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IIMI WATER DATA BOOK

A COMPENDIUM OF INFORMATION ON WATER RESOURCES, USES AND COSTS

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

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IIMI WATER DATA BOOK

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Contributors

Collation and Analysis

Ramesh Bhatia (Coordinator)

Mark Rosegrant (IFPRI)

Mohammed Badruddin

S.P. Kashyap

P.S. Rao

Fuard Marikkar

Processing and Presentation

P. Mutukumarana

Asma Bashir

David Paul

Sushilla Rajamanie

IIMI WATER DATA BOOK

PREFACE

CONTEXT

Water resources development and management will be the most critical issues in developing countries in the next century. In the context of growing competition for water, it is important to collate and disseminate a consistent set of quantitative information for the water sectors using a holistic approach at the river basin level. Although a number of international organizations and country governments are collecting and publishing a large amount of data on water resources, most of this information cannot be used for investment planning and policy analysis since it is fragmented and inadequate.

Water management activities, both for resource use and resource augmentation require enormous amounts of a variety of types of data of good quality. Reliable data are also needed for water resources assessment, project identification for water use, appraisal and implementation of projects, ex-post monitoring, performance assessment and impact evaluation. In many cases, inadequate and unrealistic data constitute a serious constraint to developing and implementing a country's water resource strategy and to manage water effectively. Specifically, good quality data are required for:

(a) assessment of both surface and subsurface water resources, and the scope for further development;
(b) the estimation of demand for water for various user sectors over time and space;
(c) the estimation of economic values of water in agriculture and alternate uses;
(d) assessing environmental impacts of current and future developments;
(e) understanding the economic and environmental trade-offs between intensive and extensive production on existing and new irrigated and rain-fed lands.

OBJECTIVE AND SCOPE

The objective of preparation of this compendium of information on water resources, uses and costs (IIMI WATER DATA BOOK) is to initiate the process of assembling an adequate set of data on water resources and irrigated agriculture that would optimize decision making processes relating to investments, food security, and sustainability. It is expected that a consistent data set on water resources availability, current and future utilization, costs and returns of water use in different sectors, socio-economic and environmental impacts of changes in water use over time and space will provide a basis for policy making which will ensure economically efficient, socially equitable and environmentally sustainable use of scarce water resources.

It is expected that the International Irrigation management Institute (IIMI) along with International Food Policy Research Institute (IFPRI) will become the repository of and reference source points for information on water resources management and irrigated agriculture. It is not envisaged that IIMI or IFPRI will take responsibility for collecting such data and information, but that these institutes will interact with national and international institutions in designing approaches and methodologies for data collection to ensure consistency of concepts and definitions across institutions and over time. Thus, in the initial phase, IIMI and IFPRI will collect and collate information which is already being collected by several agencies such as ministries and planning organizations of individual country governments, FAO, ICID, the World Bank, ADB, IFAD, IDB, World Resources Institute and several Non Governmental Organizations (NGOs) .

USERS OF THE DATA SET

The target audience who would utilize this type of data include :

- Policy makers and senior officials of government agencies and departments in developing countries;
- International and multilateral development and funding agencies such as the World Bank, ADB, IDB, IFAD,
- Bilateral funding agencies such as the USAID, GTZ, EU, SIDA, DANIDA, CIDA; .
- International organizations such as FAO, UNDP, UNEP, UNICEF, ICID;
- NGOs concerned with environment, poverty alleviation, child mortality and health, resettlement etc.
- Academics and researchers in universities and other research organizations; and non-governmental organizations working in related fields of development.

The IIMI WATER DATA BOOK will be developed and continuously revised in close collaboration with the institutions mentioned above. Among the audience groups indicated above are also the partners and principal collaborators in the activity, who are already deeply involved in this type of activity for quite some time and are very much ahead of IIMI.

ORGANIZATION OF THIS REPORT

Part I

Part I of this report provides data on a global scale. It is divided into five sectors as follows:

1. **Water Resources and their utilization.**

   This section deals with Global Water Resources and their availability for human use. Withdrawals of water for various purposes by continents is provided together with consumptive use by the sector.

2. **Agriculture.**

   This section deals with global data on irrigated areas by continent, their growth rates, and per capita availability of irrigated areas.

3. **Water use for household, Industry and Environment .**

   This section deals with water utilized for domestic purposes, industry and uses other than agriculture.

4. **Investments, Costs, Prices, & Economic Values.**

   This section provides data on global investment in irrigation development as well as cost effective use of water for different purposes.

5. **Environmental Impacts .**

   This section provides data on global impacts of water use on environment, particularly the impacts of irrigation, industrial and household use . Data on water requirements or water use for environmental improvement or sustainability and amelioration of environmental damage are provided where available.

Part II is organized in a pattern similar to Part I except that the data refers to a particular country. Data for India and Pakistan only are presented in this Draft.

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ACRONYMS

ADB	ASIAN DEVELOPMENT BANK
ARPU	AGRICULTURAL RESEARCH & PLANNING UNIT, PLANNING COMMISSION, INDIA
BCM	BILLION CUBIC METERS
CWC	CENTRAL WATER COMMISSION, INDIA
DANIDA	DANISH INTERNATIONAL DEVELOPMENT AGENCY
EU	EUROPEAN UNION
FAO	FOOD AND AGRICULTURAL ORGANIZATION
GDP	GROSS DOMESTIC PRODUCT
GIA	GROSS IRRIGATED AREA
GNP	GROSS NATIONAL PRODUCT
GR	GROSS RECEIPTS
GTZ	DEUTSCHE GESELLSCHAFT FÜR TECHNISCHE ZUSAMMENARBEIT
GVO	GROSS VALUE OF OUTPUT
Ha	HECTARE
ICID	INTERNATIONAL COMMISSION FOR IRRIGATION AND DRAINAGE
IDB	INTER -AMERICAN DEVELOPMENT BANK
IFAD	INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT
IFPRI	INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IIMI	INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
JOECF	JAPANESE OVERSEAS ECONOMIC CO-OPERATION FUND
MCM	MILLION CUBIC METERS
NA/na	NOT AVAILABLE
NCA	NATIONAL COMMISSION ON AGRICULTURE, INDIA
NGO	NON GOVERNMENTAL ORGANIZATION
NIA	NET IRRIGATED AREA
NVO	NET VALUE OF OUTPUT
NWDT	NARMADA WATER DISPUTES TRIBUNAL, INDIA
NWMP	NATIONAL WATER MANAGEMENT PROJECT, INDIA.
O&M	OPERATION AND MAINTENANCE
Rs	RUPEES
SIDA	SWEDISH INTERNATIONAL DEVELOPMENT AGENCY
UN	UNITED NATIONS
UNDP	UNITED NATIONS DEVELOPMENT PROGRAM
UNEP	UNITED NATIONS ENVIRONMENT PROGRAM
UNICEF	UNITED NATIONS INTERNATIONAL CHILDRENS, EMERGENCY FUND
US	UNITED STATES
USAID	UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
USSR	UNION OF SOCIALIST SOVIET REPUBLIC
WAPDA	WATER AND POWER DEVELOPMENT AUTHORITY, PAKISTAN
WB	WORLD BANK
WE	WORKING EXPENSES
YR/yr	YEAR

CONVERSION FACTORS

1.	1 Kilometer	=	1000 m
		=	3,280.8 ft
		=	1,093.6 yd
		=	0.621 miles (mi)
2.	1 Hectare	=	1 x 104 m^2
		=	0.01 km^2
		=	1.076 x 105 ft^2
		=	2.471 acres
3.	1 Sq.Kilometer	=	1 x 106 m^2
		=	100 hectares
		=	1.076 x 107 ft^3
		=	1.196 x 106 yd^2
		=	247.1 acres
		=	3861 mi^2
4.	1 Cubic Meter	=	1 x 10^6 cm^3
		=	1000 liter
		=	1 x 10^{-9} km^3
		=	264.2 gal
		=	35.31 ft^3
		=	1.3078 yd^3
		=	8.107 x 10^{-4} acre-ft
5.	1 Cubic Kilometer (km^3)	=	1 x 10^{12} liter
		=	1 x 10^9 m^3
		=	1 x 106 dam^3
		=	1000 ha^3
		=	8.107 x 105 acre-ft
		=	0.24 mi^3
		=	1.0 milliard
		=	0.81 million acre feet (MAF)
6.	1 Billion Cubic Meter (BCM)	=	1 x 10^9 m^3
		=	1000 x 10^6 m^3
		=	1 cubic kilometer (km^3)
		=	1 x 10^{12} litres
		=	1000 ha^3
		=	8.107 x 10^5 acre feet (af)
		=	0.8107 million acre feet (m.af)
		=	10^5 ha.meters (ha.m)
7.	1 Hectare Meter	=	104 m^3 (Cu.M)

CONCEPTS, DEFINITIONS AND UNITS

Listed below are concepts, definitions and their units of measurement, as presented in this book. Many of the concepts and definitions are the standard universally accepted ones as used in other similar publications. In cases, where there was no single universally accepted definition, the most appropriate ones were used. In certain instances, it was found necessary to alter the wording or language to more precisely represent the concept or definition as presented in this book. When it was not possible to obtain a standard definition or description of a concept from any published sources, we have attempted to provide a suitable description or definition.

The measurement units of these concepts or definitions and the data presented in the tables and appendices, are in SI Units (System International d'Unite's ie. International System of Units). In some cases, the concepts or definitions can be represented in different units, for example, mm/hr or m^3/yr. In these instances, only one such unit is used.

Agricultural water withdrawal (km^3/yr) **:**
Annual quantity of water withdrawn for agricultural purposes. It includes irrigation and livestock watering.

Alkalinity:
Soils which contain free alkaline ions or excessive quantities of sodium carbonate (black alkali) and with an alkaline reaction (Ph>8.5) causing permanent damage to soils.

Annual recharge :
The rate at which water flows in to ground water resources or aquifers, or the total quantity of water replenished in a year.

Average precipitation (mm/yr.) **:**
Double average over space and time of water falling on land in one year.

Catchment area (km^2) **:**
Total area, from which water drains into a single drainage system

Closed System:
A water drainage or watershed system where water inflow equals outflow.

Coarse cereals:
Cereals not mainly used as a staple food.

Command area (ha) **:**
Area downstream of a water source to which water can reach by gravity.

Consumptive use (km^3/yr) **:**
Water lost irretrievably during use for agriculture, industry, domestic or any other use.

Cost recovery ($/ ha- $/unit) :

Procedure for recovering costs of operation and maintenance of any project/ system that provides services to a large of community of people.

Cropping intensity (%) :

Area actually cultivated during a year over the area available for cultivation.

Cultivated area (ha) :

Land under temporary (annual) crops.

Culturable Command Area (CCA) (ha) :

Part of the GCA which can be brought under cultivation.

Deep well:

Large diameter well that has access to deep aquifer or ground water.

Dug well:

Large diameter shallow well that taps subsurface ground water.

Cultivable area (ha) :

Area of land potentially fit for cultivation.

Effluent ground water (km^3/yr) :

Percolated ground water that resurfaces downstream or at another location.

Global renewable water resources (km^3/yr) :

The sum of internal renewable water resources and incoming flow originating outside the country.

Gross irrigated area (ha) :

Area irrigated during a year (e.g., area irrigated in Kharif plus area irrigated in Rabi and Summer). For perennial crops, this should reflect the sum of area irrigated during the year for the same crop (e.g., sugarcane)

Gross Command Area (GCA) (ha) :

Area limited by canal, parent stream (on which the dam is constructed) and other stream of size (discharge) similar to the parent stream on each bank.

Gross cultivated area (ha) :

Area cultivated including bunds, perimeters and reservations.

Gross demand for water (km^3/yr) :

Total use of water for a particular purpose, inclusive of losses due to percolation, evaporation or other irretrievably lost consumptive use.

Ground water runoff (km^3/yr) :

Percolation water in the ground less the quantity, that is unavailable due to soil properties

Infiltration :

The process of which water enters the soil surface.

Infiltration capacity (mm/hr) :

The maximum rate at which water can enter the soil surface.

Irrigable area (ha) :

Area under irrigation including bunds, perimeters, reservations which is irrigable but not irrigated.

Irrigable Command Area (ICA) (ha) :

All the culturable command area that can be irrigated.

Irrigation charges ($/unit) :

Charges levied from the water user for the provision of irrigation water.

Irrigation intensity (%) :

Area actually irrigated during a year over the area available for irrigation. (ie., a sum of area irrigated in all the seasons during the year divided by area available for irrigation)

Kharif:

Wet season- June through mid October/November.

Major, Medium & Minor Schemes:

Schemes classified by the size of the area irrigated. (e.g., in India, a major scheme is ....., medium scheme is ..... and minor scheme is....

Mean annual runoff (km^3/yr) :

Total quantity of water available from a catchment at the outlet in a period of one year.

Net irrigated area (ha) :

Area which actually receives water within the irrigable area.

Net cultivated area (ha) :

Area actually cultivated within the cultivable area.

Net draft (km^3/yr) :

Actual quantity of water removed from the ground.

Open system:

A water drainage or watershed system where water inflow and outflow do not balance each other.

Operation and Maintenance (O&M):
The activities needed to run and maintain a project or a scheme.

Patwary system:
System of land revenue collection at the village level.

Percolation (km^3/yr) **:**
Downward movement of water through the soils.

Potential Evapotranspiration (PET) (km^3/yr)
Amount of water transpired in unit time by a short green crop, completely shading the ground, of uniform height, and never short of water. (Penman 1948)

Pump sets:
Electric or liquid fuel based mechanical devices used to extract water or other liquids inclusive of the required pipes and delivery systems.

Rabi:
Dry season - mid October - mid March.

Return flow of water (km^3/yr) **:**
Outflow of water from one system, that re-emerges as an inflow in another part of the system or watershed.

Evaporation (km^3/yr)**:**
The net loss of water from a surface resulting from a change in the state of water from liquid to vapor and the net transfer of this vapor to the atmosphere.

River basin (km^2) **:**
Total land area or topographically delineated area above or adjacent to a river, that drains into the river and it's tributaries into the ocean.

River runoff (km^3/yr) **:**
The quantity of water flow in a river at a particular location and over time.

Run of the river:
Water headed up and diverted for various purposes without any capacity for storage.

Runoff (km^3/yr or BCM/yr) **:**
The part of rainfall, which is not lost into the atmosphere or in to the soil .
(Runoff = Precipitation - losses)

Snow melt (km^3/yr) **:**
Mountain snow, that melts into the drainage area during the warm seasons.

Sub Watershed (km^2) **:**

Area within a larger watershed, with drainage into a identifiably separate drainage area within the overall area of the larger watershed.

Summer:

Hot season - mid February - May/June.

Surface runoff (km^3/yr) **:**

The part of runoff, which flows on or very near the surface of the soil.

Transpiration (km^3/yr) **:**

Biological modification of the evaporation process through the plant system and the environment.

Tube well:

Narrow ducted deep well that taps water from a deep aquifer, by means of water pump.

Utilizable ground water (km^3/yr) **:**

Ground water that is available for agricultural and human use.

Utilizable surface runoff (km^3/yr) **:**

Water available for agriculture and human use from surface runoff.

Utilizable water resources (km^3/yr) **:**

Water available for agricultural and human use.

Internal renewable water resources (km^3/yr);

Average annual flow of rivers and ground water generated from indigenous precipitation

Water charges (($/unit) **:**

Rate at which a water-user is charged for the water.

Water extraction cost ($/$m^3$) **:**

Total annualized cost of extracting a unit of water from any particular source.

Water withdrawal (km^3/yr) **:**

Gross amount of water which is extracted from the resources for given use. It includes conveyance losses, consumptive use and return flow.

Watershed or Catchment :

Topographically delineated area that is drained by a stream, that is , the total land area above a point on a stream or river that drains past that point. It includes areas with return flows draining in to the same system.

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PART I

WORLD DATA

- WORLD WATER RESOURCES
- MAJOR RIVER BASINS
- WATER AVAILABILITY AND USES
- IRRIGATED AGRICULTURE
- WATER USE FOR HOUSEHOLDS, INDUSTRY
- ENVIRONMENTAL IMPACTS

PART I

I.1 WORLD WATER RESOURCES

- Fresh water stocks comprise only 2.5% of the total water resources on earth or 35 million km^3.
- More than two thirds (69%) of the fresh water stocks are in the form of ice or permanent snow cover in the Antarctic or Arctic Regions (Table I.1.1)
- Thus the main source of fresh water for human consumption are the lakes, rivers and ground water, which form 31% of the world's fresh water resources or 0.8% of the world's total water resources. (Table I.1.1)
- About half a million cubic kilometers of water evaporates from the ocean surface annually, but only 10% of this quantity [50,000 km^3] is returned to the land surface. Precipitation of local origin contributes an additional 69,000 km^3 of fresh water to the land surface annually. Thus the total precipitation on land surface is 119,000 km^3 per year. (Table I.1.2)
- Annual average evaporation from land surface is estimated at 72,000 km^3, and annual average runoff at 47,000 km^3 [119,000-72,000] (Table I.1.2)
- Of the total precipitation 24% is surface runoff, 11% ground water runoff and the balance is lost as evapotranspiration.
- The main source of fresh water is surface run-off, which averages to 44,5000 km^3 without the flow of Antarctica. (Table I.1.4)
- The global surface runoff is distributed very unevenly, with Asia and South America, contributing over 56%, while Europe and Australia account for only 7% and 1% respectively [Table I.1.3a]
- The distribution of run-off within each continent is also uneven with large areas of Europe (33%), Asia (60%), South America (30%), Africa (30 %), South Western north America; and a major proportion of Australia, being classified as either arid regions or region with limited water resources.
- The Annual runoff is not a good indicator of water availability as the distribution of runoff over a year is also highly skewed. Most runoff occurs during a short period of high flood. In Asia, Africa and South America, between 70-80% for total runoff occurs during a six month period. (Table I.1.5)
- The river Amazon has the largest average runoff and drainage area in the world. The total annual runoff of this river alone is estimated at between 6,300 km3 - 6,900 km^3 per annum or 14% - 15% of the world's total annual river runoff. The drainage area of this river is 7.180 million km^2 or 5% of the world's total drainage area.

- The river Congo in Africa has the second largest runoff of 1,500 km^3 or 3.3% of the world's annual average runoff and a drainage area of 3.82 million km^2 or 2.7% of world's total drainage area .
- The river with the third largest runoff 1,400 km^3 or 3.1% of the World's runoff is the Ganges (with Brahmaputra) in Asia. The drainage area of this river is estimated at 1.73 million (km^3) or 1.2% of the world's total drainage area.
- The river with the largest runoff in North America (ninth largest in the world) is the Mississipi with 580 (km^3) or 1.3% of the world's total runoff. The drainage area of this river is 3.2 million (km^2 or 2.2% of the world's total drainage area.
- The river with the largest runoff in Europe (twenty first largest in the world) is Volga with 254 (km^3) or 0.6 % of the world's total runoff. The drainage area of this river is 1.36 million (km^2) or .9% of the world's total drainage area.
- Of the twenty five rivers with the largest runoff in the world, 11 are in Asia, 5 in North America, 4 in South America, 3 in Africa and 2 in Europe and none in Australia. These twenty five rivers together provide 45% of the world's total runoff, and make up 32% of the world's total drainage area.
- There are 13 major rivers with five or more nations forming part of the basin. The river Danube has the largest number with 12 nations followed by the river Niger with 10 nations.
- There are 15 rivers each in Africa, North and Central America, South America, Asia and Europe with 2 or more nations sharing a river basin.
- There are 15 countries with 75% or more of area in international river basins, and with low per-capita water availability. Of these 7 are in Europe, 5 in Africa, 2 in Asia and 1 in South America. The seven countries in Europe have less than 2,000 m^2 of water per capita per year.
- Sediment discharges from river runoff vary considerably, The highest average sediment discharge was 1.6 million tones/km^3 for Asia, 0.3 million tones/km^3 for Europe, 0.25 million tones/km^3 for North America, 0.18 million tones/km^3 for South America. The lowest sediment discharge was observed in USSR, 0.04 million tones/km^3 and in Africa 0.1 million tones/km^3.

I.2 WATER AVAILABILITY AND USES

- Overall per capita water availability has declined due to population growth. The largest decline had been in Africa (75% between 1950-2000) and the least in Europe (30%). In Asia and South America the decline is estimated to be around 65-66%. (Table I.2.1)
- Water availability data for 1990 shows that 20 countries from mostly the Middle East and Africa were water scarce. Twelve countries were classified as water stressed countries, while the rest were considered water abundant countries. ("Sustaining Water- Population and the Future of Renewable Water Supplies") Population Action International by Robert Engelman and Pamela Le Roy - Appendix 2- p.48, 49)
- World's water withdrawals is still a small proportion of world's annual runoff. However, while average runoff remains constant, actual withdrawals have increased from 7.5% of total runoff in 1980 to 9.2% in 1990 and is expected to reach to 11.7% in the year 2000. (Table AI.2.1)
- Withdrawals of water for agriculture which was around 90% of the total in 1900 declined to 70% by 1980, and is expected to go down to 63% by the year 2000. (Table AI.2.2)
- In most countries of Asia and Africa, the withdrawals for Agriculture are high (Table AI.2.3)
- Withdrawals of water for industry which was 6% of total in 1900, increased to 21% in 1980, and is estimated to go up to 25% of the total in the year 2000. (Table AI.2.2)
- Withdrawals for municipal use and reservoirs are expected to reach 8% and 4% of the total respectively in the year 2000, from 3% and 0.1 in 1900. (Table AI .2.2)
- Use for agriculture forms a major proportion of total consumptive use. However it has declined from 98% of the total in 1900 to 89% of the total in 1980 and is projected to fall to 86% by the year 2000. Industry and Reservoir resources will make up 4 and 8% of the total, while Municipal use remains at about 2% of the total. (Table AI.2.4)
- Consumptive use of water (water lost irretrievably) for agriculture has remained between 75% - 78% of withdrawals during the period 1900 and 1980 and is expected to remain at this level in future as well. (Table I.2.4)
- Consumptive use for Municipal use, however has declined from 25% to 20% of withdrawals between 1900-1980 and is projected to decline further to 15% of withdrawals for the year 2000. (Table I.2.4)
- Consumptive use in Industry has been between 7.5% and 9.5 % of withdrawals, during the period 1900-1990 and is projected to be 9.1% in the year 2000. (Table I.2.4)
- Total consumptive use has declined from 72% of withdrawals in 1900 to 59% in 1980 and is projected to decline to 56% by the year 2000. (Table I .2.4)

I .3 IRRIGATED AGRICULTURE

- The total world land area is 13 billion ha. (13x109 ha.). Only about 11% of the world's land area (1.48 billion ha.) is classified as cropland, of which 10.6% (1.37 billion ha) is

arable. Of the arable extent 17% (232.8 million ha) is irrigated. The bulk (62%) of the irrigated area is in Asia (146.4 million ha.), where 35% of the arable land area is irrigated. (Table I.3.1)

- World's irrigated area has doubled between 1900 and 1950 and more than doubled again to i.e. 235 million ha. in the last 40 years (Table I.3.2)
- The top five countries with the largest irrigated extent, China, India, USSR, US and Pakistan together account for 63% of the world's irrigated area. (Table I.3.3)
- Asia with over a third of its cropped land under irrigation has the largest area irrigated. South America, Africa and Oceania have 6% or less of cropped area under irrigation.(Table I.3.1)
- World's irrigated area increased by 2-4% annually during the 1950's, 1960's and 1970's. The highest rate of growth of irrigated area occurred during the 1950's, at an annual average rate of 4.3%. Thereafter it declined to 2.4 in the 1970's to 1.1% in the 1980's. (Table I.3.4)
- The world's per capita irrigated area which was rising up to the late 1970's, has started to decline since then due to population increases. (Table I.3.6)
- Over the last 15 year period, irrigated area has increased by over 30% in USSR, Europe, S.America and Oceania.
- Africa has by far the largest population per unit irrigated area (55.7 persons/ha.) according to 1989 estimates, followed by South America (32.9 person/ha), Europe (28.9 persons/ha) and Asia (20.9 persons/ha) (Table AI.3.1)
- Although only 16% of the worlds cropped area is irrigated, over a third of the worlds agricultural output is obtained from this area ("Water in Crisis" by Peter Glieck p.56)
- Average annual growth rates of irrigated agricultural area is declining in Asia since the late 1960's. The rate declined from 2.5% during the period 1965-70 to 0.4% during the period 1985-88. Growth rates were higher in South East Asia, than in the South or East Asia. (Table I.3.6)
- Area under rice in Asia has been growing at a rate of 0.73% while production has risen at an annual rate of over 3% over the period 1987-1990. Yield per hectare has been growing at a rate of 2.3% annually over this period. (Table I.3.7)
- Area under wheat in Asia has been growing at a higher rate of 1.5% annually over the period 1961-1989 in comparison to rice. Production rose at 6% per annum while yields grew at 4.5% annually over the same period. (Table I.3.8)

I.4 WATER USE FOR HOUSEHOLDS, INDUSTRY & ENVIRONMENT

- A much lower proportion of the population in low income economies had access to sanitation than to safe drinking water . A greater proportion of the urban population had access to both drinking water and sanitation, than the rural population in low income economies. (Table I.4.1).

