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North American Water Transfers: An Overview

ASIT K. BISWAS*

INTRODUCTION

Interregional water transfer is not new: it has been practised from time immemorial. For example, the ancient Egyptians diverted river water over long distances several thousand years ago.[1] But its importance has increased in recent years, especially as population pressures in many arid regions of the world have made it imperative to grow more food. Agricultural production can be increased in two ways – by increasing crop yields and by bringing new land under cultivation. Both of these alternatives can only be viable, provided adequate water supply is available.

The importance of water control for crop production can be illustrated by the following facts. On a global basis, agriculture uses 80% of all water consumption: the corresponding figure for the United States is about 40%. Total irrigated area in the world is 233 million ha, out of which 93 million ha are in developing countries.[2] Irrigated land constitutes less than 10% of global cropped area, and yet it accounts for 30–40% of total agricultural production. Thus, as populations in developing countries continue to increase, and since these countries are without exception in the tropics and subtropics, water control is increasingly becoming a major requirement to boost food production. As water resources of populated regions become fully developed, interregional transfer becomes an attractive possibility – provided the environmental and social problems associated with such major projects can be resolved.

Interregional transfer is, however, one of several alternatives of non-conventional water development. There are other possibilities, among which are weather modification, desalination, iceberg towing, and the use of VLCC (very large crude carriers) to transport fresh water to water-deficient regions. None of these are universal solutions, and each must be considered in relation to problems of the region being analysed. In other words, these solutions are site-specific. Furthermore, for most of these unconventional techniques, there exist technological, legal and environmental problems many of which have yet to be solved. In many cases, economic constraints have yet to be overcome.

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First, what is meant by water transfer? On simplest terms, it may be defined as inter-basin diversion, that is, the artificial withdrawal of water by ditch, canal or pipeline from its source in one contributing or exporting drainage basin for use in another receiving or importing basin. Before such interregional diversion can be seriously considered, it is important that

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three factors be analysed. These are assessments of available water resources, the nature of the demand function and the efficiency of water use.

Assessment of available water resources is an important factor for any water resources development plans. Availability of water varies with space and time. Thus, before 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 development and management plans can be established. However, in many parts of the world, such data are not available, or if available, they are for a rather limited time horizon. This is unfortunately the case for most developing countries. Even for North America, adequate data are not always available – especially for northern Canada and many parts of Mexico. Without a comprehensive assessment of water availability, it is difficult to contemplate interregional water transfer – or any other water planning process for that matter.

Second important consideration is the assessment of water demands for various purposes. The term "demand", in the context of water management, really 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. Thus, it should be no surprise that very little is known about constructing appropriate demand functions under varying socio-economic considerations. In other words, emphasis so far has been on supply management – that is, increase in supply is considered to be virtually the only management alternative – rather than on demand management. As the demands for water for various purposes continue to increase and available sources become more and more exploited and polluted, emphasis will have to gradually shift from supply to demand management.

Efficiency of existing water use is the third important consideration. Agricultural sector is an inefficient user of water, and where most 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. On a global basis, 1.3 million million m^3 of water is used for irrigating crops, but for this 3 million million m^3 of water have to be withdrawn.[3] In other words, 57% of water withdrawn is lost in the distribution system. This, however, does not mean that 43% of water reaching irrigated fields is efficiently used. Over-irrigation is 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 groundwater table and salinity levels.[4] Thus, before major alternatives like interbasin transfer can be analysed, the possibility of optimization of water use by increasing efficiency should be considered. As a rule, it is cheaper to obtain more water per unit cost by improving the efficiency of water use from existing projects than from building new ones. Also, the time required to plan and to build new schemes is significantly longer: the efficiency of existing projects can be improved more quickly.

