Inter Basin Water Transfers (IBWT) are in operation at a quite substantial scale, especially in several developed and emerging countries. In these countries and to a certain extent in some least developed countries there is a substantial interest to develop new IBWTs. IBWTs are being applied or developed not only for irrigated agriculture and hydropower, but also for municipal and industrial water supply, flood management, flow augmentation (increasing flow within a certain river reach or canal for a certain purpose), and in a few cases for navigation, mining, recreation, drainage, wildlife, pollution control, log transport, or estuary improvement.

Debates on the pros and cons of such transfers are on going at National and International level. New ideas and concepts on the viabilities and constraints of IBWTs are being presented and deliberated in various fora. In light of this the Central Office of the International Commission on Irrigation and Drainage (ICID) has attempted a compilation covering the existing and proposed IBWT schemes all over the world, to the extent of data availability. The first version of the compilation was presented on the occasion of the 54th International Executive Council Meeting of ICID in Montpellier, France, 14 - 19 September 2003. Then a decision was taken to establish a Task Force on Inter Basin Water Transfers for Irrigation, Drainage and Flood Management. Accordingly, the Task Force on Inter Basin Water Transfers (TF-IBWT) was constituted. The TF-IBWT would have to review the draft document, to collect and analyse additional data and information and to prepare an ICID publication in consultation with the National Committees of ICID. The specific Terms of Reference (ToR) for the Task Force were to:

- collect the relevant information on existing and proposed inter basin water transfers for irrigation, drainage and flood management;
- compile the collected information and circulate to National Committees for comments;
- analyse the crucial issues of such transfers and recommend good practices to deal with such issues;
- publish the material as an ICID reference document.

The Task Force had its first meeting in Moscow, Russia on 8 September 2004, its second meeting in Beijing, China on 13 September 2005 and its third meeting in Kuala Lumpur, Malaysia on 12 September 2006. During the meetings of the Task Force several drafts of the document have been discussed and recommendations have been given for further modifications along with the inclusion of as much as possible additional information and analysis and recommendations on IBWT schemes, based on the experiences gathered and analysed. The present 6th draft has been prepared since the Kuala Lumpur meeting. The document has been brought at such a level that it may be considered as draft final, subject to final comments during the Task Force meeting in Sacramento, USA on 2
October 2007 and final check by the ICID National Committees, shortly after the meeting.

The present composition of the Task Force was:

- **Members:** (1) Prof. Bart Schultz, PhD, MSc, President Hon. ICID, Chairman (the Netherlands), (2) Dr. José A. Ortiz Fdz.- Urrutia (Spain), (3) Mr. Maurice Roos (USA), (4) Prof. Dr. Takeshi Hata (Japan), (5) Prof. Zhu Ruixiang (China), (6) Dr. Frank Quinn (Canada), (7) Mr. Syed Jamait Ali Shah (Pakistan), (8) Mr. R.K. Sharma (India), (9) Mr. M. Gopalakrishnan, Secretary General, ICID, (10) Mrs. Jancy Vijayan, Joint Director, ICID Central Office (Coordinator);

- **Permanent Observers:** (i) Dr. C.D. Thatte, Secretary General Hon., ICID (ICOLD representative) and (ii) Mr. Boubakari Mana (Lake Chad Basin Commission); (iii) Dr. Stephen Maxwell Donkor (UN Water/Africa Secretariat).

The members of the Task Force hope that this document will improve the insight in the extent, plans and relevant aspects of IBWTs and that it may contribute to an improved decision-making on development, operation and management of existing and new IBWTs.
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      4.2.3 Chile
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4.3.4 Turkey
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4. COUNTRY WISE EXPERIENCES

In this Chapter a review will be given on the country wise experiences with Inter Basin Water Transfers (IBWT) with a focus on their application to irrigation, drainage and flood management. A distinction will be made in existing and proposed schemes. Within a certain country the schemes will be presented in the following order:

- first the typical schemes for irrigation, drainage and/or flood management;
- the multi purpose schemes with irrigation, drainage and/or flood management components;
- the other schemes.

The information is based on submissions by the ICID National Committees, the members and permanent observers of the Task Force, individual specialists and derived from literature. It is not pretended that the information gives a complete overview, but as complete as reasonably possible and to such an extent that general conclusions and recommendations can be formulated.

4.1 Asia

Asia is the world’s largest and most populous Continent. It covers 8.6% of the Earth’s total surface area and contains more than 60% of the world’s current human population. Asia, chiefly in the eastern and northern hemispheres, is defined as part of the landmass of Africa-Eurasia with the western portion of the latter occupied by Europe. It is bounded to the East by the Pacific Ocean, to the South by the Indian Ocean, and to the North by the Arctic Ocean.

The Continent Asia occupies about 36% of the world’s water resources, which supports the 60% of the world’s population living in it. The global trends of availability in water resources versus growth in population put the Continent Asia under pressure. The disparity in spread of population especially in urban areas and availability of water with respect to time and space demands for a careful management of the water resources. The needs of societies and the environment make sustainable water resources planning and development followed by management and monitoring a complicated task.

In Asia 80% of the runoff occurs between May and October. Although this runoff may be beneficial for certain economic activities, like fisheries and recession agriculture, may sustain ecosystems and wetland habitats, it may result as well in damage due to flooding of rural and urban areas. By way of storage, either in reservoirs, in aquifers, or by other means, on the one hand the risk
4. Country wise experiences

of flooding will be reduces and on the other hand the water may be used for various purposes like: for irrigated agriculture, municipal and industrial water supply, as well as for various other uses. In light of these aspects, IBWTs can play their role as well.

The main river basins in Asia are shown in Figure 4.1 and details of the basins are provided in Table 4.1. From the table it can be seen that some of the basins are shared by more than 5 countries. Hence inter basin cooperation between the riparian countries is of prime importance for sustainable development of the water resources.

IBWT schemes for irrigation or flood management were constructed and are being planned to divert water from surplus areas to deficit ones in various regions of the Continent. No IBWT for drainage could be identified on the Asian Continent. Most of the IBWTs are efficiently conserving and distributing the transferred water amongst the needy areas while some of them have their own deficiencies and adverse impacts demanding the need for strengthening participatory involvement of stakeholders, integrated development and related monitoring measures. The characteristics of the IBWTs that fit in the criteria as formulated before, in various river basins of the regions have been implemented or are in conceptual stages. These are seen in the following countries: Pakistan, India, China, Iraq, Japan, Iran, Republic of Korea, Malaysia, Central Asian States and Nepal. These will be described in the next subsections along with data on the IBWTs under Annex 2.

4.1.1 Pakistan

Located in South Asia, Pakistan borders Iran to the Southwest, Afghanistan to the West and North, China to the Northeast, and India to the East. The Arabian Sea marks Pakistan’s southern boundary. It has an area of 80 Mha with an estimated population of 163.6 million, out of which 60.8% is engaged in agricultural activities (UN, 2007). Pakistan has a large variety of climatic types ranging from temperate climate in the North to hot arid tropical in the South. The northeastern mountainous and sub mountainous areas receive more than 1,700 mm annual rainfall with the major share (1,000 mm) coming from summer monsoon. On the other hand, the extremely arid plains of southwestern Balochistan receive only 30 mm on an average during the whole year (Nasim Akhtar, 2001).

Pakistan, mainly consists of two distinct physiographic provinces: Western Highlands, and Indus Plain resulting from the deposition of sediments by the Indus River and its tributaries. The Indus Plain is the most important physiographic region since it comprises the main agricultural areas of the country. The main rivers of the region are the Indus (2,749 km within Pakistan) and its tributaries: the Chenab (730.6 km), Ravi (680.6 km), Jhelum (611.3 km), and Sutlej (530.6 km). The navigable portions of these rivers are generally small and unconnected as a result of seasonal variations in water flows and the presence of substantial irrigation structures (FRDCP: Pakistan, 2005).
Development of the irrigation system

The irrigation system of Pakistan is one of the largest integrated irrigation networks in the world, serving about 14.6 million hectares of contiguous cultivated land. The average annual river diversions for irrigation in the Indus Basin are of the order of 105 MAF (129.5 BCM). Out of which, 67 MAF (82.6 BCM) are diverted during the kharif period while 38 MAF (46.9 BCM) are diverted during the Rabi period. A further 41.6 MAF (51.3 BCM) are pumped annually from the ground water reservoirs, of which more than 90% is used for irrigation purposes. Controlled year round irrigation began in the Indus Basin in 1859 with the completion of the Upper Bari Doab Canal from Madhopur Headworks (now in India) on Ravi River. Later on in the 20th Century, it became apparent that the water resources of the individual rivers were not in proportion to the potential irrigable lands. Ravi River, serving a large area of Bari Doab, was deficient in supply while the Jhelum River had a surplus.
4. Country wise experiences

Table 4.1. Details of river basins/lakes of the Asian Region

<table>
<thead>
<tr>
<th>No</th>
<th>Name of river basin/lake</th>
<th>River basin/lake area (km²)</th>
<th>Crop land (%)</th>
<th>Wet land (%)</th>
<th>Dry land (%)</th>
<th>Irrigated cropland (%)</th>
<th>Average population density (people/km²)</th>
<th>Water supply/person/year (m³)</th>
<th>Degree of river fragmentation</th>
<th>Number of dams on main stem of river (height in m)</th>
<th>Countries within the basin/lake</th>
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</thead>
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<td>33</td>
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<td>Medium</td>
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<tr>
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<td>Lake Balkhash</td>
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<td>1.9</td>
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<td>439</td>
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<td>3.7</td>
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<td>-</td>
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<td>265</td>
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<td>1.5</td>
<td>0.0</td>
<td>0.23</td>
<td>161,359</td>
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<td>Medium</td>
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<td></td>
<td>River</td>
<td>Area (km²)</td>
<td>Length (km)</td>
<td>Elevation (m)</td>
<td>Shorline (km)</td>
<td>Flow Rate (m³/s)</td>
<td>Density (m³/km²)</td>
<td>Flow Duration (days)</td>
<td>Temperature (°C)</td>
<td>Flow Width (m)</td>
<td>Sediment (t/km²)</td>
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<td>-</td>
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<td>Yenisey</td>
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<td>2.7</td>
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<td>3</td>
<td>79,083</td>
<td>High</td>
<td>11</td>
<td>1</td>
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</table>

**Source:**
2. AQUASTAT Survey 2005: FAO’s Information System on Water and Agriculture
3. International River Basins Register :Asia (August 2002)
4. Encyclopedia Britannica Online
4. Country wise experiences
Existing IBWT Schemes

An innovative solution for addressing the disparity in availability of water was planned and developed in the form of Triple Canal Project. The work on the Triple Canal Project was commenced in 1907. In 1915, the Triple Canal Project comprising Upper Jhelum Canal, Upper Chenab Canal and Lower Bari Doab Canal were completed. The project linked the Jhelum, Chenab, and Ravi rivers, allowing transfers of surplus Jhelum and Chenab waters to the river basin Ravi.

Upper Chenab Canal

The Upper Chenab Canal was commissioned in 1912 and offtakes from Marala at Chenab with the Head Capacity of 16,500 cusecs (462 m³/s). It transfers Chenab Waters to Ravi River for feeding Lower Bari Doab Canal besides providing 5,200 cusecs (146 m³/s) for irrigation enroute at Sialkot, Gujranwala, Sheikhupura and Hafizabad Districts.

Upper Jhelum Canal

The Upper Jhelum Canal was commissioned in 1915 and offtakes from Mangla at Jhelum with Head Capacity of 12,500 cusecs (350 m³/s). It transfers surplus waters of Jhelum River to Chenab River at Khanki to feed Lower Chenab Canal System. It also provides 2,000 cusecs (56 m³/s) of irrigation water enroute in Gujrat, Mandi Bah-ud-Din and Sargodha Districts besides transferring 3,400 cusecs (95 m³/s) to Lower Jhelum Canal through Rasul Power House having an installed capacity of 22 MW.

The Triple Canal Project was a landmark in integrated inter basin water resources management and also provided the key concept for the resolution of the Indus Waters dispute between India and Pakistan in 1960.

Haveli Canal

The Haveli Canal was commissioned in 1939 and offtakes from Trimmu at Chenab with Head Capacity of 5,200 cusecs (146 m³/s). It transfers Chenab waters to Ravi River to feed Sidhnai Canal besides providing 800 cusecs (22 m³/sec) for irrigation in Jhang / Khanewal districts.

Marala Ravi Link

The Marala Ravi Link was commissioned in 1956 and offtakes from Marala at Chenab with Head Capacity of 22,000 cusecs (616 m³/s). It transfers Chenab waters to Ravi River providing 1,400 cusecs (39 m³/s) for intensifying irrigation in Sialkot District.

Montgomery – Pakpattan Link

The Montgomery – Pakpattan Link was commissioned in 1945 and offtakes from Lower Bari Daab Canal (LBDC) at Ravi with Head Capacity of 1,000 cusecs (28 m³/s). It transfers Ravi waters to supplement supplies in Pakpattan Canal off taking from Sutlej River.

Resolution of Indus Waters Treaty - 1960

At independence, the irrigation system, conceived originally as a whole, was divided between
Indian and Pakistan without regard to irrigated boundaries. This resulted in the creation of an international water dispute in 1948, which was finally resolved by the enforcement of Indus Water Treaty in 1960 under aegis of the World Bank. The Treaty assigned the three eastern rivers (Ravi, Beas, Sutlej) to India, with an estimated total mean annual flow of 40.7 BCM and the three Western rivers (Indus, Jhelum Chenab) to Pakistan with a transfer of irrigation supplies from the western rivers to areas in Pakistan formerly served by the Eastern rivers as well as some development potential for the attempt to compensate for the perpetual loss of the Eastern waters. In order to give effect to the Treaty provisions and to enable substitution of earlier arrangements, Pakistan launched a massive programme of inter linking of the concerned river sub-basins of the Indus, viz. Jhelum, Chenab and Ravi in addition to constructing dams and barrages to facilitate the transfer. This helped the integrated operation of the river system (Fahlbusch et al., 2004). The canal systems constructed under the Indus Basin Irrigation System (IBIS) are shown in Figure 4.2.

**Bombanwala Ravi Badian Depalpur Link**

The Bombanwala Ravi Badian Depalpur Link was commissioned in 1956 and offtakes from Upper Chenab Canal (UCC) at Chenab with Head Capacity of 7,000 cusecs (196 m$^3$/s). It transfers Chenab waters to feed Upper Bari Doab Canal (UBDC) System (Pakistan portion) off taking from Ravi River and Upper Debalpur Canal System of Sutlej River.

**Balloki – Sulemanki Link – I (BS-I)**

The Balloki – Sulemanki Link – I (BS-I) was commissioned in 1955 and off takes from Balloki at Ravi with Head Capacity of 15,000 cusecs (420 m$^3$/s). It transfers Ravi waters to Sutlej River to feed Sulemanki Canals and provides 4,000 cusecs (112 m$^3$/s) for Lower Debalpur Canal irrigating areas in Okara, Pakpattan and Sahiwal districts.

**Rasul – Qadirabad Link**

The Rasul – Qadirabad Link was commissioned in 1969 and off takes from Rasul at Jhelum with Head Capacity of 19,000 cusecs (532 m$^3$/s). It transfers Jhelum waters to Chenab River to feed Qadirabad Canal.

**Trimmu – Sidhnai Link**

The Trimmu – Sidhnai Link was commissioned in 1969 and off takes from Trimmu at Chenab with Head Capacity of 1,000 cusecs (28 m$^3$/s). It transfers Chenab waters to Ravi River to feed Sidhnai Canals.

The Sidhnai – Mailsi – Bahawal Link

The Sidhnai – Mailsi – Bahawal Link was commissioned in 1969 and off takes from Sidhnai at Ravi with Head Capacity of 10,100 cusecs (283 m$^3$/s). It transfers Ravi waters to feed Sutlej Canals.

**Pakpattan – Islam link**

The canal was commissioned in 1969 and off takes from upper Pakpattan Canal with Head Capacity of 1,000 cusecs (28 m$^3$/s). It transfers waters from Upper Pakpattan Canal to
upstream of the Islam Barrage.

**Qadirabad – Balloki Link**

The Qadirabad – Balloki Link was commissioned in 1970 and offtakes from Qadirabad at Chenab with Head Capacity of 25,000 cusecs (700 m³/s). It transfers 10,200 cusecs (286 m³/s) Chenab waters to Ravi River to feed Balloki Canal besides providing 4,000 cusecs (112 m³/s) for feeding part of Lower Chenab Canal System.

**Balloki – Sulemanki Link – II (BS-II)**

The Balloki – Sulemanki Link – II (BS-II) was commissioned in 1970 and offtakes from BS-I at Ravi with Head Capacity of 9,000 cusecs (252 m³/s). It transfers Ravi waters to feed Sutlej Canals.

**Taunsa – Pajnad Link**

The Taunsa – Pajnad Link was commissioned in 1970 and offtakes from Taunsa at Indus with Head Capacity of 12,000 cusecs (336 m³/s). It transfers Indus waters to Chenab River for feeding Panjnad Canals.

**Chashma Jhelum Link**

The Chashma Jhelum Link was commissioned in 1971 and offtakes from Chashma at Indus with Head Capacity of 22,000 cusecs (616 m³/s). It transfers Indus waters to Jhelum River to feed Trimmu Canals.

**Proposed Schemes**

There are two proposed schemes as shown underneath.

**Mangla – Marala Link**

The Mangla – Marala Link will off take from Mangla at Jhelum with Head Capacity of 10,000 cusecs (280 m³/s). It will transfer Mangala storage waters to Chenab River to feed Chenab Canals at Marala and Khanki.

**Kalabagh – Rasul Link**

The Kalabagh – Rasul Link will offtake from Kalabagh at Indus with Head Capacity of 1,000 cusecs (28 m³/s). It will transfer Kalabagh storage waters to Jhelum River to integrate whole of Indus Basin as one composite unit (Syed Jamait Ali Shah, 2007).
4. Country wise experiences

4.1.2 India

India forms a natural sub-continent with Himalayas to the North. The Arabian Sea and the Bay of Bengal, which are sections of the Indian Ocean, lie to the West and East respectively. India’s neighbours are China (Tibet), Bhutan and Nepal to the North, Pakistan to the Northwest, and Burma to the Northeast. To the east,
almost surrounded by India, is Bangladesh. Near India’s southern tip, across the Palk Strait, is Sri Lanka. It has an area of 329 Mha with an estimated population of 1,169 million (UN, 2007) out of which 64.6% is engaged in agricultural activities.

Rainfall in India is erratic and uneven that ranges from 11,000 mm annually in some parts of North Eastern India to 100 mm in Western India. India receives an annual precipitation of 4,000 BCM of which 75% occurs just in the four months of the monsoon period. From the annual precipitation, 1,869 BCM of water appears as runoff in various river basins. The utilizable water resource has been assessed as 1,122 BCM out of which 690 BCM is from surface runoff and the remaining 432 BCM is from groundwater (NCIWRD Report, 1999). To address this disparity and find ways for augmentation of available utilizable water resources from surplus region to deficit ones, the Government of India considers interlinking of rivers as one of the options available for implementation.

IBWT schemes in India help to supply water to major Indian cities. Delhi, the Capital of India, which is situated on the banks of the river of Yamuna, now depends on long distance water transfer from many river basins. The Bhakra dam on the river Sutlej River in the Indus Basin as well as Ramganga dam and Tehri dam on Ganges system already started supplying water to meeting the increasing demands of Delhi. The Renuka and Keshau dams are expected to meet additional future demands of Delhi. Other major cities like Hyderabad, Chennai, Mumbai etc. are other cities in India similarly depending on inter basin water transfer schemes for meeting their water needs (Rangachari et al., 2000).

Existing schemes

Interlinking of rivers, tributaries and sub-basins of mega river basins of India like Ganges and Indus, and inter-basin transfer, as a concept was popular even in Pre-British era. For example, Western Yamuna canal and Agra Canal, constructed during Mughal period (15th century) were long distance water transfer schemes extending irrigation to adjoining sub-basins. Many inter-basin transfer schemes were constructed as a part of irrigation development both during British and post Independence periods. In the middle of the 19th century, large-scale canal construction was undertaken in the Ganga, Godavari and Krishna river basins to transfer water across numerous rivers. The Krishna and the Godavari irrigation systems cover and irrigate the small river basins in between.

The Nagarjuna Sagar right bank canal (1970) irrigates areas beyond the Krishna River basin. One of the earlier classical instances of IBWTs was from the upper reaches of the west flowing Periyar River in Kerala to east flowing Vaigai River in Tamil Nadu across Western Ghats by constructing the Mullaperiyar dam more than a century ago did this. Another IBWT scheme from Periyar River to Muvattupuzha River was constructed for power generation. This also considerably increased the availability of water for the inhabitants of the Muvatthupuzha basin.

The Mahi right bank canal (MRBC), in the state of Gujarat, was developed in two stages: 1958
4. Country wise experiences

and1978. The command area has been receiving perennial irrigation since then. The reservoir is filled almost every year during and at the end of the monsoon (kharif), so that the main canal system can receive its full design discharge of 196 m$^3$/s. The system is designed to use canal water to irrigate a total of 26,000 ha during the three seasons. Presently, the total area irrigated by surface water is estimated at 200,000 ha comprising 100,000 ha in kharif and 50,000 ha each in rabi and hot weather seasons. This is supplemented by extensive pumping of groundwater that enables a further 180,000 ha to be irrigated, giving a total annual cropping intensity of 180. There are approximately 30 to 40 rainy days and the annual rainfall is 880 mm (Raju, 2002).

Some more details about the past and present existing links for inter-basin transfers of water are presented below.

*Water transfer from Ghagra-Sarda*

In the Ganges basin, waters from Ghagra sub-basin are transferred to Sarda sub-basin to irrigate large hitherto uncommanded areas. The link channel between the two barrages is of the capacity of 4.81 m$^3$/s (15.16 BCM/yr).

*Periyar-Vaigai Link System*

The Periyar Scheme is an important IBWT scheme of the last century. A masonry gravity dam has been constructed across a gorge on west flowing Periyar River. A 1,740 m long tunnel with a discharge capacity of 40.75 m$^3$/s has been driven across the mountain barrier to convey the water (1.29 BCM/yr) eastward to Vaigai basin. The scheme was commissioned in 1895 and provides irrigation water to nearly 80,000 ha. The scheme also generates 140 MW of hydropower.

*Kurnool- Cuddappa Canal*

The Kurnool-Cuddapah Canal in Andhra Pradesh transfers waters of the Krishna to the Pennar basin in Kerala. A private company started Kurnool-Cuddappa Canal in 1863. A barrier was built on River Tungabhadra upstream of Kurnool town. A 304 km canal with a capacity of 84.9 m$^3$/s (2.68 BCM/yr) takes off from the barrier to carry water from Krishna to Pennar basin and irrigates more than 50,000 ha. The scheme was taken over by the Government of India in 1882.

*Telgu Ganga Scheme*

The Telgu Ganga Scheme has been implemented to meet the needs of drinking water supply for the Chennai metropolitan area. Under this scheme, water transported from the SriSailam reservoir in the
Krishna River is first led through an open channel into the Somasila reservoir in the Pennar valley. This involves rock cuts up to 35 m deep. From Somasila, water is taken through a 45 km long canal to Kandaleru and thereafter to the Poondi reservoir in Tamil Nadu through a 200 km long canal. By mutual agreement, 0.34 BCM/yr of water is delivered to Tamil Nadu at its border from Krishna River. This greatly augments the water supply of Chennai city. The canal also irrigates 0.23 Mha in Andhra Pradesh.

**Parambikulam Aliyar Scheme**

This scheme was built during 1960s after the finalisation/signing of an agreement between Kerala and Tamil Nadu. The project is a multi-purpose project consisting of five west and two east flowing rivers. Dams were constructed on these 5 rivers and inter-connected to divert water eastward from Parambikulam (Chalakudy) catchment in Kerala to Aliyar in Bharathapuzha and Cauvery catchments in Tamil Nadu. Water is ultimately supplied to drought prone areas of Coimbatore district of Tamil Nadu and Chittoor district of Kerala. The water so diverted is used for irrigation to 16,200 ha of land. The project also generates 185 MW of hydropower.

**Madhopur – Beas Link**

The first scheme to interlink the sub basins of the mega Indus system was between Jhelum, Chenab and Ravi rivers, which were taken up in 1910 and commissioned in 1915 (Figure 4.3). It enabled the waters of Jhelum River to be transferred for irrigating the lower Bari Doab areas through links of Upper Jhelum Canal and Upper Chenab Canal. Another scheme executed in 1928, was the Ganga Canal (114 km) in erstwhile Bikaner state, which brought the Sutlej waters to the desert. The second link was built for transfer of surplus water from Madhopur Headworks on the Ravi River to Harike via the Beas River. The Madhopur-Beas Link was constructed in 1960. The link transfers Ravi waters (4.5 BCM/yr) to the Beas River for storage in the Pong dam through a link with discharge of 200 m$^3$/s. These flows are fed into the canal system taking off from Harike barrage further downstream.

![Figure 4.3. Link between Jhelum, Chenab and Ravi rivers](image-url)
Beas-Sutlej Link

Bhakra dam is the main multipurpose storage on the Sutlej River while the Pong dam has been constructed on the Beas River. Water stored in Bhakra Dam on the Sutlej River is supplied to Rajasthan, Haryana and Delhi, which are located in the Yamuna basin. The inter connected Beas-Sutlej Link of 1970s has been built to transfer water (4.9 BCM/yr) from the Beas River to the Bhakra dam in the Sutlej basin (Figure 4.4). The scheme is a power scheme envisages transfer of about 4,716 MCM/s of Beas waters to Sutlej falling through a height of 320 m and generating power in this process.

The main components of the scheme are:

- Pandoh dam of 76.20 m in height above the deepest foundation;
- Pandoh Baggi concrete tunnel of 13.1 km long and 7.62 m dia lined throughout its length and reinforced in reaches where the rock cover is inadequate is capable of carrying 254.85 cumes up to the Baggi Control Works;
- Baggi Control Works have been provided at the exit point of the Pandoh baggi Tunnel for regulation of outflows from Pandoh Reservoir to meet the fluctuating demands of Dehar Power Plant;
- Sundernagar Hydel Channel is an 11.8 km long concrete lined hydel channel, taking off from the exit portal of Pandoh Baggi Tunnel and outfalls into Sundernagar Balancing Reservoir with full supply discharge capacity of 7.3 m³/s (255 cusecs) at the head and 7.3 m³/s (248 cusecs) at the tail end;
- Sundernagar Balancing Reservoir with a live storage capacity of 3.7 million m³ has been constructed at tail of the hydel channel to provide balancing storage to take care of the variation between the supply required for the actual load on Dehar Power Plant and discharge in water conductor system;
- Sundernagar Sutlej Tunnel is a 8.53 m diameter and 12.35 km long power tunnel having carrying capacity of 11.5 m³/s (404 cusecs) of water for running six generating units of Dehar Power Plant;
- Dehar Power Plant on the right bank of river Sutlej, which is a multistoried reinforced concrete framed structure, has been designed to house six generating units of 165 MW each. The construction of powerhouse involved of tough rock excavation under hazardous condition (BBMB report).
The Indira Gandhi Nahar Scheme (IGNS), formerly known as Rajasthan Canal Scheme is one of the impressive schemes aiming to transform desert wasteland into agriculturally productive area. The scheme objectives include drought proofing, providing drinking water, improvement of environment, afforestation, employment generation, rehabilitation, development and schemecion of animal wealth and increasing agricultural production.

The scheme area lies in the Thar Desert in Indian sub-continent. The Thar Desert occupies 19.84 Mha, 58% of the geographical area of the Rajasthan State and 6% of the geographical area of India. Here the rainy season lasts for a very short spell between mid-July to first week of September. The mean annual rainfall varies between 100 mm and 360 mm. Most of the rainfalls occur as a few heavy showers otherwise the weather remain dry. Exceptionally strong winds (up to mean monthly of 27.2 km/hour in the month of June), generally from Southwest to Northeast, cause wind erosion on a large scale and blow sand. They cause movement of sand over road, disrupting transportation, canal sedimentation, and sand blasting of the vegetation etc. The annual mean potential evapotranspiration of the scheme area varies between 1,825 mm to 2,530 mm.

Severe droughts and famines have occurred almost every year in the area. The happenings of the calamities in 1860-61, 1868-69, 1869-70, 1886-87, 1899-1900, 1920, 1938-39 and 1939-40 took heavy toll of human and cattle lives. The total population migrated and a large number of them died of starvation or were wiped out by the epidemics. Famines were considered a normal feature of the life in the scheme area.

The scheme was conceived in October 1948 with the consideration of bringing prosperity to the devastated area. The scheme with an estimated costing of Indian Rs. 666.7 million was sanctioned in July 1957. In 1956-57 the Central Government of India accepted the scheme in principle and IGNP
4. Country wise experiences

Board was created in 1958. The charge of construction of the entire canal network and related infrastructures over the entire IGNP command area has ever since come under the Board. The construction commenced in 1958. The IGNP was designed to utilise 9,362 MCM/yr of the total 10,608 MCM/yr allocated to Rajasthan from the surplus waters of the Ravi and Beas rivers under ‘Indus Water Treaty’ (1960) between India and Pakistan. The construction works of the scheme were carried out in two stages.

Stage I

Stage I consists of a 204 km long feeder canal, having a headwork discharge capacity of 460 m$^3$/s, which starts from Harike Barrage. 170 km of the feeder canal lie in Punjab and Haryana and 34 km in Rajasthan. The entire system of stage-I consists of the 204 km long feeder canal, 189 km long main canal and 3,454 km long distribution system, is concrete lined, and serves 0.553 Mha of cultivable command area, out of which 0.046 Mha are served by pumping to a 60 m lift, through four pumping stations.

In addition to building irrigation and domestic water supply facilities through the scheme, mini hydroelectric power stations for utilizing the available waterfall in the canal and generating a total 12.76 MW of power have also been installed by the Rajasthan State Electricity Board (RSEB).

Stage II

IGNP Stage II starts immediately downstream of the Stage I and comprises construction of a 256 km long main canal and 5,606 km of a lined distribution system, and will serve 1.410 Mha (0.87 Mha area under gravity command and 0.54 Mha under lift) of Culturable Command Area (CCA), utilizing 4,930 MCM/yr of water. The main canal in the entire length was completed in the year 1986 (Website, Water Resources Department, Government of Rajasthan).

The scheme now envisages providing irrigation facility to about 2Mha of land spreading in the districts of Ganganagar, Bikaner, Jaisalmer, Jodhpur, Barmer and Churu utilizing 9,362 MCM of waters. The water travels from Ranjeetsagar to a farthest distance exceeding 1,500 km to irrigate land in Barmer district. The total water allocation under Stage I and Stage II is shown in Table 4.2.

Table 4.2. Total water allocation under Stage I and Stage II (MCM)

<table>
<thead>
<tr>
<th>Stage I</th>
<th>Stage II</th>
<th>Total (Stage I + Stage II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>Drinking</td>
<td>Total</td>
</tr>
<tr>
<td>Average year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4157 (94%)</td>
<td>271 (6%)</td>
<td>4428</td>
</tr>
<tr>
<td>3096 (92%)</td>
<td>271 (8%)</td>
<td>3367</td>
</tr>
</tbody>
</table>
Development of Irrigation and Command Area Development

The construction of the canal was planned in phases according to availability of water. It has however, experienced adverse impacts on account of various deficiencies such as absence of properly designed and constructed watercourses and inadequate infrastructure facilities such as roads, marketing centers, schools, primary health centers, agriculture input service and credit facilities, etc. As a result, the growth of irrigation was slow, agriculture yield levels were low and overall efficiency of system was poor and was felt to introduce an integrated command area development scheme plan.

A Command Area Development Authority (CADA) was constituted to coordinate and supervise the functions of the IGNP components. The CADA includes representation of beneficiaries apart from local members of Parliament, Legislative Assembly, Panchayat Samities and Heads of Departments concerned, etc. The existing local staff of Irrigation, Agriculture, Revenue and Cooperative Departments were placed under the direct control and supervision of the Area Development Commissioner (Administrator of CADA). The ADC was also given powers of heads of these departments. The CADA is also authorized to approve the plans and activities in the scheme area regarding Colonization, Forest, Public Works Department, and Public Health Departments to ensure integrated development in a coordinated manner.

The integrated development of about 235,000 ha of land located in the head reach of Stage I of the scheme was started in the year 1974 with the assistance from the International Development Agency (IDA). Another CAD scheme covering some 246,000 ha area was taken up in the year 1980 at a cost of Indian Rs. 930 million with the assistance of International Fund for Agricultural Development (IFAD). Integrated area development commenced in Stage II area in the year 1987. Subsequently the command area development activities continued with the support derived from India’s Five Year Plan Programs (under the Central Government Assistance). A number of planning studies, semi-detailed soil survey and intensive hydrogeological investigations resulted in a better understanding of the area. These were utilized for planning and incorporation of further command area development works/monitoring measures.

Special efforts are continuously being taken for prevention of water logging conditions and soil salinity. The activities of the CADA included construction of lined watercourses from the canals to the field, sanitary diggies for drinking water, protective forestry for canals, roads, and farms, afforestation and pasture development, fisheries, agricultural research and extension, supply of inputs and services to the farmers, developments of settlements and marketing facilities, etc. A total of 43,090 farmers have been trained in irrigated agriculture practices. More than 3822 Samities (Water User Associations) have been formed. 18,259 settler families have been benefited through free supply of ration.

Benefits accrued through the IGNP (Government of Rajasthan, 1997):
4. Country wise experiences

- the total agriculture production from the scheme has exceeded 1.21 MT/yr;
- irrigation from stage I and II has touched to a total CCA of 2Mha;
- the movement of sand has been successfully checked;
- permanent employment has been provided to about 0.45 million people;
- good quality drinking water provided round the year;
- allotted over 1,003,000 ha of land to about 139,567 persons;
- provided afforestation to more than 172,460 ha;
- experienced remarkable changes in socio-economic conditions;
- occurred enhancement in inter-and-intra-community interactions;
- adopted new technologies of irrigated farming in the command areas;
- created fresh groundwater storages for conjunctive uses of water in irrigation areas.

**Sutlej - Yamuna Link**

The Sutlej - Yamuna Link (SYL) canal is planned to transfer the Bhakra waters to Yamuna basin in Haryana. After reorganization of Punjab in 1966, its 8.9 BCM of water was equally divided between Punjab and Haryana (both received 4.3 BCM) leaving 0.25 BCM to meet Delhi’s needs. In 1978 Punjab and Haryana started to link the Sutlej River in Punjab via a canal to the Yamuna River in Haryana. This link (SYL) was necessary to provide Haryana the allocated 4.3 BCM as it could not be imported from the Ravi-Beas system.

Haryana completed the construction of its portion of the SYL canal in 1980, but it was not satisfied with Punjab’s pace of canal construction and sued Punjab. Punjab had reconsidered the planned amount of water it had to give to Haryana. Notwithstanding this, Punjab, Haryana and Rajasthan came to an agreement in 31st Dec 1981, allotting 5.2 BCM MAF to Punjab, 4.3 BCM to Haryana, 10.6 BCM to Rajasthan 0.25 BCM to Delhi and 0.8 BCM to Jammu and Kashmir. Punjab assured that it would finish the SYL within two years, but again, the state failed to keep its promise due changes of governments both at the centre and state levels followed by many disputes on water sharing and its utilizations. The SYL link still stands as an unfinished task for a further consensus from interested parties.

**Sardar Sarovar Scheme**

The Sardar Sarovar Project is an inter-state multipurpose joint venture of four states – Gujarat, Madhya Pradesh, Maharashtra and Rajasthan. Although this project was originally envisaged in 1946, a decision by Narmada Water Disputes Tribunal (NWDT) came in 1979 and the project got it clearance in 1987 from environment and forest angle, the Government of India after four long
decades. The main parameters of the decision arrived under NWDT were as under:

<table>
<thead>
<tr>
<th>State</th>
<th>Water Allocation (MAF)</th>
<th>Dependable Yield (BCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madhya Pradesh</td>
<td>18.25</td>
<td>22.51</td>
</tr>
<tr>
<td>Gujarat</td>
<td>9.00</td>
<td>11.10</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>0.25</td>
<td>0.31</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>0.50</td>
<td>0.62</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28.00</strong></td>
<td><strong>34.54</strong></td>
</tr>
</tbody>
</table>

As per the NWDT decision, each party state is free to make such changes in the pattern of water use and in the areas to be benefited within or outside the Narmada basin in its territory as it may consider necessary (Facts on Sardar Sarovar Project, 1996).

The surplus waters of the Narmada River are transferred out of the Narmada basin to areas in Saurashtra in Gujarat for domestic water supply and agricultural purposes. Sardar Sarovar Scheme (Figure 4.5) is essentially a vehicle for taking plentiful waters of Narmada basin, flowing down the sea, to the water starved regions of Saurashtra, Kachchh, North Gujarat and Rajasthan.

![Figure 4.5. Sardar Sarovar Scheme](image)

The Sardar Sarovar Scheme will provide irrigation facilities to 1,793,000 ha of land, covering 3,112 villages of 73 talukas in 15 districts of Gujarat. It will also irrigate 75,000 ha. of land in the strategic desert districts of Barmer and Jalore in Rajasthan and 37,500 ha. in the tribal hilly tract of Maharashtra through lift. A special allocation of 1.06MAF (1.31 BCM) of water has been made to provide water supply [0.86MAF (1.06 BCM) for domestic and 0.20MAF (0.25 BCM) for Industrial purposes] (Y.K. Alagh et al, 1995) to 135 urban centres and 8,215 villages (45% of total 18,144 villages of Gujarat) within and out-side command in Gujarat for present population of 18 million and
prospective population of over 40 million by the year 2021. Water supply requirement of several Industries will also be met from the scheme giving a boost to all-round production. There will be two power houses viz. River bed power house and canal head power house with an installed capacity of 1,200 MW and 250 MW respectively. The power would be shared by three states - Madhya Pradesh - 57%, Maharashtra - 27% and Gujarat 16%. It will also provide flood protection to riverine reaches measuring 30,000 ha, covering 210 villages and Bharuch city and a population of 4.0 lakh in Gujarat.

About 90% of the work with respect to the Main canal, Branch canals and distributaries are over. The work of raising the dam height of spillway of Sardar Sarovar Dam to El 121.92 m has been taken up from 8 March 2006 and planned to complete the entire works of the scheme components by 2008 (Website, Sardar Sarovar Scheme).

Tehri Dam Scheme

Tehri Hydro Development Corporation Ltd. (THDC Ltd.) was incorporated as a Limited Company under the Companies Act, 1956 in July 1988 as a Joint Venture Corporation of the Government of India (GoI) and Government of Uttar Pradesh (GoUP) to develop, operate and maintain the Tehri Dam Complex and other Hydro Schemes (Figure 4.6). The scheme comprise of two stages:

Stage-I:
- a 260.5 m high earth and rockfill dam, 1.5 km downstream of Tehri Town;
- one underground power house of 1,000 MW (4 x 250 MW power plant capacity on left bank)

Stage-II:
- one underground power house of 1,000 MW capacity on left bank (4 x 250 MW pumped storage plant);
- a 97.5 m high concrete gravity dam and a 400 MW surface power house at Koteshwar, 22 km downstream of Tehri Dam.

Tehri Hydro Power Complex Scheme is planned to yield:
- environment friendly hydro-energy to cater to peak load of 2,400 MW. Due to regulated flow in the river throughout the year, power generation in the run-off-the river schemes downstream of Tehri will be increased;
- additional irrigation facilities in 2.7 lakh ha of area in the Commands of Upper Ganga, besides stabilizing irrigation in 6.04 lakh ha of land in Ganges – Yamuna plains;
- 8.4 m$^3$/s of drinking water supply to Delhi and 5.6 m$^3$/s to U.P and will meet the requirements of 4 million people of Delhi and 3 million people in various towns and villages of Uttaranchal and
• flood moderation during monsoon by way of storage of excess water;
• development of pisciculture;
• scope for developing aquaculture;
• Rishikesh- Tehri road developed as a double lane road has opened up the hinterland;
• integrated development of the catchment area including afforestation;
• soil conservation of 36,200 ha of severely eroded land;
• development of tourism in the Garhwal region has boosted up the employment opportunities.

The drinking water supply for Delhi is carried through Upper Ganga Canal up to Murad Nagar (UP) from where it is conveyed through a raw water pipe line to the Sonia Vihar Water Treatment Plant (SVWTP) in Delhi. With the storage and regulation of water from Tehri Dam since 2006, water has already flown to the SVWTP, which caters to the South and east colonies of the Nation Capital-Delhi.

The Tehri Hydro Electric Scheme stands as a unique multi-purpose scheme with the benefits of electricity, irrigation and drinking water to the northern region of Indian Territory. The scheme is one of the most studied hydro-electric schemes from engineering and geo-stability point of view in the
Country wise experiences

country as it is the first major storage dam till constructed in the interior Himalayan ranges. Lots of input from engineers, seismic experts world over have gone into ensuring that adverse effects, if any, due to Tehri schemes are either mitigated completely or minimized.

Rehabilitation and Resettlement (R&R) of about 9,239 families living in 109 villages and 5291 families living in old and historic Tehri town was handled with a comprehensive R&R package. About 15% of the total scheme costs was for implementation of the R&R package efficiently and satisfactorily (Tehri Dam Scheme, CBIP, 2007).

Proposed schemes

The need for the concept of IBWTs was perceived as a longterm plan when the Ministry of Water Resources in 1980 formulated a National Perspective Plan (NPP) for optimum development and utilization of water resources. IBWTs to transfer water from surplus river basins to water deficit basins/area were taken up for preliminary investigation. This became of importance in view of large variation in the annual rainfall in different parts of the country, which results floods in some parts and droughts in others.

The population of India around 1,100 million in 2005 is estimated at 1,600 million by 2050. That would require annually about 450 million tons of food grains. For meeting this requirement, increasing the irrigated area to 160 Mha for all crops by 2050 will be required. India’s maximum irrigation potential that could be created through conventional sources has been assessed to be about 140 Mha. For attaining a potential of 160 Mha and also for removing the anomaly of regional imbalance in water availability in different river basins, options like feasible IBWTs are under study.

National Perspective for Water Resources Development:

In 1980, the Ministry of Water Resources had prepared a National Perspective Plan (NPP) for Water Resources Development. The National Perspective comprises of two main components:

- Himalayan Rivers Development Component (HRDC);
- Peninsular Rivers Development Component.

As per NPP, IBWT is expected to provide additional irrigation benefits of 35 Mha i.e.25 Mha from surface waters and 10 Mha from increased use of groundwater, raising the ultimate irrigation potential from 140 Mha to 175 Mha and generation of 34,000 MW of hydropower, apart from the benefits of flood management, navigation, water supply, fisheries, salinity, pollution control and employment generation, etc. As data pertaining to Himalayan regions are secret in nature, the information on the study reports conducted under Himalayan Development Component are not provided for public dissemination.
Out of total 30 links, 21 links are interdependent and 9 links are independent. The interdependent links comprise mainly of the following three linkages:

- linking of Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai in the Peninsular India to transfer the surplus waters of Mahanadi and Godavari to deficit areas of southern States;
- linking of Brahmaputra with Ganga, Subernarekha and Mahanadi to transfer the surplus waters of Brahmaputra to areas in other States, with ultimate objective to supplement the above Peninsula linkage;
- linking of Gandak, Ghagra, Sarda and Yamuna to transfer the surplus waters of Gandak and Ghagra to areas in other States including desert areas of Rajasthan and arid areas of Gujarat.

The above linkages are coming under the two components of NPP, namely, Himalayan Rivers Development Component and Peninsular Rivers Development Component.

*Himalayan Rivers Development Component (HRDC)*

The Himalayan Rivers Development Component (HRDC) envisages the construction of storages on the main Ganges and Brahmaputra rivers and their principal tributaries in India and Nepal so as to conserve monsoon flows for flood management, hydropower generation and irrigation. Interlinking canal systems will support transfer surplus flows of the Kosi, Gandak and Ghagra to the West (Figure 4.7). In addition, the Brahmaputra-Ganga Link will help for augmenting dry weather flows of the Ganga. Surplus flows available on account of interlinking of Ganges and Yamuna are proposed to be transferred to the drought prone areas of Haryana, Rajasthan and Gujarat. The scheme will enable large areas in South Uttar Pradesh and South Bihar to obtain irrigation benefits from the Ganges with a lift of less than 30 m.
Further, all lands in the Terai area of Nepal can get irrigation. Generation of about 30 million KW of hydropower in Nepal and India forms part of the overall scope of the Scheme. Besides, it will help better flood management with the scope for flood moderation in the Ganga - Brahmaputra system. With this proposal, about 140 BCM/yr of additional water would be available from these river systems for irrigating an estimated 22 Mha in the Ganga - Brahmaputra plains, apart from Haryana, Punjab, Rajasthan and Gujarat. The scheme will serve not only parts of India but also neighbouring countries of Nepal and Bangladesh (NWDA, 1998).

For the HRDC water balance studies at 19 transfer points, 16 toposheet and storages capacity studies of reservoirs, 19 toposheet studies of links and 14 pre-feasibility studies of links have been completed by National Water Development Agency (NWDA). The feasibility studies of the two links, namely Sarda-Yamuna and Ghagra-Yamuna links have also been completed.

**Peninsular Rivers Development Component (PRDC)**

The Peninsular Rivers Development Component (PRDC) is divided into four major parts (Figure 4.8):

- *Interlinking of Mahanadi-Godavari-Krishna-Pennar-Cauvery rivers and building storages at potential sites in these basins*
This part involves interlinking of the major river systems where surpluses from the Mahanadi and the Godavari are intended to be transferred to the needy areas in the south, through Krishna, Pennar and Cauvery rivers;

- **Interlinking of west flowing rivers, north of Bombay and south of Tapi**
  This scheme envisages construction of as many optimal storages as possible on these streams and interlinking them to make available appreciable quantum of water for transfer to areas where additional water is needed. The scheme provides for taking water supply canal to the metropolitan areas of Mumbai; It also provides irrigation in the coastal areas in Maharashtra;

- **Interlinking of Ken-Chambal**
  The scheme provides for a water grid for Madhya Pradesh, Rajasthan and Uttar Pradesh and interlinking canal backed by as many storages as possible;

- **Diversion of other west flowing rivers**
  The high rainfall on the western side of the "Western Ghats" runs down into numerous streams which discharge into the Arabian Sea. The construction of an interlinking canal system backed up by adequate storages could be planned to meet requirements of new areas on the western side as also for transfer of some waters towards east to meet the needs of drought affected areas.

The proposals of PRDC will enable additional water use of about 33 BCM/yr (net) from the overall diversion of about 71 BCM/yr. A core principle in the overall Indian National Water Development encompassing IBWT is the philosophy of substitution. In this principle areas served within the basin by diverted waters which, in turn, is released its own waters for adjoining basin(s) at optimal locations. The water so received through diversion will be used to supply to the states of Orissa, Andhra Pradesh, Karnataka, Tamil Nadu, Pondicherry, Maharashtra, Gujarat, Madhya Pradesh, Rajasthan, Uttar Pradesh, etc. This will provide additional irrigation of about 13 Mha and generate about 4 million kw of hydropower. The distinctive features of the National Perspective is that the transfer of water is essentially by gravity and only in small reaches by lift limiting it to 120 m.
4. Country wise experiences

For the PRDC, NWDA carried out water balance studies of 137 basins/sub-basins, 52 transfer points, 58 toposheet and storages capacity studies of reservoirs, 18 toposheet studies & pre-feasibility studies of links and 14 Feasibility studies of links. Feasibility reports of 14 Peninsular Links along with the views of the concerned States are available in NWDA website (www.nwda.gov.in). The proposed water transfers from the 14 links are shown in Table 4.3.

The following steps may become necessary for implementation of the link schemes:

- preparation of Preliminary Water balance Reports for basins and diversion points;
- preparation of Toposheet Studies of Reservoirs & links;
- preparation of Pre-feasibility Reports of the links;
- preparation of Feasibility Reports of the links;
- negotiations and agreements between the concerned States to arrive at consensus regarding surplus/deficit and sharing of water;
- preparation of Detailed Project Reports (DPRs);
- appraisal-Funding agreements and financing of the projects;
- execution of the link projects.
Table 4.3: 14 proposed Peninsular links

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the IBWT scheme</th>
<th>Donor basin</th>
<th>Recipient basin</th>
<th>Transfer BCM/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manibhadra-Dowlaiswaram</td>
<td>Mahanadi</td>
<td>Godavari</td>
<td>12.165</td>
</tr>
<tr>
<td>2</td>
<td>Polavaram-Vijayawada</td>
<td>Godavari</td>
<td>Krishna</td>
<td>5.325</td>
</tr>
<tr>
<td>3</td>
<td>Inchampalli Low Dam-Pulichintala</td>
<td>Godavari</td>
<td>Krishna</td>
<td>4.370</td>
</tr>
<tr>
<td>4</td>
<td>Inchampalli-Nagarjunasagar</td>
<td>Godavari</td>
<td>Krishna</td>
<td>16.426</td>
</tr>
<tr>
<td>5</td>
<td>Nagarjunasagar-Pennar Somasila</td>
<td>Krishna</td>
<td>Pennar</td>
<td>12.146</td>
</tr>
<tr>
<td>6</td>
<td>Krishna (Almatti)-Pennar</td>
<td>Krishna</td>
<td>Pennar</td>
<td>1.980</td>
</tr>
<tr>
<td>7</td>
<td>Somasila-Grand Anicut</td>
<td>Pennar</td>
<td>Cauvery</td>
<td>8.565</td>
</tr>
<tr>
<td>8</td>
<td>Kattalai – Vaigai-Gundar</td>
<td>Cauvery</td>
<td>Vaigai and Gundar</td>
<td>2.252</td>
</tr>
<tr>
<td>9</td>
<td>Parbati –Kalisindh-- Chambal</td>
<td>Parbati and Kalisindh</td>
<td>Chambal</td>
<td>1.360</td>
</tr>
<tr>
<td>10</td>
<td>Par-Tapi-Narmada</td>
<td>Par-Tapi</td>
<td>Narmada</td>
<td>1.350</td>
</tr>
<tr>
<td>11</td>
<td>Ken-Betwa</td>
<td>Ken</td>
<td>Betwa</td>
<td>1.020</td>
</tr>
<tr>
<td>12</td>
<td>Pamba-Achankovil-Vaippar</td>
<td>Pamba,Achan-kovil</td>
<td>Vaippar</td>
<td>0.634</td>
</tr>
<tr>
<td>13</td>
<td>Krishna (Srisailam)-Pennar</td>
<td>Krishna</td>
<td>Pennar</td>
<td>2.310</td>
</tr>
<tr>
<td>14</td>
<td>Damanganga – Pinjal</td>
<td>Damanganga</td>
<td>Pinjal</td>
<td>0.909</td>
</tr>
</tbody>
</table>

Note: In addition to the above 14 links, 2 minor links viz. Bedti-Varada and Netravati-Hemavati links are proposed which are under feasibility stage.

Present status of proposed IBWT links in India

The National Common Minimum Programme (NCMP) of the Government envisages that the UPA Government will make a comprehensive assessment of the feasibility of linking the rivers of the country starting with the South bound rivers. This assessment will be done in a fully consultative manner. It will also explore the feasibility of linking sub-basins of rivers in States like Bihar. Following five Peninsular links have been identified as priority links and are take up for consensus building:

- Ken-Betwa;
- Parbati-Kalisindh-Chambal;
- Par-Tapi-Narmada;
- Damanganga-Pinjal;
- Godavari(Polavaram)-Ktishna(Vijayawada).