- The proportion of population with access to both sanitation and drinking water increased between 1970 and 1990 in the low income economies. It was close to 100% in the case of high income or upper middle income countries, particularly for the urban population. (Table I.4.1)
- Estimated inflow /outflow of water for Industrial use in developing countries was only 7.5% of that used by developed countries. Developed countries used 93% (245 million tones) of water used in industry. (Table I.4.2)
- Excepting in India, Bangladesh and a few other countries, ground water was used mainly for domestic and municipal use followed by industry or irrigation. (Table AI.4.1)
- In the United States , the consumptive use of water per unit of production for a large majority of the industries was a small proportion of the intake It averaged about 9% for all industries. Consumptive use as a proportion of gross water used was of 3% per unit of production .
- Water efficient technologies can reduce domestic use of water by as much as 45-55%.

I.5 INVESTMENTS, COSTS AND PRICES

- Real capital costs of construction of new irrigation systems have more than doubled between 1966 and 1988 according to data from six Asian countries. (Table I.5.1)
- The steepest increase was observed in the case of Sri Lanka, and the lowest rate of increase in India. (Table I.5.1)
- Average annual lending for irrigation in Asian countries by bilateral and multi lateral aid agencies has been declining since 1969/70. In 1986/87, the average lending was half the average amount in 1977/79. A similar trend is shown for South Asia and South East Asia. (Tables I.5.2, I.5.3, I.5.4)
- Average annual public expenditure for irrigation development in Asian countries have declined by almost half between the period 1970-1990 excepting for Indonesia, Thailand and Bangladesh.[Table 8 Food Policy. Feb. 1993]. In the latter two countries, investment have remained constant, while in Indonesia it has almost doubled. (Table I.5.5)

PART I

LIST OF TABLES

I.1. WORLD WATER RESOURCES

Table I.1.1 WORLD WATER STOCKS

	Distribution Area (km^2)	Volume ($10^3 km^3$)	Percent of Fresh Water
World Ocean	5.9	1,338,000	-
Fresh Water Resources	148,800	35,030	100
Glaciers & Permanent Snow Cover	16,227	24,064	69
Fresh ground water	134,800	10,530	30
Ground Ice / Permafrost	21,000	300	1
Fresh Water Lakes	1,236	91	-
Other fresh water resources*	510,000	45	-

* Swamp water, river flows, biological water, atmospheric water and soil moisture.
Source: Based on "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.13)

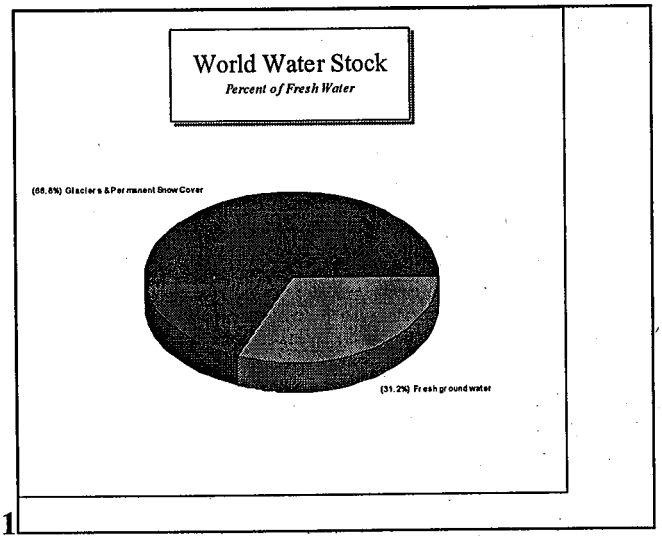


Figure 1

Table I.1.2 WATER BALANCE OF THE LAND

Continent	Precipitation		Evaporation		Runoff	
	(mm)	(km^3)	(mm)	(km^3)	(mm)	(km^3)
Europe	790	8,290	507	5,320	283	2,970
Asia	740	32,200	416	18,100	324	14,100
Africa	740	22,300	587	17,700	153	4,600
North America	756	18,300	418	10,100	339	8,180
South America	1,600	28,400	910	16,200	685	12,200
Australia and Oceania	791	7,080	511	4,570	280	2,510
Antarctica	165	2,310	0	0	165	2,310
Land as a whole	800	119,000	485	72,000	315	47,000
Areas of external runoff	924	110,000	529	63,000	395	47,000[a]
Areas of internal runoff	300	9,000	300	9,000	34	1,000[b]

Notes: a Including underground water not drained by rivers
b Lost in the region through evaporation
Source: "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.15)

Table I.1.3 ANNUAL AVERAGE WATER BALANCE OF THE CONTINENTS (km^3/yr)

Continent	Precipitation	Ground Water Runoff	Surface Water Runoff	Total Surface Wetting
Europe	7,165	1,065	2,045	5,120
Asia	32,690	3,410	9,780	22,910
Africa	20,780	1,465	2,760	18,020
North America	13,910	1,740	4,220	9,690
South America	20,355	3,740	6,640	22,715
Australia and Oceania	6,405	465	1,500	4,905
Total	101,305	11,885	26,945	83,360

Source: Adapted from "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.15)

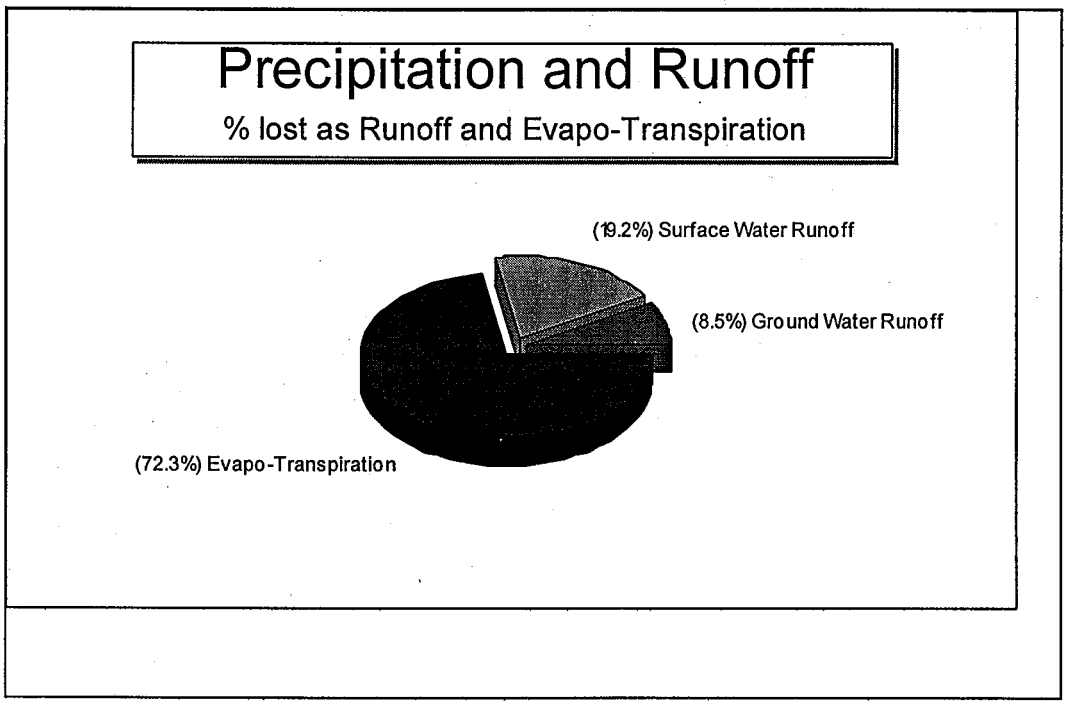


Figure 2

Table I.1.3a ANNUAL AVERAGE WATER BALANCE OF THE CONTINENTS(mm/yr)

Continent	Precipitation	Ground Water Runoff	Surface Water Runoff	Surface Wetting	Evapo-transpiration	Land Area in Million ha
Europe[a]	734	109	210	524	415	980
Asia	726	76	217	509	433	4,500
Africa	686	48	91	595	547	3,030
North America[b]	670	84	203	467	383	2,070
South America	1,648	210	378	1,275	1,065	1,780
Australia[c]	736	54	172	564	510	870
Total land area	834	90	204	630	540	13,230

[a] Europe includes Iceland [b] North America includes Central America and excludes the Canadian Archipelago
[c] Australia includes New Zealand, New Guinea and Tasmania.
Source: Adapted based on "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.124)

Table I.1.4 RIVER RUNOFF RESOURCES IN THE WORLD

Territory	Annual River Runoff		Portion of total runoff (%)	Area (10^3 km^2)	Specific discharge (l/s/km^2)
	(mm)	(km^3)			
Europe	306.0	3,210.0	7.0	10,500.0	9.7
Asia[a]	332.0	14,410.0	31.0	43,475.0	10.5
Africa[b]	151.0	4,570.0	10.0	30,120.0	4.8
N'America[c]	339.0	8,200.0	17.0	24,200.0	10.7
S'Americ[c]	661.0	11,760.0	25.0	17,800.0	21.0
Australia[d]	45.0	348.0	1.0	7,683.0	1.4
Oceania	1,610.0	2,040.0	4.0	1,267.0	51.1
Antarctic[a]	160.0	2,230.0	5.0	13,977.0	5.1
Total Land Area	314.0	46,770.0	100.0	149,000.0	10.0

Notes:
[a] Asia includes Japan, the Philippines and Indonesia
[b] Africa includes Madagascar [c] North and Central America [d] Australia includes Tasmania.
Source: "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.15)

Table I.1.5 SEASONAL DISTRIBUTION OF RUNOFF

Continent	Period of Maximum Runoff	% of Runoff
1. Europe	April- July	48.0
2. Asia	May - Oct.	80.0
3. Africa	Jan - June	74.0
4. North America	May - Aug.	54.0
5. South America	Mar - Sept.	70.0
6. Australia	Jan - March	68.0

Source: Water in Crisis, A Guide to the World's Fresh Water Resources (p.17-18)

Table I.1.6 LARGE RIVERS OF THE WORLD (with mean annual runoff greater than 200 km^3)

	River	Average Runoff (Km^2)	Area of Basin (10^3 km^3)	Length (Km)	Continent
1	Amazon	6,930	6,915	6,280	S. America
2	Congo	1,460	3,820	4,370	Africa
3	Ganges (with Brahmaputra)	1,400	1,730	3,000	Asia
4	Yangzijiang	995	1,800	5,520	Asia
5	Ornoco	914	1,000	2,740	S. America
6	Panana	725	2,970	4,700	S.America
7	Yenisei	610	2,580	3,490	Asia
8	Mississippi	580	3,220	5,985	N.America
9	Lena	532	2,490	4,400	Asia
10	Mekong	510	810	4,500	Asia
11	Irrawaddy	486	410	2,300	Asia
12	St.Lawrence	439	1,290	3,060	N.Amercia
13	Ob	395	2,990	3,650	Asia
14	Chutsyan	363	437	2,130	Asia
15	Amur	355	1,855	2,820	Asia
16	Mackenzie	350	1,800	4,240	N.America
17	Niger	320	2,090	4,160	Africa
18	Columbia	267	669	1,950	N.America
19	Magdalena	260	260	1,530	S.America
20	Volga	254	1,360	3,350	Europe
21	Indus	220	960	3,180	Asia
22	Danube	214	817	2,860	Europe
23	Salween	211	325	2,820	Asia
24	Yukon	207	852	3,000	N.America
25	Nile	202	2,870	6,670	Africa
Total of 25 Basins		19,199	37,994	46,320	
As % of the total of the 5 continents	Nile	46.0	30.0		

Notes: Figures in this table are somewhat different from those in other tables due to rounding and differences in the sources

Source: Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick (p.16)

Table I.1.7

INDUS RIVER BASIN OUTFLOW FOR THE 'PERIOD 1956/57 -1967/68 (MCM)

YEAR	NOV	DEC	JAN	FEB	MAR	APR
56	2848	1207	1267	1441	1235	3399
57	2239	4134	3317	739	237	7336
58	1407	1034	3880	3456	2875	1532
59	4260	1944	2583	599	686	6379
60	834	696	1461	751	308	3773
61	1321	820	1437	252	177	1292
62	421	398	942	62	21	171
62	259	191	1318	184	12	888
64	746	606	1266	124	33	893
65	0	117	36	2	3	2782
66	0	159	351	0	0	1850
67	240	308	2462	538	885	2342
Mean	1215	968	1693	679	539	2720
Max	4260	4134	3880	3456	2875	7336
Min	0	117	36	0	0	171
S.D	1253	1080	1101	929	803	2118
C.V	1.03	1.12	0.65	1.37	1.49	0.78

Max= Maximum
Min = Minimum
S.D = Standard Deviation

Source: WAPDA, Pakistan

Table I.1.8

INDUS RIVER BASIN OUTFLOW FOR THE 'PERIOD 1968/69 -1980/81 (MCM)

YEAR	NOV	DEC	JAN	FEB	MAR	APR
68	2	230	12	0	0	1864
69	17	270	23	0	0	866
70	0	0	0	0	0	0
71	0	0	0	0	0	0
72	0	0	0	0	0	0
73	201	276	188	32	0	184
74	0	0	0	0	0	0
75	0	49	0	0	0	0
76	827	887	898	771	81	377
77	159	38	56	0	140	639
78	666	78	103	18	3690	343
79	0	24	137	0	0	3448
80	0	78	556	731	22	0
Mean	144	148	152	119	303	594
Max	827	887	898	771	3690	3448
Min	0	0	0	0	0	0
S.D	274	243	268	278	1015	935
C.V	1.90	1.64	1.77	2.33	3.35	1.57

Max= Maximum
Min = Minimum
S.D = Standard Deviation

Source: WAPDA, Pakistan

Table I.1.9

INDUS RIVER BASIN OUTFLOW FOR THE 'PERIOD 1981/82 -1993/94 (MCM)

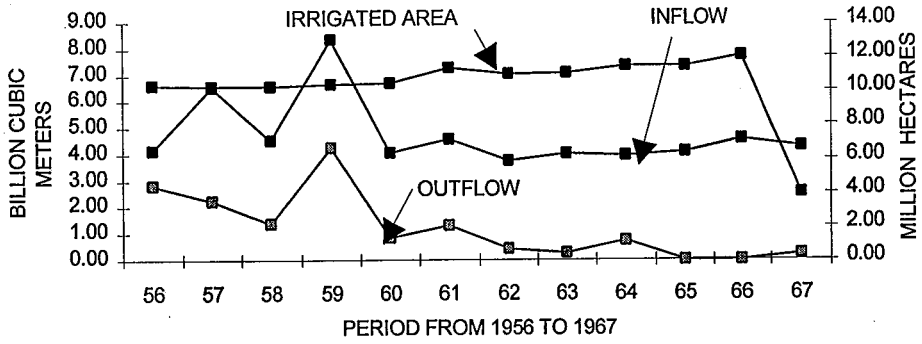
YEAR	NOV	DEC	JAN	FEB	MAR	APR
81	0	65	88	7	0	1390
82	54	59	39	0	0	506
83	73	317	998	374	0	2117
84	20	59	666	17	0	22
85	0	38	10	0	0	0
86	0	67	122	0	0	0
87	7	43	2	0	0	2395
88	1113	443	1101	374	0	0
90	0	118	330	0	0	0
91	137	161	1506	479	563	1006
92	0	70	344	1840	86	7336
93	2415	1218	1420	379	568	2420
94	51	153	205	58	5	2652
Mean	298	216	526	271	94	1526
Max	2415	1218	1506	1840	568	7336
Min	0	38	2	0	0	0
S.D	698	321	535	501	209	2037
C.V	2.35	1.48	1.02	1.84	2.22	1.33

Max= Maximum
Min = Minimum
S.D = Standard Deviation

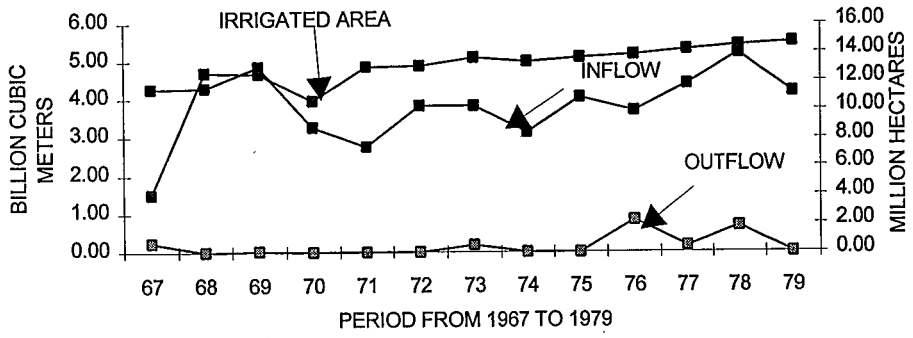
Source: WAPDA, Pakistan

FIGURE 3

INFLOW-OUTFLOW CHART
FOR THE MONTH OF NOVEMBER : VARIOUS YEARS



INFLOW-OUTFLOW CHART
FOR THE MONTH OF NOVEMBER : FOR VARIOUS YEARS



INFLOW-OUTFLOW CHART
FOR THE MONTH OF NOVEMBR : FOR VARIOUS YEARS

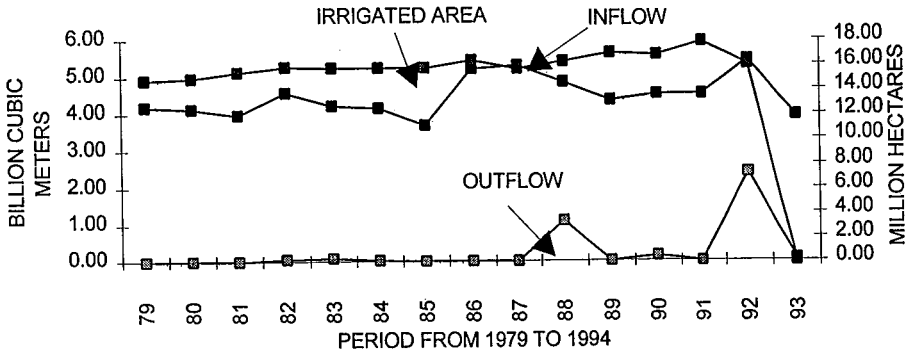
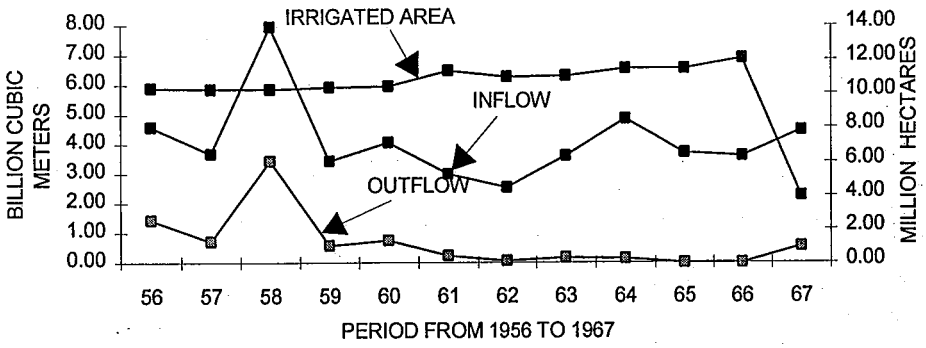
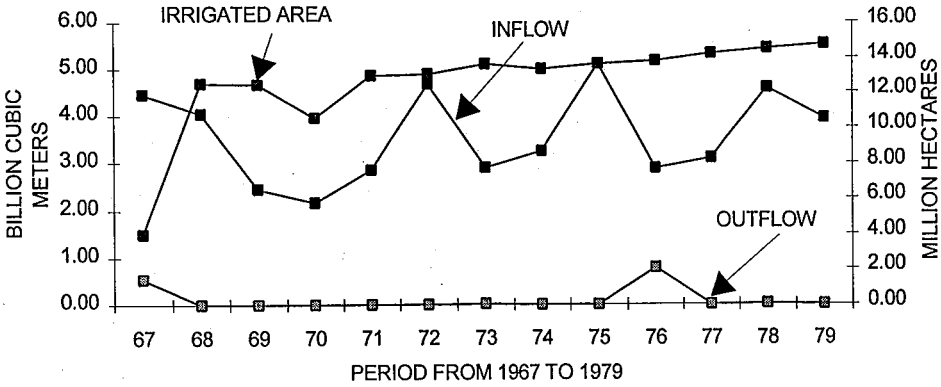


