75 % of annual rainfall on the Huang-Huai-Hai plain and in the NW part of the country.

This type of rainfall pattern creates a special problem for agriculture since spring is the sowing time for crops harvested in autumn and it is also the growing period for crops like wheat. This is the period when more water is necessary, but unfortunately very little rain falls during this time. For example, spring rainfall is less than 15 % of average annual rainfall in the Huang-Huai-Hai plain N of the Huai He. Furthermore, air is dry in spring and wind is strong, thus increasing the rate of evaporation significantly. Because of these climatological conditions, agriculture is not very productive in this region, suffering an average of nine droughts in every ten years.

Rainfall naturally controls river flows. In the Huang-Huai-Hai plain, spring river flows account for less than 10 % of average annual flow, and the driest season, winter, accounts for less than 8 %.

The largest river in China is the Chang Jiang. It has an annual flow volume of 980 billion m^3 and is the third largest river in the world. Its flow volume is 18 times higher than the Huai He (53 billion m^3) and 35 times that of the Hai He-Luan He (28.3 billion m^3) drainage basin. Viewed in another way, Chang Jiang's annual flow constitutes 38 % of the total national flow of China.

If availability of good soil coincided with abundance of water, there would of course be no major problem for intensive agricultural development. Unfortunately for China it is not the case. In S China, there is abundance of water but not enough cultivable land, and the situation is exactly the reverse in N China. The mismatch of land and water availability is even worse in NW China, where much good quality land exists but cannot be cultivated due to lack of water. The mismatch of land and water can be best seen by considering land and water available for the four major river basins in China.

River Basin	Land Available (million ha)	Average Flow (m^3/ha)
Chang Jiang	24.0	41,700
Huang He	13.1	4,290
Huai He	12.6	4,230
Hai-Luan	11.3	2,500

Because of this situation, much discussion has taken place in recent years in China to divert water from the water-abundant regions of the S to the deficit areas of the N. Currently three plans exist for a gigantic water transfer scheme, which if and when carried out, will undoubtedly become the largest water redistribution plan ever undertaken in human history (Fig 1). If and when the plans are implemented, water distribution pattern in China will be radically altered.

Water conservancy departments have carried out initial studies to transfer water from the upper reaches (Western Route), middle reaches (Middle Route) and lower reaches (Eastern Route) of the Chang Jiang.

The Western Route has now been largely abandoned after some studies by the Academia Sinica – the Chinese Academy of Sciences. This is because of the long distance over which water has to be transferred, and also the technical problems involved due to several high mountains which have to be crossed. Hence, the current studies focus on the two remaining routes – Middle and Eastern.

The basic objective of both Middle and Eastern Route is to carry water to the Huang-Huai-Hai plains, but whereas the Middle Route will deliver water to the W part of the plan, the Eastern Route will focus on the E part.

The Middle Route will divert water direct from the Chang Jiang at the Sanxia Reservoir. Water would be diverted from the E end of Danjiangkou Reservoir, which already exists on the Han River, a tributary of Chang Jiang. It will then be diverted northward through Nanyang Basin and Henan Province, and then cross Fangcheng Divide by Baofeng and Yu counties. It will cross Huang He by an aqueduct, at the NW of Zhengzhou. The canal will then proceed N along the E foothills of the Taihang Mountains to Beijing, running almost parallel to the Beijing-Guangzhou railway line. The total estimated length of the Middle Route is 1,265 km.

The Middle Route would provide an additional 23.7 billion m^3 of water for irrigation and another 7.4 billion m^3 of water for industrial, mining and municipal purposes.

The Eastern Route on the other hand will pump water at the downstream of Chang Jiang at Jiangdu station. Water will then flow northwards along the Beijing-Hangzhou Canal and cross several lakes like Hongze, Luoma, Nansi and Dongpi. It will cross Huang He through a 0.6 km tunnel and flow through gravity along the Grand Canal to Tianjin. The length of the Eastern Route is 1,150 km.

A major technical problem of the Eastern Route is its topography. The highest point of the route is at the Huang He, where the water level is 40 m higher than the pumping station in Jiangdu. In order to carry this enormous quantity of water, it is proposed to lift it in 15 steps, having a total delivery lift of 65 m. Ten major pumping stations will have to be built, having a total installed capacity of nearly one million kilowatts, with an annual electricity consumption

Fig 1 The Scheme of Water Transfer Projects and Regionalization of Water Resources in China

of 3–5 billion watts. In a dry year, it is proposed to pump 30 billion m^3 of water from Chang Jiang, falling to 14 billion m^3 during an average year – an enormous quantity by any account.

The Eastern Route, when completed, will provide irrigation – both new and improved – to 64 million mu of land, and an additional 2.7 billion m^3 of water will be available for industrial, mining and municipal uses.

The cost of both the alternatives are roughly estimated at 20–25 billion yuan. But the Middle Route has one major advantage over the Eastern Route in that no pumping will be necessary. This means no complex pumping stations have to be designed and constructed, but also that energy requirements will be substantially less.

In one respect the reaction of people in China has been somewhat identical to those in other countries, where long distance water transfer schemes have been constructed or are being seriously considered. In general, people in water-deficient areas – where additional water will be transferred from other areas – are generally in favour of such projects. The reaction, however, of the water-surplus regions, from where water will be transferred, is exactly the reverse. They claim water transfer is a short-sighted policy, since the region itself will require the surplus water in the future to ensure its own development. If the surplus water is being challenged elsewhere, it would no longer be available for their own use in the future. Thus, the people in the water-short N region of China generally welcome the project but the people in the water-surplus S region consider it undesirable.