A tripartite Memorandum of Understanding was signed amongst the Centre, Madhya Pradesh and Uttar Pradesh on 25.8.2005 for preparation of Detailed Project Report of Ken-Betwa link. Accordingly, National Water Development Agency has been entrusted with the work of preparation of DPR of this link, which may take 2-3 years. Efforts are being made by Govt. of India to arrive consensus amongst the States on other priority links.
China has an area of 964 Mha with an estimated population of 1,319 million, out of which 59.3% is engaged in agricultural activities. China is the world’s third largest country located in Eastern Asia (UN, 2007). In China, there are about 50,000 rivers each with basin area larger than 100 km$^2$ and among them more than 15,000 rivers are with basin areas larger than 1,000 km$^2$. According to the length of rivers, the Yangtze River is the longest in China (6,300 km). The other important rivers in China are the Yellow River (Huang He), the Huaihe and the Haihe Rivers. Most rivers are distributed over the eastern and southern parts of China. Majority of the rivers in China are fed by rainfall and some of them are fed by snowmelt in spring and rainfall in summer and autumn. In addition to this, there are some rivers partly fed by glacier melt water.

80.4% of water resources in China are distributed in the Yangtze also known as Changjiang river basin and to the south of it. In this area, water resources is 3,480 m$^3$ per capita while the Northern part to the Yangtze, the average water resource availability is 747 m$^3$ per capita, which is characterized by a region of scarce water resources. The average water resources availability in the other important rivers namely the Yellow River, the Huaihe and the Haihe are only around 500 m$^3$ per capita. This area suffers the most serious contradiction of water demand versus supply and most serious unmatched condition of water resources with economic and social development. In addition to this, in Huang-Huai-Hai (North China Plain) the air is dry and there are numerous heavy winds. The evaporation potential in the area is strong. The area receives less rainfall. Nine droughts in ten years in recent times seriously limit the agricultural activities and developments.

**Existing schemes**

The skewed distribution of water in China and the consequent natural calamities of flood and drought called for undertaking several water transfer schemes in the past. The Dujian Weir was completed in 300 BC and the Grand Canal in 605. Many IBWTs were constructed as a part of irrigation development, especially in down stream of Yellow River. There are about 100 intakes diverting about 9 BCM/yr Yellow River water to irrigate about 2.2 Mha land in Haihe and Huaihe river basins. In recent decades, some new IBWTs were completed, including Biliuha Dalian inter-basin water supply system, transfer of Luanhe River to Tiajian and Tengshan, inter-basin transfer of Guangdong province. Some more details about existing IBWTs are given below.

*Dujian Weir*
Dujian Weir locates in Ming River of Chengdu Plain, Sichuan province built it in 300 BC. It diverts water without a dam for irrigation. It also functions to flood management of Minjiang River.

Dujiang Weir serves as the head complex of the IBWT scheme. It is consisted of three parts: water dispatch bank, Feisha Weir (spillway), Paopingkou (water intake). The scheme solves the problems of dispatching water automatically and excluding sands automatically, controlling the amount of water transfer and eliminates the flood. The irrigation system takes water mainly from Minjiang River. The irrigation area locates in Minjiang, Fujiang, and Taojiang rivers basins. The irrigated area was 190,000 ha in 1949, and 750,000 ha today.

There are 55 main canals with the total length of 2,437 km, 536 sub-canals with total length of 5,472 km, 337 reservoirs (including 3 large scale ones, 8 medium sized ones and 326 small ones). It takes water of 11 BCM/yr from Minjiang.

Datonghe River to Qinwangchuan Area water transfer scheme

The Datonghe River to Qinwangchuan Area water transfer scheme is for irrigation and poverty releasing (Figure 4.9). It locates in middle part of Gansu province. It diverts water from Datonghe River, which is a second-grade branch of the Yellow River to Qinwangchuan Area.

The scheme has a designed flow of 32 m$^3$/s (maximum flow is 36 m$^3$/s). It can transfer 0.4 BCM/yr to irrigate water needed land. By the original program it irrigates 60,000 ha land of Yongdeng, Gaolan, Baiyin counties. After carrying out water saving program since 1998, the designed
irrigation area can reach to 70,000 ha.

This scheme gets water from Tiantang Temple in Datong River, which locates in the boundary of Gansu province and Qinhai province, and delivers water through tunnels, siphons, flumes, etc. When the water travels 86.81 km, including 33 tunnels total 75.14 km long, it arrives to the boundary of the to-be-irrigated land. Then it is dispatched to East No.1 main canal and East No.2 main canal. The total length of main canals is about 163 km. And there are 69 branch canals with total length 840 km to form the irrigation system.

This scheme was started to build in 1976, but most of the works were really start since 1987. The construction of general main canal was completed in 1994, and East No.1 canal and East No.2 canal were in 1993 and 1995. Until now this scheme has not reached the full design capacity.

The Yangtze River to North Jiansu water transfer scheme

The Yangtze River to North Jiansu water transfer scheme is a large agricultural irrigation water transfer scheme in north of Jiangsu province and also is a part of The Eastern Route of the proposed South to North water transfer scheme (Figure 4.10). This scheme pumps water from Yangtze River and transfers to Lixiahe River basin and Huaibei irrigated area in the north of Jiangsu province. It also serves for flood management, navigation.

The scheme withdraws water form Jiangdu pumping complex and Gaogang pumping complex. It uses the Grand Canal, Yinjing canal, the New Tongyang Canal as main water transfer routes. Three exiting lakes (Hongze Lake, Luoma Lake, and Weishan Lake) were used as regulation works. There

![Figure 4.10. The Yangtze River to North Jiansu water transfer scheme](image)
are nine pumping stations. The total capacity of pumping stations is 180 MW and the net pump head is about 40 m.

The Jiangdu No.1 pumping station is the first pumping station of the scheme. Construction commenced in 1961. By 1987 the system was completed. The programmed irrigation area of the scheme is 3 Mha. The planned transfer capacity is about 6-7 BCM/yr, which will depend upon water level of Yangtze River because this scheme can also divert water by gravity during certain period.

*The Yellow River to Qingdao City water transfer scheme*

The Yellow River to Qingdao City water transfer scheme supplies water to Qingdao City, which locates near the seacoast in Shandong province. The scheme mainly provide water for urban and industry uses with due consideration of agricultural water use along the scheme routes.

The designed water supply capacity is 0.24 BCM/yr with a flow of 45 m$^3$/s. The scheme gets water from Dayuzhang gate of Binzhou City in the lower reaches of the Yellow River, and diverts the water to Jihongtan Reservoir through 13 km long channel and desilting basin, and 253 km long open canal. There are five pumping stations in the water transfer route and the total installed capacity is 21.92 MW. The dam of Jihongtan Reservoir is 14.23 km long and 14.14 m high, the total reservoir storage capacity is 146 MCM.

The Yellow River to Qingdao City water transfer scheme was started to build in 1986 and completed in 1989.

*The Fuer River water transfer scheme*

The Fuer River water transfer scheme transfers water from Fuer River basin to Honhe River basin. It locates in Xinbin county of Liaoning province. The water diverted from Fuer River is regulated in Dahuofang reservoir, which is in Hunhe River, and then is supplied with water of Honhe River for industry, agriculture and city living of Shenyang City and Fushun City in Honhe river basin.

The scheme gets water from the interjunction of the main stream of Fuer River and its tributary of Jiangxi River, cross basins dividing crest of Fuer River and Hunhe River through a tunnel, enter Hongsheng reservoir through open channel, then enter Dahoufang reservoir along Suzi River. The designed capacity is 94.67 MCM/yr with a flow rate of 12 m$^3$/s.

There is an overflow weir for ensuring water transfer. It is a practical weir with a height of 5m and a length of 156 m. The scouring sluice is in the right.

The Fuer River water transfer scheme was started to build in 1991 and was completed to transfer water in 1994.
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The Biliu River to Dalian City water transfer scheme

The Biliu River to Dalian City water transfer scheme mainly provides water for urban-use of Dalian City, and also provides water for agricultural and middle and small town along the transfer canal.

This scheme consists of two reservoirs, north-part canal, and south-part pipes. Biliuhe Reservoir is the start point of this scheme, which locates in middle-lower reaches of Biliu River, 175 km north of Dalian City. Wazidian reservoir is a back-regulation reservoir, which locates on the middle of the transfer line. North to it, the canal calls north-part main canal, south to it, the pipes calls south-part main line.

The total storage capacity of Biliuhe Reservoir is 930 MCM. The main dam is 708.5 m long and 53.5 m high. The initial purposes of this reservoir were for flood management and water supply for agriculture. With the development of Dalian City, water supply for urban-use was added to its purpose-list. It was built during 1975 to 1983.

The north-part main canal is box conduit. It is 67.75 km long. The design capacity is 1.3 MCM/day (0.1 MCM/day for towns along the canal, 1.2 MCM/day entering Dianziwa Reservoir for Dalian City). It was constructed during 1995 to 1997.

The south-part main line was constructed during 1992 to 1997 by stages. The first stage was built for transfer water from Wazidian Reservoir to Dalian City.

Wanjiazhai Yellow River Water Transfer Scheme

Wanjiazhai Yellow River Water Transfer Scheme locates in the northwest of Shanxi Province. It takes water from Wanjiazhai reservoir, transfers water east to Taiyuan, Dadong and Shuozhou of Shanxi province. The main purpose of this scheme is to supply water for industry and urban usage. The total design capacity of transferring water is 1.2 BCM/yr. It was planed to construct by two stages. The first stage can transfer 0.32 BCM/yr water.

From Wanjiazhai reservoir to Xiashizhai, water is transferred through a general main tunnel, by three grades of pumping stations lifting 356m (total design lift water head). At Xiashizhai, water transfer tunnel is divided to two ways, one is the south main tunnel, and another is the north main tunnel.

The south main tunnel is 102 km long (including a connecting pipe section) with a design flow of 25.8 m$^3$/s. The design capacity is 0.64 BCM/yr. There are two grades pumping stations with a total design lift of 280 m. The water then enters into Fenhe River, and regulated by two existing reservoirs, then goes through pipes to Taiyuan city, capital of Shanxi province.

The north main tunnel is 164 km long with a design flow of 22.2 m$^3$/s. Water is flow from Xiashizhai to Zhaojiaxiachuan reservoir, Datong city by gravity.

Wanjiazhai reservoir is a multipurpose scheme. It is mainly for power generation, flood
management, water supply. The total storage capacity is 0.9 BCM. The dam is a concrete gravity one, 105 m high. The installed capacity is 1.08 GW. It was constructed during 1994-2002.

The general main tunnel, south main tunnel, and pumping stations were constructed during 1993 to 2002 (Civil works of pumping stations are completed, but installed pump capacities are 12.9 m$^3$/s for each pump station, which can transfer 0.32 BCM/yr water). The north main tunnel and other pumps will be constructed in second stage.

Dongwan to Shenzhen water supply scheme

The Dongwan to Shenzhen water supply scheme is for resolving the problem of water supplying in Hong Kong region (Figure 4.11).

The scheme started in February 1964, and supplying water to Hong Kong commenced on March 1st, 1965. The initial design water supply capacity was 68 MCM/yr, with a design flow of 9.0 m$^3$/s. For meeting the continuously increasing water demand in Hong Kong and Shenzhen, the scheme had been enlarged three times in 1970’s, 1980’s and 1990’s. The present designed water supply capacity is 1.743 BCM/yr with a flow of 80.2 m$^3$/s.

The Dongwan to Shenzhen water supply scheme gets water from the Dongjiang River nearing Dongwan city in Guangdong province, make use of the natural channel of Shima River which is a branch of Dongjiang River to transfer water to Shenzhen Reservoir. Then the water is transferred to Hong Kong and Shenzhen through the pipes and tunnels. The total length of the water transfer ways is 83 km. There are six cascades pumping stations to lift water.

Figure 4.11. Dongwan to Shenzhen water supply scheme
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Shenzhen Reservoir is in the end of this scheme and it is a middle scale regulated reservoir. The normal water level of Shenzhen Reservoir is 27.6m, the lowest operation water level is 22.0m and the dead water level is 19.0m. The reservoir storage capacity is 35.2 MCM and 9.7 MCM below normal water level and dead water level respectively.

Yantian Reservoir locates in Yantian River, which is a branch of Shima River in the west of Shenzhen Reservoir. It is also a regulation reservoir like Shenzhen Reservoir after the second enlargement. The normal water level of Yantian Reservoir is 48.6 m, dead water level is 47.05 m and the regulating storage capacity is 3.72 MCM.

Shenzhen Reservoir and Yantian Reservoir both have a water power station, which have a total installed capacity of 9.6 MW and an annual power generation of 27 million kwh.

*Luan River to Tianjing City water transfer scheme*

Luan River to Tianjing City water transfer scheme gets water form the middle reach of Luan River and delivers it to Tianjing City which locates in the tail of Haihe River (Figure 4.12). It provides water for urban and industry use and the vegetable production bases, and also provide water for agriculture along the water transfer canal in Hebei province. The designed water supply capacity is 1.95 BCM/yr, including 1 BCM for Tianjing City and 0.95 BCM for Hebei province.

This scheme consists of Panjiakou Reservoir, Daheting Reservoir, Yuqiao Reservoir, three cascades of pumping stations, and 234 km canal. The designed flow of canal is 60 m$^3$/s.

Panjiakou Reservoir is the start point of this scheme. It locates on Luan River. It regulates Luan River runoff. The total storage capacity is 2.93 BCM. The dam is a gravity concrete one; it is 1,039 m long, 107.5m high. It was constructed during 1975 to 1985. There is a hydropower station, with installed capacity of 5 MW (2 conventional units) and 90MW (3 power storage units).

Daheting Reservoir locates downstream of Panjiakou Reservoir on Luan River. The dam is a gravity concrete one. It is 1,354.5 m long, 52.8 m high. There are two power stations with the total installed capacity of 21.6MW.

Yuqiao Reservoir is in the middle of this scheme, locates in Zhou River. It was constructed for flood management during 1960’s. The total storage capacity is 1.56 BCM, with an earth dam. The dam is 2,222 m long and 24 m high. A hydropower station was also a part of Yuqiao Reservoir. The installed capacity is 5 MW. The water transfer canal was constructed in 1982 to 1983.
Proposed schemes

The water situation of less supply than demands grows more and more especially in North China. Occurrences of floods and water pollutions due to wastewater discharges in have also been increased with economic developments. For the Chinese government, thus it was a tedious task to ensure modernization processes for mitigating the flood risks in some regions while shortages of clean water resources in other regions like North. The fundamental approaches that have been considered by the Government are:

- strengthening and improving the existing water conservancy schemes and erecting new schemes to improve the ability of flood management and water supply;
- tightening up on wastewater treatment to protect water resources;
- enhancing water saving and multipurpose use of water resources to raise the use value of water.

Subsequently several proposals for inter basin water transfer schemes in China have been planned. Transfer of HanRiver water to WeiRiver basin in Sha’anxi province and South to North Water Transfer Schemes are examples. The South to North Water Transfer Scheme is described in detail below.

Planning and development of the South to North Water Transfer Scheme

The concept of the South to North Water Transfer was mooted as far back as in 1953. The scheme aims to divert water from the Yangtze River valley to Yellow river, Huaihe River and Haihe River basins to ensure the water supply for farming, industry and human needs (Figure 4.13). The scheme
4. Country wise experiences

had attracted widespread global attention:

- in the 50’s of the 20th century, the Huanghe River Commission, and the Planning Office of the Changjiang River (now the Changjiang River Commission) covered water transfer schemes in various planning documents and carried out analysis on northward water transfer from the upper reaches (Western Route), the middle reaches (Middle Route) and the lower reaches (Eastern Route) of the Chang Jiang and their possibility, necessity and options of water transfer;

- in August 29, 1958, the CRC Central Committee issued ‘Instructions to Water Resources Work’. It instructed to consider diverting water from South (mainly from the Changjiang River) to North and given priority for the formation of relatively long-term plans in the whole country for accelerating the pace of making a unified plan for connecting water systems of the Changjiang with the Huaihe, the Huanghe, the Hanjiang and the Haihe River basins;

- from 1959 to 1961 the Chinese Academy of Sciences organized scientific research personnel, engineers and technicians to conduct field investigations of the water transfer in the upper reaches of the Chang Jiang and felt that the topographic conditions are extremely complex in the region, the water transfer route is too long and the engineering is difficult because the route through which the transfer has to pass contains a large number of high mountains; and noted that it would be hard to solve this problem within the century;

- in 1976 because of the occurrence of frequent drought and water scarcity problems, the Ministry of Water Resources (MWR) restudied the aligned route of the scheme, carried out research works and issued a preliminary planning report on the scheme features;

- in 1979 and 1980s, the MWR along with engineers, technicians and scientific research personnel conducted detailed on-site investigations of the three proposed routes;

- in October 1980, the Chinese Academy of Sciences and the United Nations University cosponsored an investigative tour by Chinese and foreign experts covering the areas along the Middle and Eastern Routes to study the impact of South-to-North water transfer on the natural environment. A symposium followed in Beijing focused discussions mainly on the necessity of water transfer from South to North and the impact of water transfer on the natural environment;

- in 2002 the scheme is launched after thorough investigation, planning, study or verification on the strategic concept of the South-to-North Water Transfer Scheme in various scales or at different levels, even though with ups and downs for more than 50 years. Various interconnected Ministries, including State Planning Committee, MWR, provincial planning committee, water resources departments, urban construction departments, environment protection bureaus, land administrations, agricultural departments and price administration agencies in of the relevant Provinces or Municipalities, as well as Scientific and Research Institutions have contributed for making the scheme more solid and to an implementable one.
The scheme is proposed to implement in stages, to reform the mechanism and system in line with the socialism market economy, to ensure a healthy operation of the engineering facilities, to share the construction investment jointly by the beneficiaries both at the central level and local levels, and to select options in democratic and scientific ways.

The South-to-North water transfer scheme will have three water transfer routes, namely the Western Route, Middle Route and Eastern Route.

Middle route

The Middle route is planned in two stages; short term and longterm. The former is expected to be completed by 2010. It will transfer water from Han Jiang, a tributary of Chang Jiang at Dangjiangkou Reservoir, the existing height of Dangjiangkou Dam would be raised to 175 m from the existing height of 162 m.

The total water transfer through the route would be of 13 BCM/yr, the first stage will divert 9.5 BCM/yr. The main canal shall have to cross 686 streams. The canal will cross the Yellow River through siphon and will extend up to Beijing and Tianjin. The main canal would be 1,265 km long to Beijing, and 147 km long to Tianjin.

In the middle and lower reaches of the Han River (down stream of Dangjiangkou reservoir), four schemes will be developed to minimize impacts of environment and social development to down stream area.

The Middle route aims to provide water to Hubei, Henan, Hebei Provinces and Beijing and Tianjin in the Tangbai River basin, upper and middle reaches of the Huai River and west plains of the

Figure 4.13. General lay out of the South to North Water Transfer scheme
4. Country wise experiences

Hai River basin. The key aim of the scheme is to solve urban water shortages of over 20 medium and large cities like Beijing, Tianjin and Shijiazhuang, etc, and ecological and environmental water and agricultural water uses along the enroute area is also taken into account.

Western Route

The proposal consists of several dams and tunnels, which would run through mountainous of South-western China. All the tunnels will divert water from the upper reaches of Yangtze (Chang Jiang) to the northwestern regions and to upper reaches of the Yellow River as shown in Figure 4.13. It was planned in three stages. The first stage consists of 5 dams and 260 km tunnels, capable of transferring water of 4 BCM/yr. The second stage will add another dam and 304 km tunnels (260 km will be parallel with the first stage), capable of transferring another 5 BCM/yr. The third stage will add one more dam and 508 km tunnels (304 km is parallel with the second stage), capable of transferring water of 8 BCM/yr. The total water transfer would be of 17 BCM/yr.

The objective of this route is to solve water shortage in Qinghai, Gansu, Ningxia, Inner Mongolia, Shaanxi and Shanxi Provinces (Municipalities) in the upstream and middle stream of the Yellow River and the Guanzhong Plain along the Weihe River. In combination with the Daliushu Multi-purpose Water Scheme on the mainstream of the Yellow River and other schemes to be constructed, this route can also supply water to the Hexi Corridor in Gansu close to the Yellow River Basin. If necessary, water can be added to the downstream of the Yellow River.

Eastern Route Scheme

The Eastern Route Scheme transfers water from the lower reaches of the Yangtze River to the Yellow River and then to Tiajin. The annual transfer is 34.3 BCM for irrigation and municipal water supply.

The Eastern Route is the first component of the South to North Transfers. Water will be diverted from the Yangtze River (Chang Jiang) to the North China Plain. It uses the ancient Beijing Hangzhou Grand Canal as the main canal. The Yangtze River to North Jiansu water transfer scheme, which is described before, is part of this route. The starting point of water transfer by the Eastern Route will be the Jiangdu pumping station, from where it will flow along the Grand Canal northwards to the final destination, Tianjin. The conveyance canal would be 1,150 km long. As the elevation of the land along this route is low at both ends and high in the middle, water would have to be pumped through 13 stages, 51 pumping stations, with total lift of 65 m, involving power consumption of the order of 529 MW.

Due to the lower elevation of water transportation rivers/canals in Eastern Route, it aims to supply water to the east part of the Huang-Huai-Hai Plain and Shangdong Peninsula, to solve agricultural water shortage problem of north part of Jiangsu Province, east part of Shangdong Province
and southeast of Hebei Province and urban water shortage of regions along Jin-pu railway and in Shangdong Peninsula. It can also serve as supplement water source of Tianjin Municipality.

The scheme will be implemented in three stages. The first stage is expected to be completed before 2010. The water transferring capabilities of three stages will be 8.9, 10.6, and 14.8 k m$^3$/yr respectively (including the capacity of Yangtze River to North Jiangsu water transfer scheme) and expected to complete by 2050. It will significantly alleviate acute water shortages along the Yellow River, Huaihe and Haihe River Plains, Eastern Shandong and some areas in North-western China and will benefit Beijing and Tianjin and also northern parts of Jiangsu and Shandong provinces in East China.

The first phase of the scheme (first stage of middle route and Eastern Route) with the expected cost of US$ 21 billion was launched on 27 December 2002. It will be capable of transferring about 13.4 BCM of water annually (excluding the capacity of the existing Yangtze River to North Jiangsu water transfer scheme having a transfer capability of between 6-7 BCM of water annually). The expected benefits of the phase one are:

- **irrigation.** Supplying 1.6 BCM/yr for improvement and expansion of irrigation areas;
- **water supply for industrial and municipal uses.** 11.8 BCM/yr, over 50 million people will be benefited;
- **navigation.** Navigation in old Beijing, Hung Zhou Grand Canal from Chang Jiang to Jining could be modernized, from Jining to Dongping Lake could be used;
- **flood protection.** Flood protecting capability of down stream of Danjiang will be increased from 5% to 1% flood return frequency. Over 700,000 people will be benefited;
- **drainage improvement.** In addition to lifting water pumping infrastructure of 22 pumping stations would help drainage of waterlogged areas estimated to be around 6,800 km$^2$ during flood season;
- **pollution control.** More than 360 schemes with estimated cost of US$ 2.9 billion will be built to control en-east-route pollution;
- **environment.** Over exploiting groundwater and surface water can be limited. Pollution control activities will be strengthened in scheme areas, thus gradually improve the ecological and environmental conditions;
- Urbanization- Relieving the constraint on urbanization in North China by water shortage so as to promote local urbanization;
- Rural development- It will effectively resolve the groundwater quality issues caused by natural reasons in some parts of North China, such as high-fluoride content, brackish water or other harmful substances contained in the water so as to improve the local drinking water quality.
4. Country wise experiences

4.1.4 Iraq

Iraq, a triangle of mountains, desert, and fertile river valley, is bounded on the East by Iran, on the North by Turkey, on the West by Syria and Jordan, and on the South by Saudi Arabia and Kuwait. The country has arid desert land west of the Euphrates, a broad central valley between the Euphrates and the Tigris, and mountains in the Northeast. Iraq has common borders with Iran, 1,458 km; Jordan, 181 km; Kuwait, 240 km; Saudi Arabia, 814 km; Syria, 605 km; and Turkey, 352 km. Iraq has an area of 44 Mha with an estimated population of 28.1 million, out of which 28.5% is engaged in agricultural activities (UN, 2007). Most of Iraq has a desert climate with mild winters and dry, hot summers. Except in the northern uplands and the northeastern highlands, average annual rainfall is 100 to 170 mm. In the uplands, the range is 320 to 570 mm, and in the mountains the annual total may reach 1,000 mm (FRDCP, 2006).

There is only one river basin in Iraq, the Shatt Al-Arab basin. The Shatt Al-Arab is the river formed by the confluence downstream of the Euphrates and the Tigris, which are international rivers originating in Turkey and flows into the Persian Gulf after a course of only 190 km in Iraq. Before their confluence, the Euphrates flows for about 1,000 km and the Tigris for about 1,300 km respectively within the Iraqi territory. Nevertheless, due to the importance of the Euphrates and the Tigris, the country is generally divided into three river basins: the Tigris, the Euphrates, and the Shatt Al-Arab (referring to the part downstream of the confluence of the two rivers -Tigris and the Euphrates).

Iraq has more water than most Middle Eastern nations, which led to the establishment of one of the worlds earliest and most advanced Mesopotamia Civilization. The history of irrigation started 7500 years ago in the land between the Tigris and the Euphrates when the Sumerians built a canal to irrigate wheat and barley. Having been poorly maintained, the irrigation and drainage canals had deteriorated badly because of:

- destructive flooding;
- years of low flow due to commissioning of large developmental schemes namely Kepan and Al-Tapka upstream by other countries;
- high saline content of soil as salt rises into the topsoil through flooding or through irrigation rendering agricultural land sterile;
- flat terrain characteristic of Iraq; Baghdad, the capital of Iraq, although 550 km from the Persian Gulf, is only 34 metres above sea level and the slight gradient, makes the plains susceptible to flooding and hampers drainage;
- few appropriate sites available for constructions of dams due to existence of flat terrain.
Existing schemes

**Tharathar Scheme**

Reservoir development in upper riparian countries and the geographical factors of Iraq, necessitated the implementation of Tharathar IBWT scheme, which was taken up in 3 phases (Afif Esa Al Rawi, Faruk and Yussif, 1978) as under:

- Tigris to Tharathar depression;
- Tigris to Euphrates through Tharathar lake;
- Tharathar to Tigris.

![Figure 4.14. Tharathar Scheme](image)

Construction of Sāmarra’ barrage in the 1950s enabled the transfer of Tigris waters to the Tharthar depression in central Iraq to assist in flood management.

The 1\textsuperscript{st} stage of the scheme was completed in 1956, the main components of which are Samarra barrage on Tigris River and a regulator, on Tigris-Tharthar 64 km long canal for diverting only surplus water of Tigris River into the Tharthar depression. The basic features of the Tharthar Lake are:

- Lowest elevation : 4 m
- Lake area at elevation 64.00 m : 2,710 km\textsuperscript{2}
- Storage capacity at elevation 65.00 m : 85.4 MCM
- Volume of dischargeable live storage : 45.0 MCM

The Government of Iraq had been embarking upon intensive irrigation, flood management and drainage schemes on both Tigris and Euphrates river basins. The second stage of Tharthar Development Scheme was in 1976. Main features of the second stage are the 37.5 km long Tharthar-Euphrates canal and a head regulator located at the beginning of the canal near Tharthar Lake with a
4. Country wise experiences

maximum design discharge capacity of 1,100 m³/s for allowing the transfer into the Euphrates.

The third stage of the Scheme is a 75 km long Tharthar-Tigris canal, which transfers 600 m³/s of water to Tigris River.

The scheme was one of the largest undertaken in Iraq. Hydro power generation forms part. Planning of the New Town of Tharthar in Iraq began in 1985. Iraq can now tap the waters of the Tigris by using canals and employ water, which would otherwise have gone unused. The Tharthar canal links the Euphrates and the Tigris. The lake formed behind the Tharthar barrage had to move the farming communities of the flood plain onto the steppe-land among the Abbasid ruins of Samarra’ and enlarged the town, which remains the market center of its district.

4.1.5 Japan

Japan consists of 4 main islands (Honshu, Hokkaido, Shikoku, and Kyushu) and more than 6,800 small islands. Total geographical area of Japan is 38 Mha and the land is mountainous and volcanic and only 17% of the total area is cultivable. Estimated population of Japan is 127.7 million out of which fewer than 25% of Japan’s people live in rural areas and about 21% of it is engaged in agricultural activities (UN, 2007).

Although annual precipitation far exceeds the world average, due to Japan’s dense population, the per capita precipitation in Japan is only about one-sixth of the world average. Further, since the rivers have small basins and steep channels, rivers flow erratically and relatively little of their water is actually available for use. The rivers are prone to flooding too.

In ancient times people lived on and cultivated hilly areas or small flat areas in Valleys where no floods occurred. Gradually they moved to more spacious lowland areas where the land was more fertile and more productive. As lowland areas were vulnerable to flood disaster; people began to build levees and to dig transfer channels. In the year 743, the government issued a decree that allowed the inhabitants who have settled in the land could own it as a private property. The law encouraged the people to expand their land holdings. The landlords gradually started strengthening and expanding their farmlands through construction of small ponds and canals so as to bring irrigation facility to their field.

During the 17th century, construction of irrigation and drainage canals progressed on a large scale over to extensive areas. In the 19th century, Japan widened its abundant policy of isolationalism with the goal of strengthening itself as a nation. After World War II, amid need for alleviating food shortages and providing relief to the unemployed, vast reservoirs and extensive canals for irrigating rice paddies and upland farms were constructed. The art of science and technology slowly spread to use them for industrial and residential purposes as well.
In modern times, the amount of land under cultivation was further enlarged as a part of policy of stimulating the development of agriculture in pursuit of the goal of building a stronger Japan. In the processes, the prominent populaces of Japan like members of business community, enterprising farmers and politicians have participated actively. Each leader formulated a vision for the future passionately, advocated the need for development amongst stakeholders, lobbied the national and prefectural governments for support in solving problems that lay beyond the ability of the community to overcome and thus got schemes moving. They all shared (Shinsuke Ota, 2006):

- the vision with a bright future for their region;
- the strength of will to make that vision reality;
- the leadership skills to get the job done alongwith motivation of stakeholder’s effective participation in each stage of scheme implementation.

Existing schemes

Ryoso Irrigation Canal

In the Kanto area near Tokyo, Ryoso Canal of 80 km long transfers 11.5 m$^3$/s water from the Tone River to other areas of 210 km$^2$ of agricultural land.

Nansatsu Irrigation Scheme

In the Nansatsu Irrigation Scheme in southern Kyusyu, the canal collects water from three rivers and stores in Lake Ikeda. This water is irrigated to the fields of 6,072 ha utilizing 5.3 m$^3$/sec of water. The scheme is completed in 1984.

Hatori Dam Project

From Tsurunuma River in Agano River to Kumato River, Abukuma River diverting 5.75 m$^3$/s of water for benefiting irrigation and hydro power. The scheme is completed in 1956.

Dozen-Dogo Plain Scheme

The Shikogawa Dam at Nakayama River and Sako Dam at Shigenobu River are constructed and those water is conveyed to the newly constructed Omogo dam at Niiyodo River. Max 5.37 m$^3$/s water is delivered from this dam and irrigated total 10,318 ha farm land (paddy and orchard). In 1967, the scheme is completed.
Asaka Canal

In the beginning of the Meiji Era (1868-1912), the eastern side of the Lake Inawashiro was an area of rural farm villages where water was very scarce. The tributaries of the Abukuma River have not enough basin area and run below the agricultural fields. It was difficult to use water for irrigation. Droughts happened almost every year. In 1830s there were some development plans for the areas by Kobayashi et al. by the use of water resources in the Lake Inawashiro through the construction of a tunnel in the Oh-u mountain ranges.

The Meiji government ordered research to find a suitable place for large-scale reclamation. As the result, the Asaka area was selected as the best place for a reclamation scheme. One of the main reasons of the scheme was to provide farmlands to a large number of warriors who lost jobs due to the Meiji Restoration.

The Dutch engineer Van Doorn who had been invited by the government since 1872 investigated the feasibility of the Asaka Canal. The water of Lake Inawashiro discharges into the tributary of the Agano River, which flows into the Japan Sea to the West. He planned the canal to transfer water through Oh-u Mountains to the East to the Abukuma River, which flows, into the Pacific Ocean. The Jyurokukyo water gate was planned and constructed at the outlet in the west of the lake. This enables the water to flow into the Asaka Canal, and also maintains the water level in the lake.

Jyurokukyo was constructed with outstanding stonemasons from all over Japan. The construction began in 1879 as the first national irrigation scheme of the Meiji government. A total of 850,000 workers took part in the construction for 3 years. In 1882 the 130 km long canal was completed. The Asaka Canal supplies 9,000 ha of paddy and dry fields in the Asaka area and supports the daily life of 450,000 people in two cities of Koriyama and Sukagawa, three towns and two villages. It is capable of transferring about 1.58 BCM of water annually.

Tone Transfer Scheme

The Tone Transfer Scheme is another typical case. By diverting water from the Tone River, where many irrigation associations had already diverted river flow, this scheme was aimed at meeting the enormous water demand of the Tokyo Metropolitan Area. The major facilities constructed as a part of this scheme include two multi-purpose reservoirs, the Shimokubo and Yagisawa Reservoirs, the Tone Ozeki (which means ‘Tone grand barrier’ and diverts water of 1.87 MCM/yr from the Tone River, the Musashi Link Canal, which connects, the Tone and Ara Rivers, and the Akigase Transfer Dam on the Ara River (Figure 4.15). Most of the water for municipal and industrial use diverted at the Tone Ozeki is brought to the Ara River through the Musashi Link Canal, which has a maximum flow rate of 50.0 m³/s, and re-diverted at the Akigase Dam.
In order to get downstream water users to agree to the scheme, operational rules were established such that the flow rate at the Kurihashi Gauging Station downstream of the Tone Ozeki would be maintained above 125 m$^3$/s. Also, as in the case of the Kagawa Transfer Scheme, the Water Resources Development Public Corporation operates the Tone Ozeki (Satoh et al., 1990).

**Totsukawa and Kinokawa Integrated Development Scheme**

The Totsukawa and Kinokawa Rivers Integrated Development scheme was one of the national schemes planned for reconstruction of Japan’s war torn economy (Figure 4.16). One of the components of the scheme comprised the construction of the Sarudani dam on the Totsukawa River, to facilitate transfer of water to Kinokawa River. This transferred water together with water replenished by upstream reservoirs compensate the withdrawal of water from the Kinokawa River for irrigation along the river and transfer of water for irrigation and municipal water in the adjacent Yamato River Basin. The effective storage capacity of the Sarudani dam is 17.3 MCM and the maximum amount of transfer is 16.7 m$^3$/s. Effective storage capacities of Osako dam and Tsuburo dam, which were constructed in the upper Kinokawa river basin, are 26.7 MCM and 24.6 MCM respectively. Maximum amount of water diverted from the Kinokawa River to the Yamato River basin is about 10 m$^3$/s (Susumu Uchu, *year*).
Kagawa IBWT Scheme

The Kagawa IBWT Scheme on Shikoku Island transfers water from the Yoshino River in Tokushima Prefecture to the adjacent basin in Kagawa Prefecture where the natural water supply could not meet the agricultural demand. In this scheme, the Sameura Reservoir with a catchment area of 47,200 ha and effective storage of 289 MCM/yr, the Ikeda Transfer Dam with a catchment area of 190,400 ha, and the Kagawa Water Supply System were newly constructed (Figure 4.17). The Kagawa Water Supply System supplies water of 15.8 m$^3$/s to 25,000 ha of paddy, 5,600 ha of orchard, 20 cities, and several industrial districts.

The realization of this scheme required the consolidation of several irrigation systems in Tokushima Prefecture. This was accomplished with heavy government subsidy. The storage capacity of the Same-ura Reservoir was designed to meet the high water demand at the Ikeda Transfer Dam. This demand includes not only the Hokugan Irrigation Scheme (diverted water: 14.9 m$^3$/s), but also the high flow rate of obligatory release, 43.0 m$^3$/s, required by both potential downstream water users and existing water users in Tokushima Prefecture. All of these facilities are operated and managed by the Japan Water Agency, which was formerly called Water Resources Development Public Corporation.
The Toyogawa Canal Scheme, originally started as one of the state-run schemes with an agricultural purpose in 1949 (Figure 4.18). It was modified to a multi-purpose scheme in 1958 by including municipal and industrial water supply. It was handed over to the Aichi Canal Public Corporation in 1961 for overall scheme construction including relevant schemes of local administrations and Land Improvement Districts. The scheme was completed in 1968. Since then, the Water Resources Development Public Corporation, which is now called Japan Water Agency, has been in charge of the systematic water management and control of all the facilities.

Flows over design flows of the tributaries of Tenryu River are transferred to the Toyo River and stored by constructing Ure dam with the capacity of 29 MCM in the Ure River, a tributary of Toyo River. Additional water of 50 MCM/yr (as the maximum) is also transferred from Sakuma dam reservoir in the Tenryu River. Increased water is diverted from Ohno headwork to eastern and western main canals to irrigate farmlands of 20,000 ha and to supply for municipal and industrial waters. Since then, the region has ground by leaps and bounds and today the canal system serves as vital infrastructure underpinning the economic development of Aichi Prefecture, which besides being one of the Japan leading centres of industry also ranks among its major agriculture regions.

The massive irrigation schemes resulted at first in a surge in production of livestock and vegetables has recently led to a booming farming of flowers and vegetables. It has then transformed the whole area into one huge centre of upland crop production. In recent years, farm production income per farm household in the region has been about four times the national average. The value of industrial goods shipped has increased to about fifteen times what it was before the canal systems
4. Country wise experiences

came into existence (Shinsuke Ota, 2006).

![Figure 4.18. Toyogawa Canal Scheme](image)

**Lake Biwa Canal Project**

Lake Biwa Canal scheme is of 8.4 km length with long tunnel from Lake Biwa to Kyoto started its construction work in 1885 and completed in 1890. 8.35 m$^3$/s water was mainly used for municipal, hydropower generation and transportation. The second canal scheme of 7.4km long started in 1908 and was completed in 1912. The whole length of the canal is composed of tunnel.

The Lake Biwa Comprehensive Development scheme which is completed in 1997 after 25 years construction work produced 40 m$^3$/s water, 13 m$^3$/s of which is allotted as municipal water to other river basins.

**Uryu Hydropower Scheme**

In the Uryu Hydropower scheme, river water is gathered from tributaries of the Ishikari river, and stored water is pumped up maximum 44.2 m$^3$/s through pressured pipeline of 6.8 km long and gets effective 167.67 m elevation gap for hydropower generation. It generates 51,000 kW by discharging into the Tesio River. The scheme is completed in 1943.

**Haji Dam Project**
The Haji Dam was constructed in the Gonokawa river basin of the Japanese Sea side, and 0.3 MCM water is daily (0.1 BCM) transferred through 19 km tunnel dug under high mountains to the Ota river of the Seto Inland Sea side for municipal water supply. In 1974, the project is completed.

The described examples are limited to the inter basin water transfer among different rivers which have separate river system and separate river mouth. However, there are many cases of water transfer between tributary basins in a same river system as in the Kako river basin, transferring 12.00 m$^3$/s from Kawashiro dam constructed in the Sasayama river basin to the Ookawase dam constructed in the Toban river basin, from the dam 9.253 m$^3$/s to the Dondo dam constructed in the Yamada river, pumping up 4.0 m$^3$/s water from the Sugihara river to the Kojiya Dam in the Shidehara river basin, and so on. All these transferring roots are culvert dug in the mountainous area. There are also many cases of transferring water from a river to high land areas extended over two river basins for irrigation as the case of Tsujyun masonry culvert crossed over a river channel by designing as reverse siphon which was constructed in 1854 and transferred around 1 m$^3$/s water to high ground in southern Kyushu.

Proposed schemes

Lake Kasumigaura Development Project

Some important schemes are under way. In the Kasumigaura canal scheme near Tokyo main conduit of 42.9 km long from Nakagawa river will be completed in 2010 to transfer 15 m$^3$/s water from Nakagawa to Lake Kasumigaura in the Tone River Basin and 11 m$^3$/s from Kasumigaura to Nakagawa for improving the water quality in Lake Kasumigaura and for stabling the various water uses.

Though there are many plans for IBWT, opposition to those plans is getting strong for the preservation of natural environment. The successful schemes mentioned above are the results of huge efforts to the agreement among stakeholders, which took long periods of time sometimes more than a century.

4.1.6 Iran

Iran is located in the Middle East, between Turkey and Iraq on the West and Afghanistan and Pakistan on the East; it borders the Persian Gulf and Gulf of Oman in the South and Armenia, Azerbaijan, the Caspian Sea, and Turkmenistan in the North. The total length of the boundary between Iran and its surrounding countries is 8,731 km, of which 1,918 km (22%) is formed by rivers: 257 km with Pakistan, 236 km with Afghanistan, 407 km with Turkmenistan, 584 km with Azerbaijan, 48 km with Armenia, 35 km with Turkey and 351 km with Turkmenistan, 584 km with Azerbaijan, 48 km with Armenia, 35 km with Turkey and 351 km
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Iran has rugged mountain chains surrounding several basins collectively known as the Central Plateau. Having less than one third of the world’s average precipitation (251 mm, equal to 413 BCM/yr), Iran is one of the arid countries of the world. Besides, unequal availability of precipitation throughout the country has brought about improper water resources in Iran’s various regions. Hence, the country may be divided in two regions. The first one, is the north, west and western south areas (that is the basins of Caspian Sea, Urumia Lake, Persian Gulf, extended from the basins of Zab rivers in the west up to Mand in the Fars Province) covering 491,000 km², i.e. 30% of the country area. While the latter region, known as the basins of the Eastern, the Gharaghum & the Central Plateau, covers the remaining 70% of the country area. From the whole 120 BCM/yr potential precipitation water resources in Iran, the first one gains 83 BCM/yr, while the latter gets 37 BCM/yr approximately. In other words, 69% of Iran’s precipitation water resources are available in 30% of Iran’s area, while 31% of Iran’s precipitation water resources are estimated for the other 70% of Iran’s area. Iran’s evapo-transpiration condition is indeed the opposite of precipitation water resources.

In Figure 4.19 the annual precipitation situation is shown and in Figure 4.20 the annual evaporation in various areas of Iran. Iran’s average air temperature is about 16 ºC. In the east, eastern south, and central area of the country, the temperature is more than 20-25 ºC, while in the west & northern west it is less than 16 ºC. Iran's average evaporation is 183 mm annually.

![Figure 4.19. Annual precipitation in Iran in mm](image)

A lot of evaporation and lack of surface water resources in the east, southeast and central areas of Iran have extensively made them dependent on underground water resources.

Availability of underground water resources in Iran is more equitably allotted than the surface water resources. The index of saline water in most parts of the east, northern east, southern east and central area of the country is about 1,200 mg/l, which is not appropriate compared with the proper rate of potable water with 500 mg/l. There has been 6.1 BCM deficit of underground water resources for several years due to the required water especially in the east and central plateau of the country.
Existing schemes

There are five IBWT schemes in Iran. Four of these schemes are multipurpose with an irrigation component.

Transfers from the Persian Gulf and Oman Sea to the Central plateau

There are three IBWTs from the Persian Gulf and Oman Sea to the Central Plateau.

Chesmah Langan Scheme

Transfer of 0.12 BCM/yr from the Persian Gulf and Oman Sea to the Central Plateau for irrigation, municipal and industrial water supply.

First Tunnel From Kouhrang Mountains

Transfer of 0.30 BCM/yr from the Persian Gulf and Oman Sea to the Central Plateau for irrigation, municipal and industrial water supply.

2nd Tunnel From Kouhrang Mountains

Transfer of 0.25 BCM/yr from the Persian Gulf and Oman Sea to the Central Plateau for irrigation, municipal and industrial water supply.
4. Country wise experiences

*Transfers from the Caspian Sea to the Central Plateau*

There are two transfers from the Caspian Sea to the Central Plateau.

**Talghan Dam**

Transfer of 0.42 BCM/yr for irrigation and municipal water supply.

**Lar Dam**

Transfer of 0.18 BCM/yr for potable water supply.

**Proposed schemes**

There are seven proposed schemes. All these schemes are for municipal and/or industrial water supply.

*Transfers from the Persian Gulf and Oman Sea to the Central Plateau*

There are five proposed transfers from the Persian Gulf and Oman Sea to the Central Plateau.

**Transfer From Dez to Ghomrud**

Transfer of 0.12 BCM/yr for municipal and industrial water supply.

**Tang-Sorkh Reservoir Dam**

Transfer of 0.33 BCM/yr for municipal and industrial water supply.

**Sheshpear Reservoir Dam**

Transfer of 0.06 BCM/yr for municipal water supply.

**Kamal-Saleh Dam**

Transfer of 0.07 BCM/yr for municipal and industrial water supply.
Transfers from the Caspian Sea to the Central Plateau

There are two proposed transfers from the Persian Gulf and Oman Sea to the Central Plateau.

Talvar Dam

Transfer of 0.09 BCM/yr for municipal water supply.

Ruzbeh Spring

Transfer of 0.01 BCM/yr for municipal water supply.

Ghatari Springs scheme

Proposed transfer of 0.01 BCM/yr from Gharaghum to the Central Plateau for municipal water supply.

Considering the locational rate of water resources availability in the country, per capita renewable basin water resources in the eastern and central plateau in various years, residing 45% of population in the eastern and central areas of the country, improper underground water resources in such areas quantitatively, the authorities have focused on two approaches:
I. persuading people to migrate to the areas with abundant water;
II. implementing IBWT projects.

The second approach shall socio-economically be successful if the following feasibility studies be carefully done:
• the possibility of supplying potable water and industrial requirements in the water deficit areas;
• the optimum management of water consumption, as well as, the future demand of water compared with the available supply of water resources in the water deficit areas;
• the IBWT development potentials of various upland and down-land regions & the excess water resources of the original basins with the optimum management of water consumption.

IBWT Challenges

The most important IBWT challenges are the following:
• lack of comprehensive management on Iran basin water resources demand and supply;
• lack of basin water resources allocation shares of the beneficiary provinces;
4. Country wise experiences

- lack of precise data on basin water resources supply and uses;
- under-development of the upland regions relevant to IBWT projects;
- high level of water wastage in the country.

Opportunities to fulfill IBWT projects

The following opportunities to fulfil IBWT projects can be mentioned:

- **water management.** There is an opportunity for Iran Water Management to execute proper management on various water uses in order to allocate the wasted surplus water resources of the basins for the IBWT projects;
- **water-oriented socio-cultural growth.** Being informed on the importance of water, its national status, required proper management on water resources supply and uses, the people, water authorities and managers of the country have noticeably appreciated IBWT projects. Such an opportunity has made Iran water managers enhance further the execution of projects such as Integrated Studies on Planning Basin Water Resources and Basin Water Transfer Projects.

Paradigms of IBWT projects in Iran

Considering the importance of such projects, Iran authorities have already studied IBWT projects. Certain IBWT projects have been operated and some of them are either under process or being studied as well. The global experience of utilizing the two approaches of population density in areas with surplus water and/or population-based fair transfer of water resources makes our country to follow up IBWT projects.

Considering population disparity from viewpoint of national security justifies implementation of IBWT projects.

However, there are challenges to be overcome by committed, capable and qualified water managers to try their best and use the opportunities to reach the optimum results. Preventing the high level of water wastage as the biggest challenge & the riparian water resources as the most important opportunity are noticeable examples to follow up IBWT projects in I. R. Iran. Besides, the resultant socio-economic effects on the regional natural eco-system and on the communities should be carefully studied.
4.1.7 Republic of Korea

The Republic of Korea, commonly known as South Korea or the Korea Republic is an East Asian country. To the North, it is bordered by North Korea (Democratic People’s Republic of Korea), with which it was united until 1945. To the West, across the Yellow Sea, lies China and to the Southeast, across the Korea Strait, lies Japan. It has an area of 10 Mha with an estimated population of 48.2 million, out of which 16.8% is engaged in agricultural activities (UN, 2007). Approximately one-half of South Korea’s population lives in or near the capital city of Seoul, one of the most populous metropolitan areas in the world.

Korea is in the moderately humid zone of medium latitudes. Of the annual precipitation of 1 274 mm, approximately 66% occur during the rainy season from June to September, 16% during the transition period from April to May and the remaining 18% during the six months from October to March (Republic of Korea, Geum-Gang). Korea has a relatively high annual rainfall at 1.3 times the world average. However, the average amount of rainfall per capita per annum is about one-ninth of the world average because of the high population density. Large seasonal variations in rainfall frequently result in floods in the summer rainy season and drought in spring and winter. Water demand has been steadily increasing for the last several decades due to the increase in population, irrigation area and industries, as well as the rapid expansion of urban areas. The usable water potential is estimated at 83.1 BCM. The water potential consists of 69.7 BCM of river discharge and 13.4 BCM of groundwater.

Existing schemes

There are five existing schemes for transferring excess water to deficit areas (Figure 4.21). The Daechong Reservoir on Geum-gang-one of the largest rivers in Korea provides almost all the drinking water needs of the large cities located in the upstream of the basin. The raw water from Daechong Reservoir is treated in four treatment plants before it is delivered to the consumers.

Daechong wide area water supply

From Daechong Dam to A-san 0.36 BCM/yr municipal water supply, ready in 1985.
4. Country wise experiences

![Map showing the existing IBWT schemes in Korean Region](image)

**Figure 4.21. Map showing the existing IBWT schemes in Korean Region**

**Daechong wide area water supply**

From Daechong Dam to Chunan 0.09 BCM/yr municipal water supply, ready in 1988.

**Junju systematical wide area water supply**

From Yongdam Dam to Junju Gunsan 0.26 BCM/yr municipal water supply, ready in 1998.

**Geum River wide area water supply**

From Bu-yeo to Gunsan Junju 0.11 BCM/yr municipal water supply, ready in 2000.

**Chongju-Intake tower**

From Daechong Dam to Jibuk Filter Plant.

**Proposed scheme**

According to the long-term plans for water resources development, approximately 5.1 BCM of surface
water is scheduled to be developed by the end of 2011. The plan includes the construction of multipurpose dams (4.3 BCM) and single purpose agricultural dams (0.8 BCM) with total storage capacity of 5.1 BCM along with inclusion of IBWT schemes. However, from field realities it is observed that the water resources development has become more difficult in recent years due to an increase in construction and compensation costs, limited appropriate dam sites, and strong opposition from the inhabitants and environmental concerns.

**SumJin Water Supply Reservoir System**

Due to the seasonal fluctuations in precipitation, and the lack of dam sites in DonJin River basin, dams in SumJin basin plays a crucial role in supplying water to DonJin AC (Agricultural Cooperative) and KwangJu Metropolitan city by inter basin transfer. Even before the SumJin River Dam was rebuilt in December, 1965 by the 1st 5-year Economic Development Plan, the water right of the SumJin reservoir belonged to DongJin AC serving irrigation needs of the nation’s leading rice fields on the other side of the river basin by inter basin transfer. Korea Electric Power Corporation (KEPCO) who generates hydropower has contributed some funds for rebuilding the dam and they also have the right to generate hydropower at ChilBo before the water is released for irrigation. And yet, the dam itself is owned and operated by Korea Water Resources Corporation (KOWACO) since 1973 and it claims the water rights of 178,000 m$^3$/day for the storage over El.191.5 m, which is de facto Mean Surface Water Level (MSWL). At present, the reservoir is not operated on the designed MSWL of El. 196.5 m because of the conflict between people settled in the area of flood reserve storage. KOWACO wants to secure more water by restoring the MSWL of SumJin Dam back to the original design level by evacuating people who migrated and settled in the flood reserve area due to the prolonged drought condition in SumJin catchment area. KOWACO plans to transfer from 162,000 to 450,000 m$^3$/day (0.059 - 0.164 BCM/yr) from the SumJin Reservoir back to the original SumJin River Basin by installing a pumping facility because it is not possible to release water stored unless the storage is over the spillway crest at El. 192.7 m. Restoring more water back to the SumJin River basin is necessary to meet growing water needs at YeoChon Industrial Complex and GwangYang Steel Mill (Sheung-Kown Kim, JaeHee Kim and YoungJoon Park).