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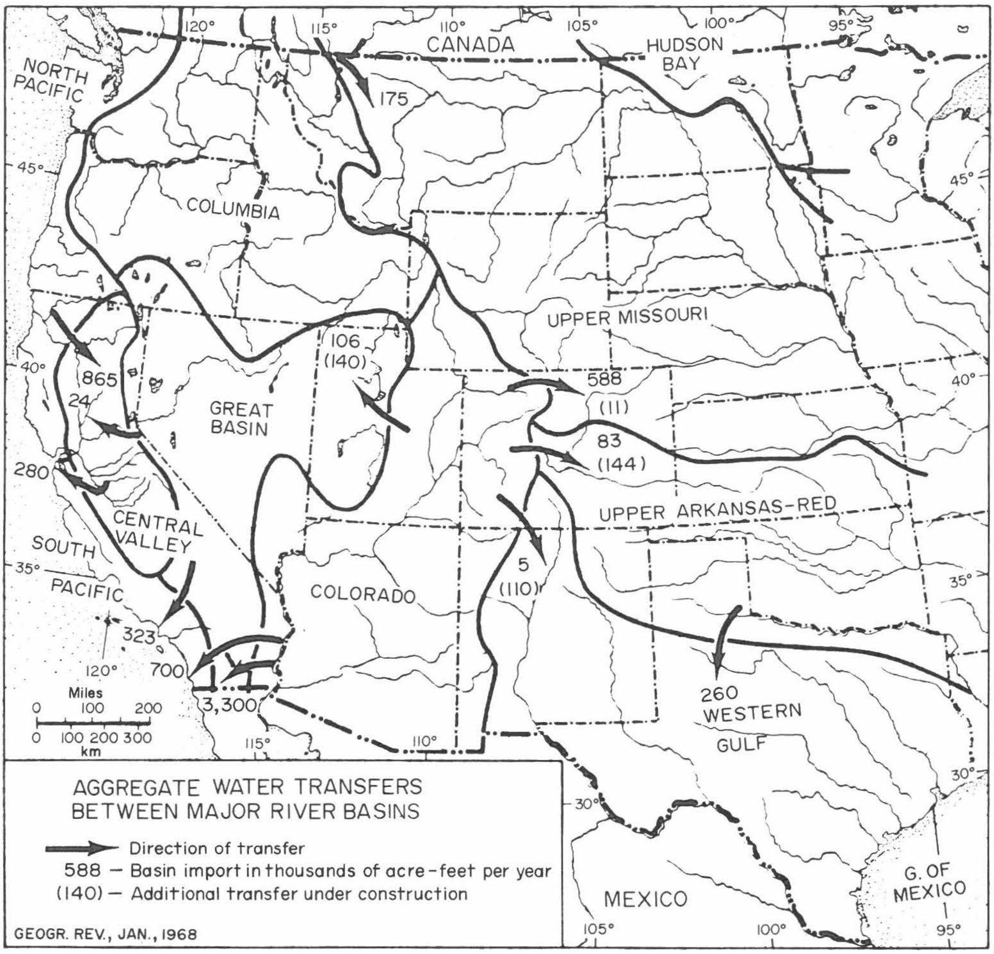

Fig. 1.

Late-developing urban centers, unable to dislodge agricultural water rights, account for most of the recent long-distance water importations. Probably one person in three in the Western United States is now served by a system which imports water from 100 or more miles away. It is quite likely that Los Angeles, Salt Lake City, Laramie, Denver and Colorado Springs would have found it impossible to each beyond their own river systems to the Colorado, if the diversions had meant crossing their state lines as well.

The same can be said for the rest of the continent. New York City takes from the Delaware; Boston from the Connecticut; Chicago from Lake Michigan into the Illinois; the province of Ontario from the Albany and Kenogami drainage of Hudson Bay into Lake Superior; British Columbia from the Nechako to the Coast at Kitimat. Their effects, of course, have sometimes been felt downstream across the boundaries.

A few select interbasin diversions will be briefly discussed herein. These have been selected primarily on the basis of their magnitude or historical importance. The experience in California or Mexico will not be discussed, since they are discussed elsewhere in this collection.

1. *Nechako–Kemano Diversion*

In 1925, the Kenny Dam on the Nechako River was completed by the Aluminum Company of Canada. The dam stores the run-off from a 5400 square mile area of the Fraser River drainage for diversion westward to the company's power plant near tidewater at Kemano. The average flow, approximately 6500 cfs at the point of diversion, is controlled by the 6.6 million acre-ft of usable storage in the reservoir. Diversion is made by means of a 10.1 mile long, 25 ft diameter tunnel leading to an underground powerhouse with a head of 2500 ft and a present installation of 707,000 kW. The average annual diversion from the reservoir is about 3300 cfs. Excess water is spilled or released to the Nechako–Fraser system.