FIGURE 6

INFLOW-OUTFLOW CHART
FOR THE MONTH OF FEBRUARY : VARIOUS YEARS



INFLOW-OUTFLOW CHART
FOR THE MONTH OF FEBRUARY : FOR VARIOUS YEARS



INFLOW-OUTFLOW CHART
FOR THE MONTH OF FEBRUARY: FOR VARIOUS YEARS

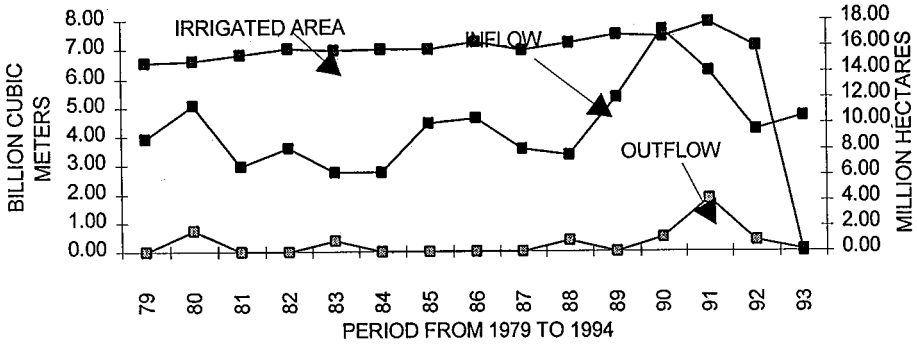
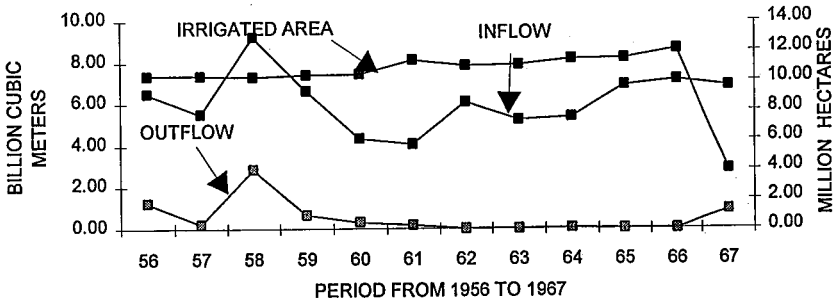
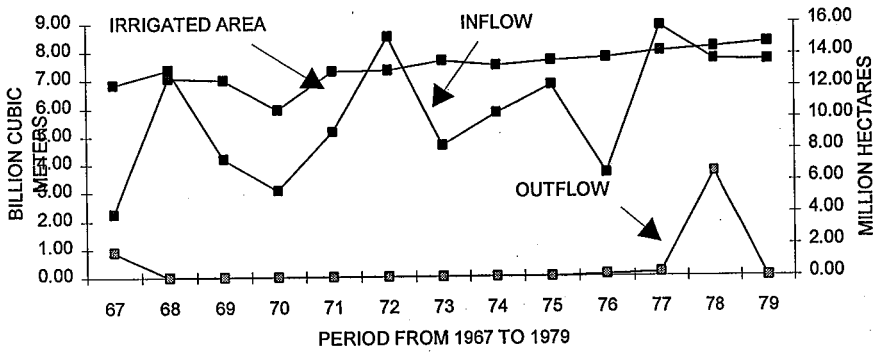


FIGURE 7

INFLOW-OUTFLOW CHART
FOR THE MONTH OF MARCH : VARIOUS YEARS



INFLOW-OUTFLOW CHART
FOR THE MONTH OF MARCH : FOR VARIOUS YEARS



INFLOW-OUTFLOW CHART
FOR THE MONTH OF MARCH : FOR VARIOUS YEARS

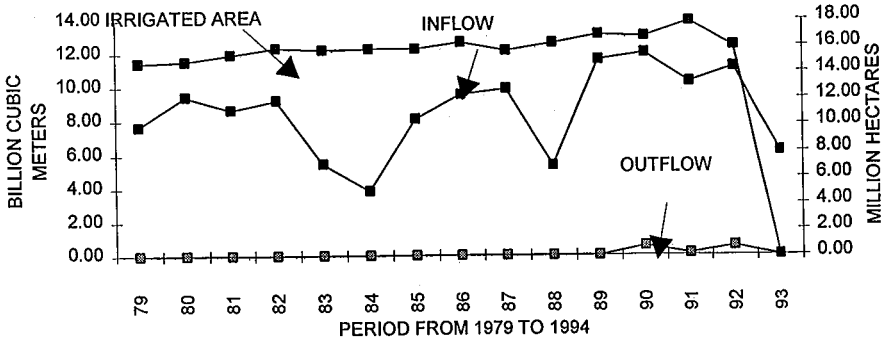
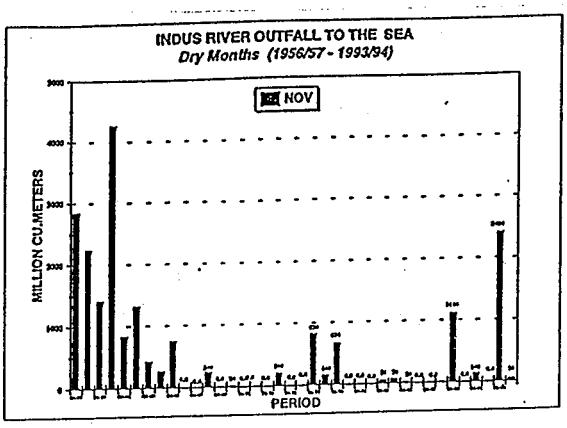
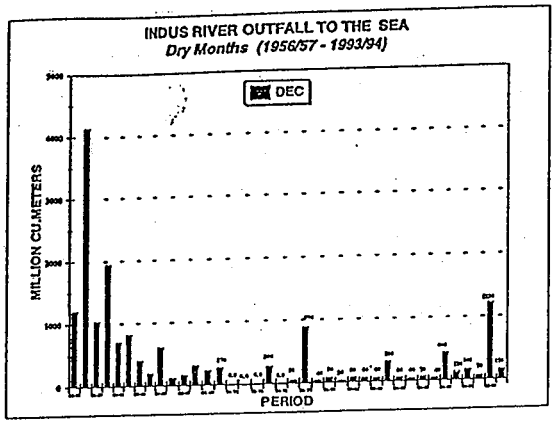
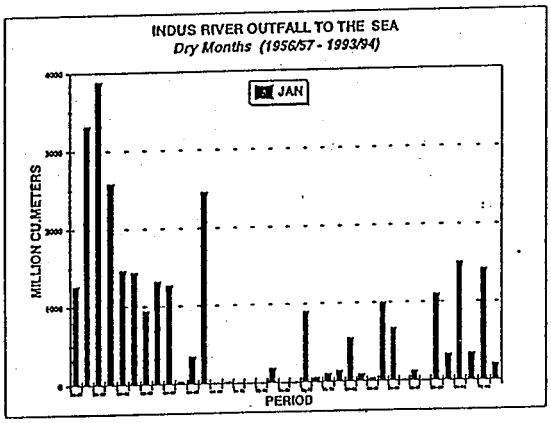
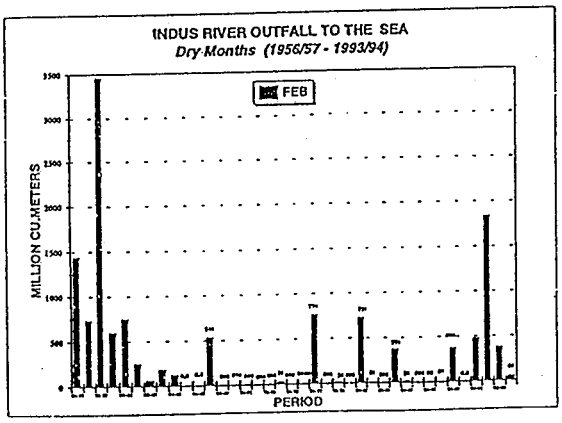


Figure 9
INDUS RIVER OUTFLOW TO THE SEA









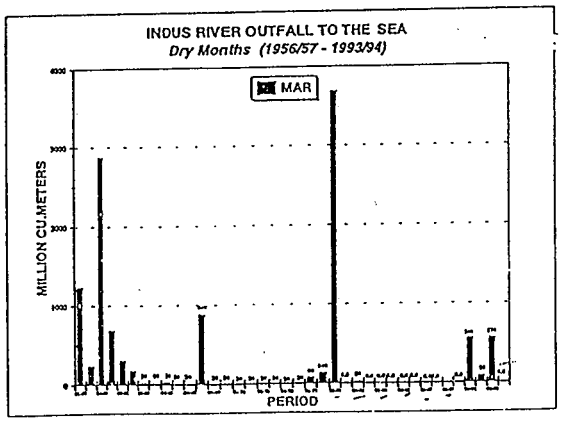


Table I.1.10
INDUS RIVER BASIN: INFLOWS, OUTFLOWS AND DIVERSIONS

PERIOD I (1956-67)				
Year	Outflow BCM	Inflow BCM	Irrigated Area in Mha	Diversions BCM
56	149.32	194.24	10.30	98.00
57	114.57	186.26	10.27	102.00
58	112.42	195.55	10.25	107.00
59	158.85	230.44	10.35	104.00
60	95.56	179.87	10.41	100.00
61	96.73	173.32	11.35	102.00
62	44.25	135.44	11.01	106.00
63	64.18	166.46	11.04	110.00
64	78.27	170.89	11.44	111.00
65	59.67	171.43	11.48	113.00
66	72.22	173.24	12.09	118.00
67	86.16	180.11	12.62	118.00
Mean	94.27	179.77	11.05	107.42
Maximum	158.85	230.44	12.62	118.00
Minimum	44.25	135.44	10.25	98.00
S.D.	33.39	21.30	0.75	6.40
CV	0.35	0.12	0.07	0.06

PERIOD II (1968-80)				
Year	Outflow BCM	Inflow BCM	Irrigated Area in Mha	Diversions BCM
68	62.22	171.41	12.56	121.00
69	53.05	165.62	12.49	121.00
70	31.63	130.93	10.59	107.00
71	28.47	128.36	12.99	107.00
72	26.18	155.75	13.06	124.00
73	119.26	202.39	13.64	119.00
74	10.03	120.55	13.34	107.00
75	48.41	171.90	13.63	122.00
76	85.22	166.96	13.83	120.00
77	37.49	157.21	14.22	127.00
78	99.42	201.66	14.47	119.00
79	36.77	162.67	14.74	129.00
80	24.80	168.47	14.90	132.00
Mean	51.00	161.84	13.42	119.62
Maximum	119.26	202.39	14.90	132.00
Minimum	24.80	128.36	10.59	107.00
S.D.	31.08	23.77	1.10	7.86
CV	0.61	0.15	0.08	0.07

S.D. = STANDARD DEVIATION
CV = COEFFICIENT OF VARIATION

Table I.1.10 (Contd.)

PERIOD III (1981-93)				
Year	Outflow BCM	Inflow BCM	Irrigated Area in Mha	Diversions BCM
81	41.69	173.49	15.39	125.00
82	11.94	151.06	15.87	127.00
83	56.63	184.73	15.72	124.00
84	36.45	166.44	15.76	125.00
85	13.54	145.24	15.79	119.00
86	33.19	181.07	16.31	130.00
87	21.62	173.91	15.68	134.00
88	65.21	199.28	16.22	130.00
89	21.25	161.90	16.89	126.00
90	52.23	204.90	16.75	135.00
91	65.68	212.02	17.85	135.00
92	100.53	209.56	16.03	132.00
Mean	42,76	178.44	16.18	128.23
Maximum	100.53	209.56	17.85	135.00
Minimum	11.94	145.24	15.39	119.00
S.D.	24.08	21.64	0.63	4.69
CV	0.56	0.12	0.04	0.04

S.D. = STANDARD DEVIATION
CV = COEFFICIENT OF VARIATION

Source: WAPDA, Pakistan

Table I.1.11
INDIA: SEASONAL AVERAGE RUNOFF NEAR OUTFLOW POINTS IN MAJOR RIVER BASINS (Km^3)

					Average values	(1983-90)	1989/90
Item No	River	Site	Catchment Area (000 sq.km)	Runoff Non Monsoon (Km^3)	Runoff Monsoon (Km^3)	Non Monsoon Runoff as % of Total	Non Monsoon Runoff (km^3)
1	Godavari	Polavaram	308	4.8	31.1	13	6.2
2	Krishna	Vijayawada	251	2.4	14.7	14	2.1
3	Narmada*	Garudeshwar	99	2.7	36.8	7	N/A
4	Mahanadi	Basantpur	58	0.5	16.8	3	0.3
5	Brahmani- Baitarni	Jenapur/Anandpur	43	2.7	20.0	12	3.2
6	Pranhita	Tekra	109	0.8	36.0	2	0.6
7	Indravati	Pathagudem	40	0.5	16.7	3	1.1
8	Bhima	Yagdir	70	0.2	8.1	3	0.2
9	Subernarekha	Ghatsila	19	0.2	5.9	4	0.2
10	Pennar	Siddavattam	39	0.1	0.8	5	0.0

* Narmada data for period 1948-65
Monsoon Runoff is during the months of Jun-Oct.
Non Monsoon is for the remaining period.

Source: Water and Related Statistics, Central Water Commission of India, March 1994, (pp.-36)

Table I.1.12

INDIA: WATER QUALITY NEAR OUTFLOW OF POINTS OF SELECTED RIVER BASINS

River Basin →	Tapi[1]	Narmada[1&3]	Mahi[1]	Sabarmati[1]	Krishna[2]	Pennar[2]	Godavari[2]	*
Site → / Water Quality ↓	Kathore	Gurudeshwar	Valsad	(Ahmedbad)	Vijayawada	Siddavattam	Polavaram	WHO/US/INDIA Standards
Ph (Average)	8.25	8.45	8.45	7.68	8.60	8.12	8.12	7.5
Turbidity (ppm)	20.20	3.80	21.10	46.50				
Conductivity(Ec)- Average	341.50	284.80	416.40	1357.00				
Max.					530.00	1953.00	412.00	
Alkalinity (SP)	187.60	141.80	194.00	434.00				
SP %				434	45.40	29.10	44.40	
DO (mg/l) Average	7.28	8.24	8.70	1.78				4-7.5
BOD (mg/l) Average	2.82	5.33	1.41	5278.00				3-4
Hardness (mg/l)	266.00	159.00	166.00	256.00	194.00	306.00	86.00	
Faecal Coliform (MPN) 100 m.l	1316.00	9528.00	20190.00	8908988.00				500
Total Coliform (MPN)/100 m.l	2267.00	9528.00	20190.00	11395824.00				5000
Cl. (mg/l)	37.30	25.90	40.60	292.00	1.84	4.06	0.79	25
Nitrogen (mg/l)			0.45	6.70	-			
NO_2 NO (mg/l)	1.47	1.04	1.56	0.29	0.93	0.28	0.07	10
Ca. (mg/l)	36.30	32.40	28.50	46.00	-			
Mg.. (mg/l)	24.70	18.40	22.50	33.90	1.97	3.37	1.97	
SO_4 (mg/l)	10.80	21.40	7.82	119.80	0.78	3.12	0.80	250
Na. (mg/l)	22.80	27.40	42.80	162.30	-			
Fe.					0.04	0.09	0.03	0.3
RSC (Max.)					3.01	0.26	0.66	
SAR (Max)					1.53	0.91	1.84	

RSC - Residual Sodium Carbonate **MPN**- Most Probable Number **SP** Sodium Percentage **BOD** - Biological Oxygen Demand
DO Dissolved Oxygen **ppm** - parts per million **SAR** Sodium Absorption Rate
H. - Logarithm to the base 10 of the reciprocal of Hydrogen ion concentration * **WHO/US/INDIA** - Standard values for stream water.

1. Sources: Paper presented at 25th Annual Conference of the Gujarat Economic Association by Kirit Pasikh " Equitable Sustainable Development of Gujarat", Indira Gandhi Institute of Development Research, Gandhinagar, India, Feb 1995.
2. Water and Related Statistics, Central Water Commission of India, March 1994 - (pp. 290-293)

Alagh Y.K, Mahesh Palthak, Buch D.J " Narmada and Environment Assessment ", Har-Anand Publications, 364 A, Chirag N.Delhi110017, Original Source: Central Water Pollution Control Board " India. Henry J Glym and Heinke, Gary W. "Environmental Science and Engineering, Prentice Hall, N.J.1989. (pp.379 & 421)

Table I.1.13

INDIA: SALIENT STATISTICS OF GBM BASIN

	Item	Sub-Basin/Basin			Total
		Ganga	Brahmaputra	Megna	
1	Area (000 Sq.km)	1,078	577	91	1,746
2	Arable (000 Sq.km)	667	86	45	798
3	Av.an.runoff (cu.km/yr)	522.80	537.32	59.80	1,276.1
4	Energy potential (MW@ 60% LF)	94,000	54,000	2,000	150,000
5	Pop. 1990-91 (Million)	416	80	39	535
6	Water per Capita (cu.m/year)	1.01	8.24	4.43	2.42
7	Water/unit cultivable land (cu.m)	0.57	7.27	4.43	1.50

Source: Harnessing the Eastern Himalayan Rivers, B.G. Verghese- Ramaswamy Iyer, center for Policy research, New Delhi. (p.12/13)

Table I.1.14

INDO- GANGETIC PLAIN: AVERAGE MONTHLY RAINFALL FROM WEST TO EAST ACROSS (mm)

State	Rajastan	Haryana	Uttar.P N.W	Uttar P E.C.S	Uttar P N.E	Bihar C.W	Bihar C.E	W. Bengal
Climatic St.	Bikaner	Hissar	Meerut	Allahabad	Gorakhpur	Patna	Bhagalpur	Calcutta
Command	Rajast. c	W. Yamuna	U. Ganga	S. Sahayek	Gandak	Sone	Chandan	Damodar
Data	30 Yrs	30 Yrs	10 Yrs	30 Yrs	30 Yrs	30 Yrs	10 Yrs	30 Yrs
Jan	6	19	30	20	19	21	35	13
Feb.	7	15	30	22	14	20	4	22
Mar	6	17	15	14	11	7	6	30
Apr.	5	6	8	5	11	8	9	50
May	8	11	9	8	41	28	48	135
Jun.	27	34	71	102	186	139	208	263
Jul.	87	122	247	275	342	266	253	320
Aug.	105	114	229	333	315	607	251	318
Sept.	45	81	152	195	253	243	246	253
Oct.	6	15	37	40	74	63	79	134
Nov.	3	8	2	7	5	6	5	29
Dec.	2	5	8	6	3	2	2	4
Kharif	263	351	699	905	1096	954	957	1154
Rabi	16	46	77	73	101	92	120	180
Summer	26	49	62	50	77	63	66	236
Total	305	446	838	1027	1274	1110	1143	1570
Wettest Yr	641	1048	1520	1936	2455	1959	1595	2626
Driest Yr	123	158	302	516	650	642	838	867

Source: Irrigation Management on the Indo-Gangetic Plain, D.J.W. Berkoff, 1990. World Bank Paper Number 129, (p.27)

Table I.1.15

INDO- GANGETIC PLAIN: AVERAGE DAILY EVAPOTRANSPIRATION AND SEASONAL AND ANNUAL Et0 FROM WEST TO EAST (mm)

State	Rajastan	Haryana	Uttar.P. N.W	Uttar P E.C.S	Uttar P N.E	Bihar C.W	Bihar C.E	W. Bengal
Climatic St.	Bikaner	Hissar	Meerut	Allahabad	Gorakhpur	Patna	Bhagalpur	Calcutta
Command	Rajast.c	W.Yamuna	U.Ganga	S.Sahayek	Gandak	Sone	Chandan	Kharif
Data	30 Yrs	30 Yrs	10 Yrs	30 Yrs	30 Yrs	30 Yrs	10 Yrs	30 Yrs
Jan	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Feb.	4.0	4.0	4.0	4.0	4.0	5.0	5.0	4.0
Mar	7.0	7.0	6.0	7.0	6.0	7.0	7.0	7.0
Apr.	9.0	8.0	8.0	9.0	8.0	9.0	10.0	8.0
May	11.0	10.0	10.0	11.0	9.0	10.0	9.0	8.0
Jun.	12.0	10.0	9.0	9.0	7.0	7.0	6.0	6.0
Jul.	8.0	8.0	6.0	5.0	5.0	6.0	5.0	5.0
Aug.	8.0	6.0	5.0	4.0	5.0	5.0	4.0	5.0
Sept.	8.0	6.0	5.0	5.0	4.0	5.0	4.0	5.0
Oct.	5.0	5.0	5.0	5.0	4.0	5.0	4.0	4.0
Nov.	4.0	4.0	4.0	4.0	3.0	4.0	4.0	4.0
Dec.	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Kharif	1,117.0	947.0	750.0	721.0	646.0	688.0	6.0	604.0
Rabi	462.0	454.0	407.0	441.0	395.0	461.0	437.0	448.0
Summer	947.0	855.0	845.0	944.0	819.0	933.0	906.0	809.0
Total	2,526.0	2,256.0	2,002.0	2,106.0	1,860.0	2,081.0	1,965.0	1,861.0

Source: Irrigation Management on the Indo-Gangetic Plain, D.J.W. Berkoff, 1990. World Bank Paper Number 129. (p.28)

Table I.1.16
INDO-GANGETIC PLAIN: CROP WATER REQUIREMENT OF PADDY TRANSPLANTED ON JULY 10, Av.Et0 - (mm)

State	Rajastan	Haryana	Uttar.P. N.W	Uttar P E.C.S	Uttar P N.E	Bihar C.W	Bihar C.E	W.Bengal
Climatic St.	Bikaner	Hissar	Meerut	Allahabad	Gorakhpur	Patna	Bhagalpur	Calcutta
Command	Rajast.c	W.Yamuna	U.Ganga	S.Sahayek	Gandak	Sone	Chandan	Kharif
Data	30 Yrs	30 Yrs	10 Yrs	30 Yrs	30 Yrs	30 Yrs	10 Yrs	30 Yrs
Jan	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Feb.	4.0	4.0	4.0	4.0	4.0	5.0	5.0	4.0
Mar	7.0	7.0	6.0	7.0	6.0	7.0	7.0	7.0
Apr.	9.0	8.0	8.0	9.0	8.0	9.0	10.0	8.0
May	11.0	10.0	10.0	11.0	9.0	10.0	9.0	8.0
Jun.	12.0	10.0	9.0	9.0	7.0	7.0	6.0	6.0
Jul.	8.0	8.0	6.0	5.0	5.0	6.0	5.0	5.0
Aug.	8.0	6.0	5.0	4.0	5.0	5.0	4.0	5.0
Sept.	8.0	6.0	5.0	5.0	4.0	5.0	4.0	5.0
Oct.	5.0	5.0	5.0	5.0	4.0	5.0	4.0	4.0
Nov.	4.0	4.0	4.0	4.0	3.0	4.0	4.0	4.0
Dec.	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Kharif	1,117.0	947.0	750.0	721.0	646.0	688.0	6.0	604.0
Rabi	462.0	454.0	407.0	441.0	395.0	461.0	437.0	448.0
Summer	947.0	855.0	845.0	944.0	819.0	933.0	906.0	809.0
Total	2,526.0	2,256.0	2,002.0	2,106.0	1,860.0	2,081.0	1,965.0	1,861.0

Source: Irrigation Management on the Indo-Gangetic Plain, D.J.W.Berkoff, 1990. World Bank Paper Number 129. (p.28)