Conflicts between the upstream and downstream residents of river basins in Korea have recently been intensified on usage of water resources. The water resources available in various river basins have traditionally been regarded as a common good resulted in the excessive depletion/production and consumption of the resource, as well as social costs in terms of pollution. These problems are compounded by failures of governances especially in institutional set up, environmental law and coordination between central and local governments about water pollution problems and lead to exacerbating social conflicts.

Although Korea has traditionally considered water to be an unlimited natural resource earlier,
the perception of water has changed significantly recently as water-related conflicts have intensified. As a matter of concern, the government introduced the following Major Policy Directions:

- diversify and expand water resources and manage water resources;
- promote water conservation policies for efficient utilization of limited water resources;
- enhance disaster prevention functions to reduce flood damages, and maintain river environments appropriately to create water-friendly spaces.

In addition to this Korea has recently announced three important water pricing policy reforms in order to resolve water conflicts and improve water quality along major river basins:

- Comprehensive Water Management Countermeasures policy of 1996 that encouraged the improvement of economic instruments to prevent and/or resolve conflicts over water. As a result, 59 of 167 local governments abandoned minimum fixed charge schemes and reintroduced volume-based water charges;
- Han River Special Law of 1999 and introduction of volume-based water charge system for publicly supplied water along the Han River Basin;
- special laws for water quality management in the Nakdong River, the Yong San–Sum Jin and the Kum Rivers passed in the parliament in December 2001 and Comprehensive Countermeasures announced thereon for Improving Water Quality in the four major rivers in August 2002 (Ministry of Planning and Budget, 2002).

As a result, the unit water price per tonne increased from 290 to 390 won/tonne\(^1\) in the Nakdong River region, from 275 to 395 won/tonne in the Kum River and from 323 to 443 won/tonne in the Yong San–Sum Jin Rivers. The countermeasures also have plans to strengthen environmental regulations relating to the total amount of pollutants from metropolitan cities, other cities and local municipalities situated along various river regions.

The law requires the designation of special monitoring areas in the upstream region to prevent pollution from business activities. It prohibits the construction of a restaurant, hotel, motel, public bath facility, factory or cattle shed within a range of between 300 m and 1km from the upstream river flows. Farming with pesticides and fertilizers is also prohibited. In order to prevent pollution from non-point polluters, the law requires the compulsory establishment of a ‘green belt area’, which includes the establishment of artificial damp, grassland and a green track of land when new development schemes are planned in the Nakdong River region. The Nakdong River Special Law also requires the installation of infrastructure for a ‘buffer zone’ to contain industrial wastewater from the Daekoo industrial complex until the level of water quality in the downstream improves.

Thus the central government played a key role in resolving the conflict, aiming to both

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\(^1\) 1,000 Won = 1.062 US$ (2007); 1000kg = 1 tonne
strengthen environmental regulations and provide a cross-subsidy for affected residents. Funds generated by the increase in charges to domestic consumers along the river basins are intended to be used for ‘income compensation’ for upstream residents who have suffered financial losses because of the environmental regulations (Min, 2004).

4.1.8 Malaysia

Malaysia is, geographically, a divided nation: the western part of the country lies on the Malay Peninsula to the south of Thailand; the eastern part consists of two states, Sabah and Sarawak, which lie on the northern side of the island of Borneo. The landscape in both East and West is similar, characterized by high mountains and fast rivers flowing down to coastal plains. It has a total area of 33 Mha with an estimated population of 27.1 million, out of which 36.5% is engaged in agricultural activities (UN, 2007).

80% of Malaysia’s population and the majority of its industry are concentrated in one third of its land area, the Malay Peninsula. Although the contribution of agriculture within the economy has been declining for some years, it continues to be a strong sector. Malaysia’s plantations, which are found mostly on the Malay Peninsula, produce more than ten million tonnes of oil per year, over half of the world’s supply. Malaysia is also the world’s leading supplier of natural rubber, 80% of which is produced by smallholders in both eastern and western parts of the country. The industrial sector is also fast growing.

The increased demand for clean water has led to competition in water use among the various water user sectors. Since the practicable limit of surface water resources development has been reached in regions of high demand, it has become necessary to consider inter basin water transfer schemes (Raja Dato’ Zaharaton Raja Zainal Abidin, 2004).

Existing scheme

The Kelinchi/Terip interbasin water transfer scheme

The Kelinchi/Terip interbasin water transfer scheme involves construction of the Sg. Kelinchi reservoir in the upper reaches of the Upper Muar reservoir catchment area. The Sg. Kelinchi reservoir stores water for subsequent transfer to the Sg. Terip reservoir via a transfer tunnel through Gunung Berembun, which separates the Upper Muar Basin and the Sg. Linggi Basin. The transfer Tunnel Length is 6.2 km, with internal diameter (lined) 2.7 m, gradient 1 in 330, design capacity 4.5 m³/s and involves gravity type flow.
4. Country wise experiences

The contract was awarded to Ho Hup - Peabody Joint Venture Company and the work was commenced on 27 December 1993 for a Contract Price of RM 54,475,539.89 with a proposed construction period of 30 months. The Contractor Company constructed the water discharge tunnel leading to the Sungai Kelinchi reservoir in 1996. The scheme transfers water from Upper Muar catchment to Sg. Terip for augmenting water supply to the 2 districts of Seremban and Port Dickson 0.14 BCM/yr.

Proposed scheme

IBWT from Kelau River to Langat River

In 1997-1998 there were low rainfalls leading to drought conditions affected some parts of Malaysia such as Selangor, Kuala Lumpur Federal Territory, Penang, Kedah, Kelantan, Sarawak, and Sabah.

This 1998 drought phenomena results in the minimum flow of 0.94 m$^3$/s for Langat River. It is noted that the catchment has undergone extensive urbanization process where the natural vegetation has given way to paved surfaces and the numerous storages/ depressions (mining ponds) were filled up and paved. This has resulted in less infiltration to the groundwater thus reducing base flow rate.

For Selangor situation, in February 1998 the water level in the Langat Dam was about 14 m above critical level (Ahmad and Low, 2002). By early April 1998 with the progression of the drought demanding release of water from the dam for abstraction downstream at Km 18 Ceras Treatment Plant (TP) and Tampoi TP, the water level came close to critical level. According to the Water Supply Department, the estimated water demand for Selangor/Kuala Lumpur in 1998 was 2,658 million litres per day (mld.). However, the water supplied in April 1998 amounted to 2,553 mld hence presenting a shortfall of 105 mld. Consequently, the tight water demand-supply situation caused by the dry weather condition, non-revenue water and the sporadic water pollution at the intakes, prompted the Selangor State government to impose water rationing to 1.8 million residents in Klang/Langat River Basins from April to September 1998(Ahmad Jamalluddin bin Shaaban, 2003).

The Kelau Dam is proposed to meet the water demands of Selangor State and Kuala Lumpur in Malaysia. The scheme will transfer around 2.26 MCM of water per day (0.23 BCM/yr) from the Kelau River in Pahang State to the Langat River in Selangor State. The scheme will be fully funded by JBIC. This scheme is supposed to ensure that supply will meet the expected demand until 2017. The scheme proposes to:

- build two earthfill dams in Pahang:
  * on the Sg. Kelau, reservoir 4,090 ha. - 10 km NE of Bentong;
  * on the Sg. Telemong, reservoir 1,532 ha. - 1 km south of Karak;
- a water intake on Sg. Kelau with 11 km of pipeline with a diameter of 3.0 m;
- a weir on the Sg. Bentong with 7 km of pipeline;
• a 44.6 km water transfer tunnel with diameter is 5.2 m. and inlet 1.5 km south of Karak that goes beneath the Main Range and has an outlet about 3 km downstream of Pekan Ulu Langat.

The tunnel transfers water of Kelau River across Main Range to Water Treatment Plant (WTP) Langat 2 in Selangor. Langat 2 WTP will be constructed in three phases according to the planned volume of water to be transferred from Pahang to Selangor; First Phase – 1,000 mld; Second Phase – 500 mld; and, Third Phase – 760 mld and is expected to take about 11 years to complete.

The scheme is not without some apprehensions that the dam will have serious impacts on the Kelau River ecosystem as it would require the resettlement of about 325 indigenous people and 120 Malay farmers seriously affecting their lives and livelihoods. These aspects are being studied by Malaysian Government.

The Malaysia Government had reviewed critically its current approaches towards water supply management. It has acknowledged the need to implement inter-basin and inter-state water transfers. To provide more thrust to the concerned areas:
• the ‘Love Our Rivers’ campaign had been launched in 1993 with the aim of improving awareness among the general public including school children, and the relevant authorities on the need to preserve rivers;
• a National Water Resources Council (NWRC) has been set up in 1998 to pursue effective water management and services;
• in 1999, the Government had evolved the ‘Guidelines for Installing a Rainwater Collection and Utilization System’;
• the importance of Integrated Water Resources Management (IWRM) in Malaysia is fully realized with the formation of Selangor Waters Management Authority that is supported by an Act (Selangor Waters Management Authority Act, 1999) commonly known as LUAS (Lembaga Urus Air Selangor) and made operational on 1 August 2000;
• the case of Pahang-Selangor Inter state water transfer scheme has been undertaken with a Detailed Environmental Impact Assessment (DEIA) of the scheme incorporating the scheme affected people together with the NGOs who have shown interest to the scheme;
• the Yen Loan Agreement for funding the Pahang-Selangor Raw Water Transfer scheme was signed in March 2005 (Raja Dato’ Zaharaton Raja Zainal Abidin, 2005).

The Ninth Plan of Malaysia (2006-10) proposes to address the three challenges systematically, viz.:
1. to deliver or make available facilities or services of a high quality;
2. to ensure an efficient and effective delivery system to meet the rising aspirations of the people;
3. to optimize the use of natural resources as well as protecting the environment in order to improve the quality of life.
4. Country wise experiences

Pahang-Selangor water transfer scheme is once again planned to solve the pending water shortage crisis of Selangor by bringing from the east coast state of Pahang and will be piped to the consumers in Selangor, Kuala Lumpur and Putrajaya after processing the diverted water in treatment plants.

There is now a general consensus among members of the local water industry that the scheme should not be delayed any longer as Selangor is expected to suffer a water crisis by 2009.

Once the scheme is completed, it is expected to meet the water demands of Selangor and Kuala Lumpur up to 2019 (Dale Ng, 2007).

4.1.9 Central Asian States

Five Central Asian countries—Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan located in a dry and arid region with immensely diverse topography ranging from high mountains and glaciers to vast and dry steppes and deserts. It has an area of 400 Mha with an estimated population of 58 million, out of which 53.8% is engaged in agricultural activities (Figure 4.22).

The region is rich in water resources but more than 90% are concentrated in the mountains of Kyrgyzstan and Tajikistan. The problem of water in the region is a problem of paramount importance because all big rivers in 5 countries of the region; the Irtysh and Ishym in the East, the Chu, Talas, Syr Darya, and Amu Darya in the South, the Ural in the west, and the Ishim and Tobol in the North are Transboundary Rivers. The largest, the Amu Darya, and the Syr Darya flow across the borders of
more than 3 countries. The most difficult situation is observed in Turkmenistan and Uzbekistan where 80 – 90% of the national economies depend on water resources coming from the Tranboundary Rivers (Igor Vasilliievich Severskiy, 2004).

**Existing schemes**

One of the main shared assets of the region is the Aral Sea Basin (ASB), which is situated in the heart of the Eurasian Continent. ASB extends over the territories of the five Central Asian Republics: the southwestern part of Kazakhstan, most of Turkmenistan and Kyrgyzstan, and all of Tajikistan and Uzbekistan. Portions of the basin are also lie in Afghanistan, China and Iran. The region’s two major rivers-Amu Darya and Syr Darya are flowing through the Aral Sea Basin. The Amu Darya, which originates in the mountains of Afghanistan and Tajikistan and flows through Uzbekistan and Turkmenistan to the Aral Sea. The Syr Darya, which originates in Kyrgyzstan and flows through Tajikistan, Uzbekistan and Kazakhstan to the Aral Sea.

The region was turned into a huge cotton plantation in the 1960s and the 1970s and this resulted in rising water consumption. An impressive irrigation network, canals, and reservoirs were built to serve cotton production. As a result, the region has become one of the world’s biggest cotton producers, with Uzbekistan alone producing and exporting as much as four million tons of cotton annually.

More than 35 reservoirs were constructed in the Amu Darya basin- some with capacities greater than 10 MCM. The aggregate capacity of these water reservoirs exceeds 29.8 BCM. The Amu Darya cascade of reservoirs operates according to specific scheme, allowing regulation by two main river channel reservoirs (Nurek and Tuyamuyun) and several on-system reservoirs on the Karakum, Karashi and Amu-Bukhara canals and small rivers (CAWATERinfo website).

The large-scale irrigated farming in Amu Darya basin is mostly based on a well developed system of irrigation and drainage facilities, including three IBWT schemes.

**Karashi Scheme**

Karashi, where pumping stations with a total capacity of 350 m$^3$/s (11.04 BCM/yr) lift of water for 180 m is developed for diverting water from Amu Darya to Uzbekistan.

**Amu-Bhakhara Canal**

The Zarafshan River is the third largest river of Uzbekistan. The water quality in the river deteriorated under the impact of the return water from irrigation and wastewaters from towns, increased water salinity and pollution. The connection of the Zarafshan River with the Amu-Darya is developed
4. Country wise experiences

through the irrigation canal - Amu-Bakhara Canal.

Amu-Bukhara canal starts from the Amu-Darya in the Farab district of Turkmenistan. The canal lifts about 200 m$^3$/s (6.31 BCM/yr) of water for 130 m. The water of Amu-Darya flows through 14 km of the main canal, before it splits into two branches, one of which keeps the name Amu-Bukhara canal, the other is the Amu-Karakul canal. The length of the Amu-Karakul canal is 40 km, the bottom width canal is 7 m, and the mean width at the surface is 32 m, at 4 m maximum depth.

The completion of the Amu-Darya-Bukhara canal (Amu-Bukhara canal) has led to major changes in water quality and in fish fauna. Before the completion, only 14 species were known from the Zarafshan. At present the Zarafshan River has 36 fish species (Urchinov, 1995).

On an average the irrigated area in the basin is 3.8-4.0 Mha. In 2000 due to low water availability, the basin irrigated area was only 3.56 Mha. Basic source providing water demands of agricultural sectors in Amu Darya basin is surface water resources (its average volume is 78.4 BCM/yr including Amu Darya flow of 62.1 BCM/yr (Interstate Coordination Water Commission website).

The schemes have enhanced the fish species as well as bio diversities, and improved the water situations in a number of lakes and reservoirs of the region. Since the waters of the two rivers namely Amu Darya and Syr Darya were almost diverted including for water crops like cotton irrigation, the water level in the Aral Sea fell by seven meters in twenty years, from 1964 till 1984.

The water supply situation has further deteriorated in the region considerably for the following reasons:

- predominant use of regional water resources (more than 90%) for irrigation farming and an orientation toward production of water-consuming crops: cotton and rice;
- dissolution of the USSR and the processes which followed: collapse of a formerly integrated economic system, a catastrophic decline in the economies of the countries of the region, social upheavals in extreme forms like the civil war in Tajikistan and conflicts in Uzbekistan and Kyrgyzstan;
- a substantiate switch in the priorities of water resources use in the upstream runoff zone (Tajikistan, Kyrgyzstan) from irrigation to power generation, which resulted in economic loss and significant deterioration of the ecological situation downstream, especially in Uzbekistan and Kazakhstan;
- imperfection of water-resource management systems at all levels; from regional to local levels;
- high rates of population growth with related aggravation of food security and drinking water supply.

Karakum Canal

The large-scale with gravity irrigation systems with the longest length in the World - about 1,000 km length and the mean annual water withdrawal is about 700 m$^3$/s. Karakum canal diverted about 18
BCM of water per year from the flow of the Amu Darya river to the southern part of Turkmenistan (CAWATERinfo website).

**Proposed scheme**

*IBWT of Siberian Rivers to Central Asia and Kazakhstan*

In the 1980s, Soviet planners developed an ambitious scheme to divert Siberian rivers to the region in order to provide more water for the cotton industry and to Aral Sea Basin. The plan (Gerradi, 1978 and Voropaev et al., 1985) aims to transfer 25 - 27 BCM/yr from the River Ob as well as lower reaches of Itrish River (Figure 4.23). The main intake of the transfer channel is proposed just downstream of the confluence of the Itrish and Ob Rivers. Two alternatives have been proposed for the transfer. Under the first alternative, a canal would follow the left bank of Lower Itrish. About 3.2 BCM/yr would be lifted through 26.5 m and conveyed by a 316 km long canal, to the storage reservoir created by the Kondisky dam.

![Figure 4.23. IBWT of Siberian Rivers to Central Asia and Kazakhstan](image)

In the second alternative, it has been proposed to transfer water in upstream direction from Itrish upto Tobolsk that is reversing its flow. Along this part of the Canal whose length will be 651 km, four dams with pumping stations will be built. The remaining part of the canal, the Tobolsk to the Tegiz storage reservoir and further to Amu Darya would be without alternatives. Along this stretch, water will also be used for industrial and municipal needs, as well as feeding Ural River and several small
4. Country wise experiences

rivers. Five pumping stations will be built along the 1,500 km stretch of the canal between Tobolsk and Regiz reservoir, lifting water to the Ob-Itrish basin and to Syr-Darya water divide. The total lift of water is of the order of 115 m. Downstream Tegiz reservoir, the canal will go to the Syr Darya and will cross it near the town of Dzhusaly. At this point, a part of water, 1.6 BCM/yr will go to the lower reaches of Syr Darya and 5.7 BCM/yr to the Lower Chardara water storage reservoir at Syr Darya. The canal will proceed 1,000 km further through the Syr Darya – Amu Darya water divide and join the latter between Tashanz and Tuyanuyan dams. The Amu Darya would receive about 9.15 BCM/yr from the canal.

This scheme is yet to take off as criticism and warnings of its dangerous environmental implications sprung up which are yet to be addressed satisfactorily.

Degradation of the natural environment in the Aral Sea Basin, which was once a spectacular and highly diverse region, is due to of severe water shortages and chronic pollution. Within a year of the dissolution of the Soviet Union in 1991, the five Central Asian Republic reached an agreement in 1992 concerning transboundary water resources, recognizing the need to cooperate on water issues.

- established Interstate Commission for Water Management Coordination (ICWC), with a mandate to control and ensure rational utilization and protection of the interstate water resources;
- since 1992, the ICWC and the two regional Basin Water Management Bodies (Bassejnovoe Vodnoje Ob’edinenie – BVO): BVO ‘Amu Darya’ and BVO ‘Syr Darya’, were responsible for short and long-term water development and allocation planning, water quality control, conservation and environmental protection.

The momentum for regional cooperation was maintained by the establishment of four other intergovernmental institutions between 1993 and 1995. These institutions were:

- Interstate Council on the Aral Sea Basin (ICAS), intended to set policy, provide intersectoral coordination and review the schemes and activities conducted in the Basin;
- Executive Committee of ICAS (EC-ICAS), intended to implement the Aral Sea Program;
- International Fund for the Aral Sea (IFAS), entrusted with the coordination of financial resources provided by member states, donors and international organizations;
- Sustainable Development Commission (SDC), designed to ensure that economic, social and environmental factors are given equal weight in planning decisions.

Efforts since 1995 to achieve progress on issues of use and management of transboundary water resources among the Aral Sea Basin states have focused on institutional issues, dispute resolution and fund aspects for developmental activities.
Institutional issues

In September 1995, representatives of the Republic met in Nukus and Uzbekistan to sign a Declaration on the sustainable development of the Aral Sea Basin. The parties affirmed their financial obligations to the ICAS and the IFAS, and their commitments to strengthening the SDC.

A subsequent draft agreement prepared in 1996 set out the composition and functions of the ICAS in highly general terms, including the improvement to the ecological situation of transboundary waters, and the development of water management policies and perspectives. The draft agreement also emphasized the importance of capacity building for interstate water management organizations and clarified the activities of the Scientific Centre (SC-ICWC) and the functions and status of the respective Basin Water Management Bodies (BVO Syr Darya and BVO Amu Darya).

International fund for the Aral Sea (IFAS)

The IFAS – has a Board composed of Deputy Prime Ministers of the five states, with portfolios involving agriculture, water and the environment. The Board meets at least three times a year to discuss the views of member states and to decide on the policies, programs, and institutional proposals recommended by the Executive Committee of IFAS, which is the permanent working body of the fund. The IFAS is also responsible for managing contributions and financing program activities, pursuant to a set of regulations on the IFAS and its Auditing Committee.

Dispute resolution

The issue of current water utilization in the region is particularly sensitive. Some recent decisions by upstream riparian governments – to reduce the water made available to downstream states and to charge for water in excess of previously agreed allocations – have resulted in disputes over allocation, pricing and payment.

The 1992 Agreement refers water disputes to the Ministers of Water Resources for the five republic. However, the Ministers were unable to resolve the dispute. A subsequent draft provides that any intentional violation within a basin state of water withdrawal limits, regimes and schedules, determined by the ICWC and its executive bodies, causing damage or affecting the interest of other basin states, leads to a penalty and to liability for compensation and such cases are to be heard by an arbitral court composed of three nationals of third states.

The 1997 draft agreements on utilization include joint management clauses, which refer to the ‘basin principle’, providing for the equality of the parties’ rights to use, and responsibility to ensure rational utilization and protection of the water resources of the region, which are defined as ‘common
4. Country wise experiences

and integral’. The parties also agree not to use more water than allocated to them.

The principle of ‘equitable and reasonable utilization’ takes into consideration of such factors as:

• geography, hydrographic, hydrological, climatic, ecological and other factors of a natural character;
• social and economic needs of the watercourse States concerned;
• population dependent on the water resources; the effects of usage on other States; existing and potential uses;
• conservation, protection, development and economy of use of water resources;
• availability of alternatives to a planned or existing use.

Additional principles of the 1997 UN Convention on International Watercourses which are of particular relevance to the Aral Sea basin States include:

• obligation not to cause significant harm to other watercourse States;
• general obligation to cooperate (through joint mechanisms or commissions);
• to exchange information on a regular basis;
• to provide timely notification of planned measures and emergency situations which may have a significant adverse effect upon other watercourse states.

**Joint planning of transboundary water resources**

Two additional draft agreements address issues related to the ‘joint planning of transboundary water resources’ among the Central Asian republics. The primary outcome of the preparation of these draft agreements has been the elaboration of a Regional Water Strategy with short (one-year), medium (five-year) and long-term (15 to 25 year) objectives. The overall objectives of the Regional Water Strategy are:

• to assess regional water resources and the potential for changes in their quality and quantity;
• to assess national and regional water requirements and the possibility of curtailing these demands through effective management;
• to promote the conditions necessary for a sustainable ecosystem in the Aral Sea zone.

Provisions relevant to joint planning under the 1997 UN International Watercourses Convention include the obligation:

• to cooperate to attain optimal utilization and adequate protection of the international watercourse;
• to protect its ecosystem through the prevention, reduction and control of pollution;
• to enter into consultations concerning the management i.e. sustainable development, rational and optimal utilization, protection and control) of the international watercourse.

Importance of Trade in natural resources for sustainable development of Aral Sea Basin

Energy resources in the Aral Sea region

Trade in the natural resources may provide solutions to water scarcities affecting the entire Aral Sea region. First, it is important to recognize the difference between upstream power generation and downstream irrigation in terms of seasonal demands for water. The peak demand of the upstream riparians in the Aral Sea Basin for power generation is in the cold winter months. However, Tajikistan and Kyrgyzstan generally store runoff from the Pamir mountain glaciers in reservoirs during the summer months to ensure adequate supplies for power generation in the winter. The dry summer months are precisely when downstream riparians have peak demand for agricultural irrigation. This is the crux of conflicting demand patterns that affect the Aral Sea Basin on an annual basis, and the origins of current conflicts over upstream decisions to charge for releases from its reservoirs.

Petroleum and coal reserves in the Aral Sea region

The substantial petroleum and coal reserves in Kazakhstan, Uzbekistan and Turkmenistan could be used to fuel power stations in Kyrgyzstan and Tajikistan and this will then reduce demand for water to generate hydroelectric power in Tajikistan and Kyrgyzstan. The approach could make additional water resources available for agricultural and industrial uses in the other Republics, and for the Aral Sea itself.

Actions taken by Central Asian Countries in trade in natural resources

With the objective of achieving a system for trade in natural resources, the prime ministers of Kazakhstan, Uzbekistan and Kyrgyzstan (with observers from Russia and Tajikistan) met in March 1998 at Bishkek, the capital of Tajikistan. Six documents were signed, including an Agreement to form a consortium on hydro-energy resources. Also, Kazakhstan reaffirmed its intention to barter coal for water supplies from Kyrgyz reservoirs; and Uzbekistan again promised deliveries of natural gas for Kyrgyz water deliveries.

Trade in natural resources may provide additional options by reducing the competition for limited water resources while addressing the energy needs of all riparian. While the development of hydrocarbon resources in the Aral Sea Basin holds the potential to stimulate local economies, it could also enhance the ability of the Central Asian Republics to find regional solutions to the Aral Sea crisis
4. Country wise experiences

(Vinogradov and Langford, 2001).

Environmental experts and Government bodies have determined the following goals too to address as the key issues of security, water and the environment (Fifth Ministerial Conference, 2003):

1. ensure sustainable operation of water basin ecosystems of vital importance for human life.

2. Prevent degradation of water basin ecosystems essential for sub regional viability;

3. sound use of and access to drinking water- supply of water, of requisite quality and in sufficient quantities, to the public, industry and ecosystems;

4. intersectoral partnership and capacity-building- establishment and reinforcement of mechanisms to coordinate the interests and strengthen the resources of the civil sector and of environmental protection and water management organizations.

Stakeholders are also trying to revive and implement this scheme for diverting the water of the two Siberian rivers, Irtish and Ob, to Central Asia by emphasizing the issue of the water shortages and Aral Sea problems in close cooperation with Russia (Zainiddin Karaev, 2004).

4.1.10 Nepal

Nepal is endowed with the world’s highest and most admired mountain systems include Mt. Everest. The country has great potential as a tourist destination due to the opportunity it provides for spectacular scenarios and wildlife for visitors. It has an area of 14.7 Mha with an estimated population of 28.2 million (UN, 2007), out of which 76.2% is engaged in agricultural activities. Nepal is endowed with abundant water resources from the availability point of view. The waters are regarded as the key strategic natural resources having the potential to be the catalyst for all round development and economic growth of the country.

Nepal has a monsoon type climate. The total rainfall varies between 1,000 to 4,000 mm with an annual average of 1,814 mm. More than 75% rainfall occurs during four months of the monsoon period (June - September). The total annual surface runoff has been estimated to be 225 BCM of which 12 BCM is estimated to be entering from the upper catchments located in China, while about 15 BCM has been estimated to be entering into the Border Rivers between Nepal and India from the tributaries located in the Indian side.

Increasing population and industrial expansion, together with a growing demand from urbanization and irrigation sector resulted in increased competition for water. In terms of volume, irrigation is the greatest water user with over 95% of the total water consumed being used in this sector. When considering the various sectors of water users, water supply for households both socially and legally has been given high priority and this is followed by agriculture. Industrial expansion
including tourism, though at present not consuming much water, is another national objective requiring more and more water. There is only one proposed IBWT scheme.

**Proposed scheme**

*IBWT from Melamchi River to Kathmandu City*

To alleviate the acute water scarcity in Kathmandu city of Nepal the Government of Nepal has recently initiated a large scale water transfer scheme to divert 170,000 m³/day of water from Melamchi River to Kathmandu City’s water supply network (Figure 4.24). There is also a provision to divert up to three times more water using the same infrastructure as demand of water increases in the Kathmandu City (CPAD and IWMI, 2006). The total scheme cost is estimated to be US$ 464 million, spread over a period of 7 years (Madhusudan Bhattarai et al., 2002).

To overcome the drinking water crisis in Kathmandu valley, a number of initiatives have been carried out and studied earlier through government plans. Among others, Melamchi drinking water scheme has been considered as technically, economically and environmentally the best alternative. By the end of tenth development plan (2002 – 2007), the scheme will be completed and provided additional drinking water to Kathmandu valley (CSP, 2003).

The scheme has been designed in three stages:

- in the first stage, the scheme will divert 19.7 m³/s (equivalent to 170,000 m³/day), of water from the Melamchi River to the Kathmandu valley through 26.5 km long tunnel.
- in the second and third stages, keeping in mind with the future water demands in the valley, the scheme will divert an additional 170,000 m³/day of water (in each 2nd and 3rd stage) by diverting water from Yangri and Larke tributaries of the Indrawati river basin (Bhattarai et al., 2002).

Three major components of the scheme are:

1. **Physical Infrastructure Development**: sub-components under this component are:
   - *Melamchi transfer scheme* is meant for the development of infrastructure needed for the scheme. This includes construction of an intake dam (without reservoir) on Melamchi River at Ribarma, construction of a 26.5 km long tunnel from Sundarijal to Ribarma, construction of an 18 km long main access road with 9 bridges from Melamchi pulbazaar to Timbu, construction of 4 access roads of about 24 km long and the provision of 33 KV line electricity;
   - *water treatment plant* includes the establishment of water treatment plant of 170,000 m³/day capacity at first stage and other 170,000 m³/day each in second and third stages. Hence a total of 510 million liters’ reservoir tank will be established. For water treatment to meet the standard of WHO, different treatment processes will be provided such as
4. Country wise experiences

chemical flocculation, sedimentation, filtration, chlorination;

- **bulk distribution system**: under this sub-component about 14 reservoir tanks will be established around the valley (of the capacity of 72 thousands cubic meters). The additional water will also be provided to the existing water reservoir tanks of Nepal Water Supply Corporation;

- **improvement and expansion of water distribution system**: includes the improvement of present drinking water distribution system inside the valley. The main purpose of this component is to ensure the equitable distribution, leakage control and improvement of water quality.

![Figure 4.24. IBWT from Melamchi River to Kathmandu City](image)

2. **Social and Environment Program**

This program covers Environment Management Plan (EMP), Social Upliftment Program (SUP) and scheme Compensation Package (PCP).

- **Environment management plan**. Basically emphasizes environmental mitigation measures that would help to maintain the minimum ecological environment at downstream. To ensure the Environment Protection Act 1994, Environment Protection Regulation 1995 and rules and regulation of the donor agencies, several environmental impact assessments (EIA) have already been carried out, which ranked the Melamchi scheme is the best among the available alternative water supply schemes to Kathmandu (Nippon Koei, 2000; IUCN, 1999). Melamchi scheme will produce the least social and environmental impacts in the basin, which can be mitigated;

- **Social upliftment program**. This is the social development program for the scheme
affected communities of 14 Village Development Committees (VDCs). To overcome the negative impacts of the scheme, it implements various schemes to improve education, health, income generation and community development, rural electrification and the development of buffer zone of the Langtang National Park area;

- Resettlement and compensation package. The scheme has some compensation packages to the scheme impacted communities. There is considerable number of households going to be impacted by the scheme including with displacement of some households. For these households the scheme will provide displacement allowances according to the resettlement policy developed by the scheme. The package will include, inter-alia, a higher secondary school at Melamchi area, a hospital and road infrastructures. Furthermore, there will be the provision of 33 KV extension line for the people, after completion of the scheme.

Melamchi scheme has also different compensation schemes such as improved road access to Kathmandu and within the Melamchi valley; increased income through the expanded market infrastructure and the upgraded local skills; reduced workload for women and improved access to education in the communities through infrastructure development and provision of scholarships to the poor; and improved basic health and nutrition, especially for women and children (CPAD and IWMI, 2006).

3. Institutional Reforms:
Institutional reform will be another major change brought about by the scheme. Under this there will be three separate entities for effective organization and management of drinking water inside the valley to improve and upgrade the quality services of Nepal Drinking Water Corporation. Those entities will be Drinking Water Management Board (DWMB), Drinking Water Service Operator (DWSO) and Drinking Water Rate Commission (DWRC).

The Melamchi scheme is expected to meet the water demand of Kathmandu city for the next 30 years or more.

4.2 Americas

The Americas are the lands of the Western hemisphere. They consist of the Continents of North America and South America with their associated islands and regions. The Americas cover 8.3% of the Earth’s total surface area (28.4% of its land area) and contain about 14% of the human population.

With coastal mountains and interior plains, the Americas have several large river basins that
4. Country wise experiences

drain the Continent. The largest river basin in South America is that of the Amazon, which has the highest volume flow of any river on Earth. The quantity of fresh water released by the Amazon to the Atlantic Ocean is enormous: up to 300,000 m³/s in rainy season.

The largest river basin in North America is the Mississippi Basin. The Mississippi River has the third largest drainage basin in the world, exceeded in size only by the river basins of the Amazon River and the Congo River. The Mississippi River discharges at an annual average rate of between 7,000 to 20,000 m³/s. Other main river basins of America’s along with the Amazon and Mississippi, based on World Conservation Union et al. (2006) classification are shown in Figure 4.25. The details of these river basins are given at Table 4.4. Table 4.4 shows that some of the river basins are shared with two to seven countries. Hence inter regional cooperation in planning and developments of these river basins are of prime importance. Existing and proposed IBWTs that fit in the criteria are seen in the following countries: Canada, USA, Chile, Brazil and Bolivia. The characteristics of these IBWTs will be described in the next subsections.

4.2.1 Canada

Canada extends across the Continent of North America from Newfoundland on Atlantic Coast to British Columbia on the Pacific Coast. The total geographical area of Canada is 997 Mha with an estimated population of about 33 million (UN, 2007), out of which about 20% is engaged in agricultural activities. Over three-fourths of Canada’s people leaving in cities or towns. Much of the rest of Canada is uninhabited or thinly populated because of the rugged terrain and a severe climate. Canada has six cultural and economic regions: Atlantic Provinces, Quebec, Ontario, Prairie Provinces, British Columbia and Territories.

Canada avails over an impressive abundance of freshwater resources with a density of inter-connected and almost-connected lakes and rivers, and low divides between river basins (except in the western Cordillera). These are a legacy of the several advances and retreats of the Pleistocene ice fronts, before which melt waters sought to escape by whatever routes possible, creating and abandoning drainage channels, or simply spilling haphazardly from one depression to another. Some coastal areas of British Columbia receive more than 2500 mm of precipitation annually while average annual precipitation ranges from about 750 mm in Southern Ontario to about 1500 mm on the coast of Newfoundland. More than 2,500 mm of snow occurs in Eastern Canada during winter (Country Profile, Canada, ICID website).

Aboriginal people and European explorers recognized the ease of portaging canoes between drainage systems long ago. Modern engineering has often taken advantage of these old spillways (e.g., reopening the Qu’Appelle Valley route of the South Saskatchewan River). As a result, Canadian
schemes have benefited from short cuts between proximate waterways and gravity flows using largely natural channels (Clarke and Jewell, 1978).

In the early 1980s a national inventory of IBWTs in Canada, existing and under construction, was undertaken by Quinn (1981, 1987) from the information contributed by provinces and regional offices of Environment Canada and collected from engineering journals. This inventory was reviewed and updated in 2003.

Figure 4.25. Main river basins of the Americas (World Conservation Union et al., 2006)
## 4. Country wise experiences

### Table 4.4. Details of various river basins of Americas

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<tr>
<th>No</th>
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<th>River basin area (km²)</th>
<th>Crop land (%)</th>
<th>Wet land (%)</th>
<th>Dry land (%)</th>
<th>Irrigated cropland (%)</th>
<th>Average population density (people/km²)</th>
<th>Water supply/person/year (m³/year)</th>
<th>Degree of river fragmentation</th>
<th>Number of dams on main stem of river (height in m)</th>
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2. FAO: AQUASTAT Survey 2005
3. International River Basins Register (August 2002)
Existing schemes

The updated inventory identifies 61 IBWTs in Canada, scattered over 9 of the 10 provinces. No transfers are recorded on Prince Edward Island or in the northern territories. The total flow diverted between basins in Canada is enormous, approximately 4,410 m$^3$/s on an average annual basis (or 139 BCM/yr), excluding the transfer of infrequent flood flows such as those passed by the Red River Floodway. If all this flow were combined to form a new river, it would be Canada’s third largest, after the Mackenzie and St. Lawrence rivers. No other country diverts nearly as much as water as that of Canada’s total transfers.

The original Welland Canal, constructed in 1829, was Canada’s first IBWT, guiding ships around Niagara Falls between lakes Erie and Ontario. In the first decades of the 20th century transfers were generally small (Annex 2), but they increased in scale gradually after mid-century and peaked between 1970 and 1985, then fell off precipitously almost until the present day.

IBWTs (Figure 4.26 and Annex 2) facilitating irrigation expansion are of greatest importance in southern Alberta and adjoining parts of Saskatchewan; other transfers protect communities from flooding, especially in southern Manitoba; while small transfers supplement urban water supplies. Most common, however, are schemes diverting flow from other rivers into those where Hydropower schemes are situated. Canada has become the largest producer and exporter of hydropower in the world (CEA and NR Canada, 2000). Publicly owned provincial corporations are responsible for almost all of these power schemes. The largest include the La Grande transfers in the James Bay region of Quebec; the Churchill River transfer at Southern Indian Lake in northern Manitoba; and the Churchill Falls transfers in Labrador (Newfoundland). These three schemes, incorporating seven transfers, account for two-thirds of all water diverted within Canada.

In as much as the US Geological Survey (1985; 1986) undertook surveys of IBWTs operating in the United States in 1982, or approximately the same time as the first Canadian inventory, it is revealing to compare findings in the two countries. An earlier study by Quinn (1968) of IBWTs in the western states was used to supplement the USGS data, which overlooked transfers between units smaller than ‘sub regions,’ thereby approaching a level of detail more comparable to the Canadian inventory.

The pattern of transfers is indicative of important differences. As mentioned above, much more water was diverted in Canada (4,360 m$^3$/s in Canada to about 110 m$^3$/s in the USA in the early 1980s). Hydropower generation dominated in Canada’s IBWT pattern, but was barely represented in the USA, where major urban centres and western irrigation accounted for the majority of schemes; and virtually all transfers operated within provincial, state and national boundaries, not across them. Despite the promotion in the 1960s and later by entrepreneurs of schemes for continental water redistribution, Canadian freshwater showed no signs of being redirected to flow south of the border.
Figure 4.26. Inter Basin Water Transfers in Canada and the USA

Has the pattern of transfers changed in the two decades since? The answer seems to be: not significantly. For the United States, the era of big dams and transfers ended for all intents and purposes with completion of the Central Arizona Scheme before 1980. More dams nationwide are being removed at present than being constructed (Grossman, 2002), and there is very little to report in terms of new transfers, except for occasional small schemes to support urban growth, e.g., the Atlanta region. Accordingly, any growth in the total USA numbers would be minimal. The situation is comparable for Canada, which has lagged the USA experience, with a more gradual decline in dam construction but an almost total disappearance of new IBWTs from the mid 1980s until after the turn of the century.

Available water supplies are also being stretched by other means throughout North America, including rationing during drought periods, recycling and reuse, desalination, infrastructure rehabilitation (e.g., sealing leaks), and upgrading technology (drip or sprinkler methods replacing flood irrigation). The growing application of these alternatives to manage water demands locally and
regionally makes the economics of large-scale and long-distance water importation increasingly dubious and probably accounts for the lack of any real pressure upon Canada to share its water wealth with the United States, or other foreign markets, despite public fears to the contrary. Leading water experts in North America have long argued that both countries have adequate water supplies and that the challenge lies in using them more efficiently (US Water News, 2003). To leave no doubt, however, about Canadian resolve with respect to water export, the federal, provincial and territorial governments have enacted laws, regulations and policies to prohibit the bulk removal of fresh water, which typically applies to major river basins within their jurisdictions (Canada, 2002).

Quebec as an exception

Quebec, however, became an important exception, with renewed IBWTs to support hydropower development. These raised the Canadian total from 4,310 m$^3$/s to about 4,360 m$^3$/s in 2004 and 2005.

While other jurisdictions have opted to rehabilitate existing schemes, and encourage the private sector to take advantage of smaller sites for their hydro potential, Quebec has revived its larger ambitions for Hydropower development with an eye on export markets. Hydro-Quebec currently is constructing transfers from tributaries of three neighbouring basins to flow through generating plants on the Bersimis River on the north shore of the St. Lawrence River. Quebec has also entered into discussions periodically with Newfoundland on further co-operative development of the Churchill River, which might include the partial transfer of two rivers from the St. Lawrence basin of Quebec into the Smallwood Reservoir above Churchill Falls, Labrador.

The largest of the province’s Hydropower complexes is La Grande Riviere, draining westward to James Bay in the northwest part of Quebec (Figure 4.27). The climate here is sub arctic and the geology hard Precambrian rock overlain with glacial debris.

Over the objections of a scattered Aboriginal population, Quebec decided in 1971 to proceed with major dams and transfers, which would be accompanied by baseline environmental studies throughout the region. In 1975 the Cree and Inuit communities agreed to various developments in exchange for compensation for land settlements, money and other considerations. La Grande was selected first for Hydropower development; between 1975 and 1983, its average annual discharge of 1,700 m$^3$/s almost doubled by transfers from neighbouring basins, 845 m$^3$/s from the Eastmain-Opinaca (87% of that river’s flow measured at its mouth) and 790 m$^3$/s from the Caniapiscau (27% of that river), with a third transfer carrying 31 m$^3$/s from the Sakami River within the La Grande basin. Peak flows were converted from spring-summer to winter to meet electricity demands. Eight generating stations were built along the La Grande and its transfer routes -- LG 1, Robert Bourassa (LG 2), LG 2A, LG 3, LG 4, LA 1, LA 2, and Brisay -- with a total installed capacity by 1996 of 15,240 MW. Construction costs exceeded Canadian $ 20 billion (Hydro-Quebec, 2003).
Proposed schemes

In 2002 Quebec negotiated an agreement with four Cree bands in the territory south of La Grande to allow further development of the James Bay region. In exchange for their assent to the agreement, the Cree will receive 3.5 billion tax-free dollars over fifty years and will attain control of development and community organizations previously managed by the province. In return, the Cree must permit large-scale forestry and mining schemes and allow Hydro Quebec to divert the Rupert River (Michael O’Brien, 2002). The Crees will achieve more control over their community and economy, and in return drop their environmental lawsuits against the province.

Hydro Quebec plans to build a Hydropower station on the Eastmain (770 MW capacity) and to divert up to 585 m$^3$/s of flow from the Rupert River northward through the Eastmain to La Grande Rivera, where it will further increase the generating capacity of stations. For initiating the processes, a subsequent agreement in April 2004 have been entered and put an end to all litigation between the two parties and opened the way to a joint environmental evaluation of the transfer of the Rupert River, northwards to the Eastmain River and on into the La Grande hydroelectric river basin. When, the environmental assessment process for this phase was undergoing, the new Grand Chief of the Crees, elected in late 2005, is opposed to the Rupert scheme and intended to convince the Quebec government of the merits of wind turbines. Preliminary studies on this point conducted has come out with the findings regarding possibilities of large potential for development of wind power in the northern portion of the Jamésie region, just to the north of the La Grande complex and rare presence of migratory birds and human settlements for hundreds of kilometres suitting for amicable scenarios for
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developments. The proposal is under scrutiny.

*Schemes for augmenting the water supply of the Prairies Provinces*

Several proposals (about 10) have been prepared by the experts in the past two to three decades for catering (about 463.6 BCM annually) to the needs of the three arid states of Alberta, Saskatchewan and Manitoba, which are also known as ‘Prairie Provinces’ and have precipitation of less than 350 mm/yr.

Some of these involve transfers that would occur solely within the country. Others relate to proposals to divert water to USA. The first proposal was the McGregor transfer scheme, which envisioned transfer of 6.3 BCM/yr from headwaters of Fraser River to headwater of Northern British Columbia. The principal purpose of the scheme was to reduce flood flow in the Fraser River and to facilitate the increase in hydropower generation on the Peace River. Another purpose was to double the volume of existing transfer scheme of Nechako River.

A scheme was also planned to provide water for urban centres in Central and South Alberta, waste dilution, irrigation, hydropower and enhanced recreational opportunities. An ambitious scheme was also proposed inter alia for transferring water in a series of stages from the Peace and Athabasca systems in the North to South. Saskatchewan - Nelson Board also prepared a scheme, which not only provided for intra basin storage and transfer but also for addition of water from the Athabasca and Churchill Rivers. The Board has investigated a few more inter-basin transfer schemes, which are yet to be implemented.

*International or Continental IBWT proposals*

A number of schemes were prepared in the early 20th century, some gigantic in nature to solve in one sweep, the water supply problem of most of North American Continent. There were smaller schemes too like the one to supply waters to Point Roberts Washington from British Columbia. The key objective of all these schemes was to divert flows from Arctic rivers, towards South for use mostly in arid and semi-arid regions of Western Canada, the USA and Mexico. These proposals involved conveying vast quantity of water over very long distance using canals, pumps, tunnels and pipelines. Similarly there were also proposals for trans-boundary IBWTs from sources located in USA to Canada.
4.2.2 USA

The USA spans the entire North American continent and, due to its size and spread, has a wide range of climates. As a general description the nation is mostly temperate with cool winters and warm summers, but tropical in Florida and Hawaii, arctic in Alaska, arid in the southwest and semiarid in much of California and the Great Plains west of the Mississippi River. The northern states are coldest with frequent snow, frost occurs but not often in the southern states. Generally speaking, irrigation is required west of the 100th meridian to grow most crops except small grains. Supplemental irrigation can improve crop yields and may be necessary for truck crops in more humid eastern areas.

The terrain is a vast central plain, mountains in the west, hills and low mountains in the east, rugged mountains in Alaska and volcanic topography in Hawaii and parts of the northwest. Total area of the nation is about 9,800,000 square kilometers, of which about 18 percent is arable, and about 250,000 square kilometers (2.5 percent) is irrigated. Total precipitation averaged over the conterminous USA is about 760 mm (30 inches) of which 30 percent becomes runoff to the sea. Total average annual estimated runoff is about 1,700 BCM from the continental USA. This does not count runoff from the huge state of Alaska, where runoff probably exceeds 1,000 BCM.

The estimated current population in 2007 is about 300 million. The medium age is 36.6 years, 35.3 for males and 37.9 for females. The annual growth rate in recent years is about 0.9 percent. Out of the total population about 22% is engaged in agricultural activities.

There are approximately 2700 reservoirs more than 6 million cubic meters in size in the USA, with a total storage capacity of nearly 600 BCM. In addition there are an estimated 50,000 smaller reservoirs and about 2 million farm ponds. In year 2000 irrigated land accounted for 25 million hectares (250,000 sq km). About 4 million ha (16 percent) was in California, the state with the most irrigated land. Other states with large irrigated area included Nebraska at 3.2 million ha, followed by Texas at 2.6 million ha (CIA, 2007).

Total estimated applied water use for irrigation was about 190 BCM (153 million acre-feet). This was 40 percent of the estimated total fresh water withdrawals of about 480 BCM. However, the total includes thermoelectric power plant cooling which required nearly 190 BCM but most of this is non-consumptive once-through cooling water. Total urban and industrial fresh water usage was estimated at 90 BCM per year (USGS, 2004). Water usage has largely leveled off during the past 20 years, partly because the easily developed supplies are nearly fully used and because of the increasing emphasis on water conservation, particularly in expanding urban areas. Because most of the tail water and deep percolation of agricultural water is reused, there is less potential net savings with conservation in farm areas. Most environmental usage is for in-stream flow and is not counted in the preceding figures. But these are increasing too, thereby competing somewhat for the water yield of existing projects serving urban and agricultural purposes. In California, for example, estimated water year 2000 environmental water use slightly exceeded that of agriculture.

The most important state of the Western U.S., the California, faces the problem of variation in the availability of water within the state. Northern California is better off compared to the
4. Country wise experiences

central and southern parts. The fertile land and favorable environment of the western states has, in general, led to a high level of urbanization and industrial development, besides the phenomenal growth of irrigated agriculture in spite of limited surface water resources. The imbalance in water availability and demand has led to the mass import of water from surplus to deficient areas in south-western states including California, Arizona, etc (Maurice Roos, 2001).

Inter-basin transfers are therefore not a recent phenomenon in the United States. In 1842 New York City completed the Old Croton Aqueduct 66 km long, with a capacity of nearly 4 m$^3$ per second to bring high quality water into the city. In the 19th century, the city of San Diego, brought water from the upper San Diego River by a flume about 57 km long. Similarly, in the Imperial Valley, a canal from the Colorado River was constructed in 1901, which enabled the introduction of irrigation in the desert lands in Salton Sink. This project later came to be known as the Imperial Valley irrigation system. The project has undergone many technical and institutional modifications since a flood destroyed the original canal in 1905. The major change was the construction of the All American Canal entirely within the United States in the late 1930s and the Coachella Canal branch to serve Coachella Valley north of Salton Sea in the 1940s. Presently, the All American Canal serves an area of 210,000 ha in the Imperial Valley and about 30,000 ha in Coachella Valley. California also managed to bring water from Owens Valley, on the east side of the Sierra Nevada Mountains more than 350 km away in 1913, which helped promote and sustain the economic growth in semi arid Los Angeles city (William E. Warne, 1978). The city of San Francisco and the cities of the East Bay also built aqueducts reaching to Sierra Nevada watersheds in the late 1920s and early 1930s for drinking water supply.

Since then, a number of well-known transfers like the Colorado and California Aqueducts have been implemented chiefly for irrigation, hydropower and municipal use. It was estimated in 1975 that 1 out of 5 people in 11 Pacific coastal and Rocky mountain states of the US was served then by a supply system that brought water from sources located more than 160 km away. Estimates made in 2000 showed that the largest volume of transfers was being made out of the Colorado River basin, which exported over 8.5 BCM, with the largest share going to Southern California.

The available information about the completed as well as proposed inter-basin transfer schemes has been included in the statistical compilation (Annex 2.2). Some are described below.

Existing Schemes
Figure 4.28. Major existing and proposed IBWTs in the USA

(Note: The map has to undergo modifications based on the comments received from Mr. Maurice Roos considering the 15 existing and 3 proposed projects described in the subsequent sections)

1. **Chicago Sanitary and Ship Canal Project**

   The Chicago Sanitary and Ship Canal Project, is also known as the Chicago Lake Michigan Diversion Project, located in Illinois, USA, transfers annually up to about 2.9 BCM of water from Lake Michigan and the west fork of the south branch of the Chicago River to the Des Plaines River, a part of the Mississippi River Basin. Its primary purpose is to dilute and convey the city’s waste discharges away from Lake Michigan to avoid polluting the water supply. The diversion began in year 1900, with the rate limited to 90.6 m³/s in 1967 by court decree.

2. **Truckee Canal**
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The Truckee Canal extends 51 km from the Derby Diversion Dam on the Truckee River east of Reno to Lahontan Reservoir on the Carson River. It includes 3 tunnels. The initial capacity is about 42 m$^3$/s, ending at about 25 m$^3$/s. Its purpose was to augment the inadequate supply of the Carson River for irrigation in the Carson Division of the Newlands Project near Fallon, Nevada, one of the first water projects built by the U. S. Bureau of Reclamation. Diversions to the Carson Division started in 1907. There is some irrigation of bench lands in the Canal’s upper reaches on the south side of the Truckee River. At its peak about 1980, some 30,000 ha were being served and the return flow drainage helped supply the Stillwater Wildlife Management Area, a wildlife refuge in the Carson Sink, the intermittent lake at the terminus of the Carson River (Joseph I. Burns & Michael C. Archer, 2001).