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Diversions of water from the Great Lakes–St Lawrence system at Chicago into the Mississippi River system have been made since 1848. Diversions reached magnitudes of slightly over 10,000 cfs in 1928 but the diversion at present is governed by United States Supreme Court decree of 12 April 1930, which provided that on and after 31 December 1938, the diversion would be limited to 1500 cfs in addition to domestic needs of the City of Chicago. The present diversion averages 3200 cfs. A new International Joint Commission (IJC) reference has been announced, authorizing a 5-year study of the effects of increasing the diversion up to a maximum of 10,000 cfs for abstraction of the water of Lake Michigan at Chicago, which will have an effect on the water levels and flow of the Great Lakes.

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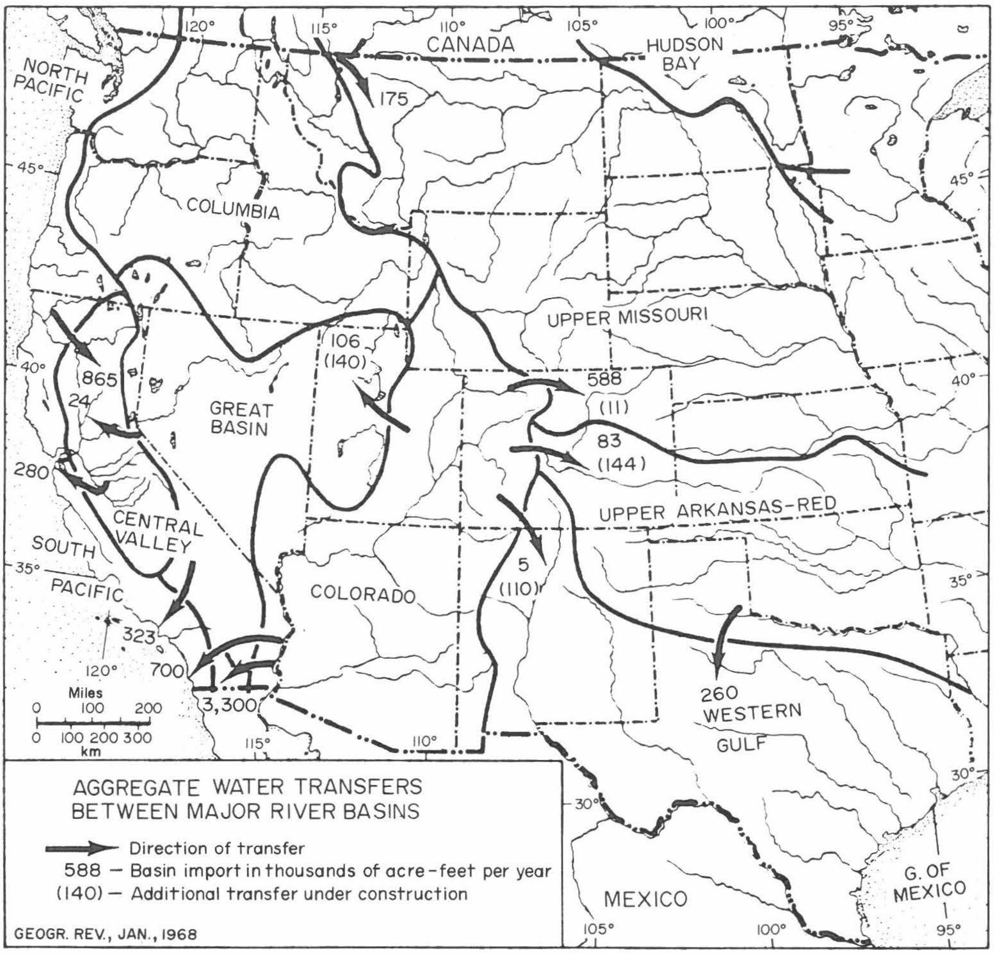

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11. *Colorado River Basin*

In 1968, as part of the Colorado River Basin Project Act, Congress prohibited federal studies of importation of water to the southwestern United States for a period of 10 years. That moratorium expires in 1978. Southwest water interest groups continue to seek studies of alternatives for importation of water from the northwest. Added pressure due to increasing droughts will undoubtedly occur when the moratorium expires.