Table I.1.17

INDO-GANGETIC PLAIN: NET SURPLUS/ DEFICIT OF 70% RAINFALL COMPARED TO WATER REQUIREMENTS FOR PADDY TRANSPLANTED ON JULY 10, Av. Et0 (mm)

State	Rajastan	Haryana	Uttar.P. N.W	Uttar P E.C.S	Uttar P N.E	Bihar C.W	Bihar C.E	W.Bengal
Climatic St.	Bikaner	Hissar	Meerut	Allahabad	Gorakhpur	Patna	Bhagalpur	Calcutta
Command	Rajast.c	W.Yamuna	U.Ganga	S.Sahayek	Gandak	Sone	Chandan	Damodar
Data	30 Yrs	30 Yrs	10 Yrs	30 Yrs	30 Yrs	30 Yrs	10 Yrs	Dec.
Jan								
Feb.								
Mar								
Apr.								
May								
Jun.	-131.0	-117.0	-84.0	-63.0	6.0	-28.0	26.0	67.0
Jul.	-297.0	-256.0	-100.0	-71.0	-21.0	-88.0	-68.0	-30.0
Aug.	-233.0	-172.0	-38.0	46.0	29.0	16.0	10.0	31.0
Sept.	-259.0	-187.0	-104.0	-59.0	-8.0	-27.0	-10.0	-11.0
Oct.	-199.0	-193.0	-153.0	-159.0	-121.0	-143.0	-118.0	-75.0
Nov.	-34.0	-30.0	-32.0	-30.0	-28.0	-32.0	-31.0	-15.0
Dec.			-512.0					
Total	-1,152.0	-954.0	-512.0	-337.0	-142.0	-302.0	-210.0	-34.0

Source: Irrigation Management on the Indo-Gangetic Plain, D.J.W.Berkoff, 1990. World Bank Paper Number 129. (p.32)

Table I.1.18

GODAVARI RIVER BASIN: SEASONAL AVERAGE OBSERVED RUNOFF (Billion Cubic Meters (BCM))

Name of Stream	Name of Site	Catchment Area in Sq.cm	1983-90		Total	Non Monsoon as % of Total
			Monsoon June-Sept	Non Monsoon		
1.0	2.0	3.0	4.0	5.0	6.0	7.0
Godavari	Dhalegaon	30,840.0	1.7	0.2	1.91	12.0
Godavari	Gangakhed Rd Bridge	33,934.0	2.1	0.1	2.21	5.9
Godavari	Yelli	53,630.0	6.1	0.3	6.33	4.3
Godavari	Mancherial	102,900.0	15.5	0.5	16.05	3.2
Godavari	Perur	260,200.0	58.9	2.1	60.95	3.4
Godavari	Koida	305,460.0	61.4	5.3	66.67	7.9
Godavari	Polavaram	307,800.0	31.1	4.8	35.86	13.2

Source: Water and Related Statistics, Statistics Directorate, Irrigation Management Organization, Central Water Commission, New Delhi. March 1994 (p.33)

Table I.1.19

KRISHNA RIVER BASIN: SEASONAL AVERAGE OBSERVED RUNOFF (Billion Cubic Meters (BCM))

Name of Stream	Name of Site	Catchment Area	1989-90		Total	Non Monsoon as % of Total
			Monsoon (June-Sept)	Non Monsoon		
1.0	2.0	3.0	4.0	5.0	6.0	7.0
Krishna	Galagali	22,560.0	11.3	0.9	12.2	7.2
Krishna	Huvinhedgi	55,150.0	14.3	0.4	14.7	2.8
Krishna	Deosaggar	129,500.0	27.1	0.0	27.1	0.0
Krishna	Krishna Agraharam	132,920.0	23.9	0.6	24.6	2.6
Krishna	Pondugala	221,220.0	14.9	3.7	18.6	19.9
Krishna	Wadenapalli	235,544.0	17.0	4.0	21.0	18.9
Krishna	Vijayawada	251,360.0	14.7	2.4	17.0	14.0
Krishna	Bhima	69,863.0	8.1	0.2	8.4	2.6
Krishna	Tungabadra	14,582.0	5.3	0.4	5.7	6.6

Source: Water and Related Statistics, Statistics Directorate,
Irrigation Management Organization, Central Water Commission. March 1994 (p.34)

Table I.1.20

KRISHNA RIVER BASIN: SEASONAL AVERAGE OBSERVED RUNOFF (Billion Cubic Meters (BCM))

Name of Stream	Name of Site	Catchment Area	1989-90		Total	Non Monsoon as % of Total
			Monsoon (June-Sept)	Non Monsoon		
1	2	3	4	5	6	7
Mahanadi	Rajim	8,760.0	0.5	0.0	0.5	3.8
Mahanadi	Basantpur	57,780.0	9.0	0.3	9.4	3.5
Mahanadi	Tikarpara	41,000.0	24.9	3.4	28.2	11.9
Brahmani	Bolani	18,070.0	6.5	0.4	6.9	6.0
Brahmani	Samal	28,200.0	0.0	0.0	0.0	0.0
Brahmani	Jenapur	33,955.0	11.7	3.1	14.8	20.6
Kharkai	Adityapur	6,309.0	2.5	0.1	2.6	3.8
Subernarekha	Mango	12,649.0	0.0	0.0	0.0	0.0
Subernarekha	Ghatsila	14,176.0	6.4	0.2	6.7	3.6
Baitarani	Anandpur	8,570.0	5.8	0.2	6.0	2.8

Source: Water and Related Statistics, Statistics Directorate,
Irrigation Management Organization, Central Water Commission. March 1994 (p.35)

Table I.1.21

SUBERNAREKHA RIVER BASIN :WATER REQUIREMENTS OF CROPS (mm)

Item No	Description of Crop	Jul	Aug	Sept.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1	Kharif Irrigated Paddy (75cm)	168	60	67	60									355
2	Kharif Irrigated Vegetable			18										18
3	Kharif Irrigated Maize		40	69	43	2								154
4	Kharif Pulse and Oilseeds													0
5	Rabi Irrigated Wheat (70 cm)					65	127	151	134					477
6	Rabi Irrigated Vegetables					136	66	154	186					542
7	Rabi Irrigated Pulses & Oil Seeds					115		154						269
8	Rabi Irrigated Maize							110	110	110				330
9	Summer Irrigated Vegetable									167	250	300	75	792
10	Summer Irrigated Gr.nut									167	250	300	75	792
11	Summer Irrigated Paddy	70									320	250	210	850
12	Perennial Sugarcane	115	115	59	133	105	62	44	47	71	149	305	260	1,465
Source: Planning for the Subernarekha River System in Eastern India. - Basawanna Sinha, Ramesh Bhatia & Supriya Lahiri,Sadhana,Vol,8 Part 3, May 1985.														

Table I.1.22

SUBERNAREKHA RIVER : BASIN HYDROLOGICAL INPUT AT EACH CONTROL POINT AND RELEASES TO ORISSA (Million Cubic Meters (MCM))

Month	Kharkai Dam	Subernarekha Dam	Kharkai Barrage	Subernarekha Barrage	Releases to Orissa
1.0	2.0	3.0	4.0	5.0	6.0
Jul	47.7	99.2	106.0	110.6	126.6
Aug	204.6	149.5	112.7	188.6	299.1
Sept.	291.3	891.0	85.1	390.3	313.9
Oct	81.1	163.3	77.4	92.1	106.2
Nov	21.2	66.9	30.6	113.4	38.5
Dec	9.0	10.5	13.4	26.1	17.2
Jan	5.2	10.4	10.2	25.1	42.0
Feb	4.5	9.7	12.6	26.2	47.6
Mar	4.4	7.7	9.8	25.2	51.3
Apr	2.4	6.3	5.1	23.8	31.4
May	4.6	10.0	7.1	25.2	6.8
Jun	17.9	127.3	64.2	32.7	43.3
Source:Policy Implications of Inter-Sectoral Linkages in Water Resources Management: Case Study from India G.Anandalingam, Ramesh Bhatia and Rita Cestti-Draft: Oct.30,1992					

Table I.1.23

SUBERNAREKHA RIVER BASIN: INFLOW AND OUTFLOW BALANCES FOR THE KHARKAI DAM (Million Cubic Meters (MCM))

Month	Inflow	Irrigation	Kharkai barrage	Reservoir losses	Storage at the end of the month
1.0	2.0	3.0	4.0	5.0	6.0
July	393.5	26.0	0.0	-	361.4
August	130.0	14.8	0.0	2.5	467.5
September	278.8	28.4	0.0	3.7	708
October	5.0	17.3	140.0	3.7	546.5
November	3.7	49.3	0.0	6.2	488.5
December	1.2	66.6	2.5	6.2	408.3
January	2.5	66.6	2.5	3.7	331.8
February	18.5	48.0	0.0	5.0	291.0
March	3.7	48.0	1.2	3.7	248.0
April	2.5	7.4	0.0	3.7	233.0
May	0.0	3.7	0.0	6.2	217.0
June	0.0	2.5	0.0	5.0	203.5

Source: Planning for the Subernarekha River System in Eastern India Basawn Sinha, Ramesh Bhatia and Supriya Lahiri, Sadhana Vol.8, Part 3, May 1985

Table I.1.24

SUBERNAREKHA RIVER BASIN: ANALYTICAL REPORT ON PHYSIO-CHEMICAL EXAMINATION OF WATER DRAWN FROM FOUR IMPORTANT NALAS (OPEN DRAINS) IN JAMSHEDPUR

SI No	Sample Source	Date & Time of collection of sample	PARAMETERS									
			Temp	pH	D.O (mg/l)	BOD 5 (mg/l)	COD (mg/l)	NH as N 3 (mg/l)	T.S. (mg/l)	T.S.S	T.D.S	Remarks
1.0	Susubgarhia Nala	11.30 am 14.5.91	40^0C	6.1	0.8	80.0	292.0	65.0	6,064.0	1190 mg/l	4874 mg/l	High cynids BOD_5 COD Ammonical, Nitrogen, Total dissolved Solids, Suspended Solids, are observe in the effluent and is highly polluting in nature
2.0	Garam Nala	10.25 am 13.05.91	34^0C	8.9	6.0	10.0	40.0	0.2	4,292.0	50.0 mg/l		Dissolved solids are beyond the tolerance limits. Does not conform to water quality and inland surface water
3.0	Jugsalai Nala	11.05 am 13.05.91	36^0C	7.0	4.5	26.0	100.0	1.0	522.0	95.0 mg/l		The water quality conforms to effluent quality and not inland surface water
4.0	Ram Mandir Nala	11.15 am 13.05.91	39.5^0C	8.5	5.1	16.0	76.0	0.4	1,000.0	624.0 mg/l		Suspended Solids are beyond the tolerance limit

Source: A Report on Water Resources Policies for Metropolitan Areas: A Case Study of Jamshedpur, India. Prepared by Metaplanners and Management Consultants, Patna, India (p.210)

Table I.1.25

SUBERNAREKHA RIVER BASIN: ANALYSIS REPORT ON PHYSIO-CHEMICAL EXAMINATION OF WATER DRAWN FROM POLLUTIONALLY RELEVANT POINTS IN RIVER SUBERNAREKHA & KHARKAI (MINIMUM & MAXIMUM RANGE DURING A YEAR).

Item No	Name of Sampling Station	Temp C^0	p^H	D.O	B.O.D	COD	N_a	Total Colifora	Faecal Colifora
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	7.0	8.0
	(A)								
1.	SUBERNAREKHA	(23^0C - 40^0C)	6.65-8.67	6.2-8.9	1.0-4.0	12.0-32	6.5 - 12.20	700-160,000	400- 54,000
2.	Chandil Bridge	(24^0C - 37^0C)	6.50-8.39	6.0-8.9	0.9-2.6	8.0-368	11.4 - 18.60	3,300-240,000	800-54,4000
3.	Kango Bridge	(23^0C - 37^0C)	6.86-8.30	2.0-8.0	0.9-5.5	16.9-268	6.5 - 21.80	54,000-240,000	3,300-92,000
4.	D/S Janshedpur U/S Galudih Barrage	(26.5^0C-39^0C)	6.80-8.20	5.8-8.5	0.8-4.6	12.0-40	.07-170.00	700- 35,000	200- 4,900
	(B) KHARKAI								
1.	Adityapur-Bistupur Road Bridge	(24^0C - 44^0C)	6.00-8.33	3.4-8.0	1.0-6.0	2.0-64	14.0 - 53.00	2,300-160,000	490- 35,000
2.	U/S of Confluence of	(24^0C - 44^0C)	6.80-8.32	3.3-7.2	1.1-4.5	12.0-56	16.0 - 31.20	2,200-24,000	400- 54,000

Source: A Report on Water Resources Policies for Metropolitan Areas: A Case Study of Jamshedpur, India. Prepared by Metaplanners and Management Consultants, Patna, India (p.217)

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.2 ACTUAL WATER AVAILABILITY AND USE

Table I.2.1

ACTUAL WATER AVAILABILITY BY CONTINENTS

Continent	1,950	1,960	1,970	1,980	2000*	% of decline* 1950-2000
Europe	5.9	5.4	4.9	4.6	4.1	30.0
N'America	37.2	30.2	25.2	21.3	17.5	53.0
Africa	20.6	16.5	12.7	9.4	5.1	75.0
Asia	9.6	7.9	6.1	5.1	3.3	66.0
S'America	105.0	80.2	61.7	48.8	28.3	65.0
Australia	112.0	91.3	74.6	64.0	50.0	45.0

* Estimated

Source: "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Glieck" (p.22)

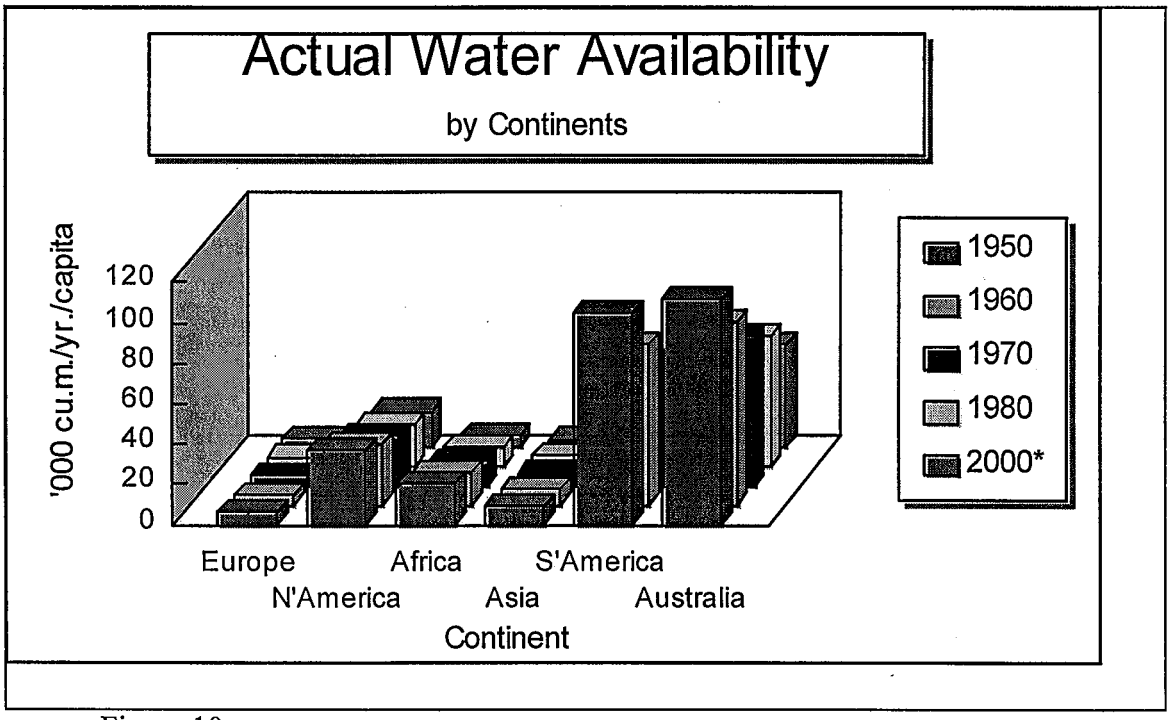


Figure 10

Table I.2.2

ANNUAL RENEWABLE FRESH WATER AVAILABLE PER PERSON (m^3 per person)

Water Scarce Countries (below 1,000m^3 per person)

Djibouti	23.0
Kuwait	75.0
Malta	85.0
Qatar	117.0
Bahrain	179.0
Barbados	195.0
Saudi Arabia	306.0
United Arab Emirates	308.0
Jordan	327.0
Yemen	445.0
Israel	461.0
Tunisia	540.0
Cape Verde	551.0
Singapore	551.0
Kenya	626.0
Burundi	655.0
Algeria	689.0
Rwanda	897.0
Malawi	939.0
Somalia	980.0

Water Stressed Countries (m3/person)

Libya	1,017
Morocco	1,117
Egypt	1,123
Oman	1,266
Cyprus	1,282
South Africa	1,317
South Korea	1,452
Poland	1,467
Haiti	1,696
Lebanon	1,818
Peru	1,856
Comoros	1,878

Water Abundant Countries (above 2,000m3/ person)

Iran	2,025
Mauritius	2,047
Syria	2,087
Ethiopia	2,207
Lesotho	2,290
Zimbabwe	2,312
China	2,427
India	2,464
Sri Lanka	2,498
Dominican Republic	2,789
Nigeria	2,838
Tanzania	2,924
Afghanistan	3,020
North Korea	3,077
Burkina Faso	3,114
Thailand	3,243
Cuba	3,299
Madagascar	3,331
Togo	3,398
Jamaica	3,430
Ghana	3,529
Turkey	3,626
El Salvador	3,674
Uganda	3,759
Pakistan	3,962
Mozambique	4,085
Trinidad and Tobago	4,126
Mexico	4,226
Mauritania	4,387
Senegal	4,777
Sudan	4,792
Philippines	5,173
Benin	5,625
Vietnam	5,638

Water Abundant Countries (m^3 per person contd.)

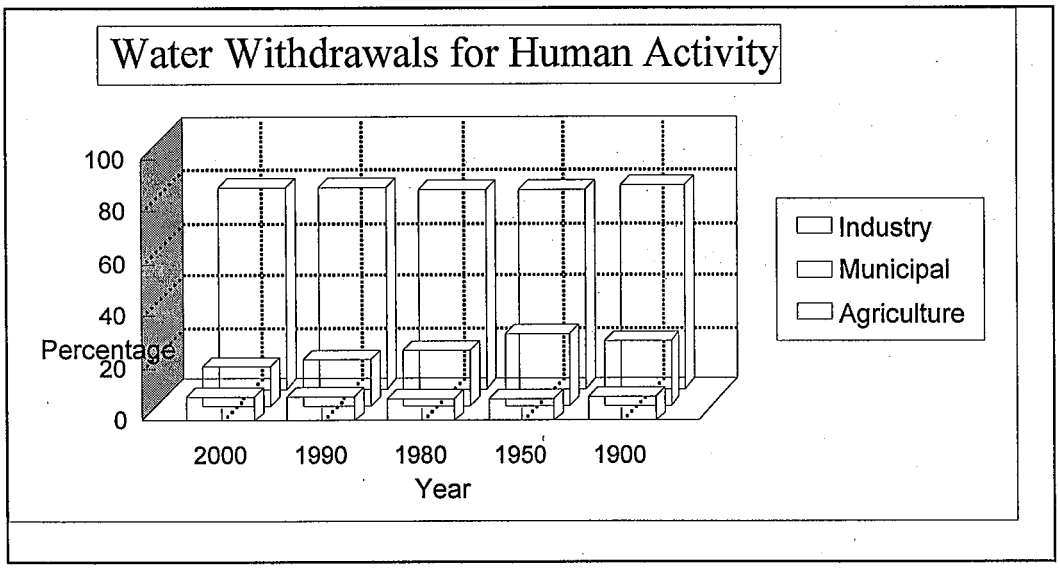
Czechoslovakia (both republics)	5,810
Greece	5,828
Iraq	6,029
Cote d'Ivoire	6,177
Namibia	6,254
Lithuania	6,433
Albania	6,462
Portugal	6,688
Mali	6,729
Chad	6,843
Nepal	8,686
Romania	8,963
Swaziland	9,268
Hungary	10,897
Yugoslavia	11,130
Estonia	11,371
Mongolia	11,416
Zambia	11,797
Guatemala	12,613
Latvia	12,654
Indonesia	13,729
Botswana	14,540
Angola	17,185
Cameroon	18,049
USSR	19,428
Honduras	19,852
Bangladesh	20,733
Malaysia	25,488
/ambia	25,552
Myanmar	25,870

Zaire	27,253
Ecudor	29,771
Argentina	30,753
Costa Rica	31,301
Guniea-Bissau	32,158
Colombia	33,127
Chile	35,527
Sierra Leone	38,545
Guinea	39,270
Fiji	39,945
Uruguay	40,078
Bolivia	41,835
Brazil	46,631

Central African Republic	46,675
Nicaragua	47,606
Panama	59,533
Cambodia	59,741
Bhutan	61,728
Laos	64,255
Venezuela	68,164
Paraguay	73,416
Belize	84,656
Equatorial Guinea	85,227
Liberia	90,097
Solomon Islands	140,625
Gabon	141,501
Papua New Guinea	206,710
Guyana	302,764
Congo	359,803
Suriname	473,934
Iceland	666,667

Source: "Sustaining Water - Population Action International" by Robert Engleman and Pamela LeRoy (p.48 & 49

Figure 11



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.3 Irrigated Agriculture

Figure 12

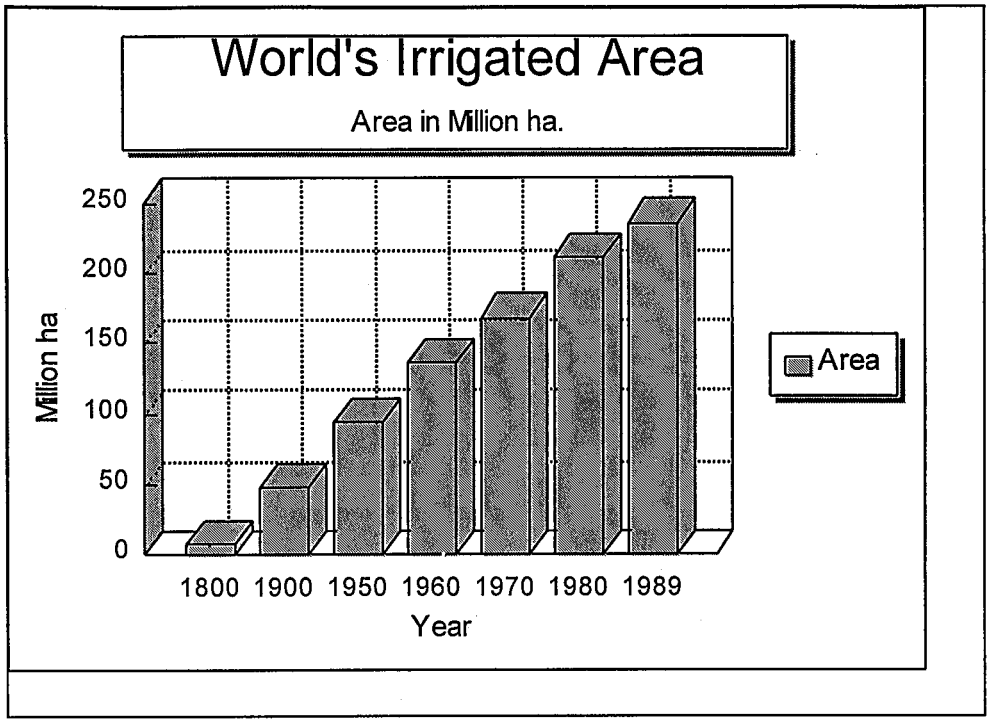
World's Irrigated Area
Area in Million ha.
250
200
150
100
50
0
Million ha
1800 1900 1950 1960 1970 1980 1989
Year
Area

Table I.3.1

WORLD'S CROPLAND BY CONTINENTS 1989 (000 ha)

	Total cropland	Arable land	Permanent cropland	Irrigated cropland	Rain-fed cropland	Percent Irrigated	Percent Rain-fed
Africa	186,995	168,102	18,833	11,186	175,809	6.0	94.0
N'&C'America	273,834	266,981	6,853	25,920	247,914	9.5	90.5
S'America	142,134	116,102	26,032	8,835	133,299	6.2	93.8
Asia	452,634	420,334	32,300	146,422	306,212	32.3	67.7
Europe	139,865	126,014	13,851	17,240	122,625	12.3	87.7
Australia	50,617	49,618	999	2,161	48,456	4.3	95.7
USSR	230,630	226,100	4,530	10,642	209,566	9.1	90.9
Total	1,476,709	1,373,251	103,398	232,828	1,243,881	15.8	84.2

Source: "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.260)

Table I.3.2

WORLD'S IRRIGATED AREA

Year	Area (Million ha)
1800	8.0
1900	48.0
1950	94.0
1960	136.0
1970	168.0
1980	211.0
1989	235.0

Source: Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick (p.265)

Table I.3.3

NET IRRIGATED AREA, TOP 20 COUNTRIES AND WORLD 1989

Country	Net irrigated area[a] (000 ha)	Share of cropland irrigated (%)
China	45,349.0	47.0
India	43,039	25.0
Soviet Union	21,064.0	9.0
United States	20,162.0	11.0
Pakistan	16,220.0	78.0
Indonesia	7,550.0	36.0
Iran	5,750.0	39.0
Mexico	5,150.0	21.0
Thailand	4,230.0	19.0
Romania	3,450.0	33.0
Spain	3,360.0	17.0
Italy	3,100.0	26.0
Japan	2,868.0	62.0
Bangladesh	2,738.0	29.0
Brazil	2,700.0	3.0
Afghanistan	2,660.0	33.0
Egypt	2,585.0	100.0
Iraq	2,550.0	47.0
Turkey	2,220.0	8.0
Sudan	1,890.0	15.0
Other	36,664.0	7.0
World	235,299.0	16.0

[a] Area actually irrigated: does not take into account double cropping.
Source: FAO Production Yearbook, 1990, FAO, Rome.