The natural sink of the Truckee River is Pyramid Lake. As a result of increased water demands on the Truckee River including the diversions into the Truckee Canal, the lake was slowly declining with a threat to its fisheries. It was down some 26 m in 1967 from 1906. In 1968 the Pyramid Lake Indian Tribe began a series of lawsuits aimed at halting the decline of Pyramid Lake. As a result of these lawsuits and operating criteria imposed by the U. S. Bureau of Reclamation, Truckee Canal diversions have been reduced. Diversions were down about 0.11 BCM in recent years from an early 1970s level of about 0.24 BCM. Attempts to partially compensate for the reduced diversions by increased irrigation efficiency in the Fallon farming area caused a reduction in return flow water supply to the Stillwater Wildlife Management Area. Irrigation water rights are being purchased from Project irrigators to supply the wildlife area. The outcome is less irrigated acreage, which can be expected to decline further with competition for water by the rapidly growing urban areas of western Nevada. Pyramid Lake has risen some and was about 7 m above the 1967 low point in 2005.

3. Los Angeles Aqueduct to transfer water from Owens Valley to Los Angeles

The city of Los Angeles was founded in 1781. Its population increased rapidly and by 1900, it was more than 100,000. During this period, irrigation also became popular and widely
practiced. By 1905, the city of Los Angeles had completely diverted the normal runoff of the Los Angeles River. To augment that supply, the city had constructed underground galleries across the river to collect the subterranean flow in the stream. In addition, wells in the southern part of the city drew upon groundwater. That supply also could no longer be replenished since all upstream flow was tapped. Having exhausted all available options to develop locally available water resource, the city of Los Angeles decided to import water from the Owens Valley, about 400 km away. As a result, the Los Angeles Aqueduct was constructed in 1913. The aqueduct was 360 km long. It was extended further about 180 km to the Mono Lake basin in 1940. In 1970 a second parallel and smaller capacity aqueduct was added to bring the total capacity to 0.63 BCM per year.

However, the exports from Mono basin were drying up Mono Lake, a unique alkaline desert lake. A 1994 State decision prohibited diversions until the lake level rose to a specified level. Once the lake recovers, long term diversions will gradually average about 30 percent of what they were before.

The Owens River diversions also dried up its terminal sink at Owens Lake which caused periodic severe dust storms from the mostly dry lakebed. Air pollution rules required further releases to control the dust. The City was also ordered to rewater the lower end of the Owens River for river channel and wetlands restoration. The supply from this aqueduct in water year 2000 was about 0.36 BCM, wet year amounts will approach aqueduct capacity.

4. New York City Delaware Aqueduct Project

Expanding needs for water in the early 20th century caused the City of New York to investigate the upper watershed of the Delaware River as a source. The Delaware River originates in central New York State then flows southward, forming the boundary between New Jersey and Pennsylvania, then on the east side of the State of Delaware into an estuary and into the Atlantic Ocean. Philadelphia and Trenton both take most of their municipal water supply from the river, which is subject to salinity intrusion from the ocean in its southern reaches if river flows are too low. Ocean tides reach up about to Trenton. New York City began diverting Delaware River water through tunnels into the adjoining Hudson River watershed at Rondout reservoir in the late 1930s. Eventually the city built 3 storage reservoirs, Pepacton, Neversink and Cannonsville on the headwaters of the Delaware River. The first two reservoirs became operational in 1955; the last, Cannonsville, was completed in 1967. Initially their project was challenged by the downstream state of New Jersey, which was an interstate conflict. The dispute was referred to the U.S. Supreme Court which issued a decree in 1931 allowing New York to divert 440 million gallons per day (0.61 BCM per year).

In 1952, the City sought to increase its diversions. All the states in the basin, New York, New Jersey, Pennsylvania and Delaware, along with New York City, returned to the Supreme Court. An amended decree was consented to all parties in 1954. It permitted New York City to export up to 800 million gallons per day (1.1 BCM per year) contingent on constructing a third storage reservoir, the Cannonsville impoundment on the West Branch of the Delaware River (which was completed in 1967). In return, under the amended decree, New York City was required to release enough water from its 3 upper basin reservoirs to meet a flow objective of 1750 cubic feet per second (49.6 m³/sec) at Montague, New Jersey, in order to ensure adequate stream flows downriver. The decree also permitted an out-of-basin diversion of up to 100 mgd (0.14 BCM per year) to central and northeastern New Jersey in the
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Delaware and Raritan Canal. A River Master employed by the U.S. Geological Survey was appointed by the Court to administer provisions of the decree. The entities also formed the Delaware River basin Commission to foster a climate of cooperation and to deal with changing conditions without litigation (Bruce E. Krejmas, 2005).

**The capacities of the 3 city reservoirs**

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Name of the reservoir</th>
<th>Capacity (BCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Pepacton</td>
<td>0.53</td>
</tr>
<tr>
<td>2.</td>
<td>Cannonsville</td>
<td>0.36</td>
</tr>
<tr>
<td>3.</td>
<td>Neversink</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>1.02 BCM</strong></td>
</tr>
</tbody>
</table>

Water from each of these reservoirs is taken through separate rock tunnels to Rondout reservoir, then by the Delaware Aqueduct to New York City where it furnishes about half the total city supply. According to the River Master, New York City diversions from the Delaware Basin in year 2000-2001 (December - November) were 0.92 BCM, 243.3 billion gallons, 83 percent of unrestricted capacity. Droughts will reduce the allowable diversions. For example, in November of 2001, the allowable rate of diversion was reduced 30 percent from the maximum decree diversion rate. In year 2001-2002, a year of severe drought, the diversion averaged about 0.70 BCM (184.3 billion gallons).

Fishery concerns have been a recent issue.

5. **All American Canal**

This canal, which replaced the old privately built inter-basin canal from the Colorado River which ran partly through Mexico, was constructed from 1934 to 1940 to convey Colorado River water to the Imperial and Coachella Valleys of southeastern California. It includes extensive desilting works near the intake at Imperial dam on the Colorado River. The capacity below the measuring point at Pilot Knob is about 290 m$^3$ per second. Added capacity in the 34 km reach to the east of Pilot Knob serves the Yuma Project. Twenty-five km below Pilot Knob is where the turnout for Coachella Canal begins. The original earth lined Coachella Canal carried about 70 m$^3$ per second; the new concrete lined canal is smaller due to the savings in seepage losses. Total transfers were about 4.3 BCM per year in 2000. (There is some question about whether all the All American Canal diversions are an inter-basin transfer because the irrigated land in Imperial Valley is part of the geologic delta of the Colorado River.)

6. **Colorado River Aqueduct**

The Los Angeles Aqueduct serving the city of Los Angeles did not solve all of Southern California’s water supply problems. The need for tackling them on a regional basis, led to importation of water from Colorado River Basin to Southern California. The Colorado River Aqueduct was constructed in 1941 to transfer water from Lake Havasu near Parker Dam on the Colorado River 390 km to Lake Mathews, a balancing reservoir near the city of Riverside. From this site, a distribution system of total length of 1050 km was constructed to deliver water to various cities and agricultural areas in Southern California extending from the boundary with Mexico to the Tehachapi Mountains. The aqueduct can transfer annually 1.5 BCM of water.
Figure 4.30 Colorado River flow and diversions for the Water Year 2000 (Source: US Geological Survey water data reports for various basins states with some figures from the US Bureau of Reclamation website http://www.usbr.gov/dataweb/. The figures indicated in the diagram are diversion quantities in 1,000 AF, 1 million acre-feet (MAF) = 1233.5 million cubic metres).

7. Colorado Transmountain Diversion Projects

Trans-basin water diversions of two kinds exist throughout Colorado: trans-mountain and trans-basin. Several trans-mountain diversions have been constructed during the past decades in four river systems (Rio Grande, Arkansas, Platte and Colorado). The first three rivers receive water from the Colorado River basin, with some diversions between adjacent pairs of these basins. These thirty or so diversions facilitated urbanization of the State. The larger trans-basin diversions are tunnels but many comprise open channels traversing high altitude catchments over mountain passes to serve agricultural or mining projects. These schemes cumulatively transfer annually about 0.70 BCM of water (UCRC Annual Report, 2003).
While Southern California was getting water supplies from Colorado River, the central part of the state, the San Joaquin Valley, also felt by 1921 the need to transfer waters from areas of surplus availability to the deficient ones. This resulted in the taking up of the Central Valley Project, which was planned by the State of California and authorized in 1933. But the State could not get financing so the U. S. Bureau of Reclamation stepped in beginning in 1935 to build the project to transfer waters from the northern Sacramento River to the southern San Joaquin River Valley. This was done by construction of a large storage dam at Shasta on the upper Sacramento River and then releasing the regulated flows into the Delta area in the middle of the Central Valley. From the Delta, a canal, known as Delta Mendota Canal, was constructed to carry water south to Mendota west of Fresno. This water was exchanged for prior San Joaquin River water rights (about 1 BCM per year) which enabled almost all the San Joaquin River runoff from the Sierra to be stored and diverted at Friant Dam (Millerton Lake) to the water deficient southern half of the San Joaquin Valley mostly via Friant-Kern and Madera Canals. Another canal from the Delta, the Contra Costa, transfers water towards the eastern San Francisco Bay area.
The San Felipe Division transfers water from the San Luis Reservoir on the west side of the San Joaquin Valley to the South San Francisco Bay and northern Central Coast regions. The CVP provides water to the San Luis area on the west side via the California Aqueduct. The California Aqueduct is a large canal built in the 1960s and 1970s from the Delta along the western side of the San Joaquin Valley into Southern California. A 170 km portion of the Aqueduct south of the 2.5 BCM San Luis Reservoir is shared with the State Water Project, as is San Luis, Reservoir storage. Other CVP features include the 3.0 BCM New Melones Reservoir on the Stanislaus River and canals on the west side of the Sacramento Valley and from Folsom Reservoir and the American River near Sacramento. All told, there is about 15 BCM of reservoir storage in 7 major reservoirs, nearly 30 percent of California’s capacity.

This complex system of water collection, conservation, storage, transfer and distribution of waters is capable of delivering about 8 BCM/yr. The Sacramento River itself receives water from Trinity River through another trans-basin project. The Central Valley Project covers an area extending from the region near the Oregon-California border on the north to the Tehachapi Mountains on the south, and from the summit of the Sierra Nevada mountains on the east to the south San Francisco Bay area on the west, providing water to nearly 1.2 million ha of land in irrigation, water supplies for about 1 million households and about 1.5 BCM/yr for fish and wildlife and wetlands.

9. **Colorado – Big Thompson Project**

![Colorado-Big Thompson Project](image)

**Figure 4.33 Colorado-Big Thompson Project**

Farming on the high plains of North-eastern Colorado began in the mid to late Nineteenth Century. As the annual precipitation was less than 35 cm, the farmers began to construct
diversion structures, canals and storages to tap available surface flows for irrigation. With more and more areas coming under irrigation, an acute shortage of water developed, highlighting the need for import of water from wetter areas. The Colorado – Big Thompson project was constructed in between 1937 – 1957 to transfer water from the Colorado River Basin to the Big Thompson River Basin on the east slope of the Rocky Mountains via a tunnel beneath Rocky Mountain National Park. The water storage component of the project consists of Green Mountain Reservoir, Willow Creek Reservoir, Lake Granby, Shadow Mountain Reservoir and Grand Lake on the west slope. Horse Tooth Reservoir, Carter Lake and Boulder Reservoir were constructed on east slope (Darell D. Zimbelman & Brian R. Werner, 2001).

Surplus water originating on the headwaters of the Colorado River on the western slope is collected and stored in Lake Granby. Water is then pumped to Shadow Mountain Lake, an extension of Grand Lake, from which the water flows through the 24 km long Alva B. Adams Tunnel about 1000 m under the continental divide. On the eastern slope, it passes through a series of conduits, power plants en-route to storage in Horse Tooth and Carter Lake Reservoirs. Project facilities are mostly managed by the Northern Colorado Water Conservancy District, but the U. S. government has retained management of facilities associated with hydropower generation.

The project is capable of water transfer of the order of 0.3 BCM per year, which is about 25 percent of the total water supply for the area. Originally, more than 95 percent of the transferred water was used for irrigated agriculture, but over the last 35 years municipal and industrial use has increased to the 30 to 50 percent range. The District presently serves more than 700,000 people and about 250,000 ha of irrigated land. Municipal and industrial users are generally charged a fee more than twice as high as agricultural users.

10. Trinity River Trans-Basin Diversion Project

The Trinity River trans-basin diversion project in northwestern California is part of the Central Valley Project. Its purpose was to supplement Sacramento River system water supply by diverting a major portion of the coastal flowing upper Trinity River flow, as well as producing hydroelectric power. The Trinity River Division, as completed in 1964, included 3 dams, including the large 3.0 BCM Trinity headwaters reservoir, Lewiston Diversion Dam downstream on the Trinity River, and, on the Central Valley side, reservoir re-regulation behind Whiskeytown Dam (Franklin E. Dimick, 2001). It included a fish hatchery at Lewistown, 2 mountain tunnels and 3 large power plants, originally at nearly 394 MW but, now, improved to about 470 MW. Diversion during the first 30 years averaged about 1.2 BCM/yr.

The fishery aspects were controversial from the beginning. During the first 10 years, 88 percent of the water at Lewistown was diverted and the Trinity River salmon and steelhead runs dropped about 80 percent in spite of the hatchery. By the early 1990s downstream fishery flows had been nearly tripled. Further studies led to a fishery restoration program which raised the fishery releases to 48 percent of the flow.
Amounts varied depending on the wetness of the year from about 0.45 to 1.00 BCM per year. With the loss of many high flow events, the stream channel downstream had been changed by vegetation encroachment and silt. Some mechanical clearing is being done to return the original gravel base and a small sediment control dam was built on a tributary creek where much of the sand sediment had come from. It is too soon in 2007 to know how well the recovery effort is paying off. Salmon runs are down on all North Coast Rivers, so the diversion project is not entirely to blame.

*Figure 4.34. Trinity River Trans-Basin Diversion Project*

(Note: The map has to undergo based on the comments received from Mr. Maurice Roos, USA).

**11. San Juan – Rio Chama Project**

This Project transfers water from Navajo, Little Navajo and Blanco Rivers, which are the upper tributaries of the San Juan River, itself a tributary of the Colorado River to Rio Chama, a tributary of Rio Grande River in New Mexico (Gould, Jaci L. and Connie L. Rupp, 2001). The primary storage reservoir for the project is Heron Reservoir and only stores the imported San Juan- Rio Chama Project water and there are no provisions for storing native water. The project is capable of transfer of about 0.13 BCM of water annually.

*Figure 4.35  San Juan – Chama Project*

**12. California’s State Water Project**

Southern California continued to grow at a rapid pace, particularly after the Second World War. To meet water needs, a new comprehensive State Water Project was designed to transfer flows from better-watered Northern California to the drier central and southern part of the state. The main features of the project are Oroville Reservoir (capacity = 4.37 BCM) to regulate the flow of the Feather River, San Luis reservoir in San Joaquin Valley for storage of winter water pumped from the Delta, the California Aqueduct, four storage reservoirs in
4. Country wise experiences

Southern California and one in the San Francisco Bay area. Smaller aqueducts provide water service in the San Francisco Bay area and the coastal area north of Santa Barbara. An important component of the project is the California Aqueduct 715 km long comprising a complex system of lined canals, pumping stations, siphons and tunnels. The construction of the first phase (20 reservoirs, 9 power plants, 20 pumping plants and 869 km of aqueducts) was completed in 1973; with current extensions, the project has 1086 km of aqueducts. Total reservoir capacity is about 7.1 BCM, of which nearly 4.5 BCM is in the Oroville complex. The project is presently delivering 5 BCM per year in a good water year but much less in dry years (CWP Update, 2005).

![California State Water Scheme](image)

**Figure 4.36** California State Water Scheme (Department of Water Resources, 1981)

13. Central Arizona Project

The Project transfers water from Colorado River to Central and South Central Arizona into the Salt, Gila and Santa Cruz River Basins to augment their existing water supplies and to
meet the growing needs of the Phoenix and Tucson urban areas. It became operational to the Phoenix area in 1985 and to Tucson in 1992. The system consists of a series of pumping plants, aqueducts and dams, which extend about 541 km into Central Arizona. Altogether there are 14 pumping plants, one pumping/generating plant, 10 siphons carrying water under riverbeds and washes and 3 tunnels. Water is diverted from the Colorado River at Lake Havasu where the intake capacity is 85 m$^3$/s. About halfway along the Aqueduct is a large off-canal storage reservoir, Lake Pleasant, with a capacity of around 1.37 BCM, behind New Waddell Dam on the Agua Fria River. The Central Arizona Project is designed to transfer annually about 1.85 BCM.

14. **Central Utah Project**

![Figure 4.37 Central Utah Project](image)

The project is a large water resources project started in 1957. One of its units known as Bonneville Unit envisaged a large trans-basin diversion from the Colorado River system into the interior of the Great Basin. Forerunner of this sub-project was another earlier trans-basin transfer scheme known as the Strawberry valley project, which transferred water from the Strawberry River in the Uinta basin, a part of the Colorado River basin, to the Utah Valley, a part of the Great Basin (Reed R. Murray & Ronald Johnston, 2001). This diversion was accomplished by construction of Strawberry Dam on the Strawberry River and transferring water through the Wasatch Mountains via a tunnel. The Bonneville Unit of the Central Utah Project built a new and larger dam, the Soldier Creek Dam, to replace the Strawberry Dam and increased the size of Strawberry Reservoir approximately four times its original capacity. It also includes diversions of seven smaller streams, tributaries to the Colorado River, along the 59 km Strawberry Aqueduct which brings water into the enlarged Strawberry Reservoir for transfer to the Utah and Salt Lake Valleys in the Great Basin via the 10 km long Syar Tunnel through the Wasatch Mountains. The unit was designed to transfer 0.17 BCM per year of water from Uinta basin to the Bonneville Basin.

15. **Garrison Diversion Project**

The State of North Dakota is relatively dry, with average annual precipitation ranging
from about 330 mm in the northwest to 500 in the southeast. Much of the land is dry farmed, except in the southwest where grazing is more predominant, and is generally very productive, depending on soil type, when average precipitation is received on a timely basis. However, high value crops which depend on consistent moisture at the right time cannot be grown on a reliable basis without irrigation. There are about 100,000 hectares under irrigation in North Dakota, the least of the 17 western states. There is some groundwater but most of it is appropriated. The Missouri River, which flows through the southwestern part of the state, is the most reliable and a high quality water supply; in fact it is about 95 percent of the state’s supply.

![Figure 4.38. Garrison Diversion Project](image)

Given the small amount of irrigation in the state, and the facts that the best water supply is in the west and two thirds of North Dakota’s population lives in the east, mostly in the Red River Basin, the need for providing water for irrigation and municipal and industrial water throughout the state was recognized early. Water supplies in many of the rural areas of North Dakota are also of poor quality with inadequate amounts. The need to develop a statewide water supply for these purposes has been recognized since before 1900 and an effort to utilize Missouri River water has been ongoing since that time (Warren L. Jamison, Jerry Schaack and Richard McCabe, 2001).

One of the first major attempts at developing the state’s water supply was in the form of the Garrison Diversion Unit (GDU) Project, a 525 million hectare (1.3 million acre) irrigation, municipal and industrial water project. This project, which was authorized by the Flood Control Act of 1944, sometimes referred to as the Pick-Sloan Act, was to divert water from the Missouri River for irrigation and other uses in various parts of the state, including the Sheyenne and Red River basins which are part of the Hudson Bay drainage. The Flood Control Act authorized development of the Missouri River Basin which included building 6 major dams on the main stem of the Missouri River. These dams were constructed and the accompanying benefits of flood control, navigation, power generation, and irrigation were and are being realized to varying degrees. The largest one, Garrison Dam, was completed in 1953, creating a huge reservoir known as Lake Sakakawea with a capacity of about 29 BCM (23.8 million acre-feet). North Dakota farmers gave up about 220,000 hectares (550,000 acres) of very productive land for the storage of water behind Garrison dam and in the upper portion of Oahe Reservoir backed up behind the downstream Oahe dam in South Dakota. In
return, the state was “promised” a large federal irrigation project, the Garrison Diversion Unit, among other things.

Construction started on the Garrison Diversion Unit in the late 1960s after authorization in 1965 for the construction of facilities to irrigate 100,000 ha (250,000 acres) in the Missouri and Red River drainage basins. A system of pumping plants and canals with an initial capacity of 57 cubic meters per second (2,000 cfs) was designed to distribute water primarily for irrigation but also municipal and industrial water into various portions of North Dakota, including the Red River basin which drains into Canada. However, construction was halted in midstream in the mid 1980s because of Canadian concerns on the potential transfer of harmful biota (non-native and invasive fish species, fish disease, and pathogens) from the Missouri basin into Canada through the Sheyenne and Red Rivers. The diversion would begin at Lake Audubon, an auxiliary reservoir created by a dike across an arm of Lake Sakakawea, using the Snake Creek Pumping Station to lift water from the main reservoir into Lake Audubon. From there water was to flow by gravity into the 119 km McClusky Canal over the continental divide to link with the 71 km New Rockford Canal in the upper James River drainage (part of the Missouri basin). The middle connecting link was to be Lonetree Reservoir in the Sheyenne River basin. The two main canals, McClusky and New Rockford canals were built; however, the dam to form the connecting Lonetree reservoir was halted due to Canadian concerns. A “plug” was left in McClusky Canal, which stopped Missouri River water from flowing into the Red River basin. Inter Basin Transfer of Water has never taken place on the project.

With the 1965 authorization stalled, other plans were pursued and the 1986 Reformulation Act authorized changes and modifications to the Garrison Diversion Unit; it was the first of many changes in the evolution of the project from irrigation to a municipal, rural, and industrial (MRI) water supply project. Among other things, the 1986 Act deauthorized all previously planned Garrison Diversion Unit irrigation in the Red River basin, leaving an authorized 53,000 ha (130,000 acres) for irrigation in the Missouri River basin. It also required more study to determine the potential effects of biota transfer and irrigation in the Red River basin. Various methods of treatment of the transferred water were investigated; however, treatment of the large quantities of water to satisfy Canadian concerns for irrigation was prohibitive. The 1986 Act also attempted to appease irrigation interests by authorizing up to $200 million for construction of MRI water facilities in the state. These monies, in the form of a 65-35 federal/local grant have essentially all been used for this purpose which, through 2006, has not entailed any interbasin transfer of water.

The 1986 Act also provided for the construction of the Oakes Test Area in the James River drainage within the Missouri River basin to study the effects or irrigation on water quality, fish and wildlife concerns, to test the concept of zero surface runoff, and other environmental factors. Most of the study results were very positive relative to Canadian and environmental concerns; however, they had little or no effect on changing the course of the project from an irrigation standpoint.

After about another 10 years of additional studies and political and environmental wrangling, the Dakota Water Resources Act of 2000 was passed. This authorized the construction of additional MRI facilities statewide up to an amount of $200 million, Native American MRI works up to $200 million, $200 million to study and provide an adequate water supply to the Red River Valley, and about $30 million for natural resources and recreation development. No federal irrigation development was authorized by the Act; however, some 11,000 ha
(28,000 acres) of irrigated land was authorized to receive reduced price federal project power as authorized under the 1946 Act. Unfortunately, this last provision has not been implemented due to a legal opinion from the Interior Department.

The construction of MRI facilities in the state has been going on since 1986; however, funding has been much slower than needed or anticipated. Irrigation development in the Garrison Diversion Unit has not taken place because of continual Canadian concerns, perceived environmental problems; lack of support from the U. S. government, and economic issues and this situation is not likely to change in the foreseeable future.

The Northwest Area Water Supply (NAWS) project was an MTI project authorized under the 1986 Reformulation Act and the Dakota Water Resources Act in 2000. It involves an interbasin transfer of water from the Missouri River basin to the Souris River basin which is also within the Hudson Bay drainage basin. Consequently, despite planned extensive water treatment, biota transfer concerns by Canada/Manitoba have also persisted and plagued this project. But construction did begin in 2002 despite years of Canadian objections. This project would transfer pre-treated Missouri River water from Lake Sakakawea across the continental divide northward to Minot and eventually to other communities in the Souris River basin. Final water treatment would be at the Minot city water treatment plant. The Missouri water would be treated to drinking water standards and distributed to a number of communities in northwestern North Dakota, replacing poor quality groundwater and undependable surface sources.

In 2002 Canada and Manitoba objected to the Environmental Assessment of the NAWS project prepared by the U. S. Bureau of Reclamation under the National Environmental Policy Act (NEPA) in early June 2001. They claimed that the level of treatment proposed within the Missouri River basin will not ensure adequate biota or pathogen removal. Canadian personnel objected to the Bureau of Reclamation conclusion that impacts were either insignificant or could be mitigated and maintained and stated that, under NEPA, a comprehensive Environmental Impact Statement (EIS) should have been prepared.

On February 3, 2005, the U. S. District Court of Columbia ruled in favor of Manitoba’s case and ordered the Bureau of Reclamation to undertake new work on the risks of biota transfer associated with the NAWS project. The ruling of the court represents a landmark decision in the consideration of invasive species for projects that propose to divert water from one basin to another.

In March 2006, the Bureau of Reclamation published a notice indicating intention to carry out a comprehensive EIS on the NAWS project, under NEPA and thereby provided an opportunity for interested parties to comment on the scoping and content of the proposed EIS. Manitoba has provided significant comments on the proposed scope of the EIS; however, construction on the pipeline has continued. Preparation of the EIS is underway and should be completed in 2007.

The Dakota Water Resources Act authorization to develop MRI water supplies is ongoing. The Red River Valley Water Supply Project is needed to supply MRI water to the eastern portion of the state which has about 2/3 of the state’s population but an inadequate water supply. If a drought occurs, severe water shortages will be experienced in Fargo and surrounding areas. This project which has been studied for the past 10 years has a preferred state alternative of diverting water from the Missouri River through a pipeline from the
McClusky Canal which is part of the Garrison Diversion Unit project to a reservoir, Lake Ashubula, on the Sheyenne River, a tributary of the Red River of the North.

This has again raised concerns with Manitoba and Canada relative to harmful biota transfer. The draft EIS for this Red River supply project, which will be completed about 2007, has addressed this issue and the concerns of all those who may feel affected by this transfer project. After review of the EIS and selection of a preferred alternative by the Secretary of the Interior, appropriate modifications will be made and the project will hopefully move forward to construction. Most of the funding for the project is expected to come from state and local revenues.

The Garrison Diversion Unit project has had a very long and tortuous history of broken promises, political compromises, changing priorities, and other opposition which has resulted in an uncompleted project and unfulfilled dreams after many years of work on the project. One of the biggest roadblocks has been the perception of the interbasin transfer of harmful biota from the Missouri River basin into Canada. Extensive studies have shown that biota transfer is much more likely due to natural and non-project processes than by project activities. Millions of dollars and hours have been spent in an honest effort to alleviate concerns; however, most of this has been to no avail and after some 35 years, the objections still persist.

The Garrison Section write-up generated here is based on the contributions made by the USCID member Mr. Jerry Schaack of North Dakota.

**Proposed schemes**

1. **The North American Water and Power Alliance (NAWAPA)**

The North American Water and Power Alliance (NAWAPA) is the largest IBWT scheme so far conceived for North America (Figure 4.14). It is the most comprehensive of a series of plans to capture and redistribute fresh water in Alaska and Canada.

![Figure 4.39. North American Water and Power Alliance (NAWAPA)](image)
NAWAPA would deliver large quantities of water to water-poor areas of Canada, the lower forty-eight states of the USA and Mexico. It would involve construction of a series of dams in Alaska and the Canadian Yukon, trapping the water of the various rivers running through this largely undeveloped wilderness area. A large portion of the water thus collected would then be transferred into a man-modified reservoir 700 km long, 15 km wide, and 100 m deep, constructed out of the southern end of the natural gorge known as the Rocky Mountain Trench in the Canadian province of British Columbia. This would be accomplished through a series of connecting tunnels, canals, lakes, dams, and lifts. To the East, a ten metres deep canal would be cut from the Trench to Lake Superior, to maintain a constant water level and clean out pollution in the entire Great Lakes system from Duluth to Buffalo. Not only would this provide more water for hydropower and irrigation of the Great Plains region of Canada and the USA, the canal could ultimately be made navigable for lake- and ocean-going vessels from the Great Lakes into the heart of Alberta, and eventually, extended westward into Howe Sound, British Columbia. The possibility of a North-west Passage would become a fact; form the Gulf of St. Lawrence to Vancouver. South of the Trench reservoir, water would be lifted through a giant dump lift to the Sawtooth Reservoir in South-western Montana, from which point it would flow by gravity through the western part of the system, passing through a tunnel in the Sawtooth Mountain thirty metres in diameter and 80 km in length, to the western and Southern US states.

South of the Rocky Mountain Trench, in central Idaho and South-eastern Washington, a series of hydropower plants would develop the Clearwater North Fork Rivers. Flow of the Columbia River would be supplemented as needed from other rivers as well as regulated at its direct connection to the Rocky Mountain Trench Reservoir to prevent flooding. NAWAPA aqueducts and reservoirs would dot the slopes of the Rocky Mountains, providing water to the Staked Plains and Rio Grande River basin and serving New Mexico, Texas, Colorado, Kansas, Nebraska, Oklahoma and Mexico via existing rivers.

Flows from the Rocky Mountain Trench and Clearwater subsystem would also supply Idaho, Oregon, Utah, Nevada, California, and Arizona in the USA; and Baja California, Chihuahua, and Sonora in Mexico. A transfer aqueduct at Trout Creek, Utah would send high-quality, low-mineral water to Southern California and Baja California. Here it would arrest soil damage caused by high-mineral Colorado River irrigation water.

For Canada, NAWAPA would deliver 50 BCM/yr for irrigation, domestic and industrial usage and provide 38,000 additional megawatts of hydropower. It would bring to the USA 100 BCM/yr of fresh water, enough to double the irrigated lands west of the Mississippi, as well as providing 55,000 MW of surplus hydropower, nearly doubling the present capacity of 70,000 MW. Mexico would get 50 BCM/yr, tripling its irrigable land, as well as 4,000 MW of installed hydropower. This scheme was included in the policy paper on April 20-22, 2001 at the ‘Summit of the Americas’ and termed as ‘Great Schemes for Rebuilding the Americas’. However, because of the high cost and environmental problems involved with the scheme components, it is necessary to make an international water treaty with Canada and carry out detailed environmental assessment study for taking care of the environmental hazards.

2. Texas Water Plan

The Texas Water Plan is drawn up to solve the water shortage problems of the State of Texas and also to provide some flow to the adjacent state of New Mexico (Figure 4.15). The
stimulus to the development of the plan was the drought of 1950 - 1956.

The main thrust of the plan is the trans-basin import of water. The delivery system would consist of three parts: the Eastern Division, Trans Texas Division and Coastal Division. The Eastern Division would consist of those facilities in the eastern part of Texas, required to receive water from the lower Mississippi (which would require a separate transport system across the state of Louisiana to the Texas border). The trans-Texas component would supply water via a canal and pumping system to north Texas and High Plains, and trans Pecos area of West Texas, as well as convey water to Mexico. About 13.5 BCM/yr would move along this route. The Coastal Division would provide water via a canal for coastal Texas from the Louisiana border to Lower Rio Grande Valley. The flow along this route would be 7.5 km. Thus annual transfers visualised will be of the order of 21 BCM/yr from lower Mississippi and Eastern Texas to Rio Grande valley, West Texas and New Mexico out of which 16 BCM/yr would be IBWT. The capital cost was estimated in 1985 as US$ 53.5 billion.

Figure 4.40. Texas Water Plan

3. High Plains Transfer

The large scale High Plains Transfer plan is an outcome of a study of water shortage problems of the High Plains region located in the states of Colorado, Kansas, New Mexico, Oklahoma, Texas and Nebraska, which presently depend on the groundwater resources of the Ogallala Aquifer (Figure 4.16). Irrigation in the Ogallala Aquifer - High Plains region has expanded rapidly over the past several decades and reached 6.5 million ha in 1981 - 1982, which were 28% of the national total. The area has a potential of 14 to 16 million ha. The present consumptive use of about 26 BCM/yr is far in excess of the natural recharge and there were fears of some areas reverting to dry land farming due to pressure to other sectors on available water supplies. A number of proposals for water transfers from the Missouri and other downstream tributaries of the Mississippi were studied and alternatives taken up for detailed
investigation. The maximum transfers were worked out for each proposal.

Figure 4.41. High Plains Transfer alternatives

The plan proposed 4 routes for ultimate firming up after investigation. The transfer envisaged was of 13.5 BCM/yr through concrete lined canals with maximum carrying capacity of 283 m$^3$/s. The construction time for any of the alternatives was 10 to 20 years and estimated cost was US$ 3.6 billion.

4.2.3 Chile

Chile is one of South America’s most stable and prosperous nations. Chile is located west of the chain of Andes Mountains in the Southern American Continent and is bordered by Argentina, Bolivia and Peru, and by the Pacific Ocean. It is elongated in shape, about 4,263 km in length North to South and only about 160 km in width and is positioned in both the western and southern hemispheres. It experiences high rainfall and drains its territory through a lot of short, steep rivers running down to Pacific Ocean.

The total geographical area of Chile is about 76 Mha with an estimated population of about 17 million (UN, 2007), out of which about 13% is engaged in agricultural activities. The climate of coastal northern Chile ranges from semi-arid to hyper-arid. The Atacama Desert in far northern Chile
is one of the driest places on Earth. Due to water scarcity problems and disparity in availability of water resources in various regions of Chile, IBWT schemes have been implemented.

Existing schemes

*Laja- Diguillin IBWT scheme*

The Laja Diguillin Irrigation scheme is located in southern Chile. The scheme had initiated in 1958, with a signing of an agreement between the Directorate of Irrigation and ENDESA, a power company to govern the regulation and use of water from Laguna de La Laja. However, constraints to the scheme moving forward to realization were mainly came from the recreational and environmental interests along with the forestry stakeholders that wanted to incorporate most of the scheme benefits/lands into their use and made the implementation of the scheme nearly to an impossible one.

Chile witnessed rapid growth of the economy during the 1980s and 1990s. However, much of the agricultural areas of the Southern Chile including the Sectors of Yungay, Pemuco, El Carmen, Larqui, San Ignacio, and Bulness, were not able to share the growing prosperity, especially due to lack of water resources availability. The federal government decided that it was essential to provide water supply during the dry season, so as to use irrigation water by the landowners along the proposed main canal alignment, who were otherwise growing only rainfed crops.

The need for implementation of Laja Diguillin Irrigation scheme once again planned. The timely actions taken by the Government in addressing the constraints and demands raised by the stakeholders effectively made the realization of the scheme during the decade of the 1990s (Priest and Dunner, 2001).

Laja Diguillin Irrigation scheme stretches across nearly 100 km of stream-dissected terrain to the south of the City of Chillan. Transmission canal of the scheme was designed to convey 40 m$^3$/s of diverted river flow from the Laja River, across six intermediate streams, into a pool created by a rubber dam. From this pool at the town of Bulnes the water is further diverted along with the flow of Diguillin River, into a system of large primary irrigation canals for providing irrigation facilities to the nearby areas.

*Teno-Chimbarongo Canal*

The Teno River, which belongs to Mataquito River basin while the Estero Chimbarongo River to Rapel River basin. The rivers are draining through the central zone of Chile. Mediterranean climate predominates in the region. Agriculture is the base of the economic activities.

The 13.66 km length Teno-Chimbarongo Canal is constructed in 1975 to join the two natural rivers, the Teno and the Estero Chimbarongo and making use of the hydroelectric plant of Rapel
Hydroelectric scheme on Rapel River Basin, which was built in 1968 with a power generation capacity of 350 MW (Figure 4.38). The canal diverts (65 m$^3$/s), the surplus flow available in the Teno River to the Chimbarongo. In the recipient Rapel basin, out of the 65 m$^3$/s water received through transfer, 25 m$^3$/s is used for power generation at the Rapel Hydroelectric Scheme, with a total discharging capacity of 696 MCM. The remaining 40 m$^3$/s of water is used for meeting the irrigation demands in the command areas of Convento Viejo Dam on Rapel River before the Rapel concrete arch gravity dam. The construction of the Convento Viejo Dam even though started in 1970, the first stage was completed only in 1993 due to stoppages of constructions in 1975 and the intervening period from 1979-1993 (Rodrigo, 2001).

The main canal of the scheme has a trapezoidal section with a constant depth of 4.5 m and varying base width of 8.25 m upto the initial 2 km reach and thereon to 10.25 m. The side slope (H:V) of the canal 2:1 varies after its initial 2 km length to 1.5:1 till to its out falling point. The intake of the canal is at 470 m upstream of Teno Bridge on the river Teno, which allows a maximum discharge of 65 m$^3$/s. The Convento Viejo Dam completed with a live storage capacity of 27 million cubic metres in 1993 consists of an earth wall of 16.5 height and 450,000 m$^3$ of embankment, with 500 m length. It has a spillway of maximum capacity 1,160 m$^3$/s, and has manually controlled by five tank gates.

The planning of the Teno-Chimbarongo Canal even though started by the Department of Civil Engineering of the National Electricity Company (ENDESA) in 1960, the full development of the system could be made possible only in 1993, due to stoppage of construction works in between. To
regulate the operation of the canal and coordinate the different parties involved, an agreement was signed and the scheme stands as an example for an important developmental structure for providing irrigation and hydroelectricity in the central zone of Chile.

Reforms made in water sector

Chile began reforming the provision of water and sanitation services in the late 1980s. It first commercialised - then, in the 1990s, privatized most of the urban service provision. Accordingly, during the 1980s and 1990s the Chilean water and sanitation sector underwent deep reforms so that private capital could finance the huge investments needed to achieve universal service. The regulatory framework put into place cleared the way for massive private equity. Users also joined in the movements and paid the price of transforming the heavily subsidized sector into a self-sustaining industry able to provide universal coverage.

The coverage and quality of services improved sharply because of the success of the government to build a social consensus around the need for the reforms. The new prices gave the privatized water and sanitation companies the right incentives to invest in new infrastructure. Average annual capital spending increased from 37 billion Chilean pesos (US$ 30 million) in 1974 - 88 to 100 billion (US$ 150 million) in 1989 - 2002 (Gabriel Bitrán and Pamela Arellano, 2005).

Before reform, tariffs were well below cost. After reform, despite substantial efficiency gains, concerns remained about the affordability of water and sanitation services. To guarantee adequate and affordable services for low income households, Chile introduced individual means-tested water consumption subsidies in the 1990s.

The subsidy program, introduced in the early 1990s, relies on the water companies to deliver the service. The government reimburses them for the subsidies on the basis of the actual amount of water consumed by each beneficiary. By law, the subsidy can cover 25–85% of a household’s water and sewerage bill for up to 20 m³/month (though the limit now used is 15 m³/month), with the client paying the rest. All consumption above the limit is charged at the full tariff. Each year the Ministry of Planning (Mid plan) determines, for each region, how many subsidies are to be granted and how they are to be applied, following several general principles: The subsidy is based on the willingness to pay for water services among low-income households. Only households that would be unable to purchase what is considered to be a subsistence level of consumption should benefit. And the subsidy should cover only the shortfall between actual charges and willingness to pay. As a crude proxy for willingness to pay, Mid plan uses the benchmark set by the Pan-American Health Organization - that no household should pay more than 5% of its monthly income in water and sewerage charges.

The subsidy scheme is funded entirely from the central government’s budget. Using household survey information for each region and each company’s published tariffs, mid plan determines how many households need a subsidy and how large benefits need to be there to meet the benchmark for
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To obtain a subsidy, a household must apply to its municipality, which determines its eligibility mainly on the basis of a scoring system. Another important criterion is that households must not have payment arrears with the service provider. The municipality must award subsidies in the order of the applicants’ obtained scores. Subsidies are normally renewed yearly for up to three years before a household reapply. But if a municipality has distributed all the subsidies assigned to it and a new applicant has a lower score than the last beneficiary, the municipality must withdraw the benefit from the last beneficiary list and assign it to the more deserving applicant (Andrés Gómez-Lobo).

Advantageous of introducing reforms in water sector:

• the water and sewerage sector, which were running with a financial deficit of about 2% of assets reported surpluses after introducing reforms;
• in 1998 companies reported a surplus close to 4% of assets and net profits of US$ 107 million, more than three times the cost of the subsidy scheme (excluding administrative costs);
• in Chile, water has been considered as a key ingredient in fueling exports and economic growth.

The review on adopted Integrated Water Resources Management (IWRM) practice in Chile underlines the following three messages:

• water resources planning needs to be strongly linked to a country’s national sustainable development strategies and carried out particularly, through a strong system of institutions, laws and rules that are closely related to the National Development Strategies;
• water reform should involve a gradual, step-by-step approach tailored to a country’s current stage of development and to its economic, social and political conditions;
• water strategies need to be adaptable, to allow decision makers to act on opportunities and identify and correct problems based on changing needs (Global Water Partnership, 2004).

4.2.4 Brazil

Brazil is the largest country in the South American Continent and covering almost 50% of South America, Brazil is bordered by Argentina, Paraguay, Uruguay, Bolivia, Peru, Colombia, Venezuela, Guyana, Suriname, French Guiana and the Atlantic Ocean. The total geographical area of Brazil is about 852 Mha with an estimated population of about 187 million, out of which about 17% is engaged in agricultural activities (UN, 2007).

The country has a vast hydrographic network having many notable rivers. Among the large
national rivers, only Amazon and Paraguay are pre-dominantly plane rivers and largely used for navigation. The San Francisco and Parana are the main plateau rivers. It is estimated that about 200,000 to 258,000 m³/s of water flows in the rivers representing about 18% of the world total (Country Profile, Brazil, ICID website).

Brazil’s weather varies widely from North to South. In the far South, conditions are subtropical, with frequent frosts in fall and winter. The northeastern area is the hottest region in the country, faces with water scarcity problems. Since from 1847 onwards, a proposal was initiated for the water transfer schemes from Rio San Francisco River of the central and north regions. Rio San Francisco River drains through the northeast region. There is no existing IBWT Scheme in Brazil.

Proposed scheme

*Rio Sao Francisco Trans-basin Transfer Scheme*

There is one proposed scheme, called the Rio Sao Francisco Trans-basin Transfer Scheme. The Sao Francisco River rises in the state of Minas Gerais in the Serra da Conastra in Brazil at an elevation of approx. 1,600 m+MSL and flows through 2,700 km North and East. The river system is considered to be the key to the future economic development of the semi-arid areas of North-Easteren Brazil. The flows of this river provide hydropower to fuel the industry, irrigation water for growing fruit and vegetable production and transportation for the goods and services. Non-riparian semi arid states of the northeastern region have long coveted the waters of this river system as these states have suffered periodically long and severe droughts that have decimated the economy, caused innumerable deaths and persistent immigration of rural people to urban areas. Proposals for major trans-basin transfers to the North and the East of the river basin have been put forth since 1847. The dream for supplementing the flows through transbasin transfer scheme from Rio Sao Francisco Transfer Scheme has been thus prepared to fulfil the aspirations of inhabitants.

The proposed scheme will have two major points for transfer. The first transfer will divert an average flow (99 m³/s) from Sao Francisco River just below the existing Sobardinho Dam at a point known as Cabrobo through the use of a series of 3 major pumping stations, 15 regulatory reservoirs, 229 km of canals, 23 km of tunnels and 3 km of aqueducts. The second transfer will be from the existing Itaparica Dam and reservoir located further downstream on the river and will divert 28 m³/s into a system of canals, pipelines and reservoirs. This system will include 6 pumping stations, 297 km of canals, 84 km of pipelines, 9.2 km of tunnels and 2.5 km of aqueducts. The scheme will also involve en-route construction of 2 hydropower plants with a total capacity of 52 MW. The total average transfer proposed from the two major points is in the order of 127 m³/s (4 BCM/yr). It is anticipated that the proposed scheme would divert appropriately 1.5 BCM/yr at the final stages of its accomplishment, after taking into account of the multi-faced utilities of water
towards hydropower generation and irrigation along with water supply for municipal and industrial purposes and environmental and ecosystem maintenance requirement of about 2.5 BCM/yr.

It has been estimated that the scheme with a cost of about one billion US$ at 1968 price tag will take at least 5 to 10 years for completion due to the complexity of the scheme components involved. This endeavour thus will require a great deal of diplomacy, political and technical skills to be incorporated and placed in position in an efficient and sustainable manner for the benefit of the citizens of the northeastern Brazil (Simpson, 2001).

4.2.5 Bolivia

Bolivia is located in South American Continent east of Chile and Andes mountain chain and drains its land through several large tributaries like Beni, Mamore into the mighty Amazon River to its North. The other small streams drain into the rivers like Paraguay and Pilcumayo, Titicaca Lake and swamps of the region. The total geographical area of Bolivia is 110 Mha with an estimated population of 9.5 million (UN, 2007).

The Cochabamba positioned in the center of the country is located in a valley experiences arid to semi arid climate. The area suffers from water shortages for several decades reducing the living standard and worsening the health conditions of the people. However, agricultural activities predominate all the time for their survival and income generation. A canal system to use the water in Cochabamba valley had been developed by the Incas, the original inhabitants of the area, long back. With the increase in population, the water supply demands for irrigation and other purposes have started increasing. Implementation of an IBWT scheme for transferring the water from the surplus areas of Misicuni to the Cochabamba regions of the central zone of the country was a dream for the populace.

**Proposed scheme**

*Misicuni Multipurpose Scheme*

In September 1999, a 40-year concession was awarded to provide water services in Cochabamba, by considering the importance of Private Sector Participation (PSP). During the period, PSP was expanding rapidly throughout the world in urban water supply. There is now a wide variety of experience around the world in the form that PSP is taking. The most common arrangement is the French-style franchise contract (lease or concession), under which the state relinquishes management control to the private sector, while retaining ownership of the assets. It has been strongly promoted by
international financial institutions as a means to improve the dismal performance of state-owned water utilities, as measured in terms of efficiency, effectiveness and equity.

The PSP has also been welcomed by national governments of Bolivia keen to access the finance needed to expand the water networks to meet the new demands for water supply to the rapid peri-urban population of Cochabamba. The concession included operation of the existing water supply system and construction of the Misicuni Multipurpose Scheme, a scheme involving the use of the water resources of the River Misicuni for hydropower, irrigation and water supply to the city. Yet within five months, the population rioted against water tariff increases and the contract was cancelled (Calderon, 1995, Lobina, 2000 and Nickson and Vargas 2002).

The Cochabamba’s Municipal Water Company (SEMAPA) provided water services in Cochabamba since 1967. By 1997 its poor performance was typical of that of many water utilities in Latin America. In addition, SEMAPA had for long experienced serious problems of water availability, with an estimated demand of 39%. There was a permanent situation of water rationing because of the shortage of water resources. The problem was so acute that many consumers with connection to the network had sunk their own wells and constructed their own water storage tanks. This growing reliance on groundwater to offset the shortage of surface water led to environmental health problems because of the contamination of aquifers.

A solution to the serious water problems facing Cochabamba had been a vociferous demand of its citizens for many years. One of the solutions proposed to increase water availability in the Long-term was the construction of the Misicuni Multipurpose scheme (MMP) (Figure 4.39). This local initiative was first conceived in the 1960s, since when many technical design studies had been made.

Figure 4.43. Misicuni Multipurpose Scheme

The Empresa Misicuni was established in 1987 as a public sector corporation in order to
4. Country wise experiences

implement the MMP. The departmental government of Cochabamba, the Municipality of Cochabamba, SEMAPA and the central government jointly owned the scheme. The objective of the MMP is to divert the waters from the Misicuni River to supply the Central Cochabamba Valley with potable water, irrigation water and electric power generation. This scheme comprises the transfer of the Titiri and Serkheta Rivers and the main tunnel connecting the transfer tunnel to the reservoir intake structure, as part of the first stage of the scheme.

The MMP comprised the multiple uses of water resources from the basin of the Misicuni, Viscachas and Putucuni rivers. It involved building a 120 m high dam, a reservoir to regulate the 6.6 m³/s flows of raw water, a 19.4 km tunnel and a hydropower plant. The scheme was expected to generate benefits in the form of drinking water to five municipalities in the Cochabamba valley, raw water for the irrigation of 10,000 ha and 120 MW in new hydropower generation capacity. With a yield of 3.9 m³/s, the discharged water will enter a stilling pond that is subsequently be diverted to the potable water conduit to supply the population with 2.5 m³/s in the Central Valley. Completion of the scheme is expected by 2007.

4.3 Europe

Europe is separated from Asia by the Ural and Ural River in the East and is bound to the North by Arctic Ocean, to the West by the Atlantic Ocean, to the South by Mediterranean Sea, to the Southeast by the Caspian Sea and the Black Sea and the waterways connecting the Black Sea to the Mediterranean. The Mediterranean Sea and the Strait of Gibraltar separate it from Africa.

The climate of Europe varies from subtropical to polar. Most of the European countries belong to the developed countries. Most of its main cities have populations exceeding two million inhabitants. Alongwith industrialization Europe evolved directives for development and management of water for agriculture, forestry, fishing and transportation networks to attaining its sustainable growth. The transportation system in Europe is highly developed with interconnecting rivers and canals, which provides inland waterways in Central and Western Europe.

On the Continental scale, Europe appears to have relatively large water resources. However, these resources are unevenly distributed, both between and within countries. Once population density is taken into account, there is quite an inequitable distribution of water resources per inhabitant. Moreover, about 20 European countries are dependent for more than 10% of their supply on river waters from neighboring states. Most of the water used for all purposes in Europe is abstracted from
surface water sources. Groundwater comprises most of the remainder, with only a minor contribution from desalination of seawater, mainly in Italy, Malta and Spain.

Even though the water resources are unevenly distributed between and within countries, many parts of Europe are currently well-provided with freshwater. However, pressure is mounting up in various river basins as a result of population growth and associated human interventions, which intern affect the quality and quantity of water resources leading to ecosystem degradation. Climate change may also play a role, especially in coastal areas where flooding may disrupt sanitation infrastructure and contamination of watercourses. In recent decades, several legal instruments have been prepared and adopted at different levels. However, civil society has been criticizing the human interventions carried out in water sectors and subsequent privatization of water resources and resistance to such actions is growing.

The European Water Framework Directive (WFD) was adopted in December 2000. It gives an important impetus to management practices and policies in Europe for the next 15 years. The WFD introduces several principles that require European countries to prevent further degradation of their water resources. The objectives are to be achieved by 2015. According to this, the water management will have to be supported by an extensive process of review and the analysis and will rely to a large extent on economic and environmental analyses. All costs that are associated with any water service will have to be accounted for and to prove that they have a good cost effectiveness ratio. The new European WFD gives great emphasis on public participation too (WWDR2, 2006). It requires that all stakeholders and public at large be kept informed about all significant issues related to the river basins of Europe. The main river basins in Europe are shown in Figure 4.40.

The main features of the river/lake basins of Europe are shown in Table 4.5. From that it can be seen that some of the river/lake basins of Europe are shared by as many as 19 countries. Some countries are highly dependent on transboundary flows, and thus water originating from outside of the country is essential to meet the needs of the population inside. These countries are therefore especially vulnerable to the effects of extraction, impoundment and pollution by countries upstream. The pressures exerted by increasing demand for water lead to over-exploitation of local reserves in many regions.