PROPOSALS FOR INTERREGIONAL TRANSFERS

Proposals for interregional transfers have been made in the 1960s, the most ambitious of which is the North American Water and Power Alliance (NAWAPA), first proposed in 1964. The immensity of the plan stirred the imagination of many engineers and economists, and within the 5 years of NAWAPA being proposed, a whole series of interregional water transfer schemes were put forward to redistribute the waters of North America. Table 1 shows twelve such schemes which are primarily national in character. Eight major international proposals are shown in Table 2.[8] Only the major one, NAWAPA will be briefly discussed.

NAWAPA project – This $100 billion project was proposed by Ralph M. Parsons Company of Los Angeles.[9] The general idea is to collect surplus water from the high precipitation areas of the northwestern part of the North American continent and distribute it to water-scarce areas of Canada, the United States and northern Mexico. A series of dams and power stations in Alaska and northern British Columbia would collect water and provide power to pump this water up to the Rocky Mountain Trench Reservoir in southeastern British Columbia. From the Rocky Mountain Trench Reservoir, water would be lifted by pumps to the Sawtooth Reservoir on Central Idaho. From there, the water would flow by gravity to the western States. NAWAPA would initially provide 137.5 billion m^3 of water annually to seven provinces of Canada, 33 states in the United States and three northern states of Mexico. The total power generation would be 100 million kW/yr. Out of this, 30 million kW/yr would be utilized by the pumping requirements of the project. NAWAPA is a gigantic project and its environmental and social costs have yet to be determined. In the present era of environmental awareness, it is highly unlikely that such a major project will receive serious planning attention – at least for another two decades.

ISSUES INVOLVED WITH INTERREGIONAL TRANSFERS

There are a number of problems associated with (and several issues involved in) large scale transfers of water. These are discussed below under four separate headings: technical, socio-economic, political and legal, and environmental.

Table 1. Interregional transfer proposals (national)

Proposal (Author)	Year proposed	Water source	Volume of diversion in millions of acre-ft	Estimated cost in billions of $
Pacific Southwestern Water Plan (Interior Dept)	1963	north coastal California	1.2	?
Western Water Project (Pirkey)	1963	lower Columbia at Dalles	13.0	12.8
Snake - Colorado Project (Nelson)	1963	middle Snake in Idaho	2.4	1.4
Modified Snake - Colorado Project (Dunn)	1964	lower Snake in Oregon	5.0	3.6
Yellowstone - Snake - Green Project (Stetson)	1964	Yellowstone and Snake, Montana and Idaho	2.0	0.4
Undersea Coastal Aqueduct (NESCO)	1965	Klamath, Eel and Rogue, mouths	11.0	8.0
Texas Water Plan (State of Texas)	1965	eastern Texas rivers	3.3	0.5
Prime Plan (Province of Alberta)	1965	Peace and Athabaska rivers	?	?
Mexican Plan (Government of Mexico)	1965	southern east coastal region	?	?
Undersea Hose (Conner)	1967	mouth of Columbia	12.0	2.0
Beck Plan (Beck)	1967 - 1968	Missouri in Nebraska	10.0	3.5
Hudson Institute Plan (Hudson Institute)	1968	Mississippi and Arkansas	34.0	12.2

Table 2. Interregional transfer proposals (international)

Proposal (Author)	Year proposed	Water source	Volume of diversion in millions of acre-ft	Estimated cost in billions of $
Grand Canal Plan (Kierans)	1959	James Bay dyked rivers "recycled" to Great Lakes	?	?
Great Lakes - Pacific Waterways Plan (Decker)	1963	Skeena, Nechako and Fraser of B.C., Peace, Athabaska, Saskatchewan of Prairie Provinces	115.0	?
North America Water and Power Alliance, NAWAPA (Parsons)	1964	Primarily the Pacific and Arctic drainage of Alaska, Yukon and B.C.; also tributaries of James Bay	110.0 initially	100
Magnum Plan (Magnusson)	1965	Peace, Athabaska and North Saskatchewan in Alberta	25.0 at border	?
Kuiper Plan (Kuiper)	1967	Peace, Athabaska and North Saskatchewan in Alberta Nelson and Churchill in Manitoba	150.0	50
Central North American Water Project of CeNAWP (Tinney)	1967	Mackenzie, Peace, Athabaska, N. Saskatchewan, Nelson and Churchill	150.0	30 - 50
Western States Water Augmentation Concept (Smith)	1963	Primarily Liard and Mackenzie drainages	38.0 at border	75
NAWAPA + MUSHEC or Mexican - States Hydroelectric Commission	1968	NAWAPA sources + lower Mississippi and Sierra Madre, Oriental rivers of southern Mexico	158 + 129 NAWAPA MUSHEC	?