Table I.3.4

GROWTH RATE OF WORLD'S IRRIGATED AREA

Period	Percent change over period	Annual average percent change over period
1900-1950	96.0	1.9
1950-1959	43.0	4.3
1960-1969	21.0	2.1
1970-1979	24.0	2.4
1980-1989	11.0	1.1

Source: "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.265)

Table I.3.5

WORLD'S PER CAPITA IRRIGATED AREA

Year	Irrigated extent (ha) per 1,000 persons
1960	45.3
1965	45.1
1970	45.4
1975	46.2
1978	48.0
1980	46.8
1989	45.0

Source: "Water in Crisis- A Guide to the World's Fresh Water Resources - Peter Gleick" (p.57)

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I.4 Water Use in Households and Industries

Table I.4.1

ESTIMATED INDUSTRIAL WATER USE BY DEVELOPED AND DEVELOPING COUNTRIES (in 10^6 tones/yr.)

	World Total		Developed Countries		Developing Countries	
	Inflow 1	Outflow 2	Inflow 3	Outflow 4	Inflow 5	Outflow 6
Iron and Steel	127,440	112,147	118,519	104,296	8,920	7,850
Other non-ferrous metals	19,181	17,705	17,838	16,466	1,342	1,239
Fertilizer	10,595	9,541	9,853	8,873	742	668
Food and agriculture	7,049	5,139	6,556	4,779	493	360
Pulp and paper	23,967	22,194	22,289	20,640	1,678	1,554
Textile	24,621	22,908	22,897	21,308	1,724	1,603
Rubber	4,613	4,538	4,290	4,220	323	318
Petroleum refining	38,395	36,475	35,707	33,922	2,683	2,553
Miscellaneous	7,628	6,350	7,094	5,905	534	495
Total	263,489	236,997	245,044	220,407	18,444	16,590

: Totals as given in original source. May not add to sum of individual industries

e: "Water in Crisis, A Guide to the World's Fresh Water Resources 1993 - Peter H.Gleick" (p.403)

Table I.4.2

WATER EFFICIENT TECHNOLOGIES FOR THE RESIDENTIAL AND LIGHT COMMERCIAL SECTORS

			Median retail price (U.S.$ per item)	Lowest retail price (U.S.$ per item)	Number of models	Number of Manufacturers
1 Toilets	19-26 liters/flush	3.8-6.1 liters/flush	191	95	40	24.0
2 Shower heads	15-23 liters/min.	5.7-9.5 liters/min.	15	5	30	16.0
3 Residential Faucets	11-23 liters/min.	1.9-9.5 liters/min.	7	2	21	12.0
4 Washing Machines	150-210 liters/load	95-110 liters/load	460	460	1	1.0
4 Washing Machines	150-210 liters/load	95-110 liters/load	460	460	1	1.0

Source: "Water in Crisis, A Guide to the World's Fresh Water Resources 1993 - Peter H.Gleick" (p.413)

Table I.4.3

Estimates of Water Withdrawals, Sales and Consumption in Mega Cities in Asia

	Year	Population Mn	Total MCM	Per Capita Per Year M^3	Withdrawals/ Sales
Bangkok	1992	4.2	823	113	Sales
Beijing	1992	10.8	487	46	Sales (Total)
Delhi	1992	9.5	817	86	Supply
Dhaka	1992	4.9	146	30	Sales (Total)
Jakarta	1991	5.6	150	27	Consumption (Domestic)
Karachi	1985	6.5	195	30	Consumption (Domestic)
Metro Manila	1991	8.1	386*	48	Sales
Seoul	1991	10.9	720	66	Consumption (Domestic)

* Refers to Watersheds

Notes:

Bangkok: Figures in 1992 represent water sales to consumers. Population covered is 75 percent of total 25.6 mn.

Beijing: Population estimates are: 10.6 mn in 1992 and 10.8 mn in 1993. 73 percent of total consumption is for residential and 20 percent for industrial consumers.

Delhi: 1992 supply was estimated at 237 litres/cap/day.

Jakarta: Consumption estimate was 12.66 million in December. This has been multiplied by 12 to get annual estimates.

Jakarta: Population served has been given as 63 percent of the total population of 8.9 million within the service area.

Dhaka: 80 percent of total sales were residential sector and 14 percent for urban services.

Source: See Asian Development Bank: Managing Water Resources to Meet Megacity Needs, Proceedings of the Regional Consultation, Manila, 24-27 August, 1993. p.52.

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Table I.5.1

REAL CAPITAL COSTS FOR CONSTRUCTION OF NEW IRRIGATION SYSTEMS, 1966-88 (US$/ha)

Year	India (1988 prices)	Indonesia (1985 prices)	Philippines (1985 prices)	Sri Lanka (1986 prices)	Thailand (1985 prices)	Un-weighted Average
1966-69	2,698	1,521	1,613	1,470	1,419	1,744
1970-74	2,368	1,681	1,882	2,056	2,584	2,114
1975-80	1,656	3,187	2,263	2,909	2,366	2,476
1981-85	4,033	3,283	2,688	5,288	2,276	3,514
1986-88	4,856	4,096	n.a.	5,776	2,812	4,385

Source: "Asian food production in the 1990s , Food Policy 1993" (p.21)

Table I.5.2

AVERAGE ANNUAL LENDING AND ASSISTANCE FOR IRRIGATION IN SOUTH AND SOUTHEAST ASIA BY THE WB, ADB, JOECF AND USAID (U$ Million, Constant 1980 Prices)

Year	WORLD BANK	ADB	JOECF	USAID	TOTAL (1)+(2)+(4)
	1	2	3	4	5
1969-70	-	53	6	-	-
1971-73		69	7	-	-
1974-76	668	84	16	-	-
1977-79	981	219	33	68	1,301
1980-82	888	253	46	71	1,258
1983-85	680	162	69	69	
1986-87	405	144	21	38	608

Source: "Asian Food Production in the 1990s, Food Policy 1993" (p.20)

Table I.5.3

AVERAGE ANNUAL LENDING AND ASSISTANCE FOR IRRIGATION IN SOUTH ASIA BY THE WB, ADB, JOECF AND USAID . (US$ Million, Constant 1980 Prices)

Year	WORLD BANK	ADB	JOECF	USAID	TOTAL (1)+(2)+(3)+(4)
	1	2	3	4	5
1969-70	-	18	0	-	-
1971-73	-	8	0	-	-
1974-76	349	32	0	-	
1977-79	514	85	4	50	653
1980-82	651	100	15	54	820
1983-85	533	74	10	68	685
1986-87	317	48	3	29	397

Source: Asian food production in the 1990s , Food Policy 1993 (p.20)

Table I.5.4

AVERAGE ANNUAL LENDING AND ASSISTANCE FOR IRRIGATION IN SOUTH EAST ASIA BY THE WORLD BANK, ASIAN DEVELOPMENT BANK, US AGENCY FOR INTERNATIONAL DEVELOPMENT AND JAPANESE OVERSEAS ECONOMIC COOPERATION FUND (US$ MILLION, CONSTANT 1980 PRICES)

Year	WORLD BANK	ADB	OECF	USAID	TOTAL (1)+(2)+(3)	TOTAL (1)+(2)+(3)+(4)
	1	2	3	4	5	6
1969-70	-	35	6	-	-	-
1971-73	-	61	7	-	-	-
1974-76	319	52	16	-	387	-
1977-79	467	134	29	18	630	648
1980-82	237	153	31	17	411	438
1983-85	147	87	59	5	293	298
1986-87	88	96	18	9	202	211

Source: "Asian food production in the 1990s , Food Policy 1993" (p.20)

Table I 5.5

INDEX OF AVERAGE ANNUAL PUBLIC EXPENDITURES FOR IRRIGATION DEVELOPMENT (1976-80=100)

Year	Bangladesh	China a	India	Indonesia	Philippine a	Sri Lanka	Thailand
1971-75	97b	70	60	20	25	37	88
1976-80	100	100	100	100	100	100	100
1981-85	143	74	94	192	125	92	151
1986-90	103	54	80	170	45	55	109

Source: Asian food production in the 1990s , Food Policy 1993 (p.21)
Source: " Sustaining Water - Popular Action International by Robert Engelman and Pamela Le Roy" (p.48 & 49)1

a For China, Indonesia and the Philippines, the recursive(?) time periods are 1969-73, 1974-78, 1979-83, 1984-88 (1974-78=100)

b 1973-75

IIMI WATER DATA BOOK

PART II

COUNTRY PROFILES

INDIA

Part II 1.1 WATER RESOURCES

POPULATION AND DEVELOPMENT INDICATORS

- India, is the second most populous country of the world. The population of India, which was estimated at 864 Million in mid 1992 has been growing at 2.1% per annum during 1981-91. Estimated mid 1995 population was 925 million.(Table II 1.1.1)

- Per capita Gross National Product (GNP) of India was estimated at US $ 310/yr in 1992, thus categorizing it as a low income economy. (Table II 1.1.1)

WATER RESOURCES

- The total estimated mean annual surface run-off available to India (excluding islands) is about 1880 BCM, implying a per-capita average run-off of about 2300 m^3/yr. (1989/90). This is much lower than that in USSR (17,500 m^3/yr.), Japan (6500 m^3/yr.) or USA (6,200 m^3/yr.). (Table II 1.1.2)

- However the utilizable surface water flow is much lower. The Central Water Commission of India has estimated the utilizable surface water flow at 690 Billion Cubic Meters (BCM) per year or 37% of the total estimated mean annual runoff. The per capita utilizable surface runoff is thus only 850 m^3/yr (1989/90), or about a third of the per capita average mean annual surface runoff. (Tables II 1.1.2 & II 1.1.3)

- The amount actually utilized is 387 BCM/year or 21% of the total mean annual runoff and 56% of the utilizable surface water flow. Water left in the rivers for such uses as navigation and flushing has not been included as part of consumption in the above estimate. (Table II 1.1.2 & II 1.1.3)

- Utilizable ground water resources are estimated at 450 BCM/year, of which only 116 BCM/year (26%) is actually utilized. (Table II 1.1.3 and Table II 1.1.6)
- Utilizable Surface and Ground Water Resources (1140 BCM/year) account for 60% of the average mean annual runoff.(1880 BCM/year). Only 44% (503 BCM/yr) of the total utilizable fresh water from surface runoff and ground water resources is actually utilized. Since surface water and ground water availability is not assessed conjunctively, the estimate of total water resource availability does not give a true picture of availability. (Table II 1.1.3)

- According to the latest CWC estimates, India has created live storage in reservoirs totaling about 162 BCM, projects under construction would create another 77 BCM of live storage and projects under consideration could create 130 BCM of live storage. Half (48%) of storage that would be created by projects under consideration is located in Brahmaputra basin and the main function will be for power generation. Taking the completed, under construction and under consideration storage together, they total only 370 BCM/yr. which is about 20% of the estimated annual flow from India. Omitting storage and run-off from Brahmaputra basin, the storage created, under construction and under consideration totals 303 BCM/yr. which represents about one fourth (23.6%) of the estimated average annual run-off of 1283 BCM. Evidently this quantity of storage is adequate to capture only a small proportion of the run-off. (Table II 1.1.5)

- Potential for future development of ground water resources is estimated at an additional 270 BCM/year. However, the actual ground water developed is only 30% of the total currently available resources (Table II 1.1.6)

- Of the total 450 BCM/yr. utilizable ground water resources 15%-17% are allocated for community and industrial uses. The remainder is earmarked for irrigation purposes. Ganga, both in terms of net draft and potential available, accounts for 39% of the ground water resources respectively

- Except for Indus, all other basins have considerable ground water potential to be tapped. Overall, only 30% of the available is utilized. However, in many areas across states there are pockets of over-utilization - net draft being more than the annual recharge. Such an over-exploitation has resulted in salt water intrusion in some coastal areas. (Table II 1.1.3, Table II 1.1.4 and Table II 1.2.2)

INDIA

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Table II 1.1.1 INDIA:

POPULATION, AREA, GROSS NATIONAL PRODUCT

India	Current (Mid 1992)
Population	864 Million
Rural Population	630 Million (73%)
Urban Population	234 Million (27%)
Geographical Area	3.29 Million Sq.km
Gross National Product (GNP)	2.74 Million U.S $
GNP per capita	310 US $ /year

Source: Economic Survey, Government of India 1994/95

Table II 1.1.2

INDIA: FRESH WATER RESOURCES

Water Resources	Total Reservoir BCM/yr	Per Capita Resources M^3/yr	
		1989	2025
A. Surface Water			
1. Average annual natural runoff	1880	2315	1343
2. Estimated Utilizable Resources	690	850	493
B. Ground Water			
1. Utilizable resources	450	554	320

Notes:

1. Mid year population of 1989 estimated at 812 million.
2. Projected population in 2025 is estimated at 1400 million (UN Medium projections)

Source: Water and Related Statistics, Statistics Directorate, Irrigation Management Organization, Central Water Commission, March 1994.

Table II 1.1.3

INDIA: FRESH WATER RESOURCES UTILIZATION

Water Resources	Total BCM/yr 1989	Per Capita Utilization (m^3/yr)	
		1989	2025
A. Surface Water			
1. Estimated Utilizable Resources	690	850	492
2. Actual Utilization	387	477	276
B.Ground Water			
1. Estimated Utilizable Resources	450	554	321
2. Actual Utilization	116	143	82
C. Withdrawals			
1. Agriculture	470	579	770
2. Domestic	17	21	40
3. Industry (including Thermal Power)	17	21	40

Notes:

1. Mid year population of 1989 estimated at 812 million.
2. Projected population in 2025 is estimated at 1400 million

Sources: Water and Related Statistics, Statics Directorate, Central Water Commission, March 1994, India

Table II. 1.1.4

INDIA: WATER RESOURCES POTENTIAL IN RIVER BASINS

Billion Cubic Meters (BCM)

Item No	River Basin	Av. Annual Potential of Surface Water (km^3)	Estimated utilizable Surface Water (km^3)	Total Replenishable Ground Water Resources (km^3)
		1	2	3
1	Indus (up to border)	73	46	25
2	Ganga	525	250	174
3	Brahmaputra	597	24	26
4	Godavari	119	76	47
5	Krishna	68	58	27
6	Cauvery	21	19	12
7	Pennar	7	7	5
8	Mahanadi	67	50	21
9	Brahamani & Baitani	36	18	5
10	Subernareka	11	7	NA
11	Sabarmati	4	2	NA
12	Mahi	12	3	NA
13	Narmada	41	35	12
14	Tapi	18	15	8
15	Others	280	81	88
16	All India	1880	690	450

Notes:

1. It should be noted that natural run-off estimated by the Central Water Commission (CWC) is inclusive of ground water outflow to the surface water drainage systems. The methodology used by Central Ground Water Board (CGWB) for evaluating ground water resources does not account for impact of developing the assessed resource on surface water flows, particularly in the dry season when effluent ground water forms the major component of river flows which often than not collect snow melt. Since surface water and ground water availability is not assessed conjunctively, this estimate should be used with caution. (World Bank, India - Irrigation Sector Review, Vol. II, 1991, figures are updated).
2. About four tenth (37%) of total utilizable water resources are contained in Ganga basin. Other major basins - Indus (7), Godavari (11), Mahanadi (6), Krishna (11), Narmada (4), taken together have water resources about equal to Ganga.

Sources:

Table II 1.1.5

INDIA: STORAGES OF SELECTED BASINS (km^3)

Item No	River Basin	Av. Annual Flow	LIVE STORAGE CAPACITIES			Total	% of likely storage to Av. Annual Flow
			Completed Projects	Projects under Construction	Projects under Consideration		
		1	2	3	4	5	6
1	Indus(up to border)	73	15	2	0	17	24
2	Ganga	525	37	17	30	84	16
3	Brahmaputra	597	1	3	63	67	11
4	Godaveri	119	17	12	7	36	30
5	Krishna	68	32	4	1	37	55
6	Cauvery	21	7	0	0	8	38
7	Pennar	7	2	0	NA	3	37
8	Mahanadi	67	9	5	12	25	38
9	Brahmani & Baitarni	36	4	0	9	13	36
10	Subernarekha	11	0	2	2	4	35
11	Sabarmati	4	1	0	0	1	35
12	Mahi	12	4	0	0	5	38
13	Narmada	41	3	20	0	23	56
14	Tapi	18	9	0	2	11	60
15	Others	280	19	11	5	36	13
16	All India	1880	162	77	131	370	20

Source: Water and Related Statistics, Statistics Directorate, Irrigation Management Organization Central Water Commission. March 1994 (p.1

Table II 1.1.6

INDIA: GROUND WATER RESOURCES AND UTILIZATION (km^3/yr)

	River Basin	Utilizable Resources for Irrigation	Net Draft (1989-90)	Potential Available for Future Development	Stage of Gr.Water Development %
Item No	1	2	3	4	5 (3) / (2)
1	Indus (Up to border)	22	17	4	77
2	Ganga	149	49	100	33
3	Brahmaputra	22	1	21	5
4	Godavari	39	7	33	18
5	Krishna	22	7	16	32
6	Cauvery	10	6	5	60
7	Pennar	4	2	3	50
8	Mahanadi	18	1	17	6
9	Brahmani with Baitarni	4	0	4	7
10	Subernarekha	2	0	1	9
11	Narmada	10	2	8	20
12	Tapi	7	2	5	29
13	Others	76	23	53	30
14	Total	385	116	269	30

Notes:

1. The most recent estimate of the utilizable ground water of India, exclusive of reservoirs in the Brahmaputra and Barak basin and the islands is about 450 Billion Cubic Meters per year (BCM/Yr.), (World Bank 1991, Annex 2, page 4).
2. As pointed out by the Central Water Commission (C.W.C), Government of India, the resources estimates (surface and ground water) have been made independently by the two organizations. (i.e. The C.W.C for surface water and the Central Ground Water Board for ground water). In view of this, interaction between the two resources and the possible changes in the utilization possible from one source because the development of the other
3. source may not have been fully considered in the figures. (As quoted in the World Bank 1991, Annex 2)

Source: Water and Related Statistics, Statistics Directorate, Irrigation Management Organization, Central Water Commission, March 1994 (p.30)

Table II 1.1.7

INDIA CATCHMENT AREA BY MAJOR RIVERS

Item No	Name of River	Length in K.ms	Catchment in Sq.Kms
1	Indus-River	1114	321289
2	Ganga-River	2525	861452
3	Brahmaputra-River	916	194413
4	Sabarmati-River	371	21674
5	Mahi-River	583	34842
6	Narmada-River	1312	98796
7	Tapi-River	724	65145
8	Brahmani-River	799	39033
9	Mahanadi-River	851	141589
10	Godavari-River	1465	312812
11	Krishna-River	1401	258948
12	Pennar-River	597	55213
13	Cauvery	800	81155
14	All Rivers	13458	2528084

Note:

Ganga accounts for 1/3 of total catchment area. Six rivers, Ganga (34%), Indus (13%), Brahmaputra (8%), Mahandi (6%), Godavari (12%) and Krishna (10%) cover 83% of the catchment area.