Flooding is the most common natural hazard in Europe. The Centre of Research on Epidemiology of Disasters (CRED) recorded 188 flood events for the period 1980 to 2000. The map of disaster frequency shows that floods are widespread and affect nearly all the countries of Europe causing more than 1,500 casualties. With 439 casualties, and over 1.8 million people exposed, Turkey is the most vulnerable country and the other extreme case is Germany (NEP-DEWA-GRID). For addressing the ground realities structural measures such as dams and inter connecting water conveying systems have been implemented. They have proven efficient in absorbing surplus rainfall, reducing the flood hazards and severity of water scarcity even though they have adversely affected the ecosystems in certain areas. IBWTs that fit in the criteria have been implemented or are proposed in the following
4. Country wise experiences

countries of Europe: Russia, Romania, Slovakia, Turkey, France, Spain, Germany, Finland, Portugal, Czech Republic, and Great Britain. These will be described in the next subsections along with detailing in Annex 2.
Figure 4.44. Main river/lake basins in Europe (World Conservation Union et al., 2006)
4. Country wise experiences

Table 4.5. Details of various river basins/lakes of the Europe Region

<table>
<thead>
<tr>
<th>No</th>
<th>Name of river basin/lake</th>
<th>River basin/lake area (km²)</th>
<th>Crop land (%)</th>
<th>Wet land (%)</th>
<th>Dry land (%)</th>
<th>Irrigated cropland (%)</th>
<th>Average population density (people/km²)</th>
<th>Water supply/person/yr (m³)</th>
<th>Degree of river fragmentation</th>
<th>Number of dams on main stem of river (height in m)</th>
<th>Countries within the basin/lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Dalaven</td>
<td>30,410</td>
<td>2.3</td>
<td>19.1</td>
<td>0.0</td>
<td>0.0</td>
<td>10</td>
<td>18,476</td>
<td>High</td>
<td>11</td>
<td>Norway</td>
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<tr>
<td>22</td>
<td>Danube</td>
<td>795,656</td>
<td>66.9</td>
<td>1.4</td>
<td>13.7</td>
<td>5.2</td>
<td>102</td>
<td>2,519</td>
<td>High</td>
<td>196</td>
<td>Albania, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, Macedonia, Moldova, Poland, Romania, Serbia, Montenegro, Slovak Republic, Slovenia, Switzerland, Ukraine.</td>
</tr>
<tr>
<td>23</td>
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<td>84.8</td>
<td>3.4</td>
<td>0.0</td>
<td>0.2</td>
<td>28</td>
<td>6,626</td>
<td>High</td>
<td>-</td>
<td>Belarus, Latvia, Russia, Lithuania</td>
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<tr>
<td>24</td>
<td>Dnieper (Nistu)</td>
<td>68.627</td>
<td>82.8</td>
<td>1.1</td>
<td>47.5</td>
<td>3.8</td>
<td>107</td>
<td>1,621</td>
<td>-</td>
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<td>Azerbaijan, Iran, Georgia, Armenia, Turkey</td>
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121
<table>
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<tr>
<th></th>
<th>Lake/River</th>
<th>Area</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Max #</th>
<th>Min #</th>
<th>Discharge</th>
<th>Medium</th>
<th>Length</th>
<th>Volume</th>
<th>Pavilion</th>
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<td>48,450</td>
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<td>-</td>
<td>-</td>
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<td>217</td>
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<td>12</td>
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<tr>
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<td>Tigris and Euphrates</td>
<td>765,742</td>
<td>25.4</td>
<td>2.9</td>
<td>99.2</td>
<td>9.1</td>
<td>57</td>
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<td>-</td>
<td>31</td>
<td>3</td>
<td>14</td>
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<td>Ural</td>
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<td>100</td>
<td>0.9</td>
<td>15</td>
<td>2,003</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Vistula</td>
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<td>3.2</td>
<td>14.3</td>
<td>0.2</td>
<td>137</td>
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<td>0</td>
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<td>55.8</td>
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<td>43</td>
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<td>15</td>
<td>-</td>
<td>8</td>
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<td>Weser</td>
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<td>1.7</td>
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<td>1,567</td>
<td>High</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

2. FAO, Irrigation in Africa in figure: AQUASTAT Survey 2005
3. International River Basins Register (August 2002)
4. Country wise experiences

4.3.1 Russia

The Russian Federation occupies in most of the Eastern Europe and North Asia, stretching from the Baltic Sea in the West to the Pacific Ocean in the East, and from the Arctic Ocean in the North to the Black Sea and the Caucasus in the South. It is bordered by Norway and Finland in the Northwest; Estonia, Latvia, Belarus, Ukraine, Poland, and Lithuania in the West; Georgia and Azerbaijan in the Southwest; and Kazakhstan, Mongolia, China, and North Korea along the southern border. Russia has an area of 1708 Mha with an estimated population of 143.2 million (UN, 2007), of which 27.4% is engaged in agricultural activities.

The erstwhile Soviet Union had enormous water resources of about 4,700 BCM/yr, which exceed the total present water consumption by 15-18 times. However the spatial distribution was highly skewed. About 84% of the country’s water resources were concentrated in Siberia and the northern regions of the European part of USSR, while its southern region, the Central Asia and Kazakhstan, had only 16% of the water resources. In the southern region of the European Continent, the available water resources had already been fully developed through large irrigation systems. In order to address the water scarcities mainly due to inequalities in distribution patterns, IBWTs have been adopted since from 14th century.

Existing schemes

Flow re-distribution among various basins on the territory of former USSR has been reformed from ancient time.

Iski-Tyuya Tartar Canal

In the 14th century the Iski-Tyuya Tartar canal has been built transferring water from full Zerafshan to shallow Sanzar River Basin over a distance of 80 km with a discharge of 12 m³/s (0.38 BCM/yr)

Volga upstream through Ladozhskoye and Ilmen lakes

In the first half of the 18th century, a water system has been built connecting Volga upstream through Ladozhskoye and Ilmen lakes with Neva Basin for navigation.

Dnepr-Bug Canal
In the end of the 18th and middle of the 19th centuries, the rivers Berezina and Western Dvina, Neman and Pripyat, Dnepr and Vistula were connected through 204 km Dnepr-Bug canal. Dnieper-Bug Canal also known as Dnepr-Bug Canal, or Dneprovsko-Bugsky Canal is a ship canal that connects Dnieper river and Western Bug river. It provides navigational access between the Baltic Sea and Black Sea water systems. It was built in 1775. Additional work was carried out in 1837 and completed around 1846-1848. More recently efforts have been undertaken to restore the Canal to a class IV inland waterway of international importance. In 2003 the Government of the Republic of Belarus adopted the inland water transport and sea transport development programme to rebuild of Dnieper-Bug canal shipping locks to meet the standards of a class Va European waterway. According to the Belarusian government, four sluice dams and one shipping lock have been rebuilt which allowing the passage of vessels of 110 m long, 12 m wide with a draught of 2.2 m. It is expected that reconstruction will continue over the next few years (www.britannia.com).

**Moscow-Volga Canal**

Moscow-Volga Canal is a canal that connects the Moskva River with the main transportation artery of European Russia - the Volga (Figure 4.41). It is located in the Moscow and Tver Oblasts, north of Moscow. The Moscow Canal, constructed by gulag prisoners during Stalin’s term in office, begins in the Ivankovskoye Reservoir near the town of Dubna and connects with the Moskva River at the 191st km from its estuary in Tushino. The length of the canal is 128 km. Through the Moscow Canal, Moscow has access to five seas, including the White Sea, Baltic Sea, Caspian Sea, Sea of Azov, and Black Sea and hence Moscow is sometimes called the ‘port of the five seas’. Apart from transportation, the canal also provides water for about half of the Moscow’s water consumption needs, and along the shores numerous reservoirs are developed for recreational purposes.

Several large canals, which redistribute water between neighbouring basins, were also built during the last few decades of the 20th century. These along with the Moscow-Volga include Karakum, Karshinsky, Irdish-Karanganda and Nevinnomissky canals. The Kara Kum Canal carries water from the Amu Darya at Kelif westward across the Caspian Kara Kum or Garagum desert to Mary and ultimately to Ashgabat, covering a distance of about 800 km. The canal water permits irrigated agriculture (mainly cotton) and industry along the southern margin of the desert. The total volume of water transfers from these schemes has been estimated to be of the order of 60 BCM/yr.
4. Country wise experiences

![Map of Moscow-Volga Canal](image)

**Figure 4.45. Moscow-Volga Canal**

**Karshinsky**

Karshinsky

**Irdish-Karanganda**

From Irdish to Karanganda

**Nevinnomissky**

Nevinnomissky

**Proposed scheme**

*IBWT of Northern Rivers to Volga Basin*

The Northern Rivers to Volga Basin WT proposal that was under active consideration and shelved some time back is again getting activated (Figure 4.42). It aims at transfer of northerly rivers and lakes to the Volga Basin. The purpose of the water transfer to Volga basin is to cater the growing demands for water and stabilize the current hydrological regime of the aquatic systems.

The scheme envisages transfer of about 20 BCM/yr in three stages. In the first stage, it is proposed to transfer 5.8 BCM/yr from the Onega River and upper Sukhona River. The 2<sup>nd</sup> stage a transfer of 3.5 BCM/yr is proposed and would be from Lake Onega. The third stage visualizes transfer of about 10 BCM/yr from the Pechora River to the Kame River, a tributary of the Volga through a 600 m<sup>3</sup>/s capacity canal.
The first stage transfer will be accomplished from two sources. The first source would be the lakes Lacha and Vozha from where 1.8 BCM/yr would be abstracted. The water will flow by gravity along Vandoga and Uhtomitsa Rivers to Lake Kubenskoye and then through the Kubenskoye-Sheksninsky canal to a storage reservoir on Sheksna River located in Volga basin. The second source of water 4.0 BCM/yr will be the River Sukhona, a tributary of North Dvina River. The power needed for lifting the water would be available from hydropower stations along the interconnected rivers.

Under the second stage, water will be transferred from Lake Onega to Rybinsk reservoir through existing Volga-Baltic Canal and Sheksna Reservoir. The lift involved is of the order of 80 m.

4.3.2 Romania

Romania is a country in South-eastern Europe. Romania borders Hungary and Serbia to the West, Ukraine and Moldova to the Northeast, and Bulgaria to the South. Romania has a stretch of sea coast along the Black Sea, and the eastern and southern Carpathian Mountains run through its center. The geographical area of Romania is 24 Mha with an estimated population of 21.4 million (UN, 2007), of which 46.7% is engaged in agricultural activities.

In relation to population, Romania’s water supplies are quite modest. They are provided by the
4. Country wise experiences

rivers, which meet 89% of the present demand (48% from the Danube and 41% from the interior rivers), and by the underground sources, which account for 11%. The country’s climate is continental, with hot, dry summers and cold winters. Severe droughts are common during the summer. The crises aggravate, because Romania’s water resources are relatively unevenly distributed in time and space. Huge infrastructure investments were therefore made to distribute the water resources availability some what uniformly and to improve flood protection and water scarcity.

Existing schemes

*Ialomita-Mostistea (Dridu-Hagiesti Div.)*

Ialomita-Mostistea (Dridu-Hagiesti Div.) from Ialomita River basin to Danube River basin 5.0 BCM/yr for irrigation. Ready in 1985.

*Danube-Black Sea Canal*


*Ialomita – Baragan Transfer*

Ialomita – Baragan Transfer from Ialomita River basin to Arges River basin 1.5 BCM/yr for Flow augmentation. Ready in 1936.

*Ialomita-Ilfov Transfer*

Ialomita-Ilfov Transfer from Ialomita River basin to Arges River basin 2.5 BCM/yr for Flow augmentation n. Ready in 1976

*Cerna-Motru Transfer*


*Cocani-Darza Transfer*

Cocani-Darza Transfer from Arges River basin to Ialomita River basin 5.0 BCM/yr for Flow

**Barcau-Varsolt Transfer**

Barcau-Varsolt Transfer from Crisuri River basin to Somes River basin 0.4 BCM/yr for municipal, industrial. Ready in 1994.

**Topolog-Cumpana Transfer**

Topolog-Cumpana Transfer from Olt River basin to Arges River basin 8.0 BCM/yr for flow augmentation. Ready in 1997.

**Prut-Barlad Transfer**

Prut-Barlad Transfer from Prut River basin to Siret River basin 1.6 BCM/yr for flow augmentation. Ready in 1998.

**Rhine-Main-Danube Canal**

The Danube River Basin (DRB) covers a vast area of 801,463 km², making it the second largest river basin in Europe, after the Volga. More than 80% of the river Danube is regulated during the last 50 years for meeting the needs of developmental activities. Regulation works for navigation in the Upper Danube region started as early as the nineteenth century. Rhine-Main-Danube Canal connects the Main and Danube from Bamberg by Nuremberg to Regensburg. Regensburg is situated on the northernmost point of the Danube River. The river Danube at an excess of 2,800 km, is the longest river in Europe. The Rhine-Main-Danube Canal forms a constantly navigable connection from the Rhine delta in Rotterdam to the Danube Delta in the Black Sea (Figure 4.43).

The development of the river Main reached Bamberg in 1962. The Main-Danube-Canal was completed in 1992. The monumental Rhine-Main-Danube Canal, fully functional since 1992-93, opens up direct access to the large ports of the North Sea coast, as well as even more extensive prospects. According to decisions of the Conference of European Ministers of Transport the connection of Rhine-Main-Danube is considered to be one of the five most important waterway schemes in Europe and permits the passage of a large motor cargo vessel with dimensions of up to 110 m length and 11.4 m beam and a draught of 2.50 m and a cargo capacity of 1,800 tons as well as a twin-barge pusher-tug assembly of up to 3,300 tons cargo capacity.

Despite the crisis in former Yugoslavia and the related partial polarization of ship traffic, the forecast transport volume was exceeded by far in the very first year of operation. Approximately 4.7
4. Country wise experiences

Million tonnes of goods were moved in an environmental friendly manner (Romania Economic Newsletter, 2003).

Figure 4.47. Rhine-Main-Danube Canal

This waterway has an extension of 3,500 km and is divided into four sections:

- 539 km Rhine section from Rotterdam to the mouth of the river Main at Mainz;
- 384 km stretch of the river Main from Mainz to Bamberg;
- 171 km stretch of the canal between Bamberg and Kelheim;
- 2,411 km section of the Danube from Kelheim to the mouth of the Danube into the Black Sea

On a long-term basis, this shipping route between the North Sea, the Rhine ports and the Black Sea could experience an enormous boom. For instance, Bayerische Lloyd (Regensburg) has already set up a new, closely-knit network with southeastern European partners. Both ports of the region - Regensburg and of Kelheim, are situated along the international waterway defined by the Danube and Rhine-Main-Danube Canal. Moreover, Danube is the basin that covers the greatest number of countries in the world, with a total of 19 states (website ICPDR).

Environmental Impacts Experienced and Control Measures Adopted in Danube

The route between the Rhine, Main and Danube has always been important for European trade. In order to make the river Danube navigable, the meanders were cut off in several places, the main channel was straightened and lateral dams were built to narrow the river’s width. Consequently, in
some parts of the river, the length of the watercourse was shortened considerably. Additional artificial waterways were also built along the Danube River for transport purposes. The hydraulic works for navigation improvement have had a major impact on natural floodplains and their ecosystems. In many places along the river, the floodplains and meanders were cut off from the river system. As a result, 80% of the historical floodplain on the large River Basin of Danube has been lost during the last 150 years. Large dikes and disconnected meanders also suppressed the exchange of surface and groundwater, which reduced the recharge of groundwater utilized for the drinking supply.

The Danube Delta, where the river Danube flows into the Black Sea, is representing a unique ecological system in Europe. Because of its high biodiversity, the whole zone has been declared as a protected area as well as World Natural Heritage Site (Danube-WWRD2, 2006) and adequate monitoring and managerial measures have been activated for maintaining the sustainability of the Danube ecosystem. Details of existing schemes in Romanian region are shown at Annex 2.

**Proposed scheme**

*Siret-Baragan Canal*

The Siret-Baragan Canal is under construction on the eastern part of Romania and is aimed at water supply for irrigation and for increasing Ialomita River flows. Once it is completed, it will capable of diverting 5 BCM/yr. The Siret-Baragan Canal, which will require some 88 million Euro, is mainly aimed at ensuring water for irrigation (Economic Newsletter, 2003).

4.3.3 **Slovakia**

The Slovak Republic was established as a new independent state on 1January 1993. Slovakia is a land-locked country in Eastern Europe and is bordered by the Czech Republic in the West, Austria in the SouthWest, Hungary in the South, Ukraine in the East, and Poland in the North. Slovakia has an area of 5 Mha with an estimated population of 5.4 million, of which 53.7% is engaged in agricultural activities (UN, 2007).

The Slovak Republic is situated on the boundary of the climatic influence of the ocean and Continent, which results in relatively mild summers and winters. Northern part of the territory is mountainous while the southern part is formed with fertile plains. More than 96% of the country area is drained to the Black Sea (via the Danube basin), and 4% into the Baltic Sea (via the Vistula basin). The long-term average annual precipitation is 780 mm (WWF, 2003) and is distributed unevenly with respect to time and space. The population growth of Slovakia and development of economic activities
during the industrial revolution intensified the pressure on the natural environment and exploitation of its natural resources. The original structure of the landscape was gradually interrupted by large melioration interventions, water pollution, inappropriate investments, and the construction of the transport network (Slovak Republic, 1998).

Existing schemes

IBWTs have been practiced in the country since ancient times. A number of schemes were constructed during the last few decades, particularly after the Second World War (Kolar and Soltesz, 1978).

**IBWT from Nitra River to Vah River**

A 7 km long canal with a capacity to carry 350 m$^3$/s (11.03 BCM/yr) was constructed to transfer water from River Nitra, taking off downstream of Nove Zamky, to River Vah. The system provides both irrigation and flood moderation benefits.

**Vazsky Dunaj to Vah River**

Water is transferred by a 9.5 km long canal of 110 m$^3$/s capacity for flood protection as well as for providing irrigation benefits. About 3.46 BCM/yr is transferred through this canal.

**IBWT from Hnilec in Hornad River Basin to Slana River basin**

A scheme to transfer 0.283 BCM/yr of water from Dedinky upon - Hnilec reservoir to Dobsena hydropower station through a 2.8 km long pipeline was executed in the years following Second World War. This scheme is used for generating power and flow regulation in the river Slana.

**IBWT from Vah to Nitra River basin**

The transfer is accomplished by pumping 10 m$^3$/s water in a pressure pipe line from Vah river to Andac, a tributary of Nitra River, to help irrigation in 20,000 ha area and also to improve the quality of water in Nitra particularly during low water stages. Annual water transfer is of the order of 0.31 BCM/yr.

Two dams viz. Sered and Kralova, which have also been constructed to enable transfer of water to irrigate by gravity about 50,000 ha. The quantum of annual water transfer is not readily available.
IBWT from Turiec River to Hron

The first water transfer scheme was put in operation during the 14th century when a 22 km canal, was constructed to carry a discharge of 0.6 m³/s from Turiec River - a tributary of Vah River to Hron River basin (Figure 4.44). That was to supply water to Kremnica mining region. Later, this system was redesigned in 1894, 1916 and 1930 to accommodate it as a multipurpose scheme with hydropower stations, compensating reservoirs and related structures. The canal was designed to carry 12 m³/s, which is still in operation. The total water transfer from the scheme is of the order of 0.38 BCM/yr.

Proposed schemes

Danube River to Southern parts, Vah, Nitra and Hron basins

The southern parts of the river basins of River Vah, Nitra, Hron and Ipel were planned to be supplied with irrigation water transferred from Danube River to lower reaches of these rivers. Besides construction of Nagymaros dam across Danube River in collaboration with Hungary, pumping will also be done to supplement supplies. The proposed area to be irrigated under this transfer scheme is about 50,000 ha (Vaclav Kolar et al., 1978).

Hron River to Zitava River

A part of Zitava River basin is planned to be irrigated by the water transferred from River Hron (taking off from Kozmalovce reservoir) and from a tributary stream of Hron (Slatinka reservoir). This transfer is designed to serve domestic and industrial demands and to control water pollution of the specific regions attached with the river Zitava.
4. Country wise experiences

4.3.4 Turkey

Turkey, with a total area of 78.3 Mha, lies between Europe and Asia and is surrounded by the Black Sea, Bulgaria and Greece in the North, the Aegean Sea in the West, the Mediterranean Sea, Syria and Iraq in the South, Iran in the East and Armenia and Georgia in the Northeast. Straddling the Continents of Europe and Asia, Turkey’s strategic location has given it major influence in the region - and control over the entrance to the Black Sea. The estimated population of Turkey is 74.9 million (UN, 2007).

Turkey, the Middle-East zone is one of the most arid and water scarce region in the world where water-related conflicts exist and rainfall is generally inadequate and unable to support the regular water needs (Hilal Elver and Jim Lee). Turkey’s dynamic economy is a complex mix of modern industry and commerce along with a traditional agriculture sector that still accounts for more than 35% of employment. It has a strong and rapidly growing private sector, yet the state still plays a major role in basic industry, banking, transport, and communication.

Of the total surface runoff of the country, estimated at 192.8 km³/yr, almost one-fourth comes from the Euphrates and the Tigris rivers. Euphrates River, which is in southwest Asia rises in Turkey and flowing through Syria and Iraq before joining the Tigris to form the Shatt al Arab. The Euphrates is 2,700 km and drains an area of 444,000 km². Although less than 30% of the river’s drainage basin is in Turkey, roughly 94% of the river’s water originates in the Turkish highlands. Too shallow for navigation, the Euphrates, along with the Tigris River, provided much of the water that supported the development of ancient Mesopotamian culture (Table 4.6) (Judith Neyer, 2006).

Table 4.6. Water potential of Euphrates and Tigris

<table>
<thead>
<tr>
<th>Countries</th>
<th>Euphrates</th>
<th>Tigris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey</td>
<td>31.58 (88.7%)</td>
<td>25.24 (51.9%)</td>
</tr>
<tr>
<td>Syria</td>
<td>4.00 (11.3%)</td>
<td>0.00 (0.0%)</td>
</tr>
<tr>
<td>Iraq</td>
<td>0.00 (0.0%)</td>
<td>23.43 (48.1%)</td>
</tr>
<tr>
<td>Total</td>
<td>35.58 (100.0%)</td>
<td>48.67 (100.0%)</td>
</tr>
</tbody>
</table>

Euphrates thus contributes about 90% of the total annual flow of Turkey, while the remaining part flows in Syria. Tigris River contributes about 52% directly to Turkey and 48% further downstream in Iraq. In general, the streams vary greatly in their flow from season to season and year to year based on the available rainfall trend. The trend shows great differences from one region to another and the average annual rainfall in the region is 643 mm, ranging from 250 mm in the Southeast to over 3,000 mm in the northeast Black Sea area. Hydrological estimation again shows that Turkey’s average annual surface runoff is about 186 BCM. The amount available for consumption
from this capacity is about 110 BCM including 12 BCM of groundwater. Turkey has also considerable hydropower potential, among the highest in Europe. The feasible hydropower energy potential is estimated at 125,000 GWh/yr (Mithat Rende, 2004).

For addressing the disparity in water availability, need for generation of energy and concerned social and economical issues in related sectors Turkey have initiated plans for IBWT Schemes through its territories. Turkey’s southern neighbors, Syria and Iraq, have objected to the Turkey’s proposal of water transfer and constructions of its interconnected dams/structures and demanded for sharing of Euphrates and Tigris waters through developing mathematical models by considering each riparian states hydrological data and water needs.

The protocol concerning the Euphrates and the Tigris rivers dates back to 1946 when Turkey and Iraq agreed that the rivers’ control and management depended to a large extent on the regulations of flow in Turkish source areas. In Turkey a State Hydraulics Works (DSI) was founded in accordance with a law inserted on 18 December 1953. DSI formed its organization in 1954 is the primary executive study agency responsible for planning, management, development and operation of Turkey’s overall water resources. DSI works under aegis of the Ministry of Energy and Natural Resources (MENR). The DSI is responsible for major tasks, namely, irrigated agriculture enhancement and hydro-electric generation, water supply to a large city and flood prevention measures.

Turkey agreed to begin monitoring the two rivers and to share related data with Iraq. In 1980 Turkey and Iraq established a Joint Technical Committee on Regional Waters of Tigris. After a bilateral agreement in 1982, Syria joined the committee. Turkey has unilaterally guaranteed to allow 15.75 BCM/yr (500 m³/s) of water across the border to Syria, but no formal agreement has been obtained so far on the sharing of the Euphrates water.

By considering the views of Syria and Iraq, Turkey formulated a three staged plan for more rational optimum equitable and reasonable utilization of the transboundary watercourses of Euphrates-Tigris basins. The plan shows the implementation of the proposed plan in three stages:

• **State 1 – Inventory Studies of Water Resources:**
  * exchange of all available data by incorporating views of experts of three countries with respect to evaporation, temperature, rainfall and snowfall (if available) on a monthly basis, which also includes – installation of gauging stations in the basins of Euphrates and Tigris in Turkey, Syria and Iraq;
  * measurement of data, checking of data, evaluation of measurements and exchange of data, calculation of natural flows at various stations after estimating water uses and water losses at sites of concern;

• **Stage 2 – Inventory Studies of Land Resources:**
  * Exchange of information concerning soil classification, drainage criteria, soil conditions for schemes that are planned, under construction and in operation. Study, discussions and
4. Country wise experiences

determinations of cropping pattern according to the soil classifications and drainage conditions for schemes planned, under construction and in operation, and calculation of irrigation and leaching water requirements;

- **Stage 3 – Evaluation of Water and Land Resources:**
  * Discussions and determination of irrigation methods and systems for the proposed scheme so as to minimize the water losses and investigations of modernization and rehabilitation of schemes in operation;
  * Determination of total water consumption of all schemes in each country including municipal and industrial water supply and possible losses from reservoirs and conveyance systems;
  * Development of simulation models to work out water demand and water supply balance and consideration of feasibility of water transfer opportunity from Tigris and Euphrates;
  * Discussion and development of criteria for determining the economic viability of planned schemes.

The three staged plan was introduced at tripartite meeting at ministerial level held in 1990 and bilateral talk with Syria and Iraq in 1993. While submitting the plan, Turkey also opined that the Euphrates and Tigris rivers are to be considered together as a single transboundary ecosystem with the two rivers joined and all existing and future agricultural water uses need to be derived from both Euphrates and Tigris water resources. Necessary means and measures should be determined to attain the most reasonable and optimum utilization of water resources of the two basins. Turkey believes that a global rational and optimum utilization of water resources can be achieved through a scientific study which will determine the true water needs of each riparian country on the basis of the three staged plan framed.

The stakeholders’ takes the move of Turkey as a positive step in the direction for creating a healthy atmosphere which will be conducive to the cooperative use of not only water, but also other natural resources for mutual benefit. During the last three decades Turkey has made great strides in water resources development and management and the corresponding illustrations are given in the following paragraphs.

**Existing scheme**

*Southeast Anatolia scheme (GAP)*

Turkey diverted a significant amount of Euphrates water as part of a long-term plan for the development of rural Anatolia. This scheme, called the Southeast Anatolia Scheme, or Projet de la Grande Anatolie (GAP) for its Turkish acronym, involves the construction of 22 dams, 19 power
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plants and 26.5 km long parallel Sanliurfa tunnels to capitalize on the steep descent of the Euphrates from the Anatolian mountains to Anatolian plains. The scheme envisages irrigation of 1.7 Mha of land and generation of 27 Billion KWh of hydroelectric power with an installed capacity of 7,500 MW. The GAP scheme area lies in southeastern Turkey (Figure 4.45).

![Figure 4.49. Southeast Anatolia scheme (GAP)](image)

The Southeastern Anatolia scheme (GAP) as a whole is one of the largest multi-purpose schemes in the world and the most comprehensive enterprise ever carried out in Turkey. The goal of the huge $32 billion hydropower and irrigation scheme developed is to remove the socio-economic ‘gap’ between the country’s more developed and least developed regions. The least developed Anatolia region corresponds to 10% of Turkey in terms of land and population and covers the eight provinces of Adiyaman, Batman, Diyarbakir, Gaziantep, Mardin, Kilis, Sanliurfa and Sirnak. Agriculture is the primary income for which the populace was depended entirely on rainfall. The Southeast GAP was hence initiated in 1970s based on the need for electric and new irrigation requirements emerged and is planned to be completed in all its respect by 2010 (Sahan et al., 2001).

The centerpiece of GAP is Atatürk Dam, one of the largest dams in the world. It was completed in 1990. The reservoir behind the dam covers an area of 816 km² and requires periodic one-month interruptions in the flow of the river for filling. The Atatürk Dam; named after Mustafa Kemal Atatürk, who was born in Salonica in 1881 and is renowned as the founder of the Republic of Turkey, is the largest hydroelectric plant in Turkey. Mustafa Kemal Atatürk was President of Turkey for 15 years, until his death in 1938. Sweeping cultural and socio-political reforms took place during this tenure. He explained his ideals about the responsibilities of humankind to each other by saying: ‘Humankind is a single body and each nation a part of that body. We must never say ‘what does it matter to me if some part of the world is ailing?’ If there is such an illness, we must concern ourselves with it as though we were having that illness’ (Website: Focus Multimedia).

In the GAP Master Plan, the strategy adopted for the regions development has the followed the four basic components:

- develop and manage soil and water resources for irrigation, industrial and urban uses in an
4. Country wise experiences

- improving land use through optimal cropping patterns and agricultural practices;
- promote agro-industry and other types of industry based on indigenous resources;
- provide better social services, education and employment opportunities to control migration and to attract qualified personnel to the area (Baysan, year not given).

After the completion of the Ataturk dam in 1990, the interconnected power plant and 26.5 km long parallel Sanliurfa tunnels were completed in 1995 and water started to flow from the tunnels since then and irrigation on a large scale began. The completed Ataturk dam and its hydro plants and the Sanliurfa tunnels with a capacity of 328 m³/s (10 BCM/yr) are standing as physical symbols of Turkey’s commitment to development (GEME: Export Promotion Centre, GAP).

Direct and indirect benefits accrued from GAP

Based on surveys and field studies conducted, the regions of the GAP are recommended to investors for taking up agro-based production, animal husbandry, textiles, construction materials, energy, chemicals and plastic industry and other services such as tourism, health and education. Achievements obtained are:

- affected people received a substantial amount of money through land expropriations;
- Turkey had taken care of the earthquakes/seismic problems of Ataturk dam and designed the structures to withstand quakes of up to eight on the Richter scale (Ataturk Dam, Case Studies);
- Syria and Iraq benefited from the GAP infrastructures built by Turkey;
- land values have been appreciated as a result of development;
- increased irrigation made more cultivable cash crop’s production;
- consumption of luxury goods such as cars etc. increased;
- boom in construction of private housing sector;
- increased number of banks and accounts opened;
- new planned industrial zones developed;
- a major six-lane highway built through Turkey, Syria and Iraq regions;
- planned to construct new international airport in Sanliurfa and complete by 2010;
- one of the largest harbours of Turkey, Mersin, is developed;
- developed more infrastructures, namely, for health, education and tourism services.

The scheme thus not only has included active farming with extensive irrigation systems and electricity production but also the tourism, mining, petrol, education, health, communication, industry and transport sectors in an integrated manner.
Ongoing/proposed schemes

Istanbul Yesilcay and Melen Water Supply Schemes

The Yesilcay scheme has been designed to convey water from the Goksu and Canak rivers in the Agva region, 60 km away from Omerli Dam to meet the medium-term water need of Istanbul. At the first stage, 145 MCM of water will be secured annually by the two regulators, which will be constructed on these rivers. The water collected by the Sungurlu and Isakoy regulators on the rivers will then be conveyed to the surge tank via the Osmangazi Pumping Station at Isakoy, the biggest of its kind in Europe, and the 2,560 m pumping main. The water will then be carried by gravity through the pipeline to the Darlik and Komurluk tunnels, and reach the Emirli treatment plant, the construction of which has already been completed. Thus, the demand for drinking water for an additional population of about 1.5 million inhabitants will be met. After construction of the Isakoy and Sungurlu regulators, 190 MCM will be added to the system, and the volume of water supply will reach 335 MCM/yr.

The total investment amount of the Yesilcay system is estimated as US$ 271 million, and a total loan of US$ 145 million has been secured in two parts by Kuwait. The first stage of the system was inaugurated in May 2003.

Figure 4.50 Conveyance Systems of Istanbul Yesilcay and Melen Water Supply Schemes

Figure 4.51 Index Map showing Link Canal Allignment of Istanbul Yesilcay and Melen Water Supply
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Schemes I

**Greater Melen Scheme**

Another planned developed for meeting the municipal water demand of Istanbul in the medium and long-term is known as the Greater Melen scheme. The Greater Melen System, which will supply 268 MCM of water per year at the first stage and 1.18 BCM of water per year at the end of the last stage (4th stage), will meet the water needs of Istanbul until 2040.

![Figure 4.52 A Field View showing lying of pipelines for Greater Melen Scheme](image)

The raw water taken from the Melen River intake structure will be pumped on Cumhuriyet Water Treatment Plant at Omerli by means of a transmission line (185 km). The other components of the transmission line are the Alacali reservoir, the Sile-Alacali and Alacali-Omerli tunnels, which are of a total length of 25 km.

The first stage of the Melen System, which features 25 km of tunnel in the 180 km transmission line, will secure an additional annual 268 MCM volume of water to meet the potable and domestic water needs of an extra 2.75 million people in Istanbul.

The scheme has been divided 12 separate work units including consultancy services. The total cost is US$ 1,180 million, in which the domestic money requirement is US$ 518 million and the foreign money requirement is US$ 662 million. For the realization of the scheme, a loan of US$ 900 million has been secured in two parts from the Japanese Bank for International Cooperation (JBIC).

The water source of the Melen scheme is the Melen River, which is 180 km east of Istanbul. The water treatment plant will be located in the northern part of the existing Omerli reservoir and will treat 720,000 m³ of water per day. The treated water will be conveyed finally to the Kagithane treatment plant service reservoir via the Cumhuriyet-Beykoz tunnel and the pipeline under the Bosphorus.

At the first stage of the Yesilcay and Melen schemes, approximately 235 km of pipeline 2.5 and 3 meters in diameter is being laid. In addition, the largest water treatment plant in Turkey, the largest treated water pumping station of Europe, and the pipeline under the Bosphorus are under construction. When the first stages of the Yesilcay and Melen systems have been completed, the Istanbul
metropolitan area will be supplied with an additional annual water volume of 415 MCM.

Peace Pipeline scheme

The Peace Pipeline scheme was first aired by then Prime Minister Turgut Ozal in 1986. A feasibility study for the scheme was completed in 1988. The scheme envisaged that Turkey would provide whole Arabian Peninsula, excluding Yemen, with water from its Seyhan and Ceyhan Rivers, both empty in Mediterranean in the Adana region, through a pipeline. The Peace Pipeline schemes consists of two separate pipelines namely western and eastern (Gulf) pipelines. It is estimated that the scheme would cost US$ 20 billion and could carry 16 MCM/day.

The western pipeline with a total length of 2,700 km will start in Turkey, continue to Syria and Jordan, probably Palestine, and reach Saudi Arabia. In the first announcement made by Turkey mention was made of a plan to use this pipeline to give water to Israel as well. However, due to negative responses from Arab countries, this plan was never mentioned again. The eastern (Gulf) pipeline is designed to pipe water from Turkey to the Gulf States namely, Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates and Oman, through Syria and Jordan. The eastern pipeline will have a 3,900 km length. The average cost of water was calculated at US$ 0.85/m³ for the eastern pipeline and slightly higher US$ 1.07 for the western pipeline. Compared with the cost of desalinated water, these are much cheaper.

The Peace Pipeline scheme has never found a chance of implementation, despite its feasibility. First due to financial problems because of its massive nature and secondly political obstacles prevented it from realization. Various stakeholders feel that a single and much shorter pipeline would be an alternative to the original scheme and build to carry water from Seyhan and Ceyhan Rivers to Syria, Jordan, and Palestine and probably to Israel cutting at least half of the original length and costs amounting nearly a total of US$ 4-5 billion depending on the developments in the peace process amongst the regions concerned (Ibrahim Kaya, 2005).

Turkish Republic of Northern Cyprus (TRNC) Water Supply Scheme

Transportation of Water to TRNC by means of Water Bags. The scheme aims to transport 7 MCM of water from Soguksu Stream to Lefkosa and Gazi Magosa via the Kumkoy reservoirs in Cyprus. The construction works on Soguksu loading and Kumkoy unloading installations have been completed. The system was transferred to TRNC Water Department on 12 June 2002.

Water transportation operations by means of water bags, known as ‘normed’, were started on 25 July 1998, but satisfactory results could not be obtained. Therefore, the contract of the carrier firm was terminated in 2002, and a new firm was selected, but it failed.

Documents for submission of tenders for transportation of water from Turkey to the TRNC by
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tanker are being prepared by TRNC.

Water Supply scheme to TRNC by Pipeline

In order to meet the water demand of the TRNC, another scheme has been developed to transfer water by pipeline from Turkey to the TRNC and engineering services for that scheme have been included in the investment programme of DSI since 2002. The scheme involves shore and offshore structures. The shore structure consists of construction of a dam, storage tanks, pumping stations, and transmission lines. The offshore structures consist of manufacturing facilities and construction of a pipeline on a supported hanger at a depth of 250 m. Water will be carried from the Alakopru Dam to be constructed on the Anamur Dragon River in Turkey through pressurized steel pipelines to the existing small Gecitkoy Small Dam in TRNC. By raising the height of the Gecitkoy Small Dam, it will be converted to Gecitkoy Dam, the reservoir of which will be used for water storage for the purposes of water supply and irrigation. The scheme was approved by the Council of Ministers’ Decree No. 98/11202 on 27 May 1998. The engineering and consultancy works of the scheme have been completed, but the contract has not yet been signed (DSI, 2007).

*Manavgat River Water Supply scheme (MRWSP)*

The Middle East is historically a water-stressed region. Sustainable supply of clean water is a major issue of social, economic and even political dimension in the Middle East. The Jordan River basin suffers serious water shortage and the situation is expected to worsen in the near future.

The Manavgat River has an annual water potential of 3.6 BCM. It follows that more water could be drawn from the river by increasing the capacity of the installations, when necessary. The MRWSP is planned to treat the water of Manavgat River so as to achieve the water quality norms and to transport to the two Single-Point Mooring (SPM) loading terminals situated three kilometers offshore by pipes laid on the sea bottom (Figure 4.49).

Turkey has finished a US$ 150 million anchorage (a pumping station and treatment plant) at the estuary of the Manavgat. The estuary, near Antalya on the Turkish Mediterranean coast, is approximately 523 km from Israel’s Ashkelon port, to which the water would be shipped. The Manavgat River has facilities capable of exporting 180 MCM of water using tankers.

Sale of the Manavgat River Water

Israel has been the only country to date expressed its political will to purchase treated water from the Manavgat River.
Need of Israel to import water from Turkey

Israel’s fresh-water resources, which average about 2,000 MCM annually (three-fourths of it potable), are already being exploited to the upper limit. With a steadily rising population, Israel will need as much as 30% more water to meet the needs of the population in 2020 (Ayca Ariyoruk, 2003).

Israel has three immediate options to meet the problem of increasing water demand and irregular water supply:

- import water from Turkey, which is estimated to cost around 0.80 US$/m³;
- desalinate seawater, at a cost of 0.52 - 0.55 US$/m³;
- recycle used water; wastewater processing plants, for around 0.35 US$/m³.

Recycling wastewater is the low-cost way to meet Israel’s water needs. Israeli water-processing plants have been operating for thirty years in the Haifa area and in Dan, south of Tel Aviv. The volume of recycled water is estimated at 270 MCM/yr, and could reach 620 MCM by 2020. However, the recycled water Israel obtains is not considered drinking-water quality and is used by Israel only for industrial purposes.
4. Country wise experiences

Seawater desalination is also operational in Israel, but on a much more limited and local scale. It can be cost effective, but is not always guaranteed to reach the desired drinking quality and has environmental consequences such as leaving salt residue. According to Shlomi Dinar, a Johns Hopkins University-based expert on international water issues, brackish water from boreholes is another viable option, as it can reach drinking quality when desalinated. At a cost of $0.33-0.42 per cubic meter, brackish water is relatively inexpensive to desalinate. Some Israeli officials have long been skeptical of importing water from Turkey on grounds of cost. Now Israeli officials say the water desalination schemes will continue and the imported water from Turkey will serve as an additional source for addressing emergencies such as droughts.

The drought experienced in the Jordan River Basin as well as other considerations as mentioned in above paragraphs led to the expression of the political will by the Prime Minister of Israel to purchase water from Turkey despite opposition from the Ministry of Finance and the desalination lobby.

Turkey’s expectations from Israel regarding the water trading commitments have been intensified recently. The Prime Minister of Israel, H. E. Ariel Sharon and the Former Minister of Energy and National Resources of Turkey, H. E. Zeki Çakan held a meeting on 6 August 2002 in Jerusalem in order to discuss the Manavgat Water Supply scheme to Israel. Subsequently, a ‘Joint Committee for the Manavgat Water Supply scheme to Israel’ was established. The First Joint Committee Meeting was held in Ankara on 14 October 2002. During the Joint Committee Meeting, various shipping companies from Turkey, Israel and third countries presented their schemes on the transportation of water from Manavgat to Israel by tankers. The Israeli experts have included the amount to be imported from Turkey in their water budget. It was made public during the Stockholm Water Week in August 2003 and signed an Inter Governmental Agreement (IGA) between Turkey and Israel. Under the agreement, Israel will buy 50 MCM of treated-water a year from Turkey for a period of 20 years. That would account for about three percent of Israel’s annual freshwater consumption of 1.5 BCM.

Turkey hopes that the Manavgat River scheme will eventually supply water to other eastern Mediterranean countries suffering from water shortages, including Syria, Jordan, and Greece. Since water is a strategic asset in this dry region, Turkey’s water supplies could contribute to reducing tension over this politically sensitive resource, given the fact that Israel, Syria, Jordan, and the Palestinians all have serious concerns about scarce water supplies.

Sale of Manavgat water to other countries is hence currently under consideration. Therefore, development of a national policy concerning determination of unit water prices is of crucial importance. This scheme would set a good precedent in case of realization of similar schemes in other countries; this could finally lead to the establishment of an international water stock exchange under the leadership of Turkey.

The Commission for Privatization took over the facility within the context of privatization with
Decision No. 2003/58 dated 8 September 2003. This indicates that the facilities will be privatized and the private sector will undertake exportation of the fresh water to countries in the Region. It could be argued that desalination may be an alternative for supplying of additional fresh water to the region. However, the quality of water of Manavgat River is far superior to desalinated water in terms of mineral content and other qualities. In addition, it is environment friendly contrary to desalination plants, which use various chemicals and release mountains of salt (Mithat Rende, 2004).

4.3.5 France

France lies in Western Europe and is bordered by the English Channel (N), the Atlantic Ocean and the Bay of Biscay (W), Spain and Andorra (SW), the Mediterranean Sea (S), Switzerland and Italy (SE), and Germany, Luxembourg, and Belgium (NE). Most of the Northern, Western and North-Central France is flat or has rolling hills. France has an area of 55.2 Mha with an estimated population of 64.1 million (UN, 2007), of which 22.6% is engaged in agricultural activities.

France is one of the world’s major economic powers. Agriculture plays a larger role than in the economies of most other industrial countries. A large proportion of the value of total agricultural output derives from livestock (especially cattle, hogs, poultry, and sheep). The country’s leading crops are wheat, sugar beets, corn, barley, and potatoes. Fruit growing is also important especially in the southern region. France is among the foremost producers of wine in the world.

Existing schemes

IBWT has been practiced in France even before the 19th century, as transfer from the Durance basin to the Rhone basin for irrigation through the Craponne Canal and Southern Alpine canals with flow capacity of 23.4 m³/s and 16.2 m³/s respectively. In the 19th century, water was transferred from Durance and Verdan Rivers to provide irrigation and urban water supply to Marseille and Aix-en-Provence through two canals of 15.2 m³/s and 6 m³/s respectively. However, these canals are now out of service. Some of the schemes constructed during the past few decades are listed below:

**IBWT from Lys River Basin to Lille Region**

A 40 km long canal has been constructed to transfer 0.365 BCM/yr from Lys River Basin to Lille Region.
4. Country wise experiences

**IBWT from Neste River to Garonne River Basin**

A 27 km long canal with a discharge capacity of 0.57 BCM/yr has been constructed in 1963 to transfer water from Neste River to the Garonne River basin for irrigation and urban water supply. The scheme also provides for environmental protection.

**IBWT from Durance Basin to Neighbouring Towns**

Several schemes cumulatively transfer 1.26 BCM/yr of water from Durance River Basin to neighbouring towns for which 120 km of tunnels and 90 km of open channels were completed in 1963.

**IBWT from Escant River to Lille Roubaix and Dunkerque**

The water is transferred from the Escant River to Lille Roubaix and Dunkerque through a navigation canal constructed in 1976. The transfer is of the order of 0.16 BCM/yr.

**IBWT from Cap-de-long River Basin to Gave-de-pau River Basin**

Water is transferred from Cap-de-long River Basin to Gave-de-pau River Basin through a 10 km long pressure tunnel for the generation of hydropower at Pragneres hydropower station.

4.3.6 Spain

Spain faces the Atlantic Ocean on its West and Northwest and the Mediterranean in the South and the East. Spain has an area of about 51 Mha with an estimated population of 45 million (UN, 2007), of which 16.22 million are working population, 7.7% of the total being directly engaged in agricultural activities.

Spanish summers are often very hot (av. 38 °C in June), but winters vary sharply, being mild in coastal areas and colder inland. A large part of Spain is semi-arid and needs water transfers from relatively water-rich basins (Gonzalez and Zabaleta, 2002). Mean annual precipitation is 668 mm. Uneven seasonal and regional patterns in water availability have been the driving forces to build large storages and extensive intra and inter-basin water transfers (R. Maria Saleth, And Ariel Dinar, 1999).

West flowing rivers enter Portugal and their water redeployment is governed by international agreements. There are four significant IBWTs in operation as described below:
Existing schemes

Upper Ebro (Zadorra River)-Bilbao

The Upper Ebro (Zadorra River)-Bilbao scheme transfers water from the upper Ebro basin to the Nervion River of the North basin. Water is transferred through 2 reservoirs located in the upper Ebro basin. The scheme consists of a main canal to cross the mountain situated in between the donor and recipient basins and a 40 km long canal, which also has tunnels in few reaches. The scheme is in operation from 1950 and is capable of transferring 200 MCM/yr.

Negratin-Almanzora IBTV

The aim of this WT is to connect the Negratin reservoir (450 MCM capacity), on the Guadalquivir river basin (province of Granada) to Almanzora area on the South of Spain basin (Almería province), to allow the irrigation of 24,000 ha, in critical situation for agriculture, as well as to supply with drinking water to some 87,000 persons in 27 municipalities of this province.

The connection, that started operating in 2004, is designed to transfer up to 50 MCM/yr, from Negratin to Almanzora area, with a flow of 2 m³/s, through a 120 km long pipeline, having 7 regulation ponds and 2 small power stations. In order to prevent any detrimental effect to the donor basin there exist a very precise regulation to carry out the water transfers, whose implementation is entrusted to a Commission made up of members of the two Water Basin Authorities and other stakeholders. The Commission takes the decisions on water volumes transferred according with the possibilities of the donor basin each year, with the only limit that transfers shall only be authorized when the available resources at Guadalquivir basin are over 30% of its General Regulation Plan.

In addition to that, and due to the much higher profitability of agriculture in Almanzora area than in Guadalquivir, a number of farmers of this basin are selling water rights which are being transferred to Almanzora area through Negratin-Almanzora transfer facilities. It is expected that in 2007 there will be transferred to Almanzora some 20 MCM of water sold by Guadalquivir owners, of which 6 MCM will be used for urban supply and 14 MCM for irrigation.

Ebro-Tarragona IBWT

Under the Ebro-Tarragona (Catalonia) IBWT scheme water is transferred from Lower Ebro basin to Tarragona area of Catalanian Internal basin. The infrastructure consists of two pumping stations placed in the southern and northern area of the Delta. A siphon has been constructed for crossing the
4. Country wise experiences

Ebro River from South to North. A pumping station helps water to pass through an 80 km long conduit. The scheme is designed to transfer around 120 MCM /yr.

Tagus-Segura IBWT (Acueducto Tajo-Segura)

The Tagus Segura Transfer (TST) is from the River Tagus, which flows into the Atlantic Ocean, and is also an international river shared by Spain and Portugal (Figure 4.50). The Segura River drains into the Mediterranean Sea.

![Figure 4.54. Tagus-Segura IBWT](image)

The Acueducto Tajo-Segura (ATS) infrastructure starts from Bolarque reservoir, which receives water from two large regulation dams in the upper basin of Tagus namely Entrepenas on the Tagus River and Buendia on the Guadiela River, a tributary of Tagus. From Bolarque reservoir which acts as the fore bay of the initial pumping station, water is lifted through 245 m up to a small reservoir La Bujeda, from where a 315 km long canal conveys water southeast, crossing the basins of Guadiana and Jucar Rivers. The Tagus-Segura Aqueduct ends in the Talave reservoir in the Segura basin after crossing Hellin mountain range through a 32 km long tunnel. The scheme (envisaged at the National Plan of Public Works, 1933), was completed in 1978 and presently transfers on average 300 MCM/yr, while the water requirements of the area are estimated 439 MCM/yr.

The impacts of ATS

Despite all the criticism for the defects that, as any human work, ATS may have, the fact is tat this transfer has been the driving force for the development and prosperity of the areas under its influence at the South-East of Spain, particularly in Valencia and Murcia, and has made possible to guarantee the water supply for domestic use as well as to consolidate irrigation to the highly productive agriculture of the area. In short the benefits of ATS to the South-Eastern region outpace by far the undoubtedly failures that might exist.
Impacts experienced in the donor basin - Tagus:
- 60% of the natural flow in the Tagus river, referred to the resources at the starting point of ATS (Bolarque reservoir), is actually being transferred;
- by lack of rainfall, the natural surplus decreased by 10%, so that the volume of water transferred has not steadily reached the designed flow of 650 MCM/yr;
- legal minimum flow of 6 m$^3$/s in Tagus is respected. Only during periods of drought, and because of force majeure, in less than 10% of the years, it may slightly drop to as much as 5.5 m$^3$/s;
- the wastewater treatment plants set to serve all towns diverting wastewater into the main river or its tributaries, prevent the water quality from being deteriorated in the donor basin Tagus.

Impacts experienced in the recipient basin - Segura:
- intensified irrigated agriculture and tourism have already overcome the adjustment failures of management and control detected at the first stages of operation of ATS;
- losses and leakages in the water supply network are presently being corrected by substituting the old ones by new pipelines and materials;
- isolated cases of eutrophication of some downstream water bodies, due to the drainage of runoff water contaminated from irrigated fields fertilized in excess have occasionally occurred;
- the water transfer has benefited not only small stakeholders but also the bigger agro business and construction companies;
- traditional farmers can now rely on a guaranteed supply of water to see consolidated their existing irrigated fields;
- latest techniques to control the volumes delivered to farmers besides an effective tariff system limits the excess demand for water and black water marketing.

Proposed scheme

Ebro water transfer scheme

The proposal for the Ebro water transfer scheme passed by the Parliament in June 2001 is a large-scale scheme. It consists two main canals with a total length of about 900 km, and a transfer capacity of 1,050 MCM/yr of water.

As shown in Figure 4.51, of the total volume (1,050 MCM/yr) to be transferred, 190 MCM/yr will go forward to the North, i.e. to the Barcelona metropolitan area through a 179 km canal. To the South will be transferred 860 MCM/yr, of which 315 MCM/yr will be passed to the Jucar basin along a 362 km canal, and - further to the South - another 450 MCM/yr to the Segura basin by means of a
167 km canal, as well as 95 MCM/yr to the Dalias irrigation fields, in Almería province, along a canal of 120 km.

The cost of this water transfer is estimated at 4.20 billion €, some of which being financed by privatisation (€ 1.2 billion), around € 1.8 billion by consumers and € 1.2 billion by EU funds. The average estimated cost of this transferred water is 0.313 €/m$^3$ and a further compensation rate of 0.03 €/m$^3$ and a further compensation rate of 0.03 €/m$^3$ will be paid to the Ebro Basin. It was proposed that the transfer would be built by an autonomous organism, to be created for this purpose by the Ministry of Environment.

The abstraction of water from the Ebro could only be made after leaving an ecological flow of 3,150 MCM/yr. In addition to a ‘reserve’ of 3,400 MCM/yr for future demands in the Ebro river catchment. Water will only be transferred from October to May and will only be withdrawn from the Maquinza and Ribarroja reservoirs in the lower stretch of the river and from the Flix dam within the Ebro Delta.