Technical

(i) The planning, design and construction of gigantic projects for transporting large bodies of water over large distances must be carried out with great care and imagination by highly qualified individuals. This is necessary because as a rule the bigger the size of such projects, the greater are the uncertainties. It may be more prudent to postpone a decision on such projects, if all investigations are not complete, or if uncertainties are enormous – rather than make decisions in a hurry. Also, such large projects can be severely affected by upstream and downstream developments, i.e. sudden failure of a hydraulic structure upstream can adversely affect the overall safety of the project.

(ii) The hydrologic and meteorologic characteristics of the drainage basins may significantly change after the completion of the project. Such changes should be adequately anticipated and considered within the planning framework.

(iii) For determining surplus water of a basin, its long-term storage requirements to take care of the time variation of run-off in the basin should be considered. Regions with a present water surplus have been understandably reluctant to permit exports which might have even a slight probability of restricting their own economic growth in the distant future. There have been controversies over diversions of the Colorado,[9] Columbia[10] and Yukon[11] rivers in the United States. However, if the population of such regions can be assured that only surplus water of their basins, calculated after taking into account their projected requirements (say, for a period of 50 years as provided in the Texas Water Plan),[12] as well as their storage requirements for taking care of the time variation of the run-off at a given location in the basin, will be diverted, the objection could perhaps be minimized.

(iv) The project should be made flexible by leaving as many options as possible open for future adjustments decisions. Large-scale transfer of water from one basin to another is, in effect, an interference with the natural water regime. For such cases, from ecological and environmental viewpoints, a cautious and conservative approach is desirable. In spite of scientific and technological developments of recent years, not much is known about the behaviour of the streams and rivers under changing flow and sediment conditions. Thus, a number of uncertainties are involved in the planning and design of such large-scale projects. It may, therefore, be desirable to make decisions on the project in various stages and the plan be kept flexible enough that only those decisions which are essential for the immediate future have to be made.

(v) Efforts should be made to determine the impact of interbasin transfer of large bodies of water on the environmental characteristics of the region. When surplus water of a river is diverted, the waste assimilative capacity of the river decreases. This may adversely affect the biological life in the downstream reaches.

(vi) Interbasin transfer routes and reservoir sitings must take into consideration earthquake-prone areas. Safety should be a significant concern of such projects.

Socio-economic

(i) Howe and Easter[13] have concluded that large-scale transfers of water are likely to cost more than they are worth to a nation, except in certain "rescue operation" cases where diverting water supplies threaten to idle immobile capital and labour. On the other hand, Wells[14] points out that the importation of water to the high plains of Texas is not economically feasible but also that the State simply cannot afford not to import water to the area. Thus, there can be great diversity of results that can be obtained from the economic analysis of such large projects. Sufficient care and effort must therefore be exercised in economic feasibility studies.

(ii) A large-scale interbasin transfer project must be justified not only in terms of the direct costs of transporting water, but also in terms of the value of services foregone by the exporting region due to the diminuition of its water supply (the opportunity cost of the diverted water).[15] Various alternatives to interbasin transfers should be investigated and that alternative which provides water to the deficient areas at the minimum cost (including special and environmental), should be selected. Alternatives might include:

(1) more efficient use of water within existing allocation patterns;
(2) reallocation of surface supplies;
(3) wastewater reduction, including desalination;
(4) improved integration of surface and groundwater supplies;
(5) management of watersheds; and,
(6) weather modification.