Source: Water and Related Statistics, Statistics Directorate, Irrigation Management Organization Central Water Commission - March 1994. (p.11)

Table II 1.1.8

INDIA: RIVER BASIN- POPULATION

Million

	River basin	Rural	Urban	Total
Item No	1	2	3	4
1	Indus (up to border)	19993	7,800	27793
2	Ganga	265352	69,989	335330
3	Brahmaputra	18855	2,935	21791
4	Godavari	43472	11,901	55369
5	Krishna	39944	15,019	54963
6	Cauvery	22418	12,456	34875
7	Pennar	4153	1,291	5444
8	Mahanadi	23620	4,027	27647
9	Brahamani & Baitarni	2757	713	3469
10	Subernareka	1475	730	2205
11	Sabarmati	NA	NA	NA
12	Mahi	NA	NA	NA
13	Narmada	9445	2,176	11621
14	Tapi	10546	4,859	15405
15	Others	165885	82150	248031
16	Total	627885	216046	843931

Source: Ministry of Agriculture Estimated on ARPU Database

II 1.2 WATER AVAILABILITY AND USE

- The irrigation sub sector is the major user of fresh water resources. In 1985 about 90% of the surface water and 83% of the ground water or 87% of total fresh water resources was utilized for irrigation. (Table II 1.2.1)

- Consumption for domestic and industrial purposes account for 13% of India's Water Budget. However, these supplies are considered essential and therefore must be ensured. Already domestic and industrial users in urban centers in certain locations, are competing with irrigation for fresh water supplies particularly in the more arid regions. (Table II 1.2.1)

- Irrigation will continue to be the dominant user of fresh water in the future too. However the proportion used for irrigation is projected to decline from 89% of total supplies in 1985 to 73% in the year 2025. Domestic use is likely to grow rapidly, from 13% to 27% of total consumption between 1985 and 2025. The above are gross demands and as such do not account for return flows and also assume a completely open system. (Table II 1.2.1)

- Domestic use is expected to rise from 3% in 1985 to 4.5% in 2025. Fresh water utilized for Industrial and Thermal Power production is expected to increase from 2.4% in 1985 to 12% in 2025 almost a five fold rise. (Table II 1.2.1)

- Only 17% of the ground water was utilized for other purposes in 1985. This proportion is expected to rise to 26% by year 2025. (Table II 1.2.1)

- Currently two thirds of the fresh water utilized is from the surface water resources. This proportion is expected to remain constant in the year 2025 too. (Table II 1.2.2)

- Total catchment area of all rivers in India is estimated at 2.5 million square kilometers. The river Ganga alone accounts for 1/3rd of total catchment area. Six rivers- Ganga (34%) Indus (13%), Brahmaputra (8%), Mahanadi (6%), Godavari (12%), Krishna (10%) covers 83% of the total. (Table II 1.1.7)

- Over two fifths of rural (42%) and total (40%) population of India lives in Ganga basin. Other major basins - Indus (3%), Godaveri (6%), Cauvary (4%), Brahmaputra (3%) taken together have about half the population living in the Ganga basin. (Table II 1.1.8)

- About 36% of total utilizable water resources are contained in the Ganga basin. Other major basins- Indus (7),Godavari (11), Mahanadi(7), Krishna (8), Narmada (5) taken together have water resources about equal to Ganga. (Table II 1.1.4)

- The Indus river runs through 80-100% of the area of the following states: Punjab(100%), Himalayan Pradesh (92%), Jammur-Kashmir (87%), and about 20% of Haryana and Rajasthan States. (Table II 1.1.9)

- The Ganga river passes through 70-100% of the area of the following States: Uttar Pradesh (100%), Bihar (83%), West Bengal (81%) and Haryana (78%) and about 45% of Madhya Pradesh and 33% of Rajasthan. (Table II 1.1.9).

- The Godavari river runs across 50% of Maharashtra and 27% of Andhra Pradesh States, while the Krishna passes through 59% of Karnataka and about 25% of Maharashtra and Andhra Pradesh States. The Cauvery passes 36% of Tamil Nadu State and 17% of Karnataka State (Table II 1.1.9)

- Over 50% of the Indus River basin falls within the state of Jammu and Kashmir, while 35% of Ganga basin fall within Uttar Pradesh and 23% within Madhya Pradesh States (Table II 1.1.9)

- About 50% of Godavari basin falls within the Maharashtra State and balance equally in Madhya Pradesh and Andhra Pradesh (Table II 1.1.9)

- In the case of Krishna river basin, 44% falls within Karnataka, and rest equally between Maharashtra and Andhra Pradesh States (Table II 1..1.9)

- Over 50% of the Cauvery river basin falls within Tamil Nadu State and balance in Karnataka State (Table II 1.1.9)

Table II 1.2.1

INDIA: SECTORAL UTILIZATION OF FRESH WATER

Sector	Actual 1985 BCM/yr		Projected Year 2000	%	Projected Year 2025 (RCM)	%
1. Irrigation						
a) Surface Water	320	89	420	84	510	73
b) Ground Water	150	83	210	84	260	74
Sub Total	470	87	630	84	770	73
2. Other Uses						
a) Surface water	40	11	80	16	190	54
b) Ground Water	30	17	40	16	90	26
Sub Total	70	13	120	16	280	27
Sub Total (1)+(2)						
a) Surface Water	360	67	500	67	700	67
b) Ground Water	180	33	250	33	350	33
Total	540	100	750	100	1050	100
4. Other Uses						
I. Domestic &	16.7	3.1	33.0	4.0	46.0	4.5
Industrial	12.7	2.4	33.0	4.0	124.0	11.9
II. Industrial Thermal	40.6	7.5	54.0	605	110.0	10.6
III. Miscellaneous						
Total	70.0	13	120.0	14.5	280.0	27.0

Source: Adopted from Central Water Commission Statement No.5.22 March 1994 Central Water Commission. March 1994 (p.19)

II 1.3 IRRIGATED AGRICULTURE

- In 1990/91 India had the highest gross irrigated area (GIA) in the world (62 million hectares). The net area irrigated (NIA) was 77% of the Gross Irrigated Area. (Table II 1.3.1)

- The Gross area cultivated in India in 1990/91 was 185 million hectares of which 77% was the net area cultivated (Table II 1.3.1)

- The net area irrigated was a third of the net area cultivated. The proportion was the same for Gross area irrigated as a percentage of gross area cultivated. (Table II 1.3.1)

- Irrigation intensity increased from 110% in 1951 to 130% in 1990/91, but is still quite low.

- Irrigation does not seem to be having any perceptible influence on cropping intensity. The surface irrigation is mainly used for protecting the kharif crop. The main impact has been due to growth of ground water, which markedly increased cropping intensity in north-west regions;

- Wells and tube wells account for more than half of net irrigated area. This is particularly an outcome of extension of surface irrigation. (Table II 1.2.3)

- Irrigation seems to be important in providing food security as almost 2/3 (67%) of gross irrigated area is accounted by food crops. (Table II.1.3.4)

- The Central Water Commission estimates that only 56% of the surface water potential has been created up to 1991/92. [Major, medium & minor irrigation]. In the case of ground water 98% of the potential has already been created up to 1991/92. Taking both surface and ground water resources together 70% of the potential has been created up to 1991/92. Thus expansion potential is available mainly for surface water resources. (Table II 1.3.2)

- Ground water resources accounts for more than half of total net irrigated area . Tube-wells cover about 32% and wells another 20% of net irrigated area. Indus and Ganga basins have almost 60% of net irrigated area through ground water resources. In some states containing these river basins - Punjab (Indus), Haryana (Indus and Ganga); Uttar Pradesh (Ganga) the cropping intensity is quite high. Expansion of tube-wells and availability of surface water from snow melt sources outside the monsoon season has enabled the growth of rabi (winter) and summer crops (Irrigation Sector Review, Vol. II). (Table II 1.3.3)

- Irrigated area by sources, across river basins has been worked out using district level (districts are administrative division within states of which, there are more than 400 districts in India) data from the data files of the Agro-Climatic Regional Planning Unit, (Planning Commission) at Ahmedabad. Parts of some districts lie in more than one river basin. In case

half or more area of a district belonged in a river basin, the entire district was made part of that basin.

- Net cultivated area apart from year to year fluctuations (possibly due to deficient rainfall), has stagnated around 140 million hectares since 1967-68. Fluctuations in net cultivated area are reflected in gross cultivated area, despite its expansion from 157 to 186 million hectares. Net irrigated area (27 to 47 million hectares) and gross irrigated area (33 to 62 million hectares) during this period grew steadily; raising the percentage of gross irrigated to gross cultivated area from less than one-fifth to about one-third. Cropping intensity in irrigated areas, though its main function has been to provide cover to kharif cultivation has been about 5 percentage point higher, (for most years) than the overall cropping intensity. (Table II 1.3.1)

- During the last 30 years major expansions in gross irrigated area has occurred in wheat, about half of the addition in gross irrigated area has occurred in wheat. Increase in irrigated cultivation of rice and wheat together accounted for two thirds of the expansion in gross irrigated area. Desire for food security, price support and high yielding varieties have all contributed to this expansion. (Table II 1.3.4)

- There is also substantial expansion of gross irrigated area under groundnut, sugarcane and cotton, taken together accounting for 13% of additions in gross irrigated area. Area under `other' has more than doubled. Coarse grains continue to be grown under rain-fed conditions. (Table II 1.3.4)

- Gross cropped area ignores duration of the crop, this fact undermines the effect of irrigation on cropping intensity.

- Over 40% of the total gross irrigated area (GIA) lies in the Ganga basins, while 15% lies in the Indus basin. Godavary and Krishna basins each have over 6% of the total gross irrigated area. (Table II 1.3.5)

- Indus basin has the highest proportion of net sown area to reporting area (69%). Tapi (63%) and Ganga (55%) basins also have more than half of reporting area under cultivation.

Table II 1.3.1

INDIA: IRRIGATED AGRICULTURE

Item No	Description	Unit	Current 1990-91
1	Net Area Cultivated	Mn.Ha	142.2
2	Gross Area Cultivated	Mn.Ha	185.5
3	Net Irrigated Area	Mn.Ha	47.4
4	Gross Irrigated Area	%	61.8
5	Net Irrigated Area as % of Net Cultivated Area	%	33.3
6	Gross Irrig. Area as % of Gross Cultivated Area	%	33.3
7	Net Irrigated Area by		
	• Canals	Mn.ha	16.9
	• Tanks	"	3.2
	• Wells	"	10.0
	• Tube Wells	"	14.2
	• Others		3.1
	Total		47.4
8	Areas Irrigated by Major Crops:	Mn.ha	19.2
	• Rice	"	19.3
	• Wheat	"	3.2
	• Sugarcane	"	2.6
	• Cotton	"	17.5
	• Others	"	61.8
	Total	"	

Notes:

1. Original source of this table is Ministry of Agriculture, Directorate of Economics and Statistics, though most of the information is derived from CWC. 1994. The data given by the Ministry of Irrigation are at variance with these as discussed in later sections.

2. The information contained in this table is an outcome of traditional patwary system. Date base rules out any conjunctive use of water. Area under crops like cotton (two seasons) and sugarcane (annual) is only counted once.

Source:

TABLE II 1.3.2

INDIA: MAXIMUM IRRIGATION POTENTIAL BY STATE

000 Ha

Item No	State	Major & Medium Surface Water	Minor Irrigation			Irrig. Potential (Maj, Med & Minor)	MIP (ha.per 000 persons)
			Surface Water	Ground Water	Total		
1		3	4			7	8
1	Andra Pradesh	5000	2300	2200	4500	9500	143
2	Assam	970	1000	700	1700	2670	119
3	Bihar	6500	1900	4000	5900	12400	144
4	Gujarat	3000	347	1500	1847	4847	117
5	Haryana	3000	50	1500	1550	4550	276
6	Karnataka	2500	900	1200	2100	4600	102
7	Kerala	1000	800	300	1100	2100	72
8	Madhya Pradesh	6000	2200	3000	5200	11200	169
9	Maharashtra	4100	1200	2000	3200	7300	92
10	Orissa	3600	1000	1500	2500	6100	193
11	Punjab	3000	600	3500	3550	6550	323
12	Rajasthan	2750	1200	2000	2600	5350	122
13	Tamil Nadu	1500	100	1500	2700	4200	75
14	Uttar Pradesh	12500	1200	12000	13200	25700	185
15	West Bengal	2310	1300	2500	3800	6110	90
16	Others	642	1240	242	1532	2174	
	Total States	58372	17337	39642	56979	115351	138
	Grand Total	58470	17378	39691	57069	115539	137
	Pot. already created upto 1991/92	30741	11457	38893	50350	81091	96/112
	% of Pot. created to Max.Pot.	52.57	65.93	97.99	88.23	70.18	

Source: Water and Related Statistics, Statistics Directorate,
Irrigation Management Organisation
Central Water Commission. March 1994 (p.42)

Table II 1.3.6

INDIA: NET IRRIGATED AREA FROM DIFFERENT SOURCES

(Million hectares)

Year	Canals	Tanks	Wells		Other Sources	Total Net Irrig. Area	Total Gross Irrig. Area	Cropping Intensity
			Tube Wells	Other Wells				
1950-51	8.3 (40+)	3.6 (17)	(a)	6.0 (29)	3.0 (14)	20.9	22.6	108
1955-56	9.4 (41)	4.4 (19)	(a)	6.7 (30)	2.2 (10)	22.7	25.6	113
1960-61	10.4 (42)	4.6 (18)	0.1 -	7.2 (29)	2.4 (10)	24.7	28.0	113
1965-66	11.0 (42)	4.3 (16)	1.3 (5)	7.4 (28)	2.5 (9)	26.5	30.9	117
1970-71	12.8 (41)	4.1 (13)	4.5 (15)	7.4 (24)	2.3 (7)	31.1	38.2	123
1975-76	13.8 (40)	4.0 (12)	6.8 (20)	7.6 (22)	2.4 (6)	34.6	43.4	125
1980-81	15.3 (39)	3.2 (8)	9.5 (24)	8.2 (22)	2.6 (7)	38.8	49.8	128
1985-86	16.2 (39)	2.8 (7)	11.9 (28)	8.5 (20)	2.5 (6)	41.9	54.3	130
1990-91*	16.9 (36)	3.2 (7)	14.2 (30)	10.0 (21)	3.1 (6)	47.4	61.8	130

(a) Included under other wells, as separate figures were not collected

\+ Percentage to total net irrigated area

* Provisional

Source: Derived from Government of India, Ministry of Agriculture, Directorate of Economics and Statistics, Indian Agricultural Statistics, 1985-86, Vol.1, New Delhi, September 1993.

Last row from C.W.C., Irrigation Management Organization, Water and Related Statistics, March 1994.

PART II.1.4 - WATER USE FOR HOUSEHOLDS, INDUSTRY

- Consumption for domestic and industrial accounts for very small part of India's water resources. The National Water Policy of India, gives the highest priority to domestic uses. In some urban centers and arid regions, there are high demands for water. In the future, while irrigation will continue to be the major user, domestic and particularly industrial uses are likely to grow quite rapidly.

- Between 1980 and 1993, the proportion of urban population with access to safe domestic water increased from 77% to 85%. The gains made by the rural population in this respect was much higher. The proportion of the rural population with access to safe drinking water increased from 31% to 79%, over the same period. (Table II.4.1)

- The proportion of urban population with sanitation facilities, increased from 27% to 48% between 1980 and 1993. The proportion of the rural population with this facility increased from just 1% to 3% over the same period. Thus a vast majority of the population are without sanitation facilities. (Table II.4.1)

Table No II.4.1

INDIA: POPULATION WITH ACCESS TO SAFE DRINKING WATER AND SANITATION

	Percent Coverage			
	1980[a]	1985	1990	1993[b]
Drinking water				
• Rural	31.0	56.0	74.0	79.0
• Urban	77.0	73.0	84.0	85.0
Sanitation facilities				
• Rural	1.0	1.0	2.4	3.3
• Urban	27.0	28.0	46.0	48.0

Notes [a] Source: World Development Report 1994. The World Resources Institutes.
[b] Provisional

PART II.1.5 - INDIA: INVESTMENTS, COSTS, PRICES & ECONOMIC VALUES

- Since 1947 massive investments , both public and private have gone into irrigation sector. In case of canal irrigation, the nation spent more than Rs. 600 million (1988/89 prices)between 1951 and 1990, taking the irrigation potential created from this source from 8.6 million ha to about 32 million ha.

- Capital outlay in irrigation projects in India has almost tripled from Rs.56 billion at constant 1980/81 prices in 1974/75 to Rs. 145.5 billion in 1988/89.

- The gross receipts do not cover even working expenses (WE).. The losses have risen and the system now requires Rs.12 Million budgetary support every year. (Table II 1.5.1)

- Gross Receipts(GR) as a percentage of working expenses has fallen from over 90% in the mid 1970's to around 30% in the late 1980's, indicating that irrigation systems have always suffered operational losses and those annual losses have almost tripled over the last 15 year period ending 1988/89. If interest on capital is included in the cost , the losses are much greater with the proportion of the gross receipts to working expenses falling from about 30% in the mid 1970's to about 8% in 1988/89. (Table II 1.5.1 , Table II 1.5.2 and Table II 1.5.3)

- Among the states, the highest rate of recovery [gross receipts/working expenses] for the year 1984/85 was 82% in Punjab, and the lowest was 6% in Karnataka. The all India average recovery was 15% for the year. In nine out of the 14 States the recovery was less than a third of the costs. The five states with about 50% or more recovery were Punjab, Orissa, Uttar Pradesh, Maharashtra Pradesh and Rajasthan (Table II 1.5.4)

- The composition of working expenses have changed over time . The share devoted to administration has risen dramatically during the 1980's. This means less funds for operation & maintenance. The administrative costs of operation varies from a high of 100% of the working expenses in Madhya Pradesh to 1-5% in Jammu & Kashmir and West Bengal. The average for the whole of India was 34% in 1974/75 and has increased to 43% in 1986/87. (Table II 1.5.5)

- An important reason for stagnancy of GR is that there is no recent revision of the water rates except Goa, Maharashtra and Madhya Pradesh). Most states continue with water rates of seventies or early eighties. (Table II 1.5.6)
- Irrigation charges as a proportion of the net value of output, was the highest for Paddy and lowest for wheat, with sugarcane in the medium range. [Data from 5 States and for 3 crops in 1987/88] (Table II 1.5.7)

- Across states crop water charges as a percent of net value of output were high, ranging from 14-47%, when the imputed land rent was included. If land rent is excluded, the proportion falls to between 7-22%. Irrigation charges as a proportion of total cost, ranges from 4-18%, inclusive of land rent. (Table II 1.5.7)

- Farmers in most states are not exclusively dependent on officially managed irrigation systems. They incur extraction charges for ground water using electricity or diesel (both are subsidized). Often they buy water. Ground water markets are quite vigorous in many States. (see T.Shah). Irrigation charges are therefore much higher than official water rates.

- Farmers obviously are paying or willing to pay close to economic charge for an efficient and reliable irrigation system. (Table II 1.5.7)

- It must be noted that across states, water rates vary between projects, perennial canals and non-perennial canals, khariff, rabi and hot weather season; long lease; season lease, single or multiple watering and by selected crops. Concessional rates are given to motivate farmers to avail of newly created irrigation facilities or to irrigate reclaimed land.

- Water rates are always on area basis (ha) rather than on volume basis. In terms of volume of water used, in quite a few states coarse cereals (usually consumed by the poor) have higher water charges than such water intensive crops as paddy and sugarcane. Thus water rates are not only low.

- Implicit irrigation rates per unit of water for various crops , differ significantly from state to state. paddy and cotton appeared to have lower implicit rates than wheat, while coarse cereals, oil seeds, pulses and sugarcane had higher rates, with coarse cereals having the highest rate. On a per hectare basis, the water rate was the highest for sugarcane and the lowest for coarse cereals, pulses and oil seeds. wheat and paddy were in the medium range. (Table II 1.5.8 and Table II 1.5.9)

- Weighted average O&M costs were the highest in West Bengal, Maharashtra and Uttar Pradesh and the lowest in Rajasthan, Orissa and Haryana. Weighted average cost of O&M per $000m^3$ of water use was the highest in West Bengal, Haryana , Maharashtra and Uttar Pradesh and lowest in Rajasthan, Orissa and Karnataka. (Table II 1.5.10)

- The increase in the proportion irrigated using ground water resources can also be gauged by the rate of increase in energization of pumpsets and tubewells. Between 1968/69 and 1991/92, the number of electric pumpsets/tubewells increased tenfold from about 1.1 million to 9.4 million. Andhra Pradesh, Madhya Pradesh, Maharashtra and Tamil Nadu account for more than 50% of the total number energized. (Table II 1.5.11)

- Collection of irrigation rates were in general below targets (80% of targets) according to data from 1990/91. In three States the targets were achieved or exceeded (Haryana, Punjab and West Bengal) Table II 1.5.12

- The cost of collection was almost equal to or greater than actual collection in a few states (Bihar & Rajasthan) (Table II 1.5.12)

- Almost all States had arrears of collection of irrigation rates running into several years. It was the highest for Madhya Pradesh and Maharashtra and the lowest for Rajasthan ,West Bengal and Uttar Pradesh. (Table II 1.5.12)

- A break up of the O&M costs showed that 60% of the total costs were for administrative purposes . In a few states, the administrative costs were more than double that of the actual costs of works. (Bihar, Haryana, Punjab and Rajasthan) (Table II 1.5.12)

- Gross receipts per hectare of irrigated land in India were only 15% of the working expenses (Table II 1.5.13)

- Input subsidies provided in irrigated agriculture varied among the states, but averaged to Rs. 1500 per hectare of gross irrigated area in India. (Data for period 1980-1987). Subsidy for irrigation and electricity added up to 80% (Rs. 1200) of the total subsidy. (Table II 1.5.13)

- Incremental benefits from irrigated agriculture was estimated at Rs. 2511/ha (Bihar - 1983/84) and Rs. 3969/ha (Haryana 1981/82) while incremental yield was estimated at Rs. 1504/ha (Bihar) and Rs.3709 /ha (Haryana) (Table II 1.5.14)

- Annual revenue from irrigation has increased from about 20% of the annual values of investments in 1970-71 to 100% of investments by 1988/89. (Table II 1.5.15

Table II 1.5.1

INDIA.: CAPITAL OUTLAY, RECEIPTS AND EXPENSES OF IRRIGATION SYSTEMS (Rs. Millions)

Year	Gross Receipts GR	Working Expenses WE	GR_X 100 WE %	Capital Outlay at the end of the year	Interest on Capital I	Profit GR-(WE+I)
1974-75	890	1387	64	56419	2022	-2520
1975-76	1293	1419	91	66285	2347	-2473
1976-77	1527	1644	93	74895	2549	-2666
1977-78	1344	1764	76	83166	2989	-3408
1978-79	1499	2152	70	96621	3544	-4198
1979-80	1190	1661	72	95627	3456	-3926
1980-81	1034	2257	46	93467	3015	-4239
1981-82	1100	2427	45	98724	3802	-5130
1982-83	1045	2121	49	110101	7785	-8861
1983-84	1345	2232	60	114605	4587	-5474
1984-85	986	2540	39	121139	4834	-6388
1985-86	1610	3503	46	129289	4905	-6797
1986-87	1140	3347	34	138307	5928	-8135
1987-88	881	3347	26	141658	5544	-8010
1988-89	984	3347	29	145523	9237	-11603

Note: Working expenses and interest charges were clubbed for 1987-88 and 1988-89. These are reported by keeping working expenses at the level of 1986-87.