According with the Ebro Water Transfer Act, from the total 1,050 MCM/yr to be transferred, 462 MCM will be set aside for water supply and 588 MCM for irrigation purposes.

The approval of the National Hydrological Plan (NHP) on 5 July 2001 has allowed, after long years of complex and hard work, to fulfill the process of hydrological planning conceived and designed by the Water Act of 1985. This planning was carried out with two instruments, namely the Basin Level Hydrological Plans and the National Level Hydrological Plan in an integrated manner. The Plan assumes the basic principles:

- no volume of water will be transferred to the receiving basins in order to increase the irrigated area;
- transfer of water for drinking water supplies and for the allocation of water for environmental purposes;
• Water transfers will only be assigned to recover the present situation of overexploited underground aquifers and to alleviate low supply and guarantee water for irrigated areas;
• Present and future use for urban supply in the receiving basins, provided that an efficient and rational water resources management is being carried out;
• To improve the environmental conditions of those ecosystems, river reaches, underground aquifer sectors or any other elements of the natural water milieu presently subject to a strong degradation;
• To consolidate the water supplies for the existing irrigated areas referred to water scarcity or due to low supply or to lack of sufficient supply guarantee, provided that an efficient and rational water resources management is being carried out.

The NHP 2001 also includes several orders related to the carrying out of special Plans for specific areas and the total investment costs are estimated to be in the order of 23,104 M€ for the period 2001-2008, out of which, 4,217 M€ will be spent on water transfer from the Ebro basin to the deficient ones and the remaining 18,887 M€ will be applied to planning actions in each one of the affected basins. A foreseen investment also includes with an amount of 6,165 M€, for the modernization of irrigation schemes, improving the irrigation channel networks and encouraging water savings in agriculture (José Maria Martin Mendiluce, 2001).

Rhone River water transfer to Barcelona Area: A study object.

As an alternative to the water shortages and deficient water quality in the Barcelona area, attention has been given to the possibility to complement such deficit taking water from the Rhone River to Catalonia.

So far only preliminary studies have been carried out, showing that the Rhone has an average flow of 1,700 m³/s (54,000 MCM/yr), the current withdrawals from the river only account for 550 MCM/yr (about 1%) and future water abstraction, if made by means of the proposed Languedoc-Rousillon-Catalonia pipeline, would be responsible for a further 450 MCM/yr. The pipeline would have a total length of 316 km, 195 km of which being in France and 121 km in Spain and the maximum change in level of some 200 m. The pipeline would require the construction of a 4 km tunnel below the Pyrenees. The approximate cost of the pipeline (at the time of this study, could be some 1,205 M€, with an estimated cost of transferred water of around 0.34 €/m³. However the preliminary study does not take into account the price of water to be paid at the source to the French donor, and so far does not exist any agreement between the two countries.

Consideration of Desalination as an alternative to IBWT
Spain is one of the countries to have given firmer backing to desalination to offset water shortages in coastal regions, this technique now producing some 200 MCM/yr. The Carboneras desalination plant, currently being built in Almería and with a final capacity of 80 MCM/yr, will be one of the largest desalination plants in the world.

The NHP aims to double the production of desalinated water in Spain from 200 MCM/yr to 400 MCM/yr, through an investment of 753 M€, for the construction of 41 new desalination plants, 16 of which being set in areas affected by the water transfer. The NHP considers desalination as supplement to water transfer, while the anti-PHN lobby and other stakeholders consider it to be greater part of the solution. The University of Zaragoza (capital of Aragon) has calculated that the construction of a further 10-12 desalination plants would eliminate the need for water transfer from Ebro river.

The disputes regarding the cost of desalinated water have served as one of the main points of friction concerning information. According to the NHP, the cost of desalination is some 0.81 €/m³ while the cost of transferred water is 0.31 €/m³. Against this it is argued that the cost of desalination is gradually falling as current technology allows reductions in energy costs. While desalination may now be established at 0.54 €/m³, it will continue to decrease down to around 0.36 €/m³. A report issued by CIRCE (Energy Resources and Consumption Research Centre, in Zaragoza) establishes that by exploiting common infrastructures for seawater, brackish water (e.g. salt water wells) and wastewater treatment, the cost may reach up to 0.30 €/m³. In addition to that the desalination would supply water of greater quality than the one supplied by the transfers from Ebro.

The pro-PHN lobby accepts that the operational costs of desalination is lower than 0.81 €/m³ but it is necessary to add the cost of amortizing the plant together with transport and environmental costs. If desalination plants are employed to produce 1.000 MCM/yr, the CO₂ emitted in the atmosphere will increase the current level of emission of 291 million Tm (in 1999) by between 0.5% (if natural gas is employed) and 1.5% (if a coal fuel is employed). Furthermore, there is the possibility that marine plankton will be affected by the discharge of brine, and particularly the Posidonia algae which makes up one of the habitats of greater biodiversity within the Mediterranean.

The main ecologist organization (Ecologistas en Acción) is strongly against desalinisation while other sectors, consider desalination as an intermediate step in the transition to a new and more advanced water management model. Furthermore, a recent report (19-06-2007) of the World Wide Forum for Nature (WWF) shows its views contrary to the proliferation of desalination plants in Spain as the best way to get water for the needy areas, because of their high financial and energetic cost, along with their harmful impacts to the climate change due to CO₂ emissions.

Views of Stakeholders on the proposed Ebro IBWT

Studies carried out by economists and environmentalists on the downstream areas of the proposed transfer point concluded that:
current ecological problems of the Ebro Delta and estuary (protected by international agreement under the Ramsar Convention) would further deteriorate;

- NHP was approved even before a comprehensive environmental impact assessment was carried out;
- the Plan did not consider any of the impacts that such a large water transfer would have on the Ebro Delta in terms of biodiversity, wetlands, ecological flow, and expected changes in land use, and in social and economic activities such as fisheries, rice production, etc.;
- the Plan did not analyze what would be the impacts of the low quality of the transferred waters on the receiving areas;
- priority of the government is to modernize the system so as to conserve and built a healthy ecosystem effectively (Monti Aguirre, 2003);
- the water could only be used directly for agriculture and irrigation of golf courses.

Some views of the new Spanish government on the proposed Ebro IBWT

The Spanish government has halted in 2004 the plan of transferring water from the Ebro River, citing costs and environmental reasons, and views the scheme as: ‘The amount diverted from the Ebro under the water transfer plan would have been equivalent to one-third of Spain’s domestic water consumption. The scheme would have destroyed the habitat on which at least 55 bird species depend, including Sandwich Tern *Sterna sandvicensis*, Audouin’s Gull *Larus audouinii*, Greater Flamingo *Phoenicopterus ruber* and Glossy Ibis *Plegadis falcinellus*. The Delta is also an important stopover point for migratory birds from Europe and Africa’ (Spanish Government’s Announcement, 2004).

The government proposes a package of measures including desalination plants and other in basin water conservation schemes for addressing the water scarcity and its uneven distribution.

However there still a general feeling that the problems and possibilities have to be analyzed in depth, so that, subsequent proposals for possible solutions according to explicitly-defined aims could be made in future, without excluding any feasible alternative.

4.3.7 Germany

Germany is located in the center of Europe, it borders the Netherlands, Belgium, Luxembourg, and France on the West; Switzerland and Austria on the South; the Czech Republic and Poland on the East; Denmark on the North; and the Baltic Sea on the Northeast. Germany has an area of about 36 Mha with an estimated population of 82.3 million (UN, 2007), of which 12.2%
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is engaged in agricultural activities.

In general, Germany as a whole can be divided into three major geographic regions: the low-lying N German plain, the central German uplands, and, in the South, the ranges of the Central Alps and other uplands. The climate is temperate although there is considerable variation.

Manufacturing and service industries are the dominant economic activities. As mentioned only about 12% of the population is involved in agricultural activities. Water is no limiting factor for the socio-economic development in Germany, as just 28% of the renewable water resources are being used per year. Nevertheless, IBWT schemes became necessary in the last 150 years in many parts of Germany to bridge the gap between demand and supply in deficit regions, and for improving water quality and meeting peak water demands in urban mega cities.

**Existing schemes**

**IBWT of Rhine-Main Region**

The Rhine-Main Region is situated in the middle of Germany covering parts of three German states of Bavaria, Rhineland-Palladium and Hessen. The main part of the region, including the cities and surrounding areas of Frankfurt, Wiesbaden and Darmstadt is situated in the south of the state of Hessen and covers 7,500 km².

Bavaria is the largest federal state of Germany. The south of Bavaria lies in the river basin area of the Danube. Rhine basin drains through the northern part (Rednitz, Regnitz and Main Rivers). Though the Bavarian Rhine Basin has an annual precipitation of nearly 700 mm, the Regnitz and Main Basins are especially dry, because they lie on the leeward side of mountains. These basins experience high temperatures and evaporation rates. The flows in the river are also extremely variable. However these sub-basins are densely populated with developed industrial infrastructure and intensive agriculture. The demand of water is higher than the water resources available.

Though IBWTs from the Danube basin for drinking water purposes have already being done, a new proposal to transfer surplus water of this river to the Regnitz Main sub basin was approved in 1971 to meet the rising demands of various sectors (irrigation, industrial and municipal) in the area.

The scheme involves pumping in five steps, up to 21 m³/s water from the existing Rhine Main- Danube Navigation Canal, to the Kleine Roth reservoir from where a constant outflow of 15 m³/s is used to augment water supply from the Rhine River. This transfer enables an assured availability of 27 m³/s to the Regnitz River at Nuremberg. In absolute terms, annual transfer from Danube River to the Rhine River Basin is of the order of 0.3 BCM/yr only in average years and 0.47 BCM/yr in dry years, which constitutes a very small percentage of the total. In addition to that, surplus water of a tributary of the Danube, the Altmühl River, is also transferred and stored for use in the area of deficit. The maximum value of the total yearly transfer volume will be amounting to about 4.7% of the average
annual discharge at the transfer point and only 1.1% of the Danube discharge at the federal boundary with Austria (Fritz Mantel, 1978).

4.3.8 Finland

Finland lies in the northern tip of Europe. It borders on the Gulf of Bothnia and Sweden in the West, on Norway in the North, on Russia in the East, and on the Gulf of Finland and the Baltic Sea in the South. Finland falls into three main geographical zones, namely the low-lying coastal strip that includes most of the country’s major cities and much of its arable land, the coastal strip with average elevation of 90 - 180 m, which includes lakes, many of which are linked by short rivers, sounds, or canals to form busy commercial waterways and the Arctic Circle, which is a part of Lapland- thinly wooded or barren land with an average elevation of about 340 m.

Finland has a total geographical area of 33.8 Mha with an estimated population of 5.3 million, of which 41.5% is engaged in agricultural activities (UN, 2007).

Finland was traditionally an agricultural country. But after World War II., it accelerated the pace of its industrialization and subsequently by the end of the 20th century, manufacturing, services, and trade and transportation were stood as the largest segments of its economy contributors.

Existing scheme

IBWT from Lake Paijanne to Helsinki Metropolitan Area

Lake Paijanne is the second largest lake in Finland and the major lake of the River Kymijoki watercourse in central Finland. Lake Paijanne is 120 km long and its width varies from 1 to 28 km. The total area of the drainage basin of Lake Paijanne is 25 times as large as the lake itself. Most of the basin is covered by forests, the proportion of farmland being only about 10%, and forested peatlands account for 25%. The population in the drainage basin is about 400,000, of which 150,000 live near the lake. There are some 30,000 holiday cottages along the shore of the lake. The water quality in northern parts of the lake was deteriorated in the 1950’s and 1960’s. As the result of recent legislative and administrative measures, waste loadings have been diminished substantially and water quality has been steadily improved.

Fresh water is supplied to the Helsinki Metropolitan area located in coastal area of the Gulf of Finland from Lake Paijanne on River Kymijoki by a 120 km long water supply tunnel (Lemmela et al., 1999), which supplies drinking water to about 1 million people in the Helsinki metropolitan area.
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(Figure 4.52). This tunnel, at the time of its completion in 1982, was the longest fresh water tunnel in the world. The scheme in addition to the drinking water needs of Helsinki Metropolitan Area is also used for restoration of the local polluted rivers and lakes. The tunnel located at 50 - 70 m under the ground surface, has a discharge capacity of 20 m$^3$/s and transfers about 0.1 BCM/yr taken from the southern end of the lake Paijanne through an intake.

![Figure 4.56 IBWT from Lake Paijanne to Helsinki Metropolitan Area](image)

4.3.9 Portugal

Portugal is bordered by Spain on the East and North and by the Atlantic Ocean on the West and South. The total geographical area of Portugal is 9.2 Mha. The population of Portugal is estimated as 10.6 million (UN, 2007), Portugal drains several river basins shared with Spain, which is the upper riparian. Availability of flow is regulated and shared internally as per international understanding (Rijo et al., 2001). The river valleys
support agriculture, and vineyards. There are great variations in terrain and climate of the regions. Portuguese agricultural techniques are less mechanized than those of most of Western Europe. The percentage of people engaged in agricultural activities is 31.1%. There is no existing IBWT.

**Proposed scheme**

*Water transfer from Guadiana River basin to Sado River basin.*

An IBWT from Guadiana River basin to Sado River basin is under implementation, integrating existing and designed dams and reservoirs. It will transfer about 0.012 BCM/yr of water from Guadiana River to Sado River basin.

The proposed Guadiana transfer scheme will come under the existing multi-purpose scheme Alqueva. The main element of the Alqueva scheme, the largest in the Iberian Peninsula, is the artificial lake with an area of 250 km². The height of the dam wall is 96 m, its length is approximately 83 km and it has a perimeter of 1 100 km. It also includes the construction of nine small dams and a global system of irrigation to equip 110 000 ha of irrigated lands, composed by a network of canals and pipelines (about 5 000 km). In this global system of irrigation is included the water transfer of Guadiana Basin water to Sado Basin, since a large part of the future irrigated lands is planned for Sado Basin. The global system of irrigation is divided into three sub-systems:

- **Alqueva** (right margin of Guadiana river): 71 000 ha, irrigated by the Alqueva and nearly 8,000 ha for the Bloco of high Alentejo;
- **Pedrogão** (right margin of Guadiana): 29,000 ha, irrigated by the Pedrogão reservoir;
- **Ardila** (left margin of Guadiana): 11,000 ha, irrigated by the Pedrogão reservoir.

The Alqueva dam is equipped with a hydroelectric power plant endowed by two turbines with a capacity of 120 MW each. This power plant will produce 380 Giga Watts/hour/yr, which will flow into the national electric system. Twenty-three kilometres downstream of Alqueva the Pedrogão dam is being constructed by taking loan from EDIA. It will create a second reservoir intended to recoup the water used for the production of electricity. Its maximum height will be 39 m and the usable volume will be 54 MCM. In 2001 the EIB also gave a loan to EDIA for the construction of this dam. The Pedrogão dam will be equipped with a hydroelectric power plant with two turbines of 4.9 MW each. The EDIA is a public enterprise, which is responsible for managing the Alqueva reservoir, and all the associated development plans.

Portuguese NGOs feel that the scheme is categorically unsustainable based on its environmental impacts (European environmental directives are being violated), its insufficient mitigation and compensation measures and also the marginal economic benefits, which are accruing to the local population. As the construction nears completion, the EIB should now be more pro-active in fulfilling
its lending responsibilities and closely follow the implementation of the scheme to reach up to the expectation of the beneficiaries (Louro et al., 2003).

The distribution and abundance of many of the 23 native fish species especially the fish species, *Anaecypris hispanica* (Steindachner), is critically endangered of the Guadiana River basin in Portugal have declined markedly in the past 20 years. The stakeholders of the region feel that this is because of increased pressure to exploit the water resources of the catchment for domestic supply, agriculture and recreation, but also as a result of general habitat degradation and the introduction of exotic species. Thirteen reservoirs have already been constructed in the region and a further 25 proposals have been put forward, mainly to supply the tourist sector in the south of the country (Collares-Pereira, 2000).

4.3.10 **Czech Republic**

It is bordered by Slovakia on the East, Austria on the South, Germany on the West, and Poland on the North. Manufacturing is the chief economic activity. It has an area of 7.9 Mha with an estimated population of 10.3 million, of which 25.2% is engaged in agricultural activities (UN, 2007). Most of Czech rivers flow into the North Sea (65%), others into the Black and Baltic Sea. The annual availability of surface water per capita is 1,400 m$^3$, that is, about one third of the European average. About 75% of the country’s 10.2 million inhabitants live in urban areas. Of the total population, 88% is supplied by public water systems. Water supply companies are privatized and in some regions, organizations of infrastructure owners have been established (Global Water Partnership, 2001).

The main water problems faced are diffused pollution from agriculture, a low portion of population connected to sewage systems and insufficient integration in basin management issues (WWF, 2002).

The territory of Slovakia belongs to the Danube river basin, the largest river basin in Europe. Slovakia is one of 18 counties that are sharing this river basin, and is actively involved in the processes coordinated by the International Commission for the Protection of the Danube River and focused on the preparation of the Danube River Basin Management Plan by the year 2009 (Miklos, 2005). There is no existing IBWT scheme.

**Proposed scheme**

*Danube-Oder-Elbe Canal*
The proposed Danube-Oder-Elbe waterway envisages connecting the River Danube with the North and Baltic Seas, crossing the very heart of the Europe Continent and offering the shortest route from the Danube countries to the main European seaports.

Danube River besides possessing the potentiality to transport route, it is also remarkable for cultural, social, environment and ecological value to millions of people. Danube is one of the most important International River and the second largest river in Europe and includes 19 countries in its entire catchment area coverage. Four important capital cities are situated on its banks and about 83 million people depending on it for various purposes including about 20 million people mainly rely for drinking water.

History

The route between the Danube and the Baltic has always been important for European trade. The initial idea of 14th century was to connect the Elbe-Vetave and Danube river basins by a navigation canal. Until 1956, the Danube-Oder-Elbe canal has always been intended for navigation. Thereafter, serious thought was given to transform it into a multipurpose scheme (Kolar and Soltesz, 1978). In the year 1700 the first proposal suggesting not only the Danube - Oder connection, but the complete connection between Danube-Oder-Elbe with three branches and a junction point near Prerov in central Moravia was published in Vienna. During the 18th and 19th century several more convenient plans for this connection were discussed. However, the increasingly dense railway network on the European Continent led to serious discrediting of waterway schemes in Europe. The important event that negatively influenced the chances of the Danube-Oder-Elbe connection was the construction of the railway link Vienna - Krakow. The route of this railway, which was finished in 1841 (the first railway line in the former Austria-Hungary) was parallel with the route of the Danube-Oder connection and offered better conditions for the transportation of goods in comparison to inland river transport.

In spite of this unfavorable situation, the scheme of the waterway was subsequently modernized in order to allow the operation of larger vessels and barges and to simplify the traffic by a reduction of necessary locks. As a result of these changes, Waterways Law came in the year 1901 and was passed in Austria. It included a construction plan for of modern waterways in the Austro-Hungarian Empire. According to this plan, the Danube-Oder-Elbe Canal was to form the main element of the proposed network that was to be finished within 20 years. However, only a minor part of the programme was realized. World War I and the fall of Austria-Hungary brought a final end to the ambitious plan. In the Czechoslovak Republic, the old Austrian plans were adapted to the new political and economic situation. On 19th November 1938 an agreement of the Czechoslovak and German governments about the construction of the Danube-Oder-Elbe canal was concluded in Berlin. According to this agreement the Danube-Oder Link was to be finished within 6 years. However, a very limited extent of the work (the excavation of the canal bed near Vienna and near Kozle) was realized. World War II put an end to
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all plans again.

The DOEC plan since the 1970s, gained new momentum, partly as a result of the Czechoslovak government’s national spatial planning strategy. In 1981 a special Group of Rapporteurs of the Economic Commission for Europe in Geneva (UN ECE) published their final report on the economic effectiveness of the Danube-Oder-Elbe Canal and was again updated in 1992. The study demonstrated very positive economic efficacy of the scheme and mentioned that the construction of the link can be considered to be an opening of international interest.

1992, a Working Group on D-O-E Canal namely ‘Working Group DOEC’ was set up. In mid-1990s, the initial guidelines for the development of the Trans-European Networks for Transport (TENs-T), which is a programme of the European Union (EU) to significantly improve the connectivity between the markets of the ‘old’ (Western) and the ‘new’ (Central and Eastern European) EU Member States markets, West Asian regions was framed. The TENs-T guidelines comprise a series of pan-European transportation corridors – made up of roads, rail, inland waterways, etc – to connect the enlarged EU from the Black Sea Coast to the Cliffs of Moher. The Danube River play significant role in the TENs-T inland waterway component.

In 1997 the foundation of the ‘Association Danube-Oder-Elbe (Association DOE)’ based in Prague was formed. The association provides ‘comprehensive documentation’ about the DOEC scheme. As per the Danube-Oder-Elbe Association details, the total cost of the scheme amounts to at least € 5.2 billion, with investment per kilometre ranging from € 5.5 million to € 15 million. The waterway has been sub-divided into five stages (1a, 1b, 2, 3 and 4). Stage 1a, the most important section (Danube - southern Moravia), has a length of 80 km and is highly uncomplicated, entailing an investment cost of around € 640 million. Stage 1b, between the navigable part of the Oder and the region of Ostrava (53 km section), is also relatively easy to build and is estimated to require € 345 million. The most straightforward section of all, however, is Stage 2 (prolongation of stage 1 to Prerov in central Moravia, 112 km, € 618.2 million), as some parts of the route, as well as the necessary dams on the river Morava, are already finished. Stage 3 (Prerov - Ostrava, 94 km, € 1 156.4 million) would complete the connection Danube-Oder, and with this stage the main goal of the scheme could be attained. Stage 4 (from Prerov to the Elbe, 160 km, € 2 405 million) is the most complicated and expensive (Mr Márton Braun, Hungary, 2005).

Most probable route of D-O-E Waterway

The initial guidelines for the development of the TENs-T were revised in 2003-2004. The revision includes a number of important developments, including integration of the new Member States and Accession Countries into the pan-European network, greater emphasis on waterways also called Highways of the sea’, cross-border stretches, removing ‘bottlenecks’ at natural barriers and borders and introduction of 30 priority schemes of ‘European importance’ has been given in the TENs-T
programme. The total costs for the extended TENs-T is estimated at some 820 billion EURO (Michael Baltzer, 2004).

Historically, the canal is highly desired by Czech, Slovak and Austrian planners, as these three countries hope that through the DOEC they can improve their links to seas. Gradually, over the last twenty years, the concept of constructing a DOEC has shifted beyond constructing a waterway for freight cargo towards creating a multifunctional canal including claims that the canal can be used for water supply and recreational (tourism) uses as well. The route was accordingly designed to transfer water from Danube to the basins of Morava, Oder and Elbe Rivers. Analysis of data showed that discharges in Danube River were greatest during summer while discharges in other streams were at their minimum. As such, water could be transferred during summer period. The pumped discharge was fixed as 60 m$^3$/s (1.89 BCM/yr). The proposal was also planned in such way to integrate with several existing dams and other schemes could be used as integral parts of the DOE system. Thus total length of the proposed route of D-O-E is 499 km (Table 4.7).

![Figure 4.57 Danube-Oder-Elbe Canal](image)

<table>
<thead>
<tr>
<th>Waterway</th>
<th>Section (branch)</th>
<th>Length (km)</th>
<th>Difference of elevations to be overcome (m)</th>
<th>Number of locks</th>
<th>Average length of a pool (km)</th>
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<tr>
<td>D-O-E</td>
<td>Danube branch</td>
<td>194</td>
<td>73.8</td>
<td>9</td>
<td>21.6</td>
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<tr>
<td></td>
<td>Oder branch</td>
<td>145</td>
<td>143.0</td>
<td>9</td>
<td>15.9</td>
</tr>
<tr>
<td></td>
<td>Elbe branch</td>
<td>160</td>
<td>337.5</td>
<td>14</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>499</strong></td>
<td><strong>554.3</strong></td>
<td><strong>32</strong></td>
<td><strong>15.6</strong></td>
</tr>
</tbody>
</table>

Source: Website, Association Danube-Oder-Elbe

The total time necessary for the completion of all stages cannot be stated explicitly. This period need not to be particularly long. At the beginning of the 20th century the above-mentioned Waterways Law foresaw the period of 20 years for the construction of the whole Austrian network (in which the
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D-O-E Link represented a part only). Before World War II the agreement between the Czechoslovak Republic and Germany calculated with 6 years for the Danube-Oder Link. Modern technology could surely shorten these time limits. The progress and speed of the construction works again will be closely connected with the extent of financial sources and with the attainable cash flow. As, the majority of works will be concentrated on the territory of the Czech Republic, the official attitude of the state will also play to some extent the decisive role for the date of commencement of the works.

Various stakeholders, NGOs including WWF are having the view that the negative social, environmental, economical and ecological impacts from the proposed transport route be significantly evaluated not only against other existing transport media but also against the possible alternatives options available for D-O-E (Position Paper DOEC, 2003).

Most recently, the idea of a DOEC was resurrected in the framework of accession of the post-communist Central and Eastern European(CEE) Countries to the European Union and the extension of the EU’s TEN-T to CEE. Though the DOEC has not been included into currently revised TEN-T priority list, it has been embodied in the EU Accession Treaty and the pro-canal lobby believes it will convince the European Countries(EC) to put forward funding for the DOEC scheme.

4.3.11 Great Britain

Great Britain comprises England (130,365 km\(^2\)); Wales (20,761 km\(^2\)); and Scotland (78,772 km\(^2\)) on the island of Great Britain. The estimated population of Great Britain is 60.2 million (UN, 2007), out of which about 10.5% is engaged in agricultural activities.

Two centuries ago, entrepreneurs of the industrial revolution in Britain understood the potentiality of inland waterways for transporting goods. They interlinked inland waterways with quarries, factories, market places and ports. The so formed British Canal network was then put in use as a mode for carrying industrial goods cheaply and efficiently. But the mode is now largely used for recreational purposes.

British Canal Network

By 1805, British canal network extended to about 4,830 km linking many of the country’s natural river system. The Midlands were the birth place of British canal network. The main canals constructed during these period, namely Grand Union, Shropshire Union, Trent and Mersey, Staffordshire and Worcester, Worcester and Birmingham and Macclesfield canals all bisect the Midlands area linking the River Trent near Nottingham with the River Severn at Worcester and the River Nene near Northampton.
Brief descriptions about British Canal constructed during and after the industrial revolution are given in the following paragraphs.

**Bridgewater Canal**

The Bridgewater Canal is the first major British canal, which was constructed during the period 1759-61 for the 3rd Duke of Bridgewater to carry coal from his collieries to Manchester. The engineer James Brindley, overcame great difficulties in the route. By 1761, it had opened as far as Stretford, and was extended to the Cornbrook wharf in Manchester by 1763. The canal, which was sold to the Manchester Ship Canal Company in 1887, continued to be used for goods traffic until the mid-1970s.

**Forth and Clyde Canal**

Forth and Clyde Canal is located in central Scotland, joining the River Forth to the River Clyde. It flows east for 60 km, from Grangemouth on the Forth to Bowling on the Clyde, and divides Scotland at its narrowest part. The canal was completed in 1791 and closed to navigation in 1963.

**Rochdale Canal**

Rochdale Canal runs from Sowerby Bridge in West Yorkshire, England, to the Bridgewater Canal in Manchester. Opened in 1804, it uses the lowest pass through the Pennines. Its banks are lined with factories, many of them in ruins; it is now closed to navigation.

**Crinan Canal**

Crinan Canal is located in Argyll and Bute unitary authority, Scotland, linking Loch Fyne and the Firth of Clyde to the Sound of Jura and the Minch. Completed in 1801, it replaced the long sea-passage around the Mull of Kintyre. The canal is only 7 m wide, too narrow and shallow for heavy commercial traffic. Pleasure cruisers, and a few fishing boats continue to navigate its waters.

**Kennet and Avon Canal**

Kennet and Avon Canal is located in South-West UK linking the Thames at Reading with the Avon at Bath, a distance of 145 km. Designed by Scottish engineer John Rennie, the canal was built 1810, closed in the 1950s, and reopened in 1990 after decades of dereliction. The Kennet and Avon is an impressive feat of engineering, made up of two river navigations and a linking stretch of canal.
4. Country wise experiences

**Caldonian Canal**

Caldonian Canal in northwest Scotland, 98 km long out of which 37 km stretch is artificial and the rest being composed of lochs Lochy, Oich, and Ness. It links the Atlantic and the North Sea. Situated between the Moray Firth and Loch Linhe, the canal was constructed as a transport route to save the long sail round Scotland. It is one of Scotland’s largest marina facilities. Thomas Telford began construction of the canal in 1803 and it was completed by 1822.

**Manchester Ship Canal**

Manchester Ship Canal links the city of Manchester with the River Mersey and the sea; length 57 km, width 14-24 m, depth 9 m. It has five locks. The canal was opened in 1894. The canal transformed Lancashire’s economy and led to the development of the cotton industry as raw cotton was transported east along the canal to Manchester and the finished textile products were shipped west to the Merseyside ports. Although the area has suffered industrial decline, the canal is still in effect in the ‘port of Manchester’, handling approximately 16 million tons per year.

**Grand Union Canal**

Grand Union Canal is part of the eastern portion of the canal system of Great Britain, connecting London, via Northampton and Leicester, to Nottingham and the River Trent. The Grand Union Canal leaves the River Thames at Brentford and climbs over fifty locks up into the Chiltern hills goes through some beautiful scenery, especially through the partly 17th century Cassiobury Park and towns Stoke Bruerne and Braunston. It descends then climbs again to a new summit in Birmingham, 220 km and 166 locks. The Leicester section branches north at Braunston and climbs a little less steeply before falling to join the River Soar, which flows into the River Trent. It has 59 locks and is 66 miles long. The Paddington Arm and Regents Canal in London go close to the city centre, through Regent’s Park and London Zoo to meet the Thames again at Limehouse Basin.

There are long tunnels at Blisworth and Braunston. The line into Birmingham goes through Royal Leamington Spa, fashionable in Victorian times and Warwick, famous for its medieval buildings and castle. The canal was opened in 1900 but suffered from mechanical and structural problems and the locks were reopened in 1908.

**Stratford-Upon-Avon Canal**

Stratford-Upon-Avon Canal runs for just 40 km from the Birmingham suburbs to the River Avon in Stratford on Avon. Although the canal is fairly short it goes through some enchanting countryside in
the very Heart of England. The canal initially suffered badly from railway competition and the lower section from Lapworth to Stratford became almost closed in the 1950’s. However there was a campaign to restore it for pleasure boating and it was taken over in 1960 by the National Trust. It was reopened after restoration work, much of it by volunteer labour, in 1964. This success gave impetus to many other restoration schemes and greatly increased interest in the use of canals for pleasure cruising.

*Lancaster Canal*

Lancaster Canal was built early on in the canal revolution but with a break between the northern section and the southern section due to the Ribble valley coming encurte. The canal was never profitable enough for the considerable engineering works, locks or aqueduct, which would have been needed to cross the deep valley. The southern section became part of the busy Leeds and Liverpool Canal but the isolated northern section became a backwater.

The canal is peaceful right through the year and the lack of locks makes it ideal for those who want a relaxing holiday. The canal was engineered by John Rennie, and the bridges and aqueducts are built on his usual massive classical scale. The five arched Lune Aqueduct is 201 m long and commonly accepted as one of the wonders of the canal world.

*Leeds and Liverpool*

Leeds and Liverpool canal with a length of 205 km is the longest canal in Britain. It links the North West seaport of Liverpool with the Aire and Calder Navigation at Leeds, forming a through route between the Irish Sea and the North Sea. The Leeds and Liverpool is a barge canal, built with locks 18 m long and 4.3 m wide, reaching a height of 148 m above sea level on the summit at Foulridge. The locks at the junction with the Bridgewater Canal allow boats to reach the narrow canals of central and southern England. A second branch links the canal at Burscough with the River Ribble via the small port of Tarleton.

*Llangollen Canal*

Llangollen Canal leaves the Shropshire Union Canal just north of Nantwich in rural Cheshire and climbs through deserted Shropshire farmlands to cross the border into Wales near Chirk. It then cuts through increasingly hilly countryside to finish alongside the River Dee tumbling out of Snowdonia, just above Llangollen. The 66 km long Llangollen Canal is the most beautiful canal in Britain.
Oxford Canal

Oxford Canal starts by the River Thames in Oxford and runs for 124 km, mainly through quiet rolling countryside, to near Coventry where it connects with the Midlands canal system. The Oxford Canal, built early on during the ‘canal mania’ period, is a contour canal following the contours around hills, rather than having cuttings and embankments like later canals. The course is very winding in places and often looks much more like a river. At one time it was the main transport route from the Midlands to the south of England and it is now one of the most beautiful and popular cruising canals.

Shropshire Union Canal

Shropshire Union Canal runs from the edge of urban Wolverhampton through some of the most underpopulated areas of England to the River Mersey at Ellesmere Port, about 97 km in all. The scenery is often quite dramatic, with sweeping views across to the Welsh Marches and the ancient Volcano ‘The Wrekin’. The northern end of the canal is at Ellesmere Port which was a transhipment port from canal to sea-going ships. The old docks now house ‘The Boat Museum’, which has a unique collection of ex-working boats and waterways exhibitions.

Staffordshire and Worcestershire Canal

Staffordshire and Worcestershire Canal leaves the wide River Severn at Stourport and potters along twisting river valleys and then through some remarkable sandstone scenery around Kinver. It skirts the edge of suburban Wolverhampton and then crosses the wide open farmland of Cannock Chase before joining the Trent and Mersey canal near the beautiful Tixall Wide. It is 74 km long with 45 locks.

Birmingham Canal

Birmingham Canal links the City of Birmingham to the Staffordshire and Worcestershire Canal and the start of the Shroshire Union Canal at Aldersley, just north of Wolverhampton. The Caldon Canal starts just south of Stoke on Trent and meanders into the Staffordshire countryside, running for short distance along the River Churnet. It has some extremely attractive stretches.

The city of Birmingham is making maximum regeneration use of the space and life that canals can bring into the heart of urban areas and building some stunning waterside developments.
The British waterways Systems were brought into public ownership in 1947 as a part of the national transport system. The Transport Act 1962 and 1968 set-up British Waterways in its present form and recognized the leisure potential of waterways systems. The British Waterways Act 1995 provides British Waterway’s heritage and environmental duties and the code of practice and procedure to developers, local authorities, statutory undertakers and their consultants when carrying out works for their purposes which affect the waterways. British Waterways is responsible for maintaining about 3,540 km of British network most of them are over 200 years old and works with the main aims:

- maintain and develop British’s inland waterways in a sustainable manner, so that they fulfill their full economic, social and environmental potential;
- fulfill statutory navigation functions;
- conserve waterways heritage and environment for the future;
- promote and enable rural and urban regeneration;
- maintain and enhance leisure, recreation, tourism and educational opportunities for the general public;
- facilitate waterway transport;
- play a lead role in coordinating other UK navigation authorities.

The British Waterways contains many ancient monuments, listed buildings and conservation areas including wildlife habitats, nature reserves, sites of special scientific interest, sites of local interest for nature conservation important and valued hedgerows, trees and woodlands and valuable fisheries. The waters contained in the canal are reasonably clean, and wildlife, people, and industry all depend on them remaining unpolluted. British Waterways has statutory duties to safeguard the environment. (British Waterways, 2005).
The vision of British Waterways by 2012 is that to create an expanded, vibrant, largely self-sufficient waterway network used by about twice as many people as today and making them as one of the nation’s most important and valued national assets. It also has the goals to delight the visitors with the quality of the experience and involve many active participants. Presently along the waterways are designed with routes/sports for boating, fishing, water sports etc including that for walking and cycling and stand as host of different activities to suit a variety of ages, budgets and fitness levels (Website, British Waterways).

4.4 Africa

Africa is the world’s second largest and most populous Continent, after Asia. It covers 6% of earth’s total surface area and is home for more than 900 million people. The Continent is characterized by complex patterns in the availability and distribution of water resources. The deserts, namely the Sahara and the Kalahari are covering respectively the northern and the southwestern parts of the Continent. Drought and desertification are regular cyclical phenomena in the Continent. At the same time the Continent, especially in its central rainforest belt across its width, is rich in annual precipitation and home to some of the largest river systems in the world.

Most of the fresh water resources of Africa are held in major transboundary river basins/lakes - some of them hold tremendous potential for various natural resources including cross-boundary hydropower generation, joint inland fishery development, joint water supply utilisation, environmental protection, wildlife conservation, recreation and eco-tourism development (United Nations Economic Commission for Africa, 2000). The main river basins/lakes in Africa are shown in Figure 4.56. The main features of the river basins/lakes are given at Table 4.8.
The average annual rainfall is 495 mm, ranging from less than 100 mm/yr in the western deserts to about 1 200 mm/yr in the eastern part of the country. Only 35% of the country has a precipitation of 500 mm or more, while 44% has a precipitation of 200-500 mm and 21% has a precipitation of less than 200 mm. South Africa is poorly endowed with groundwater too. It is mainly underlain by hard rock formations that although rich in minerals, do not contain any major groundwater aquifers, which could be utilized on a national scale. About 65% of the country does not receive enough water for successful rainfed crop production and hence, used as grazing land. Crops grown in this area are grown under irrigation. (FAO, 2005).
4. Country wise experiences

<table>
<thead>
<tr>
<th>No</th>
<th>Name of river basin/lake</th>
<th>River basin/lake area (km²)</th>
<th>Crop land (%)</th>
<th>Wet land (%)</th>
<th>Dry land (%)</th>
<th>Irrigated cropland (%)</th>
<th>Average population density (people/km²)</th>
<th>Number of dams on main stem of river (height in m)</th>
<th>Degree of river fragmentation</th>
<th>Countries within the river basin/lake</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Congo</td>
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<td>7.2</td>
<td>9.0</td>
<td>0.2</td>
<td>0.0</td>
<td>15</td>
<td>22,752</td>
<td>Medium</td>
<td>Angola, Burundi, Cameroon, Central African Republic, Republic of Congo, Democratic Republic of Congo, Rwanda, United Rep. of Tanzania, Zambia</td>
</tr>
<tr>
<td>2</td>
<td>Cuanza</td>
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<td>2.1</td>
<td>8.7</td>
<td>0.0</td>
<td>23</td>
<td>17,126</td>
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<tr>
<td>3</td>
<td>Cunene</td>
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<td>1,076</td>
<td>-</td>
<td>Ethiopia, Somalia, Kenya</td>
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<td>Lake Chad</td>
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<td>8.2</td>
<td>59.2</td>
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<td>7,922</td>
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<td>0.3</td>
<td>61</td>
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<td>0.9</td>
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<tr>
<td></td>
<td>River</td>
<td>Length (km)</td>
<td>Width at Mouth (m)</td>
<td>Area of Watershed (sq km)</td>
<td>Longest Flow Distance (km)</td>
<td>Flow (km³/year)</td>
<td>High Water at Mouth</td>
<td>Length of High Water (km)</td>
<td>Number of Deltaic Tributaries</td>
<td>Number of Deltaic Estuaries</td>
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<td>-</td>
</tr>
<tr>
<td>17</td>
<td>Senegal</td>
<td>419,575</td>
<td>4.8</td>
<td>3.6</td>
<td>95.4</td>
<td>0.0</td>
<td>10</td>
<td>5,775</td>
<td>High</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>Shaballe</td>
<td>336,604</td>
<td>7.1</td>
<td>1.8</td>
<td>90.9</td>
<td>0.5</td>
<td>29</td>
<td>1,700</td>
<td>Low</td>
<td>-</td>
</tr>
<tr>
<td>19</td>
<td>Volta</td>
<td>407,093</td>
<td>10.4</td>
<td>4.6</td>
<td>91.7</td>
<td>0.1</td>
<td>43</td>
<td>2,054</td>
<td>High</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>Zambezi</td>
<td>1,332,412</td>
<td>19.9</td>
<td>7.6</td>
<td>31.9</td>
<td>0.1</td>
<td>18</td>
<td>10,000</td>
<td>High</td>
<td>12</td>
</tr>
</tbody>
</table>

2. FAO, Irrigation in Africa: AQUASTAT Survey 2005
3. International River Basins Register (August 2002)
4. Country wise experiences

Table 4.9 shows that some of the river/lake basins of Africa are shared by as many as 10 countries. Integrated development of the resources available in these rivers/lake basins will require a strong cooperation among the riparian countries. African leaders recognized these needs as early as 1960s and 1970s, soon after most of the African countries obtained their independence. As a result, a number of inter-country cooperation mechanisms/criteria have been framed in African regions for inter regional water resources development. IBWTs that fit in the criteria as formulated before are existing or proposed in the following countries: South Africa, Morocco, Libya, Lesotho, Sudan, Tanzania, Nigeria and the Republic of Congo and alongwith detailing under Annex 2 will be described in the next subsections.

4.4.1 South Africa

South Africa is located at the southern tip of African Continent. It is bordered by Botswana and Zimbabwe to the North, Mozambique and Swaziland to the North-East and East, the Indian Ocean to the South-East and South, the Atlantic Ocean to the South-West and West and Namibia to the North-West. South Africa has an area of 122.1 Mha with an estimated population of 48.6 million (UN, 2007), of which about 41.3% is engaged in agricultural activities.

Water requirement and resource potential of South Africa

Based on the meteorological characteristics, South Africa is subdivided into seven drainage regions, namely: Northern region, Eastern Inland Region, Easter Coastal region, Southern Coastal Region, South Western Region, Karoo Region; and Central Region (Management of the Water Resources of South Africa, 1986). Water use in all the regions of South Africa is dominated by irrigation, utilizing about 62% of the total water use, most of which is used for production of fodder crops, wheat, maize, sugarcane, vegetables, fruits and pulses, and consumption of commercial afforestation /environment requirements. The domestic rural (5%) and urban (27%) use of water constitutes about 32% of the total usage, which is large in magnitude when compared to the usage of about 6% towards mining and industrial units, outside the municipal areas (FAO, 2005).

With respect to water resources, South Africa has no major rivers of a globally comparative scale. The average total surface runoff in all South African rivers is about 50 BCM (Management of the Water Resources of South Africa, 1986). Furthermore, most of the larger rivers draining through the country are shared by one or more neighbouring states. Water resources management and utilization in South Africa is
thus strongly interdependent on the needs and activities of these countries. Most of the main metropolitan and industrial growth centers, which have developed around mineral deposits and harbour sites, are situated far away from the major river courses of South Africa. Some of the irrigation developments in the country are also located in sub-optimal regions with respect to water use efficiency, having been established during times, when water was still relatively abundant. Efforts have then been initiated to maintain a balance between supplies and needs through developments of Inter Basin water transfer (IBWT) schemes for conveying both raw and potable water from areas of surplus to areas of deficit. The Tables 4.9 and 4.10 show the water requirements and resource potentials of South Africa (Basson et al., 1997).

Table 4.9. Reconciling annual water requirements and resource potential of South Africa

<table>
<thead>
<tr>
<th>Region</th>
<th>Maximum yield (MCM)</th>
<th>1996 – water requirements (MCM)</th>
<th>Net inter-regional transfer* (MCM)</th>
<th>1996–surplus available (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>2,566</td>
<td>3,373</td>
<td>957</td>
<td>150</td>
</tr>
<tr>
<td>Eastern Inland</td>
<td>4,834</td>
<td>2,320</td>
<td>-273</td>
<td>2,241</td>
</tr>
<tr>
<td>Eastern Coastal</td>
<td>13,199</td>
<td>5,604</td>
<td>-680</td>
<td>6,915</td>
</tr>
<tr>
<td>Southern Coastal</td>
<td>1,793</td>
<td>1,768</td>
<td>643</td>
<td>668</td>
</tr>
<tr>
<td>South Western</td>
<td>3,095</td>
<td>2,396</td>
<td>10</td>
<td>709</td>
</tr>
<tr>
<td>Karoo</td>
<td>6,014</td>
<td>2,555</td>
<td>-934</td>
<td>2,525</td>
</tr>
<tr>
<td>Central</td>
<td>1,789</td>
<td>2,029</td>
<td>277</td>
<td>37</td>
</tr>
<tr>
<td>South Africa**</td>
<td>33,290</td>
<td>20,045</td>
<td>-</td>
<td>13,245</td>
</tr>
</tbody>
</table>

*A negative value indicates a net export from the region ** Includes Lesotho and Swaziland

Figure 4.61 Drainage regions of South Africa
4. Country wise experiences

Existing schemes

Considering the water requirements and the needs for water augmentation of various rivers of the region, many schemes of IBWT nature have been completed (Basson et al., 1997 and Muller, 1999).

The four most economically developed countries in South Africa, namely, the Republic of South Africa, Botswana, Namibia and Zimbabwe are the most water stressed countries in the region. However, these countries are able to achieve economical developments in their region through sharing of water resources between international river basins such as Orange and Limpopo and a number of other basins with co-riparian states in a complex web of interdependence (Anthony R. Turton, 2002).

Table 4.10. Annual water requirements of South Africa in 1996

<table>
<thead>
<tr>
<th>Region</th>
<th>Urban and domestic (MCM)</th>
<th>Mining and industrial (MCM)</th>
<th>Irrigation and afforestation (MCM)</th>
<th>Environmental (MCM)</th>
<th>Total (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>704</td>
<td>433</td>
<td>1,861</td>
<td>375</td>
<td>3,373</td>
</tr>
<tr>
<td>Eastern Inland</td>
<td>150</td>
<td>44</td>
<td>1,826</td>
<td>300</td>
<td>2,320</td>
</tr>
<tr>
<td>Eastern Coastal</td>
<td>508</td>
<td>589</td>
<td>2,217</td>
<td>2,290</td>
<td>5,604</td>
</tr>
<tr>
<td>Southern Coastal</td>
<td>137</td>
<td>41</td>
<td>1,350</td>
<td>240</td>
<td>1,768</td>
</tr>
<tr>
<td>South Western</td>
<td>351</td>
<td>105</td>
<td>1,350</td>
<td>370</td>
<td>2,396</td>
</tr>
<tr>
<td>Karoo</td>
<td>65</td>
<td>10</td>
<td>2,173</td>
<td>307</td>
<td>2,555</td>
</tr>
<tr>
<td>Central</td>
<td>256</td>
<td>376</td>
<td>1,347</td>
<td>50</td>
<td>2,029</td>
</tr>
<tr>
<td>South Africa**</td>
<td>2,171</td>
<td>1,598</td>
<td>12,344</td>
<td>3,932</td>
<td>20,045</td>
</tr>
</tbody>
</table>

Proposed schemes

With the expected growth in water requirements assuming that current development trends and usage patterns prevail, it has been estimated that the country’s water resources will be fully utilized in about three decades. The growth in water requirements will essentially be in the domestic and industrial sectors, accepting the earlier assumption of limited further development in irrigation due to the foreseen shortage of water. A possible scenario for the utilization of surface water in South Africa around 2030 as assessed by Department of Water Affairs and Forestry, South Africa is given in Tables 4.11 and 4.12 (Basson, Niekerk and Rooyen, 1997).

It is evident from the projected details that the full utilization of water resources was reached and even exceeded, in many parts of the country in 1996 itself. The inevitable looming scarcity is threatening the country’s future economy. Industrial growth, employment and water supply to a growing population would be at risk, if preventative action were not taken timorously. By considering the future options on
availability and utilization of water resources in South Africa, the available adoptable options for further development and management of water resources in regions are emphasized on water conservation techniques, re-allocation of water, re-use of water, virtual or embedded water, desalinization of sea water, shipping of fresh water, ice-bergs and IBWT schemes.

Table 4.11. Possible future (2030) annual water requirements in South Africa

<table>
<thead>
<tr>
<th>Region</th>
<th>Domestic (MCM)</th>
<th>Mining/industrial (MCM)</th>
<th>Irrigation/afforestation (MCM)</th>
<th>Environmental (MCM)</th>
<th>Total (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>1,977</td>
<td>641</td>
<td>2,467</td>
<td>477</td>
<td>5,562</td>
</tr>
<tr>
<td>Eastern Inland</td>
<td>570</td>
<td>89</td>
<td>2,209</td>
<td>300</td>
<td>3,168</td>
</tr>
<tr>
<td>Eastern Coastal</td>
<td>1,851</td>
<td>1,025</td>
<td>3,509</td>
<td>2,475</td>
<td>8,860</td>
</tr>
<tr>
<td>Southern Coastal</td>
<td>341</td>
<td>73</td>
<td>1,791</td>
<td>237</td>
<td>2,442</td>
</tr>
<tr>
<td>South Western</td>
<td>1,063</td>
<td>212</td>
<td>2,239</td>
<td>370</td>
<td>3,884</td>
</tr>
<tr>
<td>Karoo</td>
<td>109</td>
<td>80</td>
<td>2,173</td>
<td>307</td>
<td>2,669</td>
</tr>
<tr>
<td>Central</td>
<td>1,025</td>
<td>1,260</td>
<td>1,486</td>
<td>59</td>
<td>3,830</td>
</tr>
<tr>
<td>South Africa**</td>
<td>6,936</td>
<td>3,380</td>
<td>15,874</td>
<td>4,225</td>
<td>30,415</td>
</tr>
</tbody>
</table>

** Includes Lesotho and Swaziland

Table 4.12. Possible future (2030) scenario for annual water utilization

<table>
<thead>
<tr>
<th>Region</th>
<th>Maximum yield (MCM)</th>
<th>Water requirements (MCM)</th>
<th>Net international transfer* (MCM)</th>
<th>2030 surplus available (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>2,566</td>
<td>5,562</td>
<td>3,014</td>
<td>18</td>
</tr>
<tr>
<td>Eastern Inland</td>
<td>4,834</td>
<td>3,168</td>
<td>-500</td>
<td>1,166</td>
</tr>
<tr>
<td>Eastern Coastal</td>
<td>13,199</td>
<td>8,860</td>
<td>-2,580</td>
<td>1,759</td>
</tr>
<tr>
<td>Southern Coastal</td>
<td>1,793</td>
<td>2,442</td>
<td>750</td>
<td>101</td>
</tr>
<tr>
<td>South Western</td>
<td>3,095</td>
<td>3,884</td>
<td>70</td>
<td>-719</td>
</tr>
<tr>
<td>Karoo</td>
<td>6,014</td>
<td>2,669</td>
<td>-2,821</td>
<td>524</td>
</tr>
<tr>
<td>Central</td>
<td>1,789</td>
<td>3,830</td>
<td>2,067</td>
<td>26</td>
</tr>
<tr>
<td>South Africa**</td>
<td>33,290</td>
<td>30,415</td>
<td>-</td>
<td>2,875</td>
</tr>
</tbody>
</table>

*A negative value indicates a net export from the region **Includes Lesotho and Swaziland

**IBWT scheme from Zambezi River- South Africa**

The Zambezi River is one of viable river basins that is reasonably close and of sufficient size to serve as a source for transfer of water to South Africa. The technical feasibility of conveying water from the Zambezi River to South Africa has been established in broad terms through several relatively superficial academic studies. Zambezi river basins contains eight co-basin states, all with varying needs and ideals for utilizing the water from the Zambezi River. All of them must agree to the export of water to South Africa before this possibility can become a reality. Southern African Development Community (SADC), a region...
encompassing 12 countries, including Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe now focuses on the needful and efforts on expanding integrated approaches in water resources development and management in these regions are ongoing (Rodger L. Mpande, Michael Tawanda, 1998).

It is important for the planners and well-wishers of water sector to come close for determining whether or not these conflicts or problems are indeed inevitable or are amenable to form interventions, which are beneficial to the societies/sectors concerned (Hangula, 1993 and Peter Ashton, 2000).

4.4.2 Morocco

Morocco, located in the North-West tip of Africa. Strategically situated with both Atlantic and Mediterranean coastlines, but with a rugged mountainous interior has a total geographical area of about 44.7 Mha. Population of Morocco is 31.2 million of which about 41.7% is engaged in agriculture activities (UN, 2007).