There is a common saying in China: *Shiwu zong shi yi fen wei er*: there are two sides to everything. Not surprisingly this dictum also applies to the water transfer scheme as well.

From a positive side, benefits accruing from the project are many. The most important benefit will be in terms of increased agricultural production. Providing better water control will significantly increase the yields of all types of crops. Current estimates indicate that the are under irrigation can be increased or improved by 4.3 million ha by the Eastern Route and another 5.3 million ha by the Middle Route. The major beneficiary of the Eastern Route will be the provinces of Hebei (1.33 million ha), Jiangsu (1.23 million ha) and Shandong (1.17 million ha). Similarly the

Middle Route would increase or improve irrigation in Henan and Hebei provinces by 2.61 and 2.16 million ha respectively.

Another important benefit will be the availability of 7.4 km^3 of supplemental water for industrial, domestic, and navigational uses by the Middle Route and 2.7 km^3 by the Eastern Route. This has an important bearing since further industrial development in areas like Tianjin is seriously constrained at present due to lack of water. Both routes will improve navigation. The Eastern Route will enable the modernisation of the ancient Beijing-Hangzhou Grand Canal from Chang Jiang to Tianjin. Similarly the main trunk canal for the Middle Route can also serve as a man-made navigation channel, navigable from Beijing to the Danjiangkou Reservoir.

The water transfer scheme will have some adverse social and environmental impacts. A major problem could be salinisation of irrigated areas, which could be aggravated as a result of water diversion. Such difficulties have been encountered in other countries like Egypt, Sudan and Pakistan with newly irrigated lands. If the ground-water level cannot be effectively controlled after water transfer by good drainage, extent of salinisation is bound to increase. Increase in salinisation will reduce agricultural production.

The second problem could be the northward migration of the dreaded snail-fever, schistosomiasis. Some 7 million Chinese were afflicted by schistosomiasis 30 years ago. Extermination of snails has reduced the number afflicted by some 70 %. Currently the northernmost point of snail fever is in Baoying County in Jiangsu province. There is a danger that schistosomiasis may migrate further northward with the transferred water.

Many other environmental problems need further study. For example, 58 earth tremors were measured between 1969 and 1973 after the construction of Danjiangkou Reservoir, the largest being 4.7 in Richter scale. Further increase of the dam height could lead to an increase in the number and magnitude of earthquakes. Furthermore incidence of malaria has increased in the area around Danjiangkou Reservoir due to the presence of anopheles mosquito. Heightening of the dam will increase the area impounded which could expand the malarial epidemic region. Expansion of inundated area will also mean that 250,000 people will have to be displaced and rehabilitated in other areas, a difficult and costly process under the best of circumstances.

While technically it is possible to construct both the routes, costs would be high. It has been very conservatively estimated that each route will cost around 10 billion yuan to construct. Final costs are likely to be much higher. It is not going to be easy to find such huge investment funds under the present economic climate. Neither will it be easy to marshall and organise the huge manpower required to construct the project.

As to be expected with such a mammoth project, there are both proponents and opponents in China. There is no doubt the Chinese will be able to handle the technical aspects of planning, design and construction of any of the two routes. Technically both the routes are feasible projects.

The real questions that have to be answered before the final decision to proceed with construction can be taken are:

1. Is the additional water necessary? Are there other alternatives which are cheaper and simpler?
2. Can the high investment to construct the project be justified in terms of projected benefits?
3. What will be the social and environmental costs of such a major water diversion project?

So far as the first question is concerned, there is no doubt water is used inefficiently in China – like in any other developing country. Probably around 60 to 70 % of water withdrawn at present is "lost". Management practices are somewhat poor. He Zhi, writing in the national newspaper *Guangming Ribao* in 1979, pointed out "in China there is no unified management department governing water resources, nor are there any laws". This has meant that water development in China is in a state of "anarchy" and water management is "in a mess, each doing things in his own way". From my personal experience, this judgement is probably somewhat harsh, but there is no doubt improving water management will make significant quantity of extra water available at a low cost and within a short period of time. The water management has to be improved, but the question then will be whether water thus saved will be enough or still more is essential.

There are still many uncertainties associated with both the routes which need to be resolved. It will probably take another 3–4 years of additional work. Fortunately, Chinese leaders and scientists are well aware of the complexities of such a large development project. Vice-Premier Fang Yi (Fig 2) confirmed during my last discussion with him that the final decision to proceed with the construction of the project will be taken only after the benefit and costs have been carefully evaluated. After the problems encountered with very large water development projects in other countries, such cautions are not only desirable but also essential.

Concluding Remarks

There is no doubt many countries, facing increasing water demands but having limited stocks of water, have to review all possible options to provide adeqaute quantity of water to satisfy different requirements. The situation is likely to deteriorate even further in the future.

Confronted with this serious problem, interregional water transfer is appearing to be a more and more attractive option for certain countries. While this type of option is not to be dismissed lightly after only superficial assess-

Fig 2 Dr. Asit K. Biswas discussing Chinese water transfer plans with H.E. Fang Yi, Vice-Premier of People's Republic of China

ments, the fact still remains that interregional water transfer is an expensive (especially if social and environmental costs are to be included) option. Planning and construction of a major water transfer project can easily take two decades or more, which means it is not a quick solution. There is also a tendency to look for technological fixes rather than "soft" solutions like better and more rational management, since technological fixes are more challenging to engineers and scientists, and in many ways comparatively easier to achieve than trying to change water management practices that have developed over centuries of profligate use of water. This, however, does not mean that interregional water transfer should be rejected out of hand, but rather all possible alternatives should be analysed before the final decision for a water transfer project is taken.

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