(iii) As an alternative to importation of water, economy in the water use should also be considered by the importing region. The philosophy of controlling water demands to eliminate or reduce further water development involves a number of factors and has been discussed by Coe[16] in detail.

(iv) The framework for the economic analysis should be properly made; not only the primary benefits, but also where possible, the secondary and tertiary benefits of the projects should be considered.

(v) Broad social objectives and benefits should be considered in the light of growing urban and industrial demands; while benefits to the agriculture sector are usually the major concern of the majority of diversion schemes, social objectives such as income redistribution, alteration in regional growth rates, reduction in unemployment and environmental protection (though not always measurable in purely economic terms) should also be considered in assessing alternative public investments *in situ* demands e.g. fish, aquatic vegetation, power, recreation and navigation should also be considered.

Political and legal

(i) In many Western States, the earliest water rights were developed simply by use and some are still unrecorded. Even in the areas where all rights have been adjudicated they are measured in quantity of water withdrawn, rather than in quantity actually consumed, which must be determined before a transfer can take place.[17]

(ii) It is more than coincidence that all transfers of water that have been effected thus far on the continent, fall within state and provincial borders. While the effects are certainly felt downstream across these borders, it is still fair to say that the present pattern of interbasin diversions strongly reflects the potential regionalization of Canada and the United States.

(iii) The foundation of Canadian–American international water law derived from the 1895 United States–Mexico dispute over the use of the Rio Grande. The United States reply is what is now referred to as the Harmon Doctrine.[18] A less stringent version of the same doctrine or principle appeared in Article II of the 1909 Boundary Waters Treaty.

(iv) Of all the difficulties associated with major interbasin transfers, the legal and political considerations are the most complex.

(v) The Supreme Court decision of *Arizona* vs *California* (373 US 566, 1963) was a landmark decision in federal–state water law. During the 10 years of litigation (1952–1963) both parties came to the conclusion that the water supply of the Colorado River was not big enough to supply the needs of both states, and therefore a supplemental source of water had to be found outside the Colorado basin.

Environmental

(i) The environmental implications of large interregional water transfer schemes are many, and these should be carefully analysed and received. A major difficulty is to assign economic values to many of the social and environmental costs stemming from such projects.[19] These should at least be subjectively evaluated.

(ii) The increase in both water-borne and water-based diseases due to major water developments, especially in the tropics and subtropics, should be carefully considered. Appropriate countermeasures should be taken to ensure that incidence of such diseases are kept to a minimum.[20]

(iii) Major interregional transfer schemes may affect the flora and fauna, and may cause irreparable damages.

(iv) Changes in micro- and macro-climate due to large-scale developments is always a possibility, especially in terms of increased evaporation and fog formation.

(v) Since the promulgation of the US National Environmental Policy Act (NEPA) of 1969 and the issuance of the Canadian Environmental Assessment Guidelines (1976), it is necessary to prepare environmental impact assessment for all significant federally funded projects. This includes, *inter alia*:

the environmental impact of the proposed action;
any adverse environmental effects which cannot be avoided should the proposal be implemented;
alternatives to the proposed action;
the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and
any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

CONCLUSIONS

Within the North American context, the following conclusions can be drawn for future large-scale interregional water transfer projects.

(1) Opposition to water exports, especially for interstate and international projects is likely to increase, especially as water becomes a scarce commodity. Logically this is hard to explain, since states and countries freely export other resources like minerals, hydrocarbons or agricultural products. In fact, for these resources, emphasis seems to be on increasing exports. Public sentiments, for some reasons, seem to be against water exports, and this is reflected within the political process. This is unlikely to change in the near future.

If the plan is self-contained within a state, its probability success is much higher.

(2) There is a tendency within the engineering and economic professions to opt for technological solutions — "soft" options are seldom seriously considered. Since water

resources development is dominated by these two professions, there is a tendency to make decisions to go ahead with technological fixes before all the alternatives are explored.

(3) The legal aspects of interstate and international transfers are quite complicated. This can be easily noticed when the number of serious disputes arising out of management of interstate and international rivers and lakes are considered. This is a global, and not exclusively North American, problem.

(4) Since the late 1960s opposition to major interregional water transfer projects has increased on environmental grounds. In the United States, it is unlikely that such schemes will be implemented within the forseeable future – at least for the next two decades.

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