The region is subjected to diverse climatic conditions. Rainfall is distributed unevenly across the landscape and it varies from 1,800 mm/yr in the northern part of the country to less than 200 mm/yr in the southern part. Insufficient rainfall and its uneven pattern cause frequent drought events in Morocco. Irrigated agriculture is fundamental to the economic and social development in Morocco. As a matter of fact, the history of water resources development in Morocco is linked to irrigation and agricultural development. Irrigation has the dominant share of total water resources developed in the country. Water for Municipal and Industrial (WMI) purposes is more important in some regions than in others and tourism is becoming another important sector in certain areas. In Morocco, there are mainly 8 river basins. Table 4.13 shows the source-wise pattern of water supply and sector-wise allocation of water resources across the river basins.

From Table 4.13, it can be seen that water supply and demand are in balance in two of the eight river basins. For the other basins, there is either a water deficit or surplus. Since the total surplus in three basins exceeds the total deficits in other basins, there is enormous scope for inter-basin water transfer as a mechanism for achieving regional water balance in Morocco (Mohammed Rachid Doukkali, 2005).

There are both past efforts and future plans for undertaking such water transfers from the surplus basins to the deficit basins. Small transfer schemes such as 0.30 Mm³ have already been implemented from the basin of Oum Er-Rabia to comparatively dry areas of Tensift basin, essentially to support the expansion of irrigated area in the latter. Similarly, 0.16MCM water also transferred from the two basins of Sebou and Oum Er-Rabia to the highly populated and deficit basin of Bou Regreg. This transfer is
obviously to support domestic water needs. Besides these transfers, additional water transfers are also under consideration for meeting the increasing future demands in various sectors; those include transfer from the surplus basin of Sebou. The details of these schemed transfers are shown in the basin map of Morocco (Fig 4.55).

Table 4.13. Supply and usage of water in eight basins of Morocco in 1990 (MCM)

<table>
<thead>
<tr>
<th>Basins</th>
<th>Supply of water</th>
<th>Demand for water</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface</td>
<td>Ground</td>
<td>Total</td>
</tr>
<tr>
<td>1.Loukkos</td>
<td>630</td>
<td>90</td>
<td>720</td>
</tr>
<tr>
<td>2.Moulouya</td>
<td>930</td>
<td>230</td>
<td>1,160</td>
</tr>
<tr>
<td>3.Sebou</td>
<td>1,690</td>
<td>350</td>
<td>2,040</td>
</tr>
<tr>
<td>4.Bou Regreg</td>
<td>310</td>
<td>250</td>
<td>560</td>
</tr>
<tr>
<td>5.Oum-er-Rbia</td>
<td>3,010</td>
<td>280</td>
<td>3,290</td>
</tr>
<tr>
<td>6.Tensift</td>
<td>880</td>
<td>850</td>
<td>1,730</td>
</tr>
<tr>
<td>7.Souss-Massa</td>
<td>300</td>
<td>590</td>
<td>890</td>
</tr>
<tr>
<td>8.South of Atlas</td>
<td>710</td>
<td>290</td>
<td>1,000</td>
</tr>
<tr>
<td>Total</td>
<td>8,460</td>
<td>2,930</td>
<td>11390</td>
</tr>
</tbody>
</table>

+ indicates surplus basin - indicates deficit basin

Figure 4.62. Basin map of Morocco
4. Country wise experiences

Existing scheme

Beni Moussa Scheme

From Oued El Rbia River to Tensift River 1.51 BCM for irrigation.

Al Wahda Scheme

Al Wahda dam on the Ouerga River in the Sebou basin with a storage capacity of more than 3.8 BCM is completed in 1996 and is Morocco’s largest dam and second largest dam in North Africa, after the Aswan High Dam in Egypt. It provides water for 100,000 to 110,000 ha in the Gharb plain and hydroelectric output of 240 megawatts (MW) per year. It has the capability of reserving one billion m$^3$ of storage capacity for flood protection. The Al Wahda dam is also designed to transfer 770 MCM per year to Moulouya basin. Out of the total transfer of 770 MCM, 470 MCM is for domestic and industrial consumption to the Casablanca metropolitan areas and 300 MCM for irrigation of the areas located between Rabat and Casablanca in the water deficit basin of Moulouya (World Bank, 1995).

Proposed scheme

Morocco is also coming up with near-term water strategy plans for smoothening water balances across basins, slowing depletion of nonrenewable groundwater resources, and improving overall efficiency of water infrastructure by strengthening water networks within intra and inter basins.

Guerdane PPP Irrigation scheme

In 2004, the Government of Morocco has chosen a highly competitive and transparent bidding process with a private partner for a Public Private Partnership (PPP) Irrigation scheme in the citrus growing area of Guerdane Taroudant province (Ahmed Badawi Malik, 2004).

The Guerdane scheme is the first PPP Irrigation scheme in the world. The bid for the PPP Irrigation scheme was won by the consortium led by Omnium Nord-African (ONA), a Moroccan Industrial conglomerate. As a part of the contractual obligations, the ONA consortium will enter into a 30-year concession for the construction, co-financing and management of the Guerdane irrigation network. The International Finance Corporation (IFC), the private sector arm of the World Bank Group with the support
of a technical assistance grant from France’s FASEP – provided the government the advice on structuring and implementing the Guerdane PPP Irrigation scheme to deliver a high quality, accountable, and financially and environmentally sustainable public service to the end users. It is estimated that the Guerdane scheme will command an area of 10,000 ha by covering about 670 farmers, mainly growing citrus crops with high value added for the export market using high standards of cultivation and operation techniques. It is hoped that more than 100,000 people will earn their living, directly or indirectly from the Guerdane scheme.

Currently the proposed area is drawn water from the Souss ground aquifers using private wells. Due to over exploitation of the groundwater, pumping in the region is now at depths between 90 and 200 metres. Farmers have started to abandon their crops due to exhaustion of their wells or the high cost of pumping. To remedy this problem, the Government has decided to allocate 45 MCM of surface water-originating from the Aoulouz-Chakoukane complex with two dams in Tensift basin, located 70 km upstream of the Guerdane command, through implementation of the proposed Guerdane scheme. This water transfer is intended to satisfy half of the Guerdane’s irrigation needs and the other half from groundwater sources. The Guerdane scheme consists of construction and operation of a 70 km long water conduit infrastructure along with a 300 km irrigation network. The investment cost of the scheme is estimated to be about US$ 85 million. To finance this, public partnership is envisaged. The Government will provide roughly half of this amount, US$ 50 million – half as a loan and half in grant form. Farmers are expected to pay about 7% through one-off connection fees and the concessionaire will have to pay about 43% of the overall cost. (Working Group on Financing Water for Agriculture, 2006).

Along with the planning and implementation of new schemes, Morocco assesses cost-economy parameters of water development schemes based on its technical feasibility. As a part of integrated development of water resources in Morocco, the government conducted a study on transportation costs of water that vary with mode of transportation (open-air canal, pipes, etc), capacity of transport, and distance.
4. Country wise experiences

A study on inter-basin transfers forecast for transportation costs of conveyance system alone has shown costs between 0.005 and 0.01 DH/m³/km. While on the basis of international experience, the most advanced techniques combined with using cheap energy could lead to a water cost close to 8 to 9 DH/m³ (around US$ 1 per m³), which is significantly less than 13.5 DH/m³ estimated by the Government of Morocco. At the same time the expected cost of inter-basin transfer of conventional water resources in case the Sebou-Casablanca transfer through Al Wahda scheme is found to be at 3.5-4 DH/m³. Although these costs may seem insignificant, water costs are prohibitive with regards to transportation costs, for any but domestic use when the distance surpasses 50 or 100 km and is considered that the continuous reduction in desalination costs due to technological progress may encourage a re-examination of desalination as a source of potable water for meeting the growing demands (Kingdom of Morocco, Water Sector Review, 1995).

4.4.3 Libya

The North African States of Libya is the fourth largest states in Africa and is one of the driest regions of the world. With a Mediterranean coast line of approximately 1,820 km in length, it is bordered by Egypt to the East, Sudan to the South East, Chad and Niger to the South with Algeria and Tunisia to the West and North-West respectively. The total geographical area of 176 Mha with an estimated population of 6.2 million of which about 10% is engaged in agricultural activities (UN, 2007).

The annual rainfall in Libya is ranging from just 10 mm to 500 mm. Only about 5% of the entire area of Libya exceeds with the 100 mm rainfall annually. Evaporation rates are also high ranging from 1,700 mm in North to 6,000 mm in South (Omar Essamin and Mark Holley, 2004). Since Libya is a desert country, finding fresh water has always been a problem and government’s priority ever since. During
1950s ways for findings oil exploration fields had revealed vast aquifers beneath Libya’s Southern Desert. According to the radiocarbon analysis, some of the water in the aquifers was 40,000 years old. Libyan’s call it as ’Fossil Water’.

**Existing/proposed schemes**

**Great Man-Made River Project**

Libya decided that the cheapest option would be to construct a network of pipelines to transport fossil water revealed from the desert to the coastal cities, where over 90% of the population live, rather than going for the other available options of desalination or transporting water from Europe. As per the plan, water is extracted in well fields and conveyed to the coast through 4 m diameter pre-stressed concrete cylinder pipes. By considering the size of the pipes and the amount of water they convey over thousands of kilometres, the scheme became known as The Great Man-Made River Project (GMMRP) (Figure 4.65).

**Figure 4.65. The Great Man-Made River scheme**

In August 1984, a foundation stone was laid for the pipe production plant at Brega. This was the beginning point for GMMRP. The world’s largest Pre-stressed Concrete Cylinder Pipe (PCCP) scheme is owned and operated by the Great Man-Made River Authority (GMRA). The scheme as per the conceptual plan in 1984 include almost 4,000 km PCCP with diameter 4 m, transporting more than 6.5 MCM of water every day from aquifers in the desert area to the coastal regions. The total cost of the scheme is about US$ 25 billion.

The scheme is planned to be implement in four phases (Figure 4.61). The phase I includes Sarir-Sirt/Tazerbo-Benghazi (SS/TB) conveyance and consists of two lines for conveying 2 MCM/day of water from the well fields in Sarir and Tazerbo to the end reservoirs at Sirt and Benghazi. The total length of PCCP is 1900 km, the majority of the pipes being 4 meters diameter. The system is designed to ultimately
4. Country wise experiences

carry a flow of 3.5 MCM/day in the future, with the additional water being drawn from a well field at Kufra. The Phase I scheme is completed and under operation.

![Figure 4.66 Field picture showing the PCCP line lying for GMMRP](image)

Phase II of the GMMRP involves conveying 2 MCM of water from well fields at East Jabal Hasouna and North East Jabal Hasouna to Tarhouna and Tripoli. 287 production wells at the East Jabal Hasouna well field will produce 1.4 MCM of water per day and 153 production wells at North East Jabal Hasouna will produce a total of 0.6 MCM/day. This phase is under operation.

Phase III the Gardabiya-Sedada system will link phase I and phase II enabling bi-directional flow. The phase is under construction. The future phases as listed below will come under Phase IV:

- the Kufra-Tazerbo System, which will add 1.5 million cubic meters per day to the Phase I conveyance from 285 wells in Kufra;
- Jaghboub-Tobruk System, which will supply Tobruk and the eastern coast of Libya with 50 Mm$^3$/yr of water for domestic use from 47 wells in Jaghboub. Exploratory wells are being drilled in Jaghboub to determine the optimum location of the wellfield;
- Gedames-Alzawia System, which will have a total production of 90 Mm$^3$/yr from 144 wells in Gedames.

The Grand Omar Mukhtar Reservoir, which is under construction at Suluq as a part of the GMMRP will be the Libya largest man-made reservoir. Libya completed the work to-date without taking financial support from any major countries or loans from the World Bank. Since 1990, UNESCO has provided training to engineers and technicians involved with the scheme (John Watkins, 2006).
Steps adopted for management and monitoring of the scheme

In August 1999, the GMRA experience its first pipe failure in the Sarir-Sirt (SS) line conveyance system. A second failure was again observed after a month later on the parallel Tazerbo-Benghazi (TB) line. Three more failures also observed between September 1999 and April 2001. The investigations conducted thereon proved that the failures were caused by chloride-induced corrosion of the pre-stressing wire. The Authority undertook and extensive survey of the conveyance systems by using traditional techniques firstly such as sounding and extended to electro-magnetic inspection techniques in 2000. The extent of the problem was established and found to affect only some of the uncoated pipes used in the conveyance systems. The SS/TB conveyance system consist of 60% uncoated pipes and 40% coated pipes. These were coated with coal tar epoxy and used in the areas, which are originally deemed as corrosive in character.

The other challenge the authority faced was regarding rehabilitation of the conveyance whilst maintaining the interrupted flow of water to the consumers. This objective was particularly critical because the GMMRP accounts for almost 90% of the domestic water supply for the entire population of over one million of the coastal region from Sirt to Benghazi.

A crash program was implemented to repair only the most severely de-stressed pipes both on the SS and TB lines. This was undertaken over a period of almost 2 years from November 2001 to September 2003. In addition to this, automatic acoustic monitoring system was also implemented in order to closely monitor the rate of deterioration of pipes that had not been removed.

The inter-connected Data Acquisition System (DAS) and the Wireless Communication System (WCS) help to evaluate, analyse and establish a rate of deterioration model that is to be used as an integrate part of the Pipe Risk Management System (PRMS) of the GMMRP. The PRMS of the GMMRP is expected to play a major role in the future management and monitoring of the various phases of the GMMRP.
4. Country wise experiences

Benefits accrued to Libyans through GMMRP, as per their own assessment:

- the water made available through the scheme changed the lifestyles of Libyans;
- the use the fossil water for agriculture production was first of its kind in the country;
- new areas of about 130,000 ha will be irrigated to grow crops of domestic markets;
- Libya plans to make inroads into European and Middle-Eastern markets and to set up an organic grape farm near Benghazi;
- the pipe factory set up at Brega produces more than half a million 4 m pre-stressed concrete cylindrical pipes;
- Libya is able to attain world leadership in hydrological engineering and export its expertise to other African and Middle Eastern countries facing the same problems.

The combination of water and oil has given Libya a sound economic platform. Ideally placed as the Gateway to the Africa, Libya is in a good position to play an increasingly influential role in the global economy. However, there are certain raised questions on the surety of how long the water will last without taking any replenishment measures for the aquifers.

4.4.4 Lesotho

Lesotho is a small land locked mountainous country completely surrounded by the Republic of South Africa. It has a total area of 3.0 Mha. The country has 2 million inhabitants (UN, 2007), of which about 65% is engaged in agricultural activities.

Lesotho is divided into four geographical regions, which are the mountain region (59%), the foothills region (15%), the lowland region (17%) and the Senqu Valley (9%). The cultivable land is largely confined to the lowlands and foothills on the Western border and the Senqu River valley in the South. Mean annual rainfall is 788 mm and varies from less than 300 mm in the western lowlands to 1600 mm in the northeastern highlands.

Lesotho’s economy is dominated by the services especially in manufacturing sectors. Lesotho’s natural renewable water resources are estimated at 5.23 BCM/yr, which is far away from its water withdrawal of 43.6 MCM in 2000. In the same year, it was observed that industry was the main water user sector (50.5%) followed by the domestic sector (48.1%) and agriculture (1.4%). Development in Lesotho has been limited mainly because of lack of investment capital. Water is the only abundant resource, which is precisely what the neighbouring South Africa, is wanting for meeting the demands of the large cities such as Pretoria and Johannesburg, which are distantly located from water sources.
Existing/proposed schemes

Lesotho Highlands Water Scheme

The Lesotho Highlands Water schemes (LHWP) is an inter basin water transfer schemes between South Africa and Lesotho. The aim of the scheme is to divert part of the southwesterly flow of the Senque River in the highlands of Lesotho towards northwards through a series of dams and deliver tunnels to the Vaal River Catchment in South Africa (Wallis S., 1993). The water is primarily used for industrial activity in the Gauteng Province for the benefits of the cities such as Johannesburg and Pretoria. The scheme also includes construction of five large dams, underground transfer tunnels through the Maluti Mountains, a hydropower station and other inter-connected infrastructures. About 90% of the construction works (divided into 4 phases, span over to three decades) would be in Lesotho territory (Wallis, 2000).

The large-scale scheme is planned to take advantages of the geographic conditions of the regions of Lesotho and South Africa. Since Lesotho is situated at a higher altitude than the South Africa, the water is transferred by gravity and thus saving costs that would have been needed for pumping. In addition to this, creating dams at a high altitude with small surface area reduces evaporation losses, submergence area and consequent rehabilitation and resettlement problems.

Figure 4.68. Lesotho Highlands Water Scheme
4. Country wise experiences

The Lesotho Highlands Development Authority (LHDA) is responsible for implementation in Lesotho. It overlooks the delivery of water to South Africa as well as follow-up of local communities affected by the scheme and implementing approved water supply and electricity schemes (LHDA, 1996). South Africa’s Trans-Caledon Tunnel Authority (TCTA) is responsible for the implementation of the scheme in this territory on behalf of the Department of Water Affairs and Forestry (TCTA, 2003). The Lesotho Highlands Water Commission (LHWC) monitors the activity of the LHDA and TCTA. The LHWC is comprised of three representatives from both the countries of Lesotho and South Africa to have a better cooperation and coordination.

The first phase of the scheme has been completed and the planned water delivery system started in 1996. It consists of phase 1A and 1B. The phase 1A contains 185 m high concrete Katse Dam, Muela Power Station and a network of transfer and delivery tunnels. Phase 1B developed the Mohale Dam, Matsoku Weir and additional transfer tunnels (LHDA, 1996). A total of 70 m$^3$/s are to be transferred through the scheme out of which South Africa’s share is about 30.2 m$^3$/s through the first phase. In return, Lesotho receives royalty payments for the water transferred.

History of the LHWP

The talk on LHWP was begun in 1956 when a South African investigator proposed to divert water from the upper reaches of the Senque/Orange River in Lesotho. However, the original scheme was not materialized mainly due to South Africa’s unwillingness to buy water and electricity from Lesotho. Another reason was that Lesotho was not having the enough economic capacity to build the infrastructure by themselves and the participation of South Africa was indispensable for its implementation.

Because of its absolute and dire need, South Africa reconsidered this option in 1966. In 1968, both parties reached agreement in principle but negotiations broke off in 1970s over the royalty payment issue (Turton A.R., 2003). However, the feasibility studies were commenced early 1980s. In January 1986, there was a regime change in Lesotho. The military rule accelerated the negotiations for the LHWP. The agreement of LHWP was signed between the Government of the Republic of South Africa and Kingdom of Lesotho on 24 October 1986 and the scheme was taken up for realization subsequently.

The signing of the treaty in October 1986 paved two ways, (i) it made the beginning of the scheme implementation, and (ii) importance was given for fixing the responsibilities and the roles of the actors involved with the scheme. Accordingly, South Africa was made responsible for the payment of all capital costs needed for construction, maintenance and operation of the water transfers schemes as well as royalty payment to Lesotho for the water delivered. In return, the Lesotho was made responsible for the costs of
the hydropower plant and any ancillary developments attached to it. The Treaty 1986 only committed the two countries to the realization of the phase 1. The possibility of further development of future faces is subjected to future negotiations upon feasibility studies and reviews. The Treaty emphasizes the LHWP as a development scheme with a clearly defined set of goals (Turton, 2003).

The direct and indirect benefits of LHWP

The primary need for Lesotho and South Africa to implement the scheme was the direct economic benefits in both the regions. For South Africa, the LHWP was cheaper due to cost reduced by gravity flow (Mohamed, 2003). The Gauteng region that receives 30.2 m$^3$/s LHWP water for industrial and potable purposes accounts for 40% of the total output of the South Africa’s economy.

For Lesotho, its water has brought in a string of benefits. Royalty income is one of the supporting factors of its GDP. The construction of the scheme generated more employment opportunities. The road infrastructure created opened up access to the highlands that indirectly benefited the rural population who were otherwise cut off from the market centres earlier. Schools and clinics developed have also given a boost to the social upbringings. Subsequently, tourism has become more popular and foreign investors being attracted (Naho Mirumachi, 2004).

4.4.5 Sudan

Sudan is the largest country in Africa and has a special geo-political location bounding the Arab World to Africa, South of the Sahara Region. On the North-East, it is bordered by the Red Sea and it shares common borders with 9 countries, Eritrea and Ethiopia in the East, Kenya, Uganda and Democratic Republic of Congo in the South, the Central African Republic, Chad and the Libyan, Arab Jamahiriya in the West and Egypt in the North.

Sudan’s total geographical area is 250.5 Mha with an estimated population of 38.6 million, of which 52.8% is engaged in agriculture activities (UN, 2007). Most of the population live along the Nile River and its tributaries and some live around water points scattered around the country. Although endowed with rich natural resources, Sudan remains comparatively under developed.

The country experiences an average annual rainfall of 416 mm, which ranges between 25 mm in the dry North and over 1600 mm in the tropical rain forests in the South. Sudan shares the river basins of Nile Basin (79%) Northern Interior Basins (12.5%), Lake Chad Basins, (4%), North-East Coast Basins, (3.8%)
4. Country wise experiences

and Rufiji Valley Basin (0.7%). The Nile River, which is shared between 10 countries, is the primary source of Sudan’s water. Sudan entered an agreement with Egypt for sharing Nile water with the first Nile Water Agreement (NWA) that was signed in 1929. It allocated Egypt the right to use 48 BCM of Nile water/yr, while it gave Sudan the right to tap only about 4 BCM/yr. In 1959, the NWA between Egypt and Sudan assigned to Sudan 18.5 BCM/yr measured at Aswan Dam at the border with Egypt. Total water withdrawal in Sudan was estimated at 37 BCM for the year 2000 out of which the largest water user was agriculture sector with about 35.75 BCM (96.6%), while the domestic and industrial sector accounted withdrawals of about 0.99 BCM (2.7%) and 0.26 BCM (0.7%) respectively (AQUASTAT Survey, 2005). There is no existing IBWT scheme.

Proposed scheme

Jonglei Canal Scheme

The Jonglei Canal Scheme proposed between Bahr El Jevel and the White Nile was planned to divert water from upstream of the Sudd region to the point further down the White Nile by passing the Swamps so as to make more water available for use downstream in Egypt (Figure 4.69).

![Figure 4.69. Jonglei Canal Scheme](image-url)
The White Nile or Bahar El Jabel as it is known after leaving Lake Albert loses most of its flow in a vast swampy area, known as Sudd region (Ibrahim, 1978). The Sudd swamps are extensive about 600 km long and a similar distance wide. Since 1961, inflow to the Sudd has increased substantially, due to increased rainfall in the head waters around lake Victoria. The inflow was 26,831 BCM/yr prior to the year 1960, but from 1960 - 1988 it averaged to 50,324 BCM/yr (Hughes and Hughes, 1992). The wetland area consequently increased drastically.

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The Swamps and the floodplains of Sudd support a rich biota, including over 400 bird species and 100 mammals species. The annual flood of the region is capable of inundating more than 15,000 km² of land and was crucial to the maintenance of the biological diversity in Sudd. Plans have therefore, been envisaged for many years to divert the waters of the White Nile around the Sudd swamps via the Jonglei canal.

The primary objective of the first stage of the scheme was to ensure a flow of about 50 BCM annually, to be equally distributed between Egypt and Sudan and provide a model for similar water conservation initiative in other water needy areas. The first stage of the scheme included the digging of a canal with a bank to bank width of about 75 m, a channel bed-width averaging 38 m, a depth varying from 4 to 8 m and a total length of 360 km conveyance canal to connect between the regions of Sudan and Egypt. The Jonglei Canal scheme which is considered as one of the most important integrated schemes between Egypt and Sudan was started in 1980 and completed about 260 km of the total length of 360 km conveyance canal. The construction was halted in 1983 followed by the Sudanese Civil War (Mohammed Abdel-Ghani Sa’oudi, 2001).

If the Jonglei Canal were implemented, it would have brought advantages of shorter river communications between Khartoum and the main urban centre of the southern Sudan at Juba, in effect to reducing the length of the journey by about 300 km. The canal would also have brought communication routes as well as water to particularly remote parts of Sudan, which are inaccessible during the rainy season and largely abandoned in dry season. Passing points and berthing places were part of the design and would led to creation of small ports which were likely to develop and open up contact with the hinterland.

However, controversies and criticisms on the proposals still exist, which are mainly from the environmentalists. It is voiced that the Jonglei Canal would drastically affect climate, groundwater recharges, silt and water quality, the destruction of fish and changes in the lifestyle of the Nilotic people. At the same time, other studies conducted claimed that the positive effects would far outweigh the negative effects (FAO, 1997). Detailed socio–environmental impact assessment and their evaluation studies are proposed for further consideration for implementation (or abandonment in its totality).
4. Country wise experiences

4.4.6 Tanzania

The United Republic of Tanzania consists of the mainland and Zanzibar, which is made up of the islands Unguja and Pemba. Its total area is 94.5 Mha. The country is bordered in the North by Kenya and Uganda, in the East by the Indian Ocean, in the South by Mozambique and in the West by Rwanda, Burundi, the Democratic Republic of Congo and Zambia. The total population estimated is 40.5 million of which 58.5% is engaged in agricultural activities (UN, 2007).

Tanzania’s annual rainfall varies from 500 mm to 1 000 mm over most of the country. Total renewable water resources amount to 93 BCM/yr. Total water withdrawal in mainland Tanzania was estimated for the year 2002 to be 5142 MCM. Agriculture consumes the largest share with 4624 MCM (almost 90% of total) of which 4417 MCM for irrigation and 207 MCM for livestock, while the domestic and industrial sectors uses about 493 MCM (10%).

In Tanzania, the conflicts over water uses are exacerbated by increasing water demands due to rapid population growth and expanding economic activities. The lack of active community involvement in management of water resources, conflicting and weak institutional capacities both in terms of regulations and protection of interests of the poor, the lack of data and information to form policy and strategies for balanced water allocation and inadequate funds for operation and maintenance and expansion of water supply systems are recognized as constrains for bringing adequate water developments in Tanzania (Kashaigili et al., 2003, World Bank, 2002).

Renowned for some of the most beautiful beaches in the world the island of Zanzibar in Tanzania is a popular tourist destination however, while the quality of life for visiting tourists may be good, the living conditions for most Zanzibaris is stark. Most of the rural and urban communities in Zanzibar have long suffered from an inadequate supply of clean and safe water. The proposed Zanzibar Urban Water scheme is planned as a remedial measure for controlling the water scarcity crisis.

Proposed scheme

Zanzibar Urban Water scheme

Tanzania’s semiautonomous island of Zanzibar and the Japanese government signed an agreement on 7 June 2006 for a US$ 13 million three-year water supply scheme designed to boost provision of the
commodity in the island’s urban areas of Stone Town under JICA’s grant aid scheme (JICA, 2002).

Water supply for the majority of Zanzibar’s one million people had been free of charge for the past years. But the government recently amended the Water Act to enable it to charge consumers for water supplied, keeping in view of mutual benefits that can accrue from water developmental schemes. The new law allows the Zanzibar Water Authority (ZWA) to sell water to residents, most of whom experienced an acute water shortage due to drought that recently swept the East African region. The law prohibits pollution of waterworks or catchment areas and construction of buildings near such facilities. It imposes a prison term of six months to a year or a fine of $300 to $1,000 for those found guilty.

Boreholes, reservoirs and pipelines would be built under the Zanzibar Urban Water scheme Supply Development scheme. Currently, 49% of the rural population and 25% of the urban dwellers have no piped water. Stone Town, Zanzibar’s densely populated capital, is home to at least 450,000 people who require about 45 million litres of water daily. However, according to ZWA, the city currently receives 23 million litres daily. This situation needs to be changed before 2020, and water targets for Zanzibar are to increase access of urban populations to safe water from 75% to 95%, and from 51% to 60% for urban and rural population respectively by 2010.

4.4.7 Nigeria

Nigeria is located in the Tropical Zone of the West Africa and has a total area of 92.4 Mha. Nigeria is bordered to the West by Benin to the North-West and North by Niger, to the North-East by Chad and to the East by Cameroon, while the Atlantic oceans forms the southern regions of Nigerian Territory. Nigeria is the most populous country in Africa with its 148.1 million people accounting for about 1/7th of the total population of Africa of which about 44.2% is engaged in agricultural activities (UN, 2007). More than 50 million Nigerians suffer from a combination of diseases and mal-nutrition. The social and economical consequences of these are felt widely not only in health sub-sectors but also in agriculture services and human resources (FAO, 2005).

The country is well drained with a closed network of rivers and streams. There are four principal water basins in Nigeria and these are Niger Basin (63%), Lake Chad Basin (20%), the South Western Littoral Basins (11%) and the South-Eastern Littoral Basins (6%). Nigeria’s total annual renewal water resources are estimated at 286.2 BCM and for a withdrawal of 8 BCM for the year 2000 out of which 69% was for agriculture, 21% for domestic and 10.0% for industrial sectors. There is no existing IBWT scheme in Nigeria.
4. Country wise experiences

Proposed schemes

Gurara Water Transfer scheme

The Federal Government of Nigeria has developed the Gurara Water Transfer scheme to supply water to the city of Abuja, the federal capital of Nigeria. The scheme consists of Gurara Dam on Gurara River in Kaduna State of the country with a storage capacity of 850 MCM, and a 72 km long, 3 m diameter, welded steel pipeline to transfer about 1500 MCM annually. The pipeline will convey raw water by gravity from Gurara Dam to the existing Lower Usuma Dam near Abuja. The Gurara water transfer is being developed after giving consideration to all other feasible alternatives to bring water to Abuja. Abuja receives presently water from the Lower Usuma Dam and water shortages resulted in their inability to meet with the growing demands. The Dam upon completion will meet the water demands of Abuja city for the next 50 years expectedly (Wale Okediran, 2005). In addition to this, the scheme would facilitate a farming and agro-allied activities that would benefit the people of Kaduna and Niger states. Apart from increased food production and additional employment opportunities, about 30 megawatts of electricity would be generated and fed into the national grid from the scheme (Kimo Goree, 2003).

Various components of the scheme are currently under construction. A 3 m diameter 15 mm wall thickness closed conduit conveys water transfer. A pipe factory near to the scheme site by SCC (Nigeria) Ltd. Handles the manufacturing about 4,000 pipes required for the scheme, each with 18.1 m length.

Figure 4.70 Gurara Water Transfer scheme’s conveyance system

During the 2007 Budget Speech by His Excellency President Olusegun Obasanjo at the Joint Session of the National Assembly Abuja on 11 October 2006 mentioned that ‘the completion of the Gurara Water scheme for the supply of water to the residents of Abuja and its environs is accorded priority. Work is also at an advanced stage on the Gurara Water Scheme, which is expected to provide a
Komadugu - Yobe Scheme

The Komadugu-Yobe scheme is proposed for improving land and water resources in the Komadugu-Yobe Basin (KYB) including the Lake Chad Region. It is a joint initiative of the World Conservation Union (IUCN), Nigerian Conservation Foundation (NCF) and Nigeria Federal Ministry of Water Resources (FMWR) (Figure 4.68).

The Lake Chad provides a vital source of water to human, livestock and wildlife communities of the region. This lake is an extremely shallow one with an average depth of about 7 m. The lake, which is one of the largest fresh water lakes in Africa, has begun to shrink dramatically over the last 40 years. In addition, the vegetation of the North part of the Lake has disappeared and sand dunes have begun to fall on the dry lake bed. The lake shrinkage is reported due to the attributed combination of (i) dry up climate; (ii) growing human water demands; (iii) inadequacy of approaches to resource management in the Lake Chad region; (iv) absence of an integrated drainage basin management strategy and (v) inter-sector conflicts/disputes regarding usage of water resources within the lake regions.

To address the problems associated with the Lake Chad, a Lake Chad Basin Commission (LCBC), an inter-governmental agency was established on 22 May 1964 by inducting the Heads of the 4 riparian countries. As originally formed, the conventional basin covered 427,000 km² (Chad 42%, Niger 28%, Nigeria 21% and Cameroon 9%). In 1994, Central African Republic was admitted as the 5th Member State and coverage of the basin was also expanded to include the upstream areas of the Charii-Logone and
4. Country wise experiences

Komadugu-Yobe river basins, thereby increasing the Conventional Basin area of 966,955 km². Finally, Sudan was admitted as a member during the 10th Summit of the Heads of States, held on 28 July 2000. The admission of Sudan increased the conventional area of the lake to 1035,000 km² in 2000, which effectively covers the hydrologically actively part of the drainage basin.

The Nigerian sources contribute less than 10% to the overall waters of the Lake Chad. The affluent of the Lake Chad within Nigeria consists of the Komadugu-Yobe and the Ngadda and Yedseram systems. The systems encompass five states (Kano, Jigawa, Bauchi, Yobe and Borno (Roger Blench, 2004).

The KYB covers a total area of 14.8 Mha in Northeast Nigeria (95% of the basin area) and South-East Niger (5%). The basin is drained by two main rivers sub-systems, namely, the Yobe river and the Komadugu Gana or Missau. The KYB contains very important wetlands, in particular, the Hadejia Nguru Wetlands (HNWs), which has Nigeria’s premier Ramsar site. These regions are of immense local, national and international economic and ecological importance. Due to the semi-arid conditions, which are prevalent in the basin, scarcity of water has been, and continues to be, the major stimuli of the major development initiatives, which has placed the integrity of the KYB at risk. Presently substantial proportions of the available water sources that can be economically exploited have already been developed or are in the process of being developed. The estimated demand for water in the basin by formal users stands at 2.6 times of the available water. The situation is made worse by lack of reliable hydro-meteorological information on the basin. In addition, many development initiatives taking place in the upper reaches of the basin often penalize inhabitants of lower reaches of the basin, whose productive systems are highly dependent on the river flow. Furthermore, the basin area is densely populated with concentration mainly in dry land region making the water scarcity problems more severe. The management of the sources of the internationally shared water resources is therefore, important and is bearing on the diplomatic relationships between Nigeria and with other countries namely Niger, Chad, Cameroon and Central African Republic. These countries share the Lake Chad Basin in which is located the KYB sub-basin.

The proposed KYB scheme will start with an initial phase (Phase I) of two years and three months. The phase is embedded with the following main components:

- establishment and sharing of a sound knowledge base to facilitate stakeholder negotiations and inform decision-making;
- pilot testing of improved water management interventions in selected sites in the basin;
- development of a catchment management plan;
- adoption of a water management charter and establishment of the appropriate institutional framework for implementing agreed management principles;
- effective management of the KYB scheme.
The partners identified for realization of the scheme are the IUCN – West Africa Office (IUCN-BRAO), NCF, FMWR and the Lake Chad Basin Commission (LCBC). The possibility of incorporating other potential partners such as Department for International Development – Joint Wetlands Livelihoods (DFID-JWL) scheme, World Bank through the Fadama scheme, Food and Agriculture Organization (FAO) etc. are under consideration (Scheme Document – Abridged version, 2005).

The exact contribution of the Komadugu Yobe to Lake Chad is uncertain. The lack of co-ordination in management and utilization resulted in higher demand over available water, which leads to a tenuous competition for water between sectors and the regions. This is culminating in several instances into conflicts. The current situation in the basin calls for a fair and judicious allocation of water resources between competing sectors (irrigation, domestic, industrial, and the ecosystem water uses both upstream and downstream states and communities, including South-East Niger). It also calls for an integrated management of the land, water and living resources of the basin so as to promote their sustainable use, conservation and equity in access to them. The proposed KYB scheme addresses these needs.

4.4.8 Republic of Congo

The Republic of Congo (ROC) or known as ‘Congo’ borders Gabon, Cameroon, Central African Republic, Democratic Republic of Congo, Angola and the Gulf of Guinea. The Congo has a history, which is characterized by coups and a series of civil wars in the 1990s. The country continues to feel the effects of the war that ended in 2003, displaced millions of people and ravaged the economy. Although Congo is one of the largest oil producers in Africa, capable of allocating the resource for reconstruction, rehabilitation and reintegration, a large proportion of the population lives in poverty.

The Republic of Congo has a total geographical area of 34.2 Mha with population of 3.8 million (UN, 2007). The population is mainly urban, concentrated in the capital, Brazzaville, and the port city of Pointe Noire. The population engaged in agricultural activities is about 1.2 million, which is 31.6% of the total population. Food crop production is below the country’s consumption requirements, resulting in increased food imports (IRIN website, 2007).

The largest transboundary basins of the Central African Region (CAR) are the Congo (Africa’s largest river basin) and Ogooue river basins, and the internally draining Lake Chad basin. Rainfall and freshwater resources are unevenly distributed. The Congo Basin contains a wide diversity of freshwater habitats, including swamps, lakes and floodplains, and is an important livelihood resource. The Lake Chad
basin supports more than 20 million people and is among the most productive freshwater systems in Africa.

The average rainfall in the Congo River basin ranges from 1,200 mm/year in the North and South to more than 2,000 mm in the centre. Despite the relative abundance of water resources in most of the countries, rapid population growth and climate variability (with an increasing incidence of droughts over the past 30 years) have increased the pressure on the resources. Information and data remain a challenge for integrated development of the region. Several network schemes, such as the Waza Logone scheme of The World Conservation Union (IUCN), the Western and Central Africa Flow Regimes from International Experimental and Network Data (FRIEND) scheme of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the African Multidisciplinary Monsoon Analysis (AMMA) support data collection and analysis. There is great opportunity for expansion of irrigated agriculture.

The Congo River’s catchment area amounts to 3.7 million km², and total annual discharge is 1,269 BCM. The DRC, CAR, and the Congo fall within it. For the DRC, 98.7% of its land area falls within the basin; for Congo this is 72.2%; for the CAR 64.8%; and in Cameroon only 20.3%. There is huge potential for hydroelectric power generation on the Congo River. The Inga Hydroelectric Facility on the Congo River could play an important role in providing power to Central, Northern and Southern Africa, and even to Southern Europe (Encyclopedia of Earth website, 2007).

According to the Convention and the Statutes of the LCBC, its primarily responsibilities are to regulate and control the utilization of water and other natural resources in the basin; to initiate promote and coordinate natural resources development scheme and research within the basin area; and to examine complaints and promote the settlement of disputes and thereby promoting regional cooperation.

For many years, countries in the LCBC are taking steps to introduce water transfer schemes so as to effectively recharge the Lake Chad situated on the edge of Sahara Desert and revive it sufficiently to provide benefits to its user countries.

Proposed scheme

Water transfer from Congo River to Lake Chad

The 49th Session of the LCBC Council of Ministers held in Yaounde, Cameroon during 8-18 January 2002 emphasised the need to accelerate the feasibility study of the Lake Chad Restoration scheme involving water transfer from Congo to Lake Chad. The proposed IBWT scheme, still in conceptual stage envisages to moving about 900 m³/s (28.38 BCM) of water annually from Oubangui River in a navigable canal about 100-150 km in length. It involves construction of a dam at the donor basin at Palambo, which would
then be used to produce about 30 to 35 GWh of electricity, as well as improve navigation downstream of Bangui. This water supply, along with the oil to be produced in Chad, would contribute towards meeting the sub-regions energy requirements. The canal to be used to transfer water from the Oubangui also is expected to facilitate the transport of goods and services within the region. When there is enough water, irrigation will boost agricultural production, fishing as well as reforestation. It is also proposed that an area between 50,000-70,000 km² in the Lake Chad drainage basin would be put into extensive irrigation development as a result of this inter-basin water transfer scheme. Overall, it will provide an opportunity to rebuild the ecosystem, rehabilitate Lake Chad and reconstitute its biodiversity.

The LCBC, which is the most relevant international organization in regard to the sustainable use of Lake Chad, has submitted requests for funds to donor countries, both directly and through the New Partnership on African Development (NEPAD). It plans to begin the feasibility studies soon to examine the social, economic and environmental impacts of the proposed inter-basin water transfer scheme, once it is able to acquire about US$ 6 million required for the studies (Odada, et al., 2003).

4.5 Oceania

Oceania is the smallest Continent. The region combines all of Australia, New Zealand, Papua New Guinea, as well as the thousands of coral atolls and volcanic islands of the South Pacific Ocean, including the Melanesia and Polynesia groups. Oceania also includes Micronesia, home to about 2 million people, a majority of which (75%) live in rural areas.

The current water coverage status is relatively good in this region. The main river basins of Oceania are shown at Figure 4.69. Except for the Murray-Darling, most of the rivers are short and drain the eastern coast. The rivers of Oceania are fast-flowing and produce an average annual runoff of about 2,000 BCM. Details of the above mentioned five river basins of Oceania are given in Table 4.14.

In the Oceania region IBWTs as formulated before have been implemented or are in conceptual stages in Australia. The characteristics of these IBWTs will be described in next subsection.

4.5.1 Australia

Australia is the largest island Continent. The Continent is a federation of six states, namely, (1) New South Wales (NSW), (2) Victoria...
4. Country wise experiences

(VIC), (d) Queensland (QLD), (4) South Australia (SA), (5) Western Australia (WA), and (6) Tasmania (TAS). In addition to this, these are - two mainland territories, the Northern Territory (NT) and the Australian Capital Territory (ACT); and several small island territories. Apart from offshore marine environment, resource ownership is vested in the states and territories.

The total geographical area of Australia is 774 Mha with an estimated population of about 21 million out of which about 8% is involved in agricultural activities (UN, 2007). Australia is generally dry. About 80% of Australia receives an average annual rainfall lower than 600 mm and 50% lower than 300 mm, with the overall average being 450 mm. Less than 4% of the Continent has a rainfall higher than 1,200 mm per year (Australian Bureau of Statistics, 2001). Only a few areas near the coast receive enough rainfall. The main river basin of Australia is the Murray-Darling basin. Generally, the coastal region to which most of the perennial streams are confined is considered water surplus, whereas the inland region, which has a few rivers with intermittent flow is considered as water deficit.

![Figure 4.72. Main river basins in Australia (World Conservation Union et al., 2006)](image)

Existing scheme

The southeast region of the Australian Continent is divided by a mountain range, the Great Dividing Range, into a narrow coastal strip and a flat inland plain. About 90% of the population, however, is concentrated on the coastal region where most of the surface waters occur. Yet the coastal cities and towns including coastal irrigation schemes can use only a fraction of the total available water, which could be used inland. Accordingly, several inter-basin transfer schemes diverting easterly flowing waters of coastal river basins into semi-arid inland areas have been constructed during the early 20th century. While a number of relatively small IBWT schemes are constructed for urban water supply purposes, the largest
multi-purpose scheme by far is the Snowy Mountains Scheme (Figure 4.73).

The Snowy Mountains Scheme is located in southeastern Australia, providing water for hydropower and irrigation. It impounds the waters of the Snowy River and its tributaries, which flow eastward to the sea from the Snowy Mountains, Australia’s largest mountain range, and diverts them inland by long tunnels driven through mountains to the Murray and Murrumbidgee Rivers. In travelling through the trans-mountain tunnels, and shafts, the diverted waters fall through about 750 m, generating large quantities of electricity as they pass through a number of hydropower stations and into irrigation reservoirs west of Snowy Mountains. The scheme covers 825,000 ha of area. There are 135 km of tunnels, 7 power stations, a major pumping plant, 15 large dams and some 80 km of aqueducts.
### 4. Country wise experiences

Table 4.14. Details of various river basins of Oceanian Region

<table>
<thead>
<tr>
<th>No</th>
<th>Name of river basin/lake</th>
<th>River basin/lake area (km²)</th>
<th>Crop land (%)</th>
<th>Wet land (%)</th>
<th>Dry land (%)</th>
<th>Irrigated cropland (%)</th>
<th>Average population density (people/km²)</th>
<th>Water supply/person/yr (m³/yr)</th>
<th>Degree of river fragmentation</th>
<th>Number of dams on main stem of river (height in m)</th>
<th>Countries within the basin/lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>Burdekin-Belyando</td>
<td>146,219</td>
<td>2.2</td>
<td>0.3</td>
<td>73.6</td>
<td>1.3</td>
<td>1</td>
<td>239,338</td>
<td>-</td>
<td>1</td>
<td>0</td>
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<tr>
<td>111</td>
<td>Dawson</td>
<td>152,375</td>
<td>3.1</td>
<td>0.3</td>
<td>91.3</td>
<td>1.8</td>
<td>1</td>
<td>39,587</td>
<td>-</td>
<td>3</td>
<td>0</td>
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<tr>
<td>112</td>
<td>Fly</td>
<td>78,855</td>
<td>2.4</td>
<td>41.7</td>
<td>0.0</td>
<td>0.0</td>
<td>3</td>
<td>555,800</td>
<td>-</td>
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<td>0</td>
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<tr>
<td>113</td>
<td>Murray-Darling</td>
<td>1,050,116</td>
<td>28.4</td>
<td>3.4</td>
<td>80.7</td>
<td>1.6</td>
<td>2</td>
<td>11,549</td>
<td>-</td>
<td>116</td>
<td>1</td>
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<tr>
<td>114</td>
<td>Sepik</td>
<td>80,321</td>
<td>6.6</td>
<td>33.8</td>
<td>0.0</td>
<td>0.0</td>
<td>9.45</td>
<td>143,175</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source:
2. International River Basins Register (August 2002)
The construction work for the scheme commenced in 1949 and completed in 1974. The scheme has enabled the inland transfer of about 2.3 BCM/yr of water and generation of 3,750 MW of hydropower. It is implemented at a total cost of US$ 900 million (Johnson and Millner, 1978).

The Snowy Mountains Scheme comprises two principal components viz. between the rivers Snowy - Tumut and Snowy-Murray. The Snowy-Tumut transfer envisages:

- flows for Eucumbene River are diverted to upper reaches of the Tumut River, a tributary of Murrumbidgee;
- Upper Tooma River, a tributary of Murray is diverted to Tumut River and then to Murrumbidgee;
- the Upper Murrumbidgee River is diverted to Lake Eucumbene, the principal storage of the Scheme, and thence to Upper Tumut River, from where, it returns to Murrumbidgee River, some 360 km downstream of the original point of transfer.

The Snowy Murray transfer consists:

- transfer of Snowy River inland under the Great Dividing Range through a 15 km long Snowy-Geehi tunnel from a dam at Island Bend on the eastern side of the range to Geehi reservoir and Khancoban regulating pondage on the Swampy Plains River, a tributary of Murray River;
4. Country wise experiences

- A 23 km long Eucumbene Snowy Tunnel with Lake Eucumbene;
- collection of inflows below Eucumbene dam and Island Bend Pondage in Jindabyne dam and pumping into the Snowy-Geehi Tunnel and thereafter to the Murray.

The storage and regulation of the waters of the Snowy-Tumut, Upper Tooma and Upper Murrumbidgee Rivers in three large reservoirs (Lake Eucumbene, Jindabyne, and Tantagara) is an essential feature of the Scheme. The regulation afforded by these reservoirs makes possible an almost uniform output of electrical energy from the scheme, regardless of the inflow conditions. The scheme has made a significant contribution to the economic and social life of large number of rural and urban Australians.

With passages of time, various water quality deterioration issues and aspects regarding environmental and ecological degradations came as a challenge for the Murray-Darling Scheme. In June 1993, the Murray-Darling Basin Ministerial Council (MDBMC) initiated an audit of water use in the Murray-Darling Basin and completed in 1995 (MDBMC, 1995). It is indicated that the increasing transfers were reducing the security of supply to all users and exacerbating river health problems. Following further studies, the Ministerial Council decided to introduce an interim Cap on water transfers of the Basin’s surface water resources, limiting to the volume of water that would have been diverted under 1993-1994 levels of development. In December 1996, this was declared as a permanent Cap and made effective from 1 July 1997 onwards. Procedures have been put up in place for monitoring and reporting on compliance with the Cap.

The Cap Review identified progress in the related states and Australian Capital Territory and in 2002 the MDBMC directed the Murray-Darling Basin Commission to identify and address key issues such as equity, property rights and water trading for the River Murray. As a follow up:

- discussion paper entitled The Living Murray was released in 2002;
- sanctioned US$ 500 million in 2003 to address the over-allocation of water to consumptive use in the Murray-Darling Basin;
- decided to provide an additional flow augmentation of about 500 MCM of water per year over the next five years on an average basis to the river system at six key areas having important ecological assets;
- decided to collect water for the above purpose through on-farm initiatives, efficiency gains, infrastructure improvements and some purchase of water from willing sellers using the allocated budget of US$ 500 million in 2003.

The Council of Australian Governments (COAG) further created a National Water Initiative (NWI) Agreement and established a National Water Commission (NWC). The NWC will report to COAG and will assess progress in implementing the NWI Agreement and advice on actions required. The Commission will be funded by the Federal Government, and will be made up of seven members.
with relevant expertise, of whom four (including the Chair) will be appointed by the Federal Government and three by state/territory governments.

![Figure 4.74. Location of the six significant ecological assets for the Living Murray](image)

Key elements of the NWI Agreement:

- water access entitlements and planning framework;
- water markets and trading;
- best practice for water pricing and institutional arrangements;
- integrated management of water for environment and other public benefits;
- water resources accounting;
- urban water reform;
- community partnerships.

**Proposed schemes**

**Kimberley Pipeline Scheme**

Western Australia has significant volumes of surface and groundwater resources. The volume of water that can be feasibly and economically harvested is a fraction of the total available resources (Water and Rivers Commission, 2000).

Water withdrawal at the beginning of the 20th century was very low. Total withdrawal more than doubled between 1980 and 2000. In 1999-2000, irrigated agriculture used 40% of the State’s water withdrawal, followed by: mining 24%; households 13%; services 7%; gardening 5%; parks 4%; industry 4%; and stock water 3% (Government of Western Australia, 2003).
The Western Australian Government released a State Water Strategy Plan in 2003 and calls for strong community, government and industry partnership to ensure a sustainable water future for Western Australians. The objectives of the Strategy are: (1) improving water use efficiency in all sectors including irrigated agriculture, mining, and households; (2) achieving significant advances in water reuse; (3) fostering innovation and research; (4) planning and development of new sources of water in a timely manner; and (5) protecting the value of the State’s water resources.

The Western Australian Water Resources Council (1988) studied the long-term options for water supply to Perth and the south of the State. It is assessed that population growth at a rate of 1.7% per year, would require an additional supply of 130 MCM/yr by 2020, and 235 MCM/yr by 2050.

Options considered are:
- extraction of more than 100 MCM of groundwater per annum;
- development of surface water resources;
- reuse of treated wastewater;
- desalination of seawater;
- transfer of water from the Kimberley region.

The Kimberley Region is located in the northern part of the Western Australia. Rainfall varies from about 350 mm along the southern border of the region to over 1,400 mm in the northwestern coastal area. It has an estimated population of 31,200. The annual sustainable yield of its water resources is 3.2 BCM while its water use is about 272 BCM/yr (Water and Rivers Commission, 2000).

The Kimberley Pipeline Scheme was proposed to supply additional water to the Perth metropolitan area from unused water resources of the Kimberley region.

Current Western Australian Government’s policy is to use water resources of the Kimberley Region for local development and expects that the need of Kimberley region will increase in future due to expected population growth and related development activities.

In 2002 reviewed and evaluated the impact of the Kimberley Pipeline. It concluded that:
- the scheme is technically feasible but highly complex;
- the proposed pumping components of the scheme would consume 3 times more energy than desalination;
- the scheme would create significant ecological impacts particularly relating to Fitzroy River;
- construction of the scheme would cost $11.7 billion, and its annual operating cost would be about $105 million;
- at an estimated cost of more than $6.10 per m³ of delivered water the scheme remains economically unviable compared with desalination.

In 1998, the Water Corporation prepared a desalination strategy and in 2000 published
information on various aspects of desalination and the possibilities for its application in Western Australia (Water Corporation, 2000). By considering the decreasing costs of seawater desalination and the increasing costs associated with other options of water transfer, in 2002 a proposal developed for a desalination plant for Perth metropolitan area. The proposal involved construction and operation of a 45 MCM/yr capacity Reverse Osmosis desalination plant at either Kwinana Power Station or at East Rockingham, both at less than 36 km south of Perth (Environmental Protection Authority, 2002). In May 2003, the Minister for Environment approved the proposal (Fereidoun Ghassemi and Ian White, 2006).