Source: Statistics Directorate, Irrigation Management Organization, Central Water Commission, 1994

TABLE II 1.5.2

INDIA: ESTIMATED COSTS AND REVENUE OF MAJOR AND MEDIUM IRRIGATION AND MULTI PURPOSE PROJECTS OF MAJOR STATES 1985-86

State	Estimated[1] working expenses in Rs.Millions	GIA in Million Cu.Meters (MCM)	Cost/ha in Rs.	Water[2] Delivered/ha (MCM)	Cost/ MCM (Rs)	Gross Revenue (Million Rs.)				Increase in Revenue Required to cover cost	
						Total	Irrigation	Water Sales	Other Receipts	Rs. Millions	As a multiple of current gross receipts
Item No	1	2	3	4	5	6	7	8	9	10	11
Andhra	511	303.00	172	0.682	252	175	N.A	43	132	342	1.95
Pradesh	422	2.17	194	0.845	230	92	92	-	-	330	3.58
Bihar	422	0.70	603	0.650	928	86	67	10	9	336	3.91
Gujarat	344	1.74	198	0.838	236	104	88	-	16	240	2.31
Haryana	301	1.11	271	0.830	327	63	-	-	63	238	3.78
Karnataka	66	0.51	129	0.677	191	12	8	2	2	54	4.50
Kerala	490	1.32	371	0.860	431	125	55	24	46	365	2.92
Madhya	450	0.96	469	0.800	586	131	83	16	32	319	2.43
Pradesh	136	1.51	90	0.983	92	54	22	-	32	82	1.51
Maharastra	294	2.45	120	0.903	133	121	89	14	19	173	1.42
Orissa	605	1.42	426	0.732	582	131	116	6	10	474	3.61

Punjab	273	1.22	224	1.070	222	13	5	3	5	260	20.00
Rajasthan	932	5.52	169	0.820	206	600	581	5	14	332	0.55
Tamil Nadu	200	1.47	136	1.100	124	13	12	-	1	187	14.38
Uttar Pradesh											
West Bengal											
All above States	5457	25.13	216	0.839	257	1720	1218	123	381	3730	2.17

Working Expenses of major and medium multi-purpose projects as reported by CWC (Average for 3 years centered on 1984-85) plus 25% overheads plus 1.% interest on cumulative capital outlay at the end of 1981-82 (i.e. 3 ears prior to 1984-85). Based on CWC estimates for storage projects. It is assumed that this applied also to run-of the river schemes.

Source: Report of the Committee on Pricing of Irrigation Water, Planning Commission, Government of India, New Delhi, September 1992 (p.149)

Table II 1.5.3

INDIA: CAPITAL OUTLAY, REVENUE EXPENDITURE AND REVENUE RECEIPTS RELATING TO MAJOR AND MEDIUM IRRIGATION PROJECTS

Million Rupees

State	Year	Capital Outaly at the End of the Year	Revenue expenditures during the year	Revenue Receipts during the year	Depreciation	Excess of Expenditure (Excluding Depreciation) over receipts	Excess of Expenditure (Including Depreciation) over Receipts
Item No	1	2	3	4	5	6	
Andhra Pradesh	1989-90	28983.7	3155.3	352.1	276.1	2803.2	3079.4
Bihar	1989-90	30200.7	583.9	60.9	287.5	522.9	810.4
Gujarat	1989-90	22326.7	3559.0	170.5	210.1	3388.5	3598.7
Haryana	1989-90	212.8	3.5	.02	2.0	3.6	5.6
Karnataka	1989-90	8635.1	1161.1	135.7	84.4	1025.4	1109.9
Kerala	1989-90	20892.2	1536.1	161.4	198.4	1374.7	1573.2
Madhya	1989-90	7601.0	192.9	16.4	72.2	176.6	248.9
Pradesh	1989-90	25865.0	578.7	123.0	246.8	455.6	702.5
Maharashtra	1989-90	40051.7	4389.4	275.9	375.4	4113.5	4488.9
Orissa	1989-90	15952.3	161.1	45.6	152.5	115.5	268.0
Punjab	1989-90	8873.5	781.2	173.7	87.9	607.5	695.4
Rajasthan	1989-90	15517.0	1298.9	159.9	149.1	1139.0	1288.2
Tamil Nadu	1989-90	6519.1	809.0	15.0	63.6	793.2	856.7
Uttar Pradesh	1989-90	32179.8	3507.0	366.1	310.1	3140.8	3451.0
West Bengal	1989-90	5553.1	456.9	15.7	53.4	441.1	494.5

Source: Report of the Committee on Pricing of Irrigation Water, Planning Commission, Government of India, New Delhi, September 1992 (p.235)

Table II 1.5.4

INDIA : WORKING EXPENSES AND GROSS RECEIPT PER HECTARE OF POTENTIAL UTILIZED OF IRRIGATION AND MULTIPURPOSE RIVER PROJECTS 1984-85. (Rs/Ha)

	States	Gross Receipts	Working Expenses	Gross receipts as a % of Working Expenses
1	Andhra Pradesh	25	115	22
2	Bihar	35	117	30
3	Gujarat	141	398	35
4	Haryana	64	170	38
5	Jammu & Kashmir	12	199	6
6	Karnataka	56	189	30
7	Madhya Pradesh	94	312	30
8	Maharashtra	148	312	47
9	Orissa	28	44	64
10	Punjab	71	87	82
11	Rajasthan	93	212	44
12	Tamil Nadu	7	90	8
13	Uttar Pradesh	57	118	48
14	West Bengal	10	111	9
All India		22	142	15

Notes : 1) The table is based on data for the year 1984-85 for which all the relevant information was readily available.

Source: Statistics Directorate, Central Water Commission, March 1994.

Table II 1.5.5

INDIA : DIRECTION AND ADMINISTRATION AS PERCENTAGE OF WORKING EXPENSES ON MAJOR & MEDIUM PROJECTS. (1974-75 TO 1986-87)

Item No	State	74-74	77-78	80-81	83-84	86-87
1	Andhra Pradesh	21	18	59	42	59
2	Bihar	52	49	55	67	70
3	Gujarat	24	29	25	39	45
4	Haryana	22	24	24	37	27
5	Jammu & Kashmir	36	27	14	13	5
6	Karnataka	8	14	2	28	36
7	Kerala	23	29	26	58	73
8	Madhya Pradesh	-	100	100	100	100
9	Maharashtra	49	42	54	50	55
10	Orissa	10	11	6	11	8
11	Punjab	67	59	67	60	68
12	Rajasthan	42	21	36	29	15
13	Tamil Nadu	13	11	27	8	19
14	Uttar Pradesh	46	42	28	27	47
15	West Bengal	11	1	11	86	86
	All India	34	30	26	37	43

Source: Central Water Commission (Statistics Directorate) March 1994

Table II 1.5.6
INDIA: YEAR OF LAST REVISION OF WATER RATES IN MAJOR STATES.

	Name of the State	Year in which water rates were last revised
1	Andhra Pradesh	1986
2	Assam	No water rates levied
3	Bihar	1984 and for some projects in 198 .
4	Goa	1988
5	Gujarat	1981
6	Haryana	1975
7	Himachal Pradesy	1977
8	Karnataka	1985
9	Kerala	1974
10	Madhya Pradesh	1992
11	Maharashtra	1990
12	Orissa	1981
13	Punjab	1974
14	Rajasthan	1982
15	Tamil Nadu	No major changes since 1962 except for standard scale of water rates on dry land which was revised in 1987
16	Uttar Pradesh	1983
17	West Bengal	1977 and 1984 for Minor Irrigation

Source: Statistics Directorate, Irrigation Management Organization, CWC, Prices of Water in Public systems in India, New Delhi, 1993.

Table II 1.5.7
INDIA. IRRIGATION CHARGES AS PERCENT OF GROSS VALUE OF OUTPUT (GVO) AND NET VALUE OF OUTPUT (NVO) FOR SELECTED CROPS, 1987-88

		Paddy		Wheat		Sugarcane		
Item		**Haryana**	**Punjab**	**Haryana**	**Punjab**	**Maharashtra**	**Tamil Nadu**	**Andhra Pradesh**
1	Irrigation Charges IC RB/ha	793	821	385	198	1678	1231	802
2	IC as % of Gross Value of output	9.9	8.5	6.0	2.7	8.3	5.8	4.8
3	IC as % of							
	NVO (A)	33.1	46.6	26.7	14.1	28.5	15.1	33.6
	NVO (B)	21.8	20.6	14.7	6.8	18.2	10.5	10.9
4	IC as % of							
	Total Cost (A)	14.0	10.4	7.8	3.3	11.8	9.3	5.7
	Total Cost (B)	17.9	14.5	10.3	4.5	15.5	12.8	8.7
5	Irrigation charges for surface water Rs./ha	74	48	44 to 62	29	1000	NA	222

Notes: 1. A. While calculating NVO or Total Cost imputed land rent is taken part of cost
B. Land rent is excluded

2. The crops across States occupy 95% or more area under irrigation.

Source: A. Row 5 Pricing of Water in Public Systems in India, Statistics Directorate, Irrigation Management Organization, Central Water Commission. 1993.
B. Ministry of Agriculture, Government of India, New Delhi, 1991, Cost of Cultivation of Principal Crops in India

TABLE II 1.5.8

INDIA: IMPLICIT IRRIGATION RATES PER UNIT OF WATER IN SELECTED STATES (Rs./Hectare Meter)

Item No	Crop	Gujarat	Karnataka	Madhya Pradesh	Orissa	Punjab	Uttar Pradesh
1	Paddy	121	112	59	47	39	113
2	Coarse Cereals	222	163	246	50	150	262
3	Wheat	147	65	100	84	57	188
4	Pulses	261	128	86	74	150	157
5	Sugar Cane	298	144	176	82	42	98
6	Oil Seeds	167	197	225	38	73	400
7	Cotton	93	103	150	N.A	56	59
8	Average for Coarse Cereals, Pulses and Oilseeds	220	160	190	63	120	270

Notes: Implicit water rates have been estimated by dividing the figure for Rs per ha. by irrigation water depth in meters. For example, in Gujarat, for paddy the estimated water depth is 0.91m hence implicit water rate is Rs.110/0.91= Rs. 121 per ha.m. For the same state, for wheat the water depth is 0.75 m which gives an implicit water rate of Rs.110/0.75= Rs.147 per ha.m

Source: Report of the Committee on Pricing of Irrigation Water, Planning Commission, Government of India, New Delhi, September 1992 (p.384)

TABLE II 1.5.9

INDIA: WATER RATES ON MAJOR AND MEDIUM WORKS (Rs/Ha)

Item No	Crop	Gujarat	Karnataka	Madhya Pradesh	Orissa	Punjab	Uttar Pradesh
1	Paddy	110	87	59	40	48	98
2	Coarse Cereals	40	19	37*	21	30	68
3	Wheat	110	54	62*	32	29	98
4	Pulses	60	37	42	11*	24	66
5	Sugar Cane	830	370	297	100	68*	168
6	Oil Seeds	100	59	54	26	32	68
7	Cotton	100	99	59	N.A	33	35

Source: Report of the Committee on Pricing of Irrigation Water, Planning Commission, Government of India, New Delhi, September 1992 (p.383)

TABLE II 1.5.10

INDIA: MAJOR AND MEDIUM PROJECTS (OTHER THAN NWMP STATEWISE (O&M) COSTS.

State	No. of projects other than NWMP sub-projects	Weighted average O&M cost Rs/ha	Weighted average O&M Rs / 000 m^3 water used
Andhra Pradesh	5	164*	13*
Haryana	2	146	27
Karnataka	1	160	17
Maharashtra	9	226	24
Orissa	4	113	14
Rajasthan	13	72	10
Uttar Pradesh	14	189	23
West Bengal	3	241	48

* The O&M cost of projects in Andhra Pradesh in the above abstract works out much higher than O&M cost of projects included under National Water Management Project (NWMP). Under NWMP only completed projects are included, whereas in the above list Magarjunasagar & Sriram Sagar Projects are included, where distribution system are still incomplete. Partly irrigated area have to bear the full cost of head works well as completed main canal system.

Source: Report of the Committee on Pricing of Irrigation Water, Planning Commission, Government of India, New Delhi, September 1992 (p.257)

TABLE II 1.5.11

INDIA: ELECTRIC PUMPSETS/TUBE WELLS IN SELECTED STATES 1968-69 TO 1991-92

000 Nos.(Cumulative)

State	1968 -69	1980 -81	1985 -86	1990-91	1991-92	
	(000 Nos)					% to total
Andhra Pradesh	123	472	736	1165	1281	13.68
Assam	-	2	4	35	3	0.03
Bihar	50	160	202	255	258	2.75
Gujarat	42	231	317	460	486	5.19
Haryana	45	218	282	359	382	4.08
Karnataka	92	311	490	723	816	8.71
Kerala	14	90	146	222	243	2.59
Madhya Pradesh	25	315	509	879	953	10.18
Maharashtra	125	658	1014	1608	1703	18.18
Orissa	1	17	33	51	58	0.62
Punjab	59	291	441	602	621	6.63
Rajasthan	18	205	286	389	414	4.42
Tamil Nadu	410	912	1074	1319	1359	14.51
Uttar Pradesh	76	399	539	649	677	7.23
West Bengal	1	29	48	89	92	0.98
All India	1089	433	615	8818	9	10

Source: Centre for Monitoring Indian Economy, Basic Statistics: States, 1994

II 1 5.12

INDIA: STATEMENT SHOWING AREA IRRIGATED, DEMANDS RAISED, ACTUAL COLLECTION AND ACCUMULATED ARREARS OF IRRIGATION CHARGES AND O&M COSTS IN RESPECT OF MAJOR AND MEDIUM IRRIGATION SECTOR DURING 1990-91 IN VARIOUS STATES. areas in 000ha Million Rupees

State	Year	Area irrigated	Demand Raised	Actual collection	Cost of collection	Arrears		Operation & Maintenance Cost		Total
						Annual	Cumulative	Estt.	Works	
1	2	3	4	5	6	7	8	9	10	11
Bihar	1990-91	2108	184	49	114	158	388	310	155	465
Gujarat	1990-91	700	129	70	N.A	59	386	N.A	N.A	292
Haryana	1990-91	1972	117	158	2% of collection	(-) 42	103	231	116	347
Madhya Pradesh	1989-90	1597	279	126	23	153	807	36	109	145
Maharashtra	1990-91		190	162	N.A	28	718	N.A	N.A	N.A
Orissa	1990-91	1371	92	42	N.A	50	N.A	12	22	34[1]
Punjab	1990-91	2853	99	104	30	NIL	NIL	292	87	379
Rajasthan[2]	1991-92	1388	162	114	95.3	6	68	90	26	116
Tamil Nadu	1989-90	770	34	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Uttar Pradesh	1989-90	5663	643	604	10-12% of collection	39	58	474	541	1016**
West Bengal	1990-91	1700	26	75	50	19	N.A	146	131	277

Notes: 1 Relates to 4 major and 5 medium projects 2 Relates to 5 major and 5 medium projects
* Includes arrears also ** Relates to canal irrigation system only
N.A Not available

Table II 1.5.13

INDIA :IRRIGATED AGRICULTURE AND STRUCTURE OF SUBSIDIES IN SELECTED STATES

Variables	Andhra Pradesh	Haryana	Punjab	Maharashtra	Tamil Nadu	All India
1. Gross Irrigated Area (1988-89) (000 ha)	5440	4070	6837	2489		
2. % Area irrigated by source (1988-89)*						
I. Canals	45	49	38	42		
II. Tanks	23	-	-	-		
III. Wells	28	51	61	58		
IV. Others	4	-	1	-		
3. Multipurpose River Projects (1984-85)						
3.1 Working Expenses (Rs/Ha)	115	170	87	312		
3.2 Gross Receipts (Rs/Ha)	25	64	71	148		
3.3 Range of Water rates (Rs/Ha)	49-371	7 to 99	14 to 81	20 to 750		
4. Input subsidies (Average for 1980-81 to 11986-87) (Rs. million)						
4.1 Total	8982	4645		5943		
4.2 Irrigation	6625 (74)**	3426 (74)	7132	2649 (55)		
4.3 Electricity	606 (7)	513 (11)	4716 (66)	1194 (19)		
4.4 Irrigation & Electricity	7231 (81)	3939 (85)	977 (14)	3793 (74)		
5.Irrigation and Electricity subsidy per Gross irrigated Ha (Rs.)	1329	968	5693 (80)	1524		1208
			833			

Notes: * Percentage on the basis of Net Irrigated Area

** Percentage of total subsidy

Source: (a) Rows 1 and 2 from Ministry of Agriculture, Directorate of Economics and Statistics- Indian Agricultural Statistics 1985-86, 1989-90, New Delhi, 1993

(b) Row 3, Central Water Commission, Statistics Directorate, Water and Related Statistics, New Delhi, March 1994.

(c) Row 4, Ashok Gulati: Input Subsidies in Indian Agriculture, A Statewise Analysis , Economic and Political Weekly, June 24, 1989

Table II 1.5.14
INDIA: IRRIGATION CHARGES AND ADDITIONAL NET INCOME FROM IRRIGATION (excluding irrigation charges from canal irrigation) IN BIHAR & HARYANA.

	Irrigation Charges		Net return to farm family resources from irrigated farm		Net return to farm family resources from un-irrigated farm		Additional net income benefits from irrigation	
	Rs/ha/yr.	Kg.rice/ha/yr.[a]						
Estimate I								
Bihar (1983-84)	72	43.1	5774	3458	3263	1954	2511	1504
	(130)	(81.3)	(7012)	(4383)	(2639)	(1649)	(4373)	(2773)
Haryana (1981-82)	105	98.1	6109	5709	2140	2000	3969	3709

Farm harvest prices of unmilled rice have been used in computing kg. rice per ha. These were Rs.1.67 per kg in 1983-84, Rs. 1.60 per kg in 1982-83 in Bihar, and for Haryana they were Rs. 1.36, 1,26 and 1.07 per kg each in 1983-84, 1982-83 and 1981-82 respectively. Figures in parentheses are for data from Cost of Cultivation Studies, These data are for 1982-83.
Sources: Table 6.22 and 6.24 Financing Irrigation Services in India. A literature review and selected case studies in Asia.

Table II 1.5.15
INDIA: TRENDS IN IRRIGATION INVESTMENTS & REVENUE

Year (1)	Revenue from Irrigation (2)	Investments in Irrigation (3)	Total Revenue & Investments in Irrigation [(2)+(3)] (4)	Irrigation Revenue as percent of Investment [(2) as % of (3)] (5)	GDP of Agricultural Sector in current prices (6)	Irrigation Revenue & Expenditure as % of GDP in Agriculture (7)
1970-71	59	296	355	19.93	16821	2.11
1971-72	69	348	417	19.83	17105	2.44
1972-73	238	348	586	68.39	18772	3.12
1973-74	260	349	609	74.5	24836	2.45
1974-75	382	551	933	69.33	27057	3.45
1975-76	435	659	1094	66.01	26651	4.10
1976-77	486	939	1425	51.76	27105	5.26
1977-78	574	1135	1709	50.57	32238	5.3
1978-79	717	1327	2044	54.03	32815	6.23
1979-80	792	1506	2298	52.59	33586	6.84
1980-81	928	1675	2603	55.4	42466	6.13
1981-82	1059	1864	2923	56.81	47736	6.12
1982-83	1167	1979	3146	58.97	50527	6.23
1983-84	1409	2196	3605	64.16	61241	5.89
1984-85	1574	2428	4002	64.83	65135	6.14
1985-86	2097	2681	4778	78.22	69911	6.83
1986-87	2674	2880	5554	92.85	74438	7.46
1987-88	3102	3057	6159	101.47	81458	7.56
1988-89	3595	3234	6829	111.16	-	-

Source: Adapted from Shetty, S.L 1990, Investments in Agriculture, Brief Review of Recent Trends- *Economic and Political Weekly.* February 1990.

PART II 1.1.6 ENVIRONMENTAL IMPACTS

- There were a total of approximately 8.5 million hectares affected by water logging in 1984/85. The worst affected states were Bihar, Uttar Pradesh, Andhra Pradesh and Haryana and the least affected states Maharashtra, Kerala , Tamil Nadu and Karnataka. (Table II 1.6.1)
- Another 3.3 million hectares are affected by salinity in India, The most affected states were Uttar Pradesh, Gujarat and Punjab. The least affected states were Maharashtra, Andhra Pradesh and Karnataka and Rajasthan. (Table II 1.6.2)
- Alkali and Saline soils can be reclaimed with benefits at a cost ranging from Rs. 2000 - 13000/per hectare. The cost benefit/cost ratio for the above varies from 1.22 to 3.99, depending on subsidy payments (Table II 1.6.3)

Table II 1.6.1 INDIA: AREAS UNDER SALT AFFECTED SOILS IN SLEETED STATES

State	NCA (2976)	Working Group	Reconciled Estimates
Andhra Pradesh	240.00	N.A	27.80
Assam	N.A	N.A	N.A
Bihar	4.00	N.A	224.30
Gujarat	1214.00	911.00	911.00
Haryana	526.00	N.A	197.20
Karnataka	404.00	51.40	51.35
Kerala	16.00	N.A	N.A
Madhya Pradesh	242.00	35.79	35.79
Maharashtra	534.00	5.35	5.35
Orissa	404.00	N.A	N.A
Punjab	688.00	490.00	490.00
Rajasthan	728.00	N.A	70.00
Tamil Nadu	4.00	140.30	140.00
Uttar Pradesh	1295.00	1150.80	1150.00
West Bengal	855.00	N.A	N.A
Delhi	16.00	N.A	N.A
Total	7165.00	2784.59	3303.89

Table II.1.6.2

INDIA: COST AND BENEFIT OF TECHNOLOGICAL OPTIONS FOR RECLAIMING SALT-AFFECTED AND WATER-LOGGED SOILS

Option	Year	Cost	Benefit Cost Ratio	Employment
Alkali Soil;				
Crop Production				
No Subsidy	1975/76	4054	1.34	135
75% Subsidy	1975/76	2525	1.42	135
Afforestation				
Acacia	1983/84	6416	1.63	156
Eucalyptus	1983/84	6416	1.22	134
Saline Soils:				
Drainage for crop reduction				
Farmers' field	1989/90	10712	1.26	107
Potential	1985/86	13552	3.99	128

Source: Report of the Committee on Pricing of Irrigation Water, Planning Commission, Government of India, New Delhi, September 1992 (p.309)

IIMI WATER DATA BOOK

COUNTRY PROFILE

PAKISTAN

1. WATER RESOURCES
2. WATER AVAILABILITY AND USE
3. IRRIGATED AGRICULTURE
4. WATER USE FOR HOUSEHOLDS, INDUSTRY
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Table II.2.6.3: Chemical Status and Soil Profiles in the Irrigated Areas of the Indus Basin

PAKISTAN DATA COUNTRY PROFILE

1. WATER RESOURCES

A. PULATION AND DEVELOPMENT INDICATORS

1. Pakistan with a population of 128 million in 1995 has one of the highest rates of population growth in the world - 3.1 per cent per annum (1985-93) (Table II.2.1.1).

2. Per Capita Gross National Product (GNP) of Pakistan was estimated at U.S. $ 430/year in 1993 (Table II.2.1.1).

B. WATER RESOURCES

1. Surface Waters

- The total estimated mean annual surface run-off available to Pakistan is about 177 BCM (Table II.2.1.2) implying a per capita average run-off of about 1380 M^3/year (1995).