Inter-basin transfer of water remains as one of the key policy issues of Australia. Recently, the ambitious plan to pipe water 3700 km from the Kimberley to Perth has been resurrected by the West Australian Opposition as part of a proposal to make the state the nation’s food bowl (Elizabeth Gosch, 2007).

Future challenges and aims for natural resource management

Australia has identified the need to take an integrated approach to natural resource management. The major aims of the Natural Resources Management Strategy are:

- prevent further resource degradation;
- restore degraded resources;
- promote sustainable user practices;
- ensure appropriate resource use planning and management;
- ensure a viable long-term economic future for Basin dependents;
- minimize adverse effects of resource use;
- ensure community and government co-operation;
- ensure self-maintaining populations of native species;
- preserve cultural heritage;
- conserve recreation values (Country Profile, Australia, ICID Website).
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Website: www.narmada.org, Sardar Sarovar scheme.
Website: www.tinavienna.at/doev/, Association Danube-Oder-Elbe Canal
    Washington D.C., USA.
Annex 1. Abbreviations and acronyms

### List of Abbreviations and Acronyms

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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
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<td>Australian Capital Territory</td>
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<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<td>Aral Sea Basin</td>
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<tr>
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<td>Acueducto Tajo-Segura</td>
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<td>African Multidisciplinary Monsoon Analysis</td>
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<td>BBMB</td>
<td>Bhakra Beas Management Board</td>
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<tr>
<td>BCM</td>
<td>Billion Cubic Meter</td>
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<td>BCM/yr</td>
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<td>Garrison Diversion Unit</td>
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<td>Gross Domestic Product</td>
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<td>Garrison Transfer Unit</td>
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<td>Government of India</td>
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<td>GoUP</td>
<td>Government of Uttar Pradesh</td>
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<td>GRID</td>
<td>Global Resource Information Database</td>
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<td>Geological Survey of India</td>
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<td>GWh</td>
<td>GAP Southeast Anatolia Project</td>
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<td>Acronym</td>
<td>Full Form</td>
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<td>Interstate Commission for Water Management Coordination</td>
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<td>Integrated Water Resources Management</td>
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<tr>
<td>LBDC</td>
<td>Lower Bari Daab Canal</td>
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<td>LCBC</td>
<td>Lake Chad Basin Commission</td>
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<td>LHDA</td>
<td>Lesotho Highlands Development Authority</td>
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<td>LHWC</td>
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<td>LHWP</td>
<td>Lesotho Highlands Water Projects</td>
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<td>MDBMC</td>
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<tr>
<td>MAF</td>
<td>Million Acre Feet</td>
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<td>MCM/yr</td>
<td>Million Cubic Meter Per Year</td>
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<td>Mha</td>
<td>Million Hectare</td>
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<td>MMP</td>
<td>Misicuni Multipurpose Project</td>
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<td>Single-Point Mooring</td>
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<td>Sq.km</td>
<td>Square Kilometer</td>
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<td>Sarir-Sirt</td>
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<td>SS/TB</td>
<td>Sarir-Sirt/Tazerbo-Benghazi</td>
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<td>SYL</td>
<td>Sutlej – Yamuna Link</td>
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<td>TB</td>
<td>Tazerbo-Benghazi</td>
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<td>Description</td>
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<td>WWF</td>
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<td>WWF</td>
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<td>Zanzibar Water Authority</td>
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Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

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<thead>
<tr>
<th>Country/state/province</th>
<th>Name of the scheme</th>
<th>Inter basin water transfer</th>
<th>Average transfer (BCM/yr)</th>
<th>Purpose(s)</th>
<th>Year of completion, under construction/proposed</th>
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<td>Pakistan</td>
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<td>Marala at Chenab River</td>
<td>Ravi River</td>
<td>14.57</td>
<td>Irrigation</td>
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<td>2. Haveli Canal</td>
<td>Trimmu at Chenab River</td>
<td>Ravi River</td>
<td>4.60</td>
<td>Irrigation</td>
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<td>3. Marala Ravi Link</td>
<td>Marala at Chenab River</td>
<td>Ravi River</td>
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<td>Irrigation</td>
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<td>4. Rasul - Qadirabad Link</td>
<td>Jhelum</td>
<td>Chenab</td>
<td>16.96</td>
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<td>5. Trimmu - Sidhnai Link</td>
<td>Chenab</td>
<td>Ravi</td>
<td>9.80</td>
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<td>7. Qadirabad – Balloki Link</td>
<td>Chenab</td>
<td>Ravi</td>
<td>16.61</td>
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<td>8. Upper Jhelum Canal</td>
<td>Jhelum River</td>
<td>Chenab River</td>
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<td>Irrigation, hydropower</td>
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<td>9. Montgomery – Pakpattan Link</td>
<td>Ravi River</td>
<td>Sutlej River</td>
<td>0.88</td>
<td>Link</td>
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<td>13. Tanunsa - Panjnad Link</td>
<td>Indus</td>
<td>Chenab</td>
<td>12.58</td>
<td>Link</td>
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<td>15. Pakpattan – Islam Link</td>
<td>Upper Pakpattan Canal</td>
<td>Islam Barrage</td>
<td>0.88</td>
<td>Link</td>
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<td><strong>Sub-total existing IBWT schemes Pakistan</strong></td>
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<tr>
<td><strong>India</strong></td>
<td></td>
<td></td>
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<td></td>
<td>1. Ghagha-Sarda</td>
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<td>Sharda</td>
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<td>2. Periyar Vegai Link</td>
<td>Periyar</td>
<td>Vaigai</td>
<td>1.29</td>
<td>Irrigation, municipal water supply</td>
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<td></td>
<td>3 Kurnool Cudappa Canal</td>
<td>Krishna</td>
<td>Pennar</td>
<td>2.68</td>
<td>Irrigation, municipal water supply</td>
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<tr>
<td>No.</td>
<td>Scheme Name</td>
<td>Source River</td>
<td>Link River</td>
<td>Area (Km²)</td>
<td>Water Supply</td>
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<tr>
<td>1</td>
<td>Bedti- Varada</td>
<td>Bedti</td>
<td>Krishna</td>
<td>0.24</td>
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<td>Netravati- Hemavati</td>
<td>Netravati</td>
<td>Cauvery</td>
<td>0.19</td>
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<td>3</td>
<td>Manibhadra- Dowlaiswaram</td>
<td>Mahanadi</td>
<td>Godavari</td>
<td>12.17</td>
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<td>Polavaram-Vijayawada</td>
<td>Godavari</td>
<td>Krishna</td>
<td>5.33</td>
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<td>5</td>
<td>Inchampalli Low Dam- Pulichintala</td>
<td>Godavari</td>
<td>Krishna</td>
<td>4.37</td>
<td>Irrigation, municipal and industrial water supply, hydropower</td>
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<td>Inchampalli- Nagarjunasagar</td>
<td>Godavari</td>
<td>Krishna</td>
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<td>Nagarjunasagar-Pennar Somasila</td>
<td>Krishna</td>
<td>Pennar</td>
<td>12.15</td>
<td>Irrigation, municipal and industrial water supply, flow augmentation, hydropower</td>
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<td>Pennar</td>
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<td>9</td>
<td>Indira Gandhi Nahar Scheme</td>
<td>Ravi River</td>
<td>Beas River (Rajasthan)</td>
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<td>10</td>
<td>Sardar Sarovar Scheme</td>
<td>Narmada Basin, Gujarat</td>
<td>Areas in Rajasthan, Maharastra and Madhya Pradesh states of India</td>
<td>34.22</td>
<td>Irrigation, municipal and industrial water supply, hydropower</td>
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<td>11</td>
<td>Tehri Dam Scheme</td>
<td>Bhagirithi, Ganga Basin, Uttarakhand</td>
<td>Uttar Pradesh and Delhi regions</td>
<td>0.44</td>
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Sub-total existing IBWT schemes India: 72.9

# not added in the subtotal entry, as are not completed
Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

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<th>Quantity</th>
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<td>Ken-Betwa</td>
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<td>Betwa</td>
<td>1.02</td>
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<td>14.</td>
<td>Pamba-Achankovil-Vaippar</td>
<td>Pamba, Achankovil</td>
<td>Vaippar</td>
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<td>16.</td>
<td>Damanganga – Pinjal</td>
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<td>17.</td>
<td>Diversions through 13 Links under Himalayan Components</td>
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Sub-total schemes under construction or proposed India 211.0

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<td>China</td>
<td>1. Dujian Weir</td>
<td>Ming River</td>
<td>Minjiang, Fujiang, and Taojiang Rivers</td>
<td>11</td>
<td>Irrigation, flood management</td>
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<td>2. Datonghe River - Qinwangchuan water Transfer Scheme</td>
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<td>Irrigation</td>
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<td>3. Yangtze to North Jiansu, River</td>
<td>Yangtze River</td>
<td>North Jiansu, River</td>
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<td>Irrigation, flood management, navigation</td>
<td>1987</td>
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<td>4. Yellow River to Qingdao city water transfer Scheme</td>
<td>Yellow River</td>
<td>Qingdao City</td>
<td>0.24</td>
<td>Irrigation, municipal and industrial water supply, hydropower</td>
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<td>5. Fuer River Water Transfer Scheme</td>
<td>Fuer River</td>
<td>Honhe River</td>
<td>0.10</td>
<td>Irrigation, municipal and industrial water supply</td>
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<td>6. Biliu River - Dalian City Water Transfer Scheme</td>
<td>Biliu River</td>
<td>Dalian city</td>
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<td>Irrigation, municipal water supply, flood management</td>
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<td>7. Wanjiazhai Yellow River Water Transfer Scheme</td>
<td>Wanjiazhai Reservoir</td>
<td>Taiyuan, Dadong and Shuozhou of Shanxi Province</td>
<td>0.32 (first stage)</td>
<td>Flood management, municipal and industrial water supply, hydropower</td>
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<td>Source Rivers/Reservoirs</td>
<td>Quantity (cubic kilometers per year)</td>
<td>Main Use(s)</td>
<td>Year(s)</td>
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<td>8. Dongwan-Shenzhen Water Supply Scheme</td>
<td>Dongjiang River, Dongwan, Shenzhen Reservoir</td>
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<td>9. Luan River to Tianjing City Water Transfer Scheme</td>
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<td>1. Eastern Route Scheme</td>
<td>Lower reaches of Yangtze, Yellow River and then to Tianjin</td>
<td>34.3</td>
<td>Irrigation, municipal water supply</td>
<td>Scheme launched on 27 Dec. 2002</td>
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<td>2. Middle Route Scheme</td>
<td>Middle reaches of Yangtze River, Yellow River</td>
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<td>Under construction and completed by 2010</td>
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<td>3. Western Route Scheme</td>
<td>Upper reaches of Yangtze River, Yellow River</td>
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<td>Proposed (likely to start in 2010)</td>
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<td>1. Ryoso Irrigation Scheme</td>
<td>Tone River, Ichinomiya River</td>
<td>0.36</td>
<td>Irrigation</td>
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<td>2. Nansatsu Irrigation</td>
<td>Umawatari River and 2 Rivers, Lake Ikeda</td>
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<td>3. Hatori dam</td>
<td>Tsurunuma River in Agano River, Kumato River, Abukuma River</td>
<td>0.18</td>
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<td>Nakayama River, Shigenobu river, Omogo</td>
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<td>Irrigation, hydropower</td>
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<td>5. Asaka Irrigation Canal</td>
<td>Lake Inawashiro (Agano River basin), Gohyaku River (Abukuma River)</td>
<td>1.58</td>
<td>Irrigation and water supply</td>
<td>1882</td>
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<td>6. Tone Transfer Scheme</td>
<td>Tone River, Ara River</td>
<td>3.94</td>
<td>Irrigation, municipal and industrial water supply</td>
<td>1965</td>
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<td>7. Totsukawa and Kinokawa Scheme</td>
<td>Totsu River, Kino River, Kino River, Yamato River basin</td>
<td>0.32</td>
<td>Irrigation, hydropower</td>
<td>1983</td>
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<td>8. Kagawa Canal Scheme</td>
<td>Yoshino River, Kagawa Prefecture</td>
<td>1.83</td>
<td>Irrigation, municipal and industrial water supply</td>
<td>1981</td>
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<td>9. Toyogawa Canal Scheme</td>
<td>Tenryu River, Toyogawa River</td>
<td>0.50</td>
<td>Irrigation, municipal and industrial water supply</td>
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<td>10. Lake Biwa Canal Scheme</td>
<td>Lake Biwa, Kyoto, Kamo River</td>
<td>0.13</td>
<td>Municipal, hydropower, transportation</td>
<td>1890</td>
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Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>No.</th>
<th>Scheme Name</th>
<th>Origin River(s)</th>
<th>Destination River(s)</th>
<th>Volume (km³)</th>
<th>Water Use</th>
<th>Year</th>
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<tr>
<td>11.</td>
<td>Uryu Hydropower Scheme</td>
<td>Ishikari River</td>
<td>Tesio River</td>
<td>1.40</td>
<td>Hydropower</td>
<td>1943</td>
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<td>12.</td>
<td>Haji Dam</td>
<td>Gonokawa River</td>
<td>Ota river</td>
<td>0.10</td>
<td>Municipal water supply</td>
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**Sub-total existing IBWT schemes Japan**

- 10.6

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<tr>
<th>Scheme Name</th>
<th>Origin River(s)</th>
<th>Destination River(s)</th>
<th>Volume (km³)</th>
<th>Water Use</th>
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<tbody>
<tr>
<td>1. Kasumigaura Project</td>
<td>Nakagawa river</td>
<td>Kasumigaura Lake</td>
<td>0.82</td>
<td>Flow augmentation and water quality control</td>
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Sub-total proposed or under construction IBWT schemes Japan

- 0.8

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<tr>
<th>Scheme Name</th>
<th>Origin River(s)</th>
<th>Destination River(s)</th>
<th>Volume (km³)</th>
<th>Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cheshmah Langan</td>
<td>Persian Gulf and Oman Sea</td>
<td>Central Plateau</td>
<td>0.12</td>
<td>Irrigation, municipal and industrial water supply</td>
</tr>
<tr>
<td>2. First Tunnel from Kouhrang Mountains</td>
<td>Persian Gulf and Oman Sea</td>
<td>Central Plateau</td>
<td>0.30</td>
<td>Irrigation, municipal and industrial water supply</td>
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<tr>
<td>3. 2nd Tunnel from Kouhrang Mountains</td>
<td>Persian Gulf and Oman Sea</td>
<td>Central Plateau</td>
<td>0.25</td>
<td>Irrigation, municipal and industrial water supply</td>
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<tr>
<td>4. Talghan Dam</td>
<td>Caspian Sea</td>
<td>Central Plateau</td>
<td>0.42</td>
<td>Irrigation and municipal water supply</td>
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<td>5. Lar Dam</td>
<td>Caspian Sea</td>
<td>Central Plateau</td>
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Sub-total existing IBWT schemes Iran

- 1.3

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<th>Scheme Name</th>
<th>Origin River(s)</th>
<th>Destination River(s)</th>
<th>Volume (km³)</th>
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<tbody>
<tr>
<td>1. Ghatari Springs</td>
<td>Gharaghum</td>
<td>Central Plateau</td>
<td>0.01</td>
<td>Municipal water supply</td>
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<tr>
<td>2. Transfer From Dez to Ghomrud</td>
<td>Persian Gulf and Oman Sea</td>
<td>Central Plateau</td>
<td>0.12</td>
<td>Municipal and industrial water supply</td>
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<td>3. Tang-Sorkh Reservoir Dam</td>
<td>Persian Gulf and Oman Sea</td>
<td>Central Plateau</td>
<td>0.33</td>
<td>Municipal and industrial water supply</td>
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<td>4. Talvar Dam</td>
<td>Caspian Sea</td>
<td>Central Plateau</td>
<td>0.09</td>
<td>Municipal water supply</td>
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<tr>
<td>5. Sheshpear Reservoir Dam</td>
<td>Persian Gulf and Oman Sea</td>
<td>Central Plateau</td>
<td>0.06</td>
<td>Municipal water supply</td>
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<td>6. Ruzbeh Spring</td>
<td>Caspian Sea</td>
<td>Central Plateau</td>
<td>0.01</td>
<td>Municipal water supply</td>
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<tr>
<td>7. Kamal-Saleh Dam</td>
<td>Persian Gulf and Oman Sea</td>
<td>Central Plateau</td>
<td>0.07</td>
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Sub-total schemes under construction or proposed in Iran

- 0.7

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<th>Scheme Name</th>
<th>Origin River(s)</th>
<th>Destination River(s)</th>
<th>Volume (km³)</th>
<th>Water Use</th>
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<tbody>
<tr>
<td>1. Daechong wide area water supply</td>
<td>Daechong Dam</td>
<td>A-san</td>
<td>0.36</td>
<td>Municipal water supply</td>
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<tr>
<td>2. Daechong wide area water supply</td>
<td>Daechong Dam</td>
<td>Chunan</td>
<td>0.09</td>
<td>Municipal water supply</td>
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<tr>
<td>3. Junju systematical wide area water supply</td>
<td>Yongdam Dam</td>
<td>Junju Gunsan</td>
<td>0.26</td>
<td>Municipal water supply</td>
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<tr>
<td>4. Geum River wide area water supply</td>
<td>Bu-yeo</td>
<td>Gunsan Junju</td>
<td>0.11</td>
<td>Municipal water supply</td>
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<tr>
<td>5. Chongju-Intake tower</td>
<td>Daechong Dm</td>
<td>Jibuk Filter Plant</td>
<td>-</td>
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</table>

Sub-total existing IBWT schemes Korea 0.8

| 1. SumJin Water Supply Reservoir System | SumJin River | DonJin River | 0.11 |

Sub-total schemes under construction or proposed in Korea 0.1

Malaysia 1. Kelinchi/Terip | Upper Muar Basin | Linggi Basin | 0.14 | Water supply | 1996 |

Sub-total existing IBWT scheme Malaysia 0.1

1. Kelau-Langat | Kelau River | Langat | 0.55 | Water supply | Proposed |

Sub-total scheme under construction or proposed Malaysia 0.6

Central Asian Countries Karashi Scheme | Amu Darya | Uzbekistan |

Amu-Bukhara Canal | Amu Darya | Uzbekistan |

Karakum Canal | Amu Darya | Southern part of Turkmenistan |

Sub-total existing IBWT schemes Central Asian Countries

1. Partial transfer of Siberian Rivers to Urals, West Siberia, Central Asia and Kazakhstan | Ob Ural, Syr Darya, Amu Darya River system | Irrigation, hydropower, Municipal water supply, feeding of Ural Sea and Rivers | 27 | Proposed |

Sub-total scheme under construction or proposed Central Asian Countries 27

Nepal Melamchi River to Kathmandu City | Melamchi River | Kathmandu City | 0.62 | Water supply | Under construction |

Sub-total schemes under construction or proposed Nepal 0.6

Sub-total Asia existing schemes 293.1

Sub-total Asia schemes under construction or proposed 314.8

Americas


Little Bow Canal | Highwood River, Bow River Basin | Little Bow River, Oldman Basin | 0.057 | Irrigation | 1910 |

Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>Country</th>
<th>District</th>
<th>Source Rivers, Basins</th>
<th>Destination Rivers, Basins</th>
<th>Volume</th>
<th>Use</th>
<th>Year</th>
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</thead>
<tbody>
<tr>
<td>Canada</td>
<td>2. Western Irrigation District</td>
<td>Bow River, South Sask. Basin</td>
<td>Bow and Red Deer Rivers, South Sask. Basin</td>
<td>0.135</td>
<td>Irrigation</td>
<td>1910</td>
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<td>Alberta</td>
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<td>Canada</td>
<td>3. Eastern Irrigation District</td>
<td>Bow River, South Sask. Basin</td>
<td>Bow and Red Deer Rivers, South Sask. Basin</td>
<td>0.602</td>
<td>Irrigation</td>
<td>1914</td>
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<tr>
<td>Canada</td>
<td>4. Waterton-Belly-St. Mary Transfers</td>
<td>Waterton, Belly and St. Mary Rivers, Oldman River Basin</td>
<td>Oldman and South Sask., South Sask. Basin</td>
<td>0.467</td>
<td>Irrigation</td>
<td>(1915) 1969</td>
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<td>Alberta</td>
<td>(a) Belly-St. Mary Canal</td>
<td>Waterton and Belly Rivers, Oldman, South Sask.</td>
<td>St. Mary Reservoir, Oldman, South Sask.</td>
<td>0.173</td>
<td>Irrigation</td>
<td>1959</td>
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<td>Alberta</td>
<td>(b) Waterton-Belly Canal</td>
<td>Waterton Reservoir, Oldman River Basin</td>
<td>Belly River, Oldman River Basin</td>
<td>0.110</td>
<td>Irrigation</td>
<td>1968</td>
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<td>Canada</td>
<td>5. Lethbridge Northern Irrigation District</td>
<td>Oldman River, South Sask. Basin</td>
<td>Little Bow and Oldman Rivers, South Sask. Basin</td>
<td>0.151</td>
<td>Irrigation</td>
<td>1924</td>
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<tr>
<td>Canada</td>
<td>6. Mnt. View-Leavitt-Aetna Irrigation Canal</td>
<td>Belly River, Oldman River Basin</td>
<td>St. Mary River, Oldman River Basin</td>
<td>0.016</td>
<td>Irrigation</td>
<td>(1936) 1945</td>
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<td>Canada</td>
<td>7. Cypress Lake Transfers</td>
<td>Belanger and Davis Creeks (Frenchman River) and Battle Creek</td>
<td>Cypress Lake, Frenchman River and Battle Creek</td>
<td>0.019</td>
<td>Irrigation</td>
<td>1939</td>
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<td>Canada</td>
<td>8. Swift Current Irrigation Scheme</td>
<td>Swift Current Creek, South Sask. Basin</td>
<td>Rush Lake, Old Wires Lake Basin</td>
<td>0.016</td>
<td>Irrigation</td>
<td>1953</td>
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<td>Saskatchewan</td>
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<td>Canada</td>
<td>9. Adam Creek</td>
<td>Mattagami River, Moose River Basin, James Bay</td>
<td>Adam Creek, Mattagami, Moose River Basin</td>
<td>(94.5)#</td>
<td>Flood management</td>
<td>1961</td>
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<td>Ontario</td>
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<td>Canada</td>
<td>10. Seine River Transfer</td>
<td>Seine River, Red River Basin</td>
<td>Red River, Red River Basin</td>
<td>(2.678)#</td>
<td>Flood management</td>
<td>1961</td>
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<td>Manitoba</td>
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<td>Canada</td>
<td>13. Vernon Irrigation District</td>
<td>Duteau Creek, Sluswap-Thompson-Fraser River Basin</td>
<td>Vernon Creek, Okanagan Lake, Columbia River Basin</td>
<td>0.190</td>
<td>Irrigation, municipal supply</td>
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<td>British Columbia</td>
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*Notes:*
- Volume values are in cubic kilometers (km³).
- Irrigation and flood management refer to the primary purpose of water transfers.
- Dates in parentheses indicate the period of construction or development.
<table>
<thead>
<tr>
<th>Country</th>
<th>Province</th>
<th>Project Name</th>
<th>Waterbodies</th>
<th>Purpose</th>
<th>Duration</th>
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<tbody>
<tr>
<td>Canada</td>
<td>Saskatchewan</td>
<td>Qu’Appelle Transfer</td>
<td>Lake Diefenbaker, South Saskatchewan River, Nelson Basin</td>
<td>Qu’Appelle River, Assiniboine River, Nelson Basin</td>
<td>0.082</td>
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<td>Canada</td>
<td>Manitoba</td>
<td>Pasquia Land Resettlement</td>
<td>Pasquia River, Saskatchewan Basin</td>
<td>Carrot River, Saskatchewan Basin</td>
<td>0.154</td>
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<td>Canada</td>
<td>Saskatchewan</td>
<td>Saskatoon Southeast Water Supply System</td>
<td>Lake Diefenbaker, South Saskatchewan River</td>
<td>Little Manitou Lake and other reservoirs en route</td>
<td>0.050</td>
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<td>Canada</td>
<td>Manito</td>
<td>Pasquia Land Resettlement</td>
<td>Pasquia River, Saskatchewan Basin</td>
<td>Carrot River, Saskatchewan Basin</td>
<td>0.154</td>
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<td>Saskatchewan</td>
<td>Saskatoon Southeast Water Supply System</td>
<td>Lake Diefenbaker, South Saskatchewan River</td>
<td>Little Manitou Lake and other reservoirs en route</td>
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<td>Welland Canal</td>
<td>Lake Erie, Great Lakes Basin</td>
<td>Lake Ontario, Great Lakes Basin</td>
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<td>Canada</td>
<td>New Brunswick</td>
<td>St. John Water Supply</td>
<td>Loch Lomond, Mispec River, Bay of Fundy</td>
<td>Little River, Saint John, Bay of Fundy</td>
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<td>British Columbia</td>
<td>Coquitlam-Buntzen</td>
<td>Coquitlam Lake (Coquitlam R.), Fraser River Basin</td>
<td>Buntzen Lake, Burrard Inlet</td>
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<td>Manitoba</td>
<td>Winnipeg Aqueduct</td>
<td>Shoal Lake, Lake of the Woods Basin</td>
<td>City of Winnipeg, Red River Basin</td>
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<td>Nova Scotia</td>
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<td>Sandy Lake, Indian River</td>
<td>Northeast River, St. Margaret’s Bay</td>
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<td>British Columbia</td>
<td>Alouette</td>
<td>Alouette Lake, Fraser River Basin</td>
<td>Stave Lake, Fraser River Basin</td>
<td>0.662</td>
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<td>Canada</td>
<td>Nova Scotia</td>
<td>Jordan</td>
<td>Jordan Lake via L. Rossignol</td>
<td>Mersey River</td>
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<td>British Columbia</td>
<td>Bridge River</td>
<td>Carpenter Lake (Bridge River), Fraser River Basin</td>
<td>Seton Lake (Seton R.), Fraser River Basin</td>
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<td>Canada</td>
<td>Ontario</td>
<td>Long Lac</td>
<td>Long Lake, Albany River Basin, James Bay</td>
<td>Aguasabon River, Lake Superior, Great Lakes Basin</td>
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<td>Onaping</td>
<td>Onaping Lake, Vermilion and Spanish Rivers, Great Lakes Basin</td>
<td>Moncrieff Creek, Spanish River, Great Lakes Basin</td>
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<td>Nova Scotia</td>
<td>Ingram</td>
<td>Ingram River, St. Margarets Bay Lake</td>
<td>St. Croix River</td>
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Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>Canada</th>
<th>Number</th>
<th>Description</th>
<th>Source River, Basin</th>
<th>Destination River, Basin</th>
<th>Hydropower</th>
<th>Year</th>
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<tr>
<td>Alberta</td>
<td>29</td>
<td>Ghost-Minnewanka Transfer</td>
<td>Ghost River, Bow River Basin</td>
<td>Lake Minnewanka, Cascade, Bow Basin</td>
<td>0.044</td>
<td>1941</td>
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<td>Ogoki Transfer</td>
<td>Ogoki River, Albany River Basin, James Bay</td>
<td>Little Jackfish River, Lakes Nipigon, Superior, Great Lakes Basin</td>
<td>3.560</td>
<td>1943</td>
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<td>Donahue Transfer</td>
<td>Donahue Lake, Larry’s River</td>
<td>Dickie Brook, Salmon River, Chedabucto Bay</td>
<td>0.441</td>
<td>1948</td>
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<td>Alberta</td>
<td>32</td>
<td>Spray Hydro Complex (a) Smith-Dorrien Transfer</td>
<td>Spray and Kananaskis Rivers, Bow Basins</td>
<td>Bow River, South Sask. Basin</td>
<td>0.360</td>
<td>(1949) 1959</td>
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<td>Smith-Dorrien Creek, Kananaskis, Bow Basin</td>
<td>Spray River, Bow River Basin</td>
<td>0.022</td>
<td>(1949)1959</td>
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<td>Kemano Transfer</td>
<td>Tahtsa Lake (Nechako River), Fraser River Basin</td>
<td>Kemano River, Pacific Ocean</td>
<td>3.623</td>
<td>1952</td>
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<td>Pine Creek Transfer</td>
<td>Pine Creek, Roseau River Basin</td>
<td>Roseau Wildlife Management Pools (US)</td>
<td>0.022</td>
<td>1953</td>
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<td>Quebec</td>
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<td>Megiscane transfer</td>
<td>Megiscane River, Bell and Nottaway Rivers, James Bay</td>
<td>Gouin Reservoir, St. Maurice River, St. Lawrence River Basin</td>
<td>0.347</td>
<td>1953</td>
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<td>36</td>
<td>Doran Lake Transfer</td>
<td>Doran Lake, Great Central Lake Stamp and Somass Rivers Alberni Inlet</td>
<td>Taylor River, Sproat Lake, Somass River Alberni Inlet</td>
<td>0.032</td>
<td>1955</td>
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<td>Cheakamus Transfer</td>
<td>Cheakamus River, Squamish River Basin, Howe Sound</td>
<td>Squamish River, Howe Sound</td>
<td>1.166</td>
<td>1957</td>
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<td>Ash River Transfer</td>
<td>Elsie Lake (Ash R.) Somass River Basin, Vancouver Island</td>
<td>Great Central Lake (Stmp. R.), Somass River Basin, Vancouver Island</td>
<td>0.630</td>
<td>1958</td>
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<td>39</td>
<td>Campbell River Transfer</td>
<td>Heber (Gold), Quinsam and Salmon Rivers, Vancouver Island</td>
<td>Campbell River, Vancouver Island</td>
<td>0.378</td>
<td>1958</td>
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<td>Saskatchewan</td>
<td>40</td>
<td>Wellington Lake Hydro Scheme</td>
<td>Tazin Lake, Talton Basin</td>
<td>Charlot River, Lake Athabasca-Slave Basin</td>
<td>0.882</td>
<td>1958</td>
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<td>Canada</td>
<td>Province</td>
<td>Project Name</td>
<td>Basin, Lake, River Details</td>
<td>Water Supply Type</td>
<td>Date</td>
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<tr>
<td>Canada</td>
<td>British Columbia</td>
<td>Victoria Lake</td>
<td>Victoria Lake, Marble River Basin, Vancouver Island</td>
<td>Hydropower, industrial water supply</td>
<td>1960</td>
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<tr>
<td>Canada</td>
<td>Quebec</td>
<td>Manouane River</td>
<td>Manouane River, Peribonca River, St. Lawrence River Basin</td>
<td>Hydropower, industrial water supply</td>
<td>1960</td>
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<td>Canada</td>
<td>Ontario</td>
<td>Little Abitibi</td>
<td>Little Abitibi River, Moose River Basin, James Bay</td>
<td>Hydropower</td>
<td>1963</td>
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<tr>
<td>Canada</td>
<td>Newfoundland</td>
<td>Deer Lake</td>
<td>Indian Brook, Birch Lake, Deer Lake</td>
<td>Hydropower</td>
<td>1963</td>
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<tr>
<td>Canada</td>
<td>Ontario</td>
<td>Opasatika</td>
<td>Oposatika River, Missinaibi River, Moose River Basin, James Bay</td>
<td>Hydropower</td>
<td>1965</td>
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<td>Canada</td>
<td>Ontario</td>
<td>London</td>
<td>Lake Huron, Great Lakes Basin</td>
<td>Municipal water supply</td>
<td>1967</td>
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<td>Canada</td>
<td>Newfoundland</td>
<td>Bay d’Espoir</td>
<td>Victoria, White Bear, Grey and Salmon Rivers</td>
<td>Hydropower</td>
<td>1969</td>
<td></td>
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<tr>
<td>Canada</td>
<td>Newfoundland</td>
<td>Churchill Falls</td>
<td>Julian-Unknown River</td>
<td>Hydropower</td>
<td>1971</td>
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<tr>
<td>Canada</td>
<td>Newfoundland</td>
<td>Churchill Falls</td>
<td>Naskaupi River</td>
<td>Hydropower</td>
<td>1971</td>
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<tr>
<td>Canada</td>
<td>Newfoundland</td>
<td>Churchill Falls</td>
<td>Kanairiktok River</td>
<td>Hydropower</td>
<td>1971</td>
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<tr>
<td>Canada</td>
<td>Quebec</td>
<td>Barriere transfer</td>
<td>Cabonga Reservoir, Gatineau and Ottawa Rivers, St. Lawrence River Basin</td>
<td>Hydropower</td>
<td>1975</td>
<td></td>
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<tr>
<td>Canada</td>
<td>Alberta</td>
<td>Beaver Creek Transfer</td>
<td>Beaver Creek, Athabasca River Basin</td>
<td>Mining</td>
<td>1976</td>
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<tr>
<td>Canada</td>
<td>Manitoba</td>
<td>Churchill Transfer</td>
<td>Southern Indian Lake, Churchill River Basin</td>
<td>Hydropower</td>
<td>1976</td>
<td></td>
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<tr>
<td>Canada</td>
<td>Quebec</td>
<td>La Grande (Boyk-Sakami Transfer)</td>
<td>Eastmain and Opinaca Rivers, Eastmain River Basin</td>
<td>Hydropower</td>
<td>1980</td>
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Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>Canada</th>
<th>Nova Scotia</th>
<th>Project Description</th>
<th>Diverted water</th>
<th>Purpose</th>
<th>Date</th>
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<tbody>
<tr>
<td>Canada</td>
<td>Nova Scotia</td>
<td>Wreck Cove</td>
<td>Gisborne Reservoir, Wreck Cove Brook</td>
<td>0.331</td>
<td>1980</td>
</tr>
<tr>
<td>Canada</td>
<td>Nova Scotia</td>
<td>Bloody Creek</td>
<td>Paradise River, Annapolis River</td>
<td>0.113</td>
<td>1981</td>
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<tr>
<td>Canada</td>
<td>Quebec</td>
<td>La Grande (Fregate transfer)</td>
<td>Fregate Lake</td>
<td>La Grande River</td>
<td>0.977</td>
</tr>
<tr>
<td>Canada</td>
<td>Quebec</td>
<td>Portneuf transfer</td>
<td>Pipmuacan Lake, Bersimis River, St. Lawrence Basin</td>
<td>0.315</td>
<td>2004</td>
</tr>
<tr>
<td>Canada</td>
<td>Quebec</td>
<td>Sault-aux-Cochons transfer</td>
<td>Pipmuacan Lake, Bersimis River, St. Lawrence Basin</td>
<td>0.205</td>
<td>2004</td>
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<td>Canada</td>
<td>Quebec</td>
<td>Manouane (II) transfer</td>
<td>Pipmuacan Lake, Bersimis River, St Lawrence Basin</td>
<td>0.945</td>
<td>2005</td>
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# Not included in diverted flow totals

Sub-total existing IBWT schemes Canada 137.5

<table>
<thead>
<tr>
<th>Sub-projection</th>
<th>Diverted water</th>
<th>Purpose</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. McGregor transfer</td>
<td>Headwaters of Fraser River</td>
<td>Headwaters of Peace River</td>
<td>6.3</td>
</tr>
<tr>
<td>2. Grand Canal Replenishment and Northern Lakes Development</td>
<td>James Bay St. Lawrence River</td>
<td>Great Lake</td>
<td>20.95</td>
</tr>
<tr>
<td>3. Canadian Water</td>
<td>Several Canadian Rivers like Peace, Atha Basca, and Saskatchewan</td>
<td>Various Western States</td>
<td>184.5</td>
</tr>
<tr>
<td>4. Magnum Plan</td>
<td>Peace, Athabasca, Saskatchewan</td>
<td>Missouri</td>
<td>5.75</td>
</tr>
<tr>
<td>5. Central, North American Water Scheme</td>
<td>Mackenzie Churchill Nelson</td>
<td>Great Lakes, Western States</td>
<td>184.5</td>
</tr>
<tr>
<td>No.</td>
<td>Project Description</td>
<td>Location</td>
<td>Volume</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------------------------------</td>
<td>-----------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>1.</td>
<td>Chicago Sanitary and Ship Canal Project</td>
<td>Lake Michigan (Chicago river)</td>
<td>2.9</td>
</tr>
<tr>
<td>2.</td>
<td>Truckee Canal</td>
<td>Truckee river</td>
<td>0.15</td>
</tr>
<tr>
<td>3.</td>
<td>Los Angeles Aqueduct</td>
<td>Owen valley</td>
<td>0.36</td>
</tr>
<tr>
<td>4.</td>
<td>New York Delaware Aqueduct Project</td>
<td>Delaware River</td>
<td>1.10</td>
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<tr>
<td>5.</td>
<td>All American Canal</td>
<td>Colorado river</td>
<td>4.3</td>
</tr>
<tr>
<td>6.</td>
<td>Colorado River Aqueduct</td>
<td>Lower Colorado river</td>
<td>1.5</td>
</tr>
<tr>
<td>7.</td>
<td>Colorado Transmountain Diversion Projects</td>
<td>Upper Colorado and San Juan rivers</td>
<td>0.70</td>
</tr>
<tr>
<td>8.</td>
<td>Central Valley Project (Northern California)</td>
<td>Sacramento river</td>
<td>4.6</td>
</tr>
<tr>
<td>9.</td>
<td>Colorado-Big Thompson Project</td>
<td>Lake Granby, Colorado river basin</td>
<td>0.3</td>
</tr>
<tr>
<td>10.</td>
<td>Trinity River Transbasin Diversion Project</td>
<td>Trinity</td>
<td>1.0</td>
</tr>
<tr>
<td>11.</td>
<td>San Juan – Rio Chama Project</td>
<td>San Juan river (upper Colorado river basin)</td>
<td>0.13</td>
</tr>
<tr>
<td>12.</td>
<td>California’s State Water Project</td>
<td>Feather river</td>
<td>5.0</td>
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</tbody>
</table>
### Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>Annex</th>
<th>Description</th>
<th>Location</th>
<th>Water Source</th>
<th>Diverted Water</th>
<th>Type</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.</td>
<td>Central Utah Project</td>
<td>Duchesne river a tributary of Upper Colorado</td>
<td>Bonneville portion of the Great Basin</td>
<td>0.17</td>
<td>Irrigation, Municipal, Industrial</td>
<td>1957</td>
</tr>
<tr>
<td>15.</td>
<td>Garrison Diversion Project</td>
<td>Missouri river</td>
<td>Red and Soure rivers</td>
<td>0.1</td>
<td>Municipal, Industrial, Irrigation</td>
<td>Work was stopped for want of detailed EIS</td>
</tr>
</tbody>
</table>

**Sub-total existing IBWT schemes USA** 23.73

* The individual amount of diversions is counted under the projects given at sr. no. 7.

<table>
<thead>
<tr>
<th>Country</th>
<th>Description</th>
<th>Location</th>
<th>Water Source</th>
<th>Diverted Water</th>
<th>Type</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1. North American Water and Power Alliance (NAWAPA)</td>
<td>North West Canada; Alaska, NW USA</td>
<td>South-West USA; Northern Mexico; South-Central Canada; Great Lakes</td>
<td>200</td>
<td>Irrigation, hydropower, municipal &amp; industrial water supply and navigation</td>
<td>High cost and environmental problems.</td>
</tr>
<tr>
<td></td>
<td>2. Texas Water Plan</td>
<td>Lower Mississippi; Eastern Texas</td>
<td>West Texas; Rio Grande; Texas Gulf Coast; Eastern New Mexico</td>
<td>21.0</td>
<td>Irrigation; municipal and industrial water supply, estuary improvement</td>
<td>Modifications are likely due to cost and environmental problems.</td>
</tr>
<tr>
<td></td>
<td>3. High Plains Water Transfer Alternatives</td>
<td>Middle and Lower Missouri; tributaries of lower Mississippi; Sabine River</td>
<td>Central and Western Nebraska; Eastern Colorado; Western Kansas; Northern Texas; Western New Mexico</td>
<td>13.5</td>
<td>Irrigation</td>
<td>Preliminary study completed in 1982. Recommended for further studies.</td>
</tr>
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</table>

**Sub-total schemes under construction or proposed USA** 234.5

<table>
<thead>
<tr>
<th>Country</th>
<th>Description</th>
<th>Location</th>
<th>Water Source</th>
<th>Diverted Water</th>
<th>Type</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>1. Laja Diguillin</td>
<td>Laja River</td>
<td>Diguillin</td>
<td>1.26</td>
<td>Irrigation</td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>2. Teno-Chimbarongo Canal</td>
<td>Teno River sub-basin, tributary of Mataquito River basin</td>
<td>Chimbarongo sub-basin of Rapel River basin</td>
<td>2.05</td>
<td>Irrigation, hydropower</td>
<td>1975</td>
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</table>

**Sub-total existing schemes Chile** 3.3

<table>
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<tr>
<th>Country</th>
<th>Description</th>
<th>Location</th>
<th>Water Source</th>
<th>Diverted Water</th>
<th>Type</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>1. Rio-Sao Francisco Trans-basin Transfer</td>
<td>Rio-Sao Francisco</td>
<td>North East region of Brazil</td>
<td>4.0</td>
<td>Irrigation, water supply, hydropower</td>
<td>Proposed</td>
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</table>

**Sub-total schemes under construction or proposed Brazil** 4.0

<table>
<thead>
<tr>
<th>Country</th>
<th>Description</th>
<th>Location</th>
<th>Water Source</th>
<th>Diverted Water</th>
<th>Type</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>1. Misicuni Multipurpose Scheme</td>
<td>Titiri and Serkheta Rivers</td>
<td>Cochabama</td>
<td>0.2</td>
<td>Irrigation, hydropower, municipal water supply</td>
<td>Under construction</td>
</tr>
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</table>

**Sub-total schemes under construction or proposed Bolivia** 0.2

**Sub-total Americas existing schemes** 165

**Sub-total Americas schemes under construction or proposed** 702
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<th>Europe</th>
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<tbody>
<tr>
<td>Russia</td>
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<tr>
<td>Sub-total existing IBWT schemes Russia</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Sub-total schemes under construction or proposed Russia</td>
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<tr>
<td>Romania</td>
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<td>Sub-total existing IBWT schemes Romania</td>
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Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>Country</th>
<th>Scheme Description</th>
<th>Status and Water Uses</th>
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<tr>
<td>Romania</td>
<td></td>
<td><strong>Under construction</strong></td>
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<tr>
<td></td>
<td>1. Siret-Baragan Canal</td>
<td>Siret, Baragan 5.0</td>
</tr>
<tr>
<td>Slovakia</td>
<td>1. Nitra – Vah</td>
<td>Nitra at a point d/s of Nove Zamky Vah 11.03 Irrigation, flood management Completed</td>
</tr>
<tr>
<td></td>
<td>2. Vazsky – Vah</td>
<td>Vazsky Dunaj Vah 3.46 Irrigation, flood management Completed</td>
</tr>
<tr>
<td></td>
<td>3. Hnilec – Slana</td>
<td>Dedinky - Hinlee reservoir Slana 0.28 Hydropower, flow regulation Completed</td>
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<tr>
<td></td>
<td>4. Vah – Nitra</td>
<td>Vah Nitra – Zitava basin 0.31 Irrigation, pollution control Completed</td>
</tr>
<tr>
<td></td>
<td>5. Turiec – Hron</td>
<td>Turiec (Vah) Hron 0.38 Hydropower, municipal water supply Completed</td>
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<td><strong>Sub-total existing IBWT schemes Slovakia</strong></td>
<td>15.5</td>
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<tr>
<td></td>
<td>1. Danube southward transfer</td>
<td>Danube Vah, Nitra, Hron and Ipel - Irrigation, flow augmentation Proposed</td>
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<tr>
<td></td>
<td>2. Hron – Zitava</td>
<td>Hron (Kozmalovee reservoir and Slatinka reservoir Zitava - Municipal and industrial water supply, pollution control Proposed</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total schemes under construction or proposed Slovakia</strong></td>
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</tr>
<tr>
<td>Turkey</td>
<td>1. Southeast Anatolia Scheme</td>
<td>Euphrates River Anatolia region 10.00 Irrigation, hydropower, municipal and industrial water supply 1990-1995-2010</td>
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<td></td>
<td><strong>Sub-total existing IBWT scheme Turkey</strong></td>
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<td></td>
<td>1. Istanbul Yesilceay and Greater Melen Scheme</td>
<td>Goksu River and Canak River Istanbul 0.15 Municipal water supply</td>
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<td></td>
<td>2. Greater Melen Scheme</td>
<td>Melen River Istanbul 0.27 Municipal water supply</td>
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<tr>
<td></td>
<td>3. Peace Pipeline Scheme</td>
<td>Tukey Syria and Jordan, Palestine, Saudia Arabia, Kuwait, Saudia Arabia, Bahrain, Qatar, United Arab Emirates and Oman, 5.84 Municipal water supply</td>
</tr>
<tr>
<td></td>
<td>4. Turkish Republic of Northern Cyprus (TRNC) Water Supply Scheme</td>
<td>Soguksu Stream Lefkosa and Gazi Magosa 0.01 Municipal water supply</td>
</tr>
<tr>
<td>5. Manavgat River Water Supply Scheme</td>
<td>Manavgat River</td>
<td>Antalya on the Turkish Mediterranean coast-Israel</td>
</tr>
</tbody>
</table>

| **Sub-total scheme under construction or proposed Turkey** | 6.3 |

| France | 1. Lys- Lille region | Lys | Lille region | 0.37 | Irrigation, municipal water supply | Completed |
| | 2. Neste-Garonne | Neste | Garonne | 0.57 | Water supply | 1963 |
| | 3. Durance water supply scheme | Durance | Nearby urban downs | 1.26 | Municipal water supply | 1963 |
| | 4. Escant - Lille Rousaux | Escant River | Lille Roubaix c elais and Dunkerque | 0.16 | Navigation | 1976 |
| | 5. Cap de - Gave de | Cap de long River | Gave de pau River basin | - | Hydropower | Completed |

| **Sub-total existing IBWT schemes France** | 2.4 |

| Spain | 1. Upper Ebro-Bilbao | Zodarra | Bilbao | 0.2 | Irrigation, municipal and industrial water supply | 1950 |
| | 2. Negratin - Almanzora | Guadalquivir River Basin | Almanzora area | 0.05 | Irrigation, municipal water supply | 2004 |
| | 3. Ebro – Tarragonna | Ebro | Tarragonna (Catalonia) | 0.12 | Irrigation, municipal and industrial water supply | Completed |
| | 4. Tagus – Segura | Tagus | Segura | 1.0 | Municipal and industrial water supply | Completed in 1979 |

| **Sub-total existing IBWT schemes Spain** | 1.4 |

| Germany | 1. Rhine-Main Region | Danube | Rhine (Kleine Roth Reservoir) | 0.47 | Water supply and navigation | Completed |

| **Sub-total schemes under construction or proposed Spain** | 1.1 |

| Finland | 1. Helsinki Metropolitan area | Lake Paijanne | Helsinki area | 0.10 | Municipal water supply | 1982 |

| **Sub-total existing IBWT scheme Finland** | 0.1 |

| Portugal | 1. Multipurpose Alqueva Scheme | Guadiana River basin | Sado River basin | 0.01 | Irrigation, municipal and industrial water supply, hydropower | Under construction |

| **Sub-total scheme under construction or proposed Portugal** | 0.0 |
Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>Czech Republic</th>
<th>1. Danube-Oder-Elbe</th>
<th>Danube</th>
<th>Oder – Elbe</th>
<th>1.89</th>
<th>Irrigation, navigation, municipal water supply</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Forth and Clyde Canal</td>
<td>River Forth.</td>
<td>River Clyde.</td>
<td>-</td>
<td>Recreation</td>
<td>1791</td>
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<td>3. Rochdale Canal</td>
<td>Sowerby Bridge in West Yorkshire, England</td>
<td>Bridgewater Canal in Manchester</td>
<td>-</td>
<td>Closed</td>
<td>1804</td>
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<td>4. Crinan Canal</td>
<td>Loch Fyne and the Firth of Clyde</td>
<td>Sound of Jura</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>1801</td>
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<td>5. Kennet and Avon Canal</td>
<td>Thames at Reading</td>
<td>Avon at Bath</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>1810</td>
</tr>
<tr>
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<td>10. Lancaster Canal</td>
<td>northern section, Ribble valley</td>
<td>southern section, Ribble valley</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>-</td>
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<td></td>
<td>11. Leeds and Liverpool</td>
<td>North West seaport of Liverpool</td>
<td>Aire and Calder Navigation at Leeds</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>-</td>
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<tr>
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<td>12. Llangollen Canal</td>
<td>Shropshire Union Canal</td>
<td>Shropshire farmlands</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>-</td>
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<tr>
<td></td>
<td>13. Oxford Canal</td>
<td>River Thames in Oxford</td>
<td>Midlands Canal system</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>-</td>
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<tr>
<td></td>
<td>14. Shropshire Union Canal</td>
<td>Urban Wolverhampton</td>
<td>River Mersey at Ellesmere Port</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>-</td>
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<tr>
<td></td>
<td>15. Staffordshire and Worcestershire Canal</td>
<td>Wolverhampton</td>
<td>Farmland of Cannock Chase before joining the Trent and Mersey Canal</td>
<td>-</td>
<td>Navigation, recreation</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>16. Birmingham Canal</td>
<td>City of Birmingham</td>
<td>Staffordshire and Worcestershire Canal and the start of the Shroshire Union Canal at Aldersley</td>
<td>-</td>
<td>Navigation, recreation</td>
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Sub-total existing IBWT scheme Great Britain | 126 |

Sub-total Europe scheme under construction or proposed | 34 |
<table>
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<tr>
<th>Africa</th>
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<tr>
<td>South Africa</td>
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<tr>
<td>2. Orange – Fish</td>
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<td>3. Vaal - Crocodile</td>
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<td>4. Vaal - Olifants</td>
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<td>5. Olifants - Sand</td>
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<td>6. Komati - Olifants</td>
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<td>7. Usutu - Olifants</td>
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<td>8. Assegaal - Vaal</td>
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<td>9. Buffalo - Vaal</td>
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<td>10. Tugerla - Vaal</td>
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<td>11. Tugela - Mhluzuze</td>
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<td>12. Mooi - Mgeni</td>
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<td>13. Fish - Sundays</td>
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<td>14. Orange – Lower Vaal</td>
</tr>
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<td>15. Caledon - Modder</td>
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<td>16. Lesotho – Vaal</td>
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| Sub-total existing IBWT schemes South Africa | 3.6 |
| 1. Zambezi transfer scheme | Zambezi River | South Africa | - | - | Conceptual stage |

| Morocco | 1. Beni Moussa scheme | Oued El Rbia River | Tensift River | 1.51 | Irrigation |
Annex 2. International experiences in existing and proposed Inter Basin Water Transfers (IBWT)

<table>
<thead>
<tr>
<th>Region</th>
<th>Scheme Description</th>
<th>Source/Region</th>
<th>Flow (MCM3)</th>
<th>Purpose</th>
<th>Date</th>
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<td></td>
<td>1. Guerdane Scheme</td>
<td>Sarir and Tazerbo</td>
<td>0.73</td>
<td>Irrigation, municipal and industrial water supply</td>
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<td>2. Guerdane Scheme</td>
<td>East and North Jabal Hsона</td>
<td>0.73</td>
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<td>1. Great Man Made River scheme (Phase II)</td>
<td>Senqu River</td>
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<td>Congo Basin</td>
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<thead>
<tr>
<th>Oceania</th>
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<tbody>
<tr>
<td>Australia</td>
</tr>
<tr>
<td>1. Snowy Mountain Scheme</td>
</tr>
<tr>
<td>Eucumbene River, Tooma River and Upper Murrumbidgee</td>
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<tr>
<td>Murrumbidgee through its tributary Tumut, Lake Eucumbene and Murray River</td>
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<td>2.3</td>
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<td>Irrigation, hydropower</td>
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