- The Indus River Basin in Pakistan has by far the largest water resource, with the Inland Basins of Baluchistan and the Coastal Streams which together account for 30 per cent of the geographical area, having only 3 per cent of the surface waters (Table II.2.1.2).

- The Indus and three of its main tributaries, the Rivers Jehlum, Chenab and Kabul, account for 96 per cent of river run-off in the Indus Basin (Table II.2.1.3).

- The annual inflows in the rivers are highly variable; the 80 percent probability inflows being 80 percent of the mean annual (Table II.2.1.3).

- Over the year the river flows vary greatly. On an average, 84 percent of the flow occurs during the summer cropping season of Kharif (April to September) and only 16 percent during the cropping season of Rabi (October to March) (Table II.2.1.4).

- The river waters have low Total Dissolved Solids (TDS), not exceeding 400 ppm in the Indus River water outflowing to the Sea. (Table II.2.1.5).

2. Groundwater

- The useable groundwater potential is estimated at 45.6 BCM or 25 percent of the mean annual river run-off (Table II.2.1.6).

- The groundwater recharge in the Canal Command Areas of the Indus Basin, amounting to 56.21 BCM, is derived to the extent of 83 percent from the canal systems and irrigation applications (Table II.2.1.7).

- Over the 16.36 mha of Gross Canal Commanded Area an area of 9.95 mha or 60 percent has groundwater with less than 3000 ppm TDS in the depth range 0 to 350 ft. (about 100 m). (Table 1.8).

2. WATER AVAILABILITY AND USE

A. SURFACE WATER

i Five-Year Average Annual Canal Head Diversions in the Indus Basin, during 1956 to 1961 of 102 BCM increased to 130.7 BCM during 1989-94 representing an increase by 25 percent from 67 to 83.5 BCM while the Rabi diversions went up by 35 percent from 35 BCM to 47.2 BCM (refer to combined Canal Head Diversions, faxed on Dec. 20, 1995).

ii The present annual Canal Head Diversions of 130.7 BCM are 76 percent of the mean annual inflows of the Indus Basin.

iii The present Rabi Canal Head Diversions of 47.2 BCM exceed the mean Rabi River Inflow of 27.2 BCM by 73 percent, representing inter-seasonal transfer of water through surface storages.

B. GROUNDWATER

i. In the last 14 years (1978-79 to 1992-93) the number of Public Tubewells increased from 11290 to 16087 whereas the number of private tubewells has gone up from 167217 to 358012 representing an annual growth rate of 5.6 percent (Table II.2.2.1).

ii. While 95 percent of the Public Tubewells are Electrically driven, only 27 percent of the private tubewells have access to electric power (Table II.2.2.1).

iii. About 60 percent of the private tubewells have been installed for supplementing canal water whereas 28 percent were intended for irrigation in rainfed areas (Barabi/Sailaba land). The balance represented replacement of wells/karezes (Table II.2.2.2).

iv. In the Canal Commanded Areas, the groundwater availability at the farm-gate increased from 31.6 BCM in 1975-76 to 56.7 BCM in 1992-93 representing an increase of 79.5 percent (Table II.2.2.3).

v. Presently (1992-93), Private tubewells account for 73 percent of the groundwater availability at the farm-gate in the Canal Command areas (Table II.2.2.3).

vi. The net groundwater abstraction during 1985-86 in the Canal Command Areas amounted to 86 percent of the useable groundwater recharge (Table II.2.2.4).

vii. Considering a uniform rate of groundwater recharge in the Canal Commanded Areas, useable groundwater was being over-exploited in 1985-86 in 28 percent of the area whereas in the rest of the area there was an estimated groundwater potential of 10.17 BCM (Table II.2.2.5).

C. COMBINED SURFACE & GROUNDWATER USE

In the Canal Commands of the Indus Basin, the use of groundwater has gradually increased. In 1975-76 groundwater supplemented the canal supplies at the farm-gate by 43 percent whereas in 1992-93 this supplement was 58 percent (Table 2.3).

3. IRRIGATED AGRICULTURE

A. Of the total Reported Area of 58.12 m ha, only 24.90 m ha or 43 percent is under agricultural use (Table II.2.3.1).

B. Of the 24.90 mha, under agricultural use, 3.44 mha or 14 percent is under forests and the remainder is the Cultivated Area (Table II.2.3.1).

C. Of the cultivated area of 21.46 mha current follow accounts for 24 percent, and area sown more than once for 27 percent. The total cropped area is thus 103 percent of the cultivated area (Table II.2.3.1).

D. Of the total cultivated area, over 80 percent is irrigated (Table II.2.3.2).

E. Wheat, Fodders, Cotton and Rice are the principal crops accounting for 75 percent of the Cropped Area, all of which depend heavily on irrigation (83 to 100 percent) (Table II.2.3.3).

F. During the last 12 years, the Index of the acreage of all crops increased to 113 in 1992-93, whereas the index of production stood at 141, having suffered a decline of 20 points from the previous year 1991-92 (Table II.2.3.4).

4. WATER USE FOR HOUSEHOLDS, INDUSTRY

A. Presently (1990) 82 percent of Urban and 42 percent of the rural population has access to safe drinking water (Table II.2.4.1).

B. Presently (1990) Sanitation facilities are available for 53 percent of the Urban population and only 12 percent of the rural population (Table II.2.4.1).

5. INVESTMENTS, COSTS, PRICES AND ECONOMIC VALUES

A. The cost of supplying canal water per irrigable hectare during 1988-89 was found to range from US $ 3.82 to 22.68 in the different provinces (Table II.2.5.1).

B. The recoveries from farmers for the supply of canal water per irrigable hectare during 1988-89 ranged from US $ 1.71 to 4.21, representing subsidies ranging from 81 to 21 percent (Table II.2.5.1).

C. The cost of 1,000 cube meters of irrigation water during 1988-89 was found to vary from US $ 0.25 to 2.82 in the different provinces (Table II.2.5.2).

D. Water rates are 1.6 to 4.5 percent of the Gross margins for the principal irrigated crops (Table II.2.5.3).

6. ENVIRONMENTAL IMPACTS

A. High water Table, within 1.5 m of the surface, persists throughout the year in 12 to 15 percent of the Canal Commanded Areas of the Indus Basin. Over the last 15 years there has been no significant trend (Table II.2.6.1).

B. Area of high water table (0 to 1.5 m depth) increases after the monsoon season to affect about 30 of the Canal command Areas (Table II.2.6.1).

C. Soil Salinity was found to affect 26 percent of the surface soils during 1977-79. Earlier appraisals (1953-75) gave a figure of 42 percent, indicating an improvement (Table II.2.6.2).

D. Soil profiles are affected by Salinity/Sodicity to a greater extent (38 percent) as compared to the extent of surface salinity (26 percent) Table II.2.6.3).

Table II.2.1.1
Pakistan Country Profile

Location
Latitude: 24N o 37N
Longitude: 61N to 76N

Geographical Area: *1

By Province and for Country

PROVINCES

Punjab	Sindh	N.W.F.P.	Baluchistan	Islamabad	Total Pakistan
205344	140914	101741	347190	906	796095

Population: *2

As Per Latest Census (1981)
By Provinces and for the Country

Punjab	Sindh	N.W.F.P.	Baluchistan	Islamabad	Total Pakistan
47292	19029	13260	4332	340	84253

Present Population (1995) Estimated: 128.01 million *3
Estimated Population Growth Rate (1985-93): 3.1 percent *4

Gross National Product: (1993) US$ 53,250 Million *4

Per Capita GNP (1993): US$ 430 *4
Per Capita GNP Real Growth Rate (1985-93) 1.5 percent *4

Share of Agriculture in GDP (1993): 25 Percent *4

Source:
*1 Monthly Statistical Bulletin, Oct 1994, Federal Bureau of Statistics, Govt. of Pakistan

*2 Agricultural Statistics of Pakistan, Economic Wing, Min. of Food Agriculture & Livestock

*3 Economic Survey 1994-95, Economic Advisers Wing

*4 The World Bank Atlas, 1995; The World Bank

Table II.2.1.2

Mean Annual River Run-off Available in the Hydrologic Units of Pakistan

Hydrologic Unit	Area in Pakistan Sq.Km	Mean Annual River Inflows (BCM)
Indus River Basin	553,410	171.38 *2
Closed Basin of Baluchistan	120,180 *1	6.20 *3
Coastal Streams	122,510 *1	
Total	796,100	177.58

Source: *1 A Program for Water and Power Development in West Pakistan, Harza Engg. Co. Int'l, 1963.

*2 Adapted from: Guide to the Indus Basin Model Revised, Environment Operations and Strategy Dvn. The World Bank 1990, as quoted in Water Sector Investment Planning Study by Consultants NES Pak et. al. 1990.

*3 Concept Eighth Five Year Plan 1993-98, Government of Baluchistan, Pakistan/Netherlands Project, 1994.

Table II.2.1.3
Annual Inflows of the Indus River System Available in Pakistan

BCM

Sources (Period of Record	Mean annual inflows	80% probability inflows
Indus River : 1936-88	75.31	63.39
Jehlum River : 1922-88	27.27	21.08
Chenab River : 1922-88	30.20	24.84
Kabul River : 1966-76	31.56	23.00
Tributary inflows : 1966-76	7.04	4.91
Total.....	**171.38**	**137.22**

Source: WAPDA

Table II.2.1.4
Seasonal Inflow of Indus River System Available to Pakistan

(In Billion Cubic Meters)

Sources	Mean Inflow (BCM)			Kharif Inflow as % of Annual
	Annual	**Kharif**	**Rabi**	
Indus River	75.31	65.24	10.07	86.6
Jehlum River	27.27	21.82	5.45	80.0
Chenab River	30.20	25.40	4.80	84.1
Kabul River	31.56	25.85	5.71	81.9
Tributary Inflows	7.04	5.88	1.16	83.5
Total	**171.38**	**144.19**	**27.19**	**84.1**

Source: Adapted from Guide to the Indus Basin Model Revised, Environment Operations and Strategy Division. The World Bank 1990, as quoted in Water Sector Investment Planning Study by Consultants NES Pak et. al. 1990.

Table II.2.1.5
Quality of Indus River Water Outflowing to the Sea
Total Dissolved Solids (TDS) in Parts Per Million (ppm)

YEAR	MONTHS											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1975	252	252	295	368	263	168	151	182	210	224	252	252
1976	260	260	298	296	298	210	227	102	245	242	326	325
1977	326	304	403	397	298	263	183	182	224	224	226	228
1978	228	308	273	236	238	182	273	189	306	266	301	266
1979	228	245	242	273	182	193	140	165	186	139	193	182
1980	172	305	319	336	273	182	175	189	186	187	235	236
1981	247	277	350	347	248	168	158	209	195	199	221	239
1982	249	266	261	350	270	237	181	175	207	162	186	193
1983	193	221	298									
1984				343	344	337	196	200	224	245	244	241
1985	224	280	302	280	374	228	183	179	173	168	208	232
1986	191	249	281									
Ave	233.64	269.73	302.00	322.60	278.80	216.80	186.70	187.20	215.60	205.60	239.20	239.40
Max.	326.00	308.00	403.00	397.00	374.00	337.00	273.00	209.00	306.00	266.00	326.00	325.00
Min.	172.00	221.00	242.00	236.00	182.00	168.00	140.00	165.00	173.00	139.00	186.00	182.00

Source: Pakistan Drainage Sector Environment Assessment - National Drainage Programme

Table II.2.1.6
Usable Groundwater Potential in Pakistan

Aquifers	Mean Annual Recharge (BCM)
Indus Basin Aquifer under Canal Commands	35.60 *[1]
Indus Basin Aquifer outside Canal Commands	9.10 *[2]
Aquifers in Baluchistan	0.90 *[3]
Other Aquifers	N.A
Total	45.60

Source: *[1] Groundwater Development Potential (Canal Command Area), Drainage Section, Water Resources Planning, Planning Division, WAPDA; in Water Sector Investment Planning Study by Consultants NES PAK et.al 1990.

*[2] Revised Action Programme for Irrigated Agriculture, Master Planning and Review Division WAPDA, 1979.

*[3] Concept Eighth Five Year Plan 1993-98, Government of Baluchistan; Pakistan/Netherlands Project, 1994.

Note: Usable Groundwater Potential under canal commands estimated for areas having salt content in 0 to 350 ft. depth range of less than 3,000 ppm TDS.

Table II.2.1.7
Groundwater Recharge by Sources in the Canal Commands of the Indus Basin

Source of Recharge	Recharge BCM	Percent of Total
1. Canals	21.99	39.1
2. Watercourses & Fields	21.99	39.1
3. Link Canals	2.74	4.9
4. Precipitation	7.79	13.9
5. Rivers	1.70	3.0
Total	**56.21**	**100.0**

Source: Adapted from Groundwater Development Potential (Canal Command Area), Drainage Section, Water Resources Planning, Planning Division WAPDA; in Sector Investment Planning Study by Consultants NESPAK, et.al. 1990

Table II.2.1.8
Area within Different Groundwater Quality Ranges

Sr. No	Canal Commands		G A (M H)			
				Usable Zone		Saline Zone
		CCA (M H)	TOTAL	<1500 PPM	1500-3000 PP	>300 PPM
	PAKISTAN	14.01	16.36	8.01	1.94	6.42
	Punjab	8.20	9.72	6.71	1.34	1.67
1	U. Dipalpur	0.15	0.17	0.17	0.00	0.00
2	Ravi Syphon	0.26	0.32	0.18	0.08	0.06
3	Raya Branch	0.17	0.18	0.18	0.00	0.00
4	U. Chenab	0.41	0.45	0.45	0.00	0.00
5	M.R. Link	0.06	0.07	0.07	0.00	0.00
6	Sadiqia	0.39	0.47	0.01	0.03	0.43
7	Fordwah	0.17	0.23	0.15	0.03	0.04
8	Pakpattan	0.42	0.45	0.42	0.02	0.01
9	L. Dipalpur	0.25	0.29	0.29	0.0	0.00
10	L.B.D.C.	0.68	0.81	0.65	0.12	0.04
11	Jhang	0.47	0.70	0.42	0.20	0.08
12	Gugera	0.76	0.85	0.60	0.15	0.10
13	U. Jhelum	0.22	0.28	0.27	0.00	0.00
14	L. Jhelum	0.61	0.72	0.45	0.09	0.18
15	Bahawal	0.24	0.33	0.14	0.10	0.09
16	Mailsi	0.40	0.44	0.25	0.10	0.09
17	Sidhnai	0.35	0.35	0.30	0.04	0.01
18	Havali	0.07	0.07	0.06	0.00	0.01
19	Rangpur	0.14	0.17	0.15	0.01	0.01
20	Panjnad	0.55	0.60	0.38	0.05	0.17
21	Abbasia	0.06	0.06	0.02	0.01	0.03
22	Thal	0.66	0.99	0.63	0.21	0.16
23	Muzaffargarth	0.33	0.33	0.27	0.03	0.03
24	D.G. Khan	0.37	0.39	0.21	0.06	0.12
	N.W.F.P.	0.33	0.40	0.35	0.05	0.00
25	U. Swat & Pehur	0.11	0.16	0.14	0.02	0.00
26	L. Swat	0.07	0.08	0.08	0.01	0.00
27	Warsak	0.05	0.05	0.05	0.01	0.00
28	Kabul	0.05	0.06	0.05	0.01	0.00
	Sindh & Baluchistan	5.49	6.24	0.94	0.55	4.75
30	Pat	0.30	0.33	0.01	0.01	0.30
31	Desert	0.13	0.15	0.02	0.01	0.12
32	Begari	0.41	0.44	0.15	0.08	0.21
33	Ghotki	0.35	0.39	0.11	0.08	0.20
34	N. West	0.49	0.51	0.06	0.05	0.40
35	Rice	0.21	0.22	0.01	0.04	0.18

36	Dadu	0.24	0.26	0.04	0.06	0.16
37	Khairpur East	0.17	0.17	0.10	0.05	0.02
38	Khairpur West	0.15	0.23	0.02	0.03	0.18
39	Rohri	1.04	1.19	0.42	0.14	0.63
40	Nara	0.88	1.02	0.00	0.00	1.02
41	Kalri	0.24	0.31	0.00	0.00	0.31
42	Lined Channel	0.20	0.24	0.00	0.00	0.24
43	Fuleli	0.37	0.41	0.00	0.00	0.41
44	Pinyari	0.31	0.39	0.00	0.00	0.39

Source: Report on Groundwater Development Potential for Water Sector Investment Planning Study, Planning Division, WAPDA, 1990.

Table II.2.2.1
Number of Tubewells in Pakistan

Year	Public			Private			Public & Private		
	Electric	Diesel	Total	Electric	Diesel	Total	Electric	Diesel	Total
1978-79	11033	257	11290	60068	107149	167217	71101	107406	178507
1979-80	12184	262	12446	64642	111824	176466	76826	112086	188912
1980-81	13178	239	13417	70677	115579	186256	83855	115818	199673
1981-82	14196	271	14467	74262	118350	192612	88458	118621	207079
1982-83	14450	236	14686	77766	120774	198540	92216	121010	213226
1983-84	14356	309	14665	80489	135382	215871	94845	135691	230536
1984-85	14875	202	15077	82160	151641	233801	97035	151843	248878
1985-86	15254	211	15465	83970	157874	241844	99224	158085	257309
1986-87	14668	257	14925	84864	168664	253528	99532	168921	268453
1987-88	15262	229	15491	87452	185510	272962	102714	185739	288453
1988-89	15392	231	15623	91809	197799	289608	107201	198030	305231
1989-90	15564	513	16077	96098	213004	309102	111662	213517	325179
1990-91	15632	382	16014	98003	225823	323826	113635	226205	339840
1991-92	15637	743	16380	96903	242557	339460	112540	243300	355840
1992-93	15371	716	16087	98148	259864	358012	113519	260580	374099

Source: Agricultural Statistics of Pakistan, 1992-93 Ministry of Food, Agriculture and Livestock. As reported by Provincial Agriculture Departments.

Table II.2.2.2
Private Tubewells (Including Surface Pumps) by Purpose* of Installation

Administrative Unit	Total Number of Tubewells Surface Pump	Tubewells/Surface Pumps Reporting Installation					
		Supplementing Canal Water		Irrigation of Barani/Sailaba Land		Replacement of Wells/Karezes	
		Number	% of Total	Number	% of Total	Number	% of Total
Punjab	203602	128713	63	55222	27	41763	21
Sindh	7321	4613	63	1278	17	1985	27
N.W.F.P.	8570	1830	21	4876	57	2109	25
Baluchistan	5068	235	5	1717	34	3200	63
Pakistan	224561	135391	60	63093	28	49057	22

* Some Tubewells Reported Multiple Purpose of Installation So the Total of Column 3,5 and 7 is Greater than the total.

Source: Agricultural Statistics of Pakistan, 1992-93 Ministry of Food, Agriculture and Livestock

Table II.2.2.3
Annual Irrigation Water Availability at Farm gate

(In Billion Cubic Meters)

Year	Canal Head Diversion	Water Farm Gate by Sources			
		Canals	Public Tubewells	Private Tubewell	Total
1975-76	122.01	73.29	7.60	23.97	104.86
1976-77	120.06	72.04	6.97	25.31	104.32
1977-78	126.67	75.53	7.6	26.66	109.84
1978-79	119.19	75.69	8.17	28.11	111.96
1979-80	129.81	76.03	8.67	29.57	114.27
1980-81	132.48	76.51	9.18	31.01	116.70
1981-82	125.63	77.02	10.07	32.45	119.54
1982-83	127.42	81.69	12.29	32.43	126.41
1983-84	123.98	78.94	12.58	33.33	124.85
1984-85	124.68	80.81	12.83	34.23	127.86
1985-86	118.84	80.95	13.10	35.13	129.18
1986-87	130.63	85.96	13.37	36.01	135.34
1987-88	134.57	87.87	13.64	36.91	138.42
1988-89	129.64	89.65	14.01	37.77	141.43
1989-90	125.94	91.48	14.38	38.63	144.49
1990-91	135.19	93.30	14.75	39.40	147.55
1991-92	135.31	95.16	15.07	40.31	150.55
1992-93	120.76	97.08	15.54	41.20	153.82

Source: Agricultural Statistics of Pakistan, 1992-93 Ministry of Food, Agriculture and Livestock as Reported by Water Resources Section - Planning & Development Division

Table II.2.2.4
Groundwater Pumpage in the Canal Commands of the Indus Basin 1985-86 and Estimated Usable Recharge

(In Billion Cubic Meters)

Provinces	Groundwater Pumpage			Net Groundwater Abstraction	Usable Recharge
	Public Sector	Private Sector	Total		
Punjab	8.26	27.14	35.40	26.77	28.49
N.W.F.P.	0.12	0.37	0.49	0.37	1.73
Sindh & Balu chistan	2.10	2.71	4.81	3.70	5.43
Total	10.48	30.22	40.71	30.84	35.65

Source: Adapted from Groundwater Development Potential (Canal Command Area), Drainage Section, Water Resources Planning WAPDA; in Water Sector Investment Planning Study by Consultants NESPAK et.al. 1990

Table II.2.2.5
Extent of Over & User Exploitation of Useable Groundwater in the Canal Commands of the Indus Basin 1985-86

(In Billion Cubic Meters)

Provinces	Areas of Over Exploitation			Areas of Under Exploitation		
	Recharge	Exploitation	Over Draft	Recharge	Exploitation	Potential
Punjab	8.20	13.19	5.00	20.31	13.57	6.74
N.W.F.P.	-	-	-	1.73	0.40	1.33
Sindh & Baluchistan	1.95	2.38	0.41	3.44	1.34	2.10
Total	**10.15**	**15.57**	**5.4**	**25.48**	**15.31**	**10.17**

Source: Adapted from Groundwater Development Potential (Canal Command Area), Drainage Section, Water Resources Planning WAPDA; in Water Sector Investment Planning Study by Consultants NESPak et.al. 1990

Table II.2.3.1
Land Utilization in Pakistan, 1993-94

(Million Hectare)

Total Geographical Area		79.61
Total Area Reported:		58.12
Less:		
Not Available for Cultivation	24.38	
Culturable Wastes:	8.84	
	33.22	
Cultivated Area & Area Under Forests:		24.90
Area Under Forests:	3.44	
Cultivated Area:		21.46
Net Area Sown:	1.622	
Area Sown more than once:	5.93	
	22.15	
Total Cropped Area:		22.15

Source: Agriculture Statistics of Pakistan, 1993-94
Ministry of Food Agriculture & Livestock

Table II.2.3.2
Irrigation Status of Farms

Farms Reporting Irrigated Areas as Percent of Cultivated Area	Cultivated Area m ha	Percent of Total Cultivated Area
0%	3.065	19.6
Under 51 %	0.936	6.0
51% to Under 76%	0.577	3.7
76% to Under 100%	0.542	3.5
100%	10.512	67.2
Total	**15.632**	**100.0**

Source: Census of Agriculture 1990.

Table II.2.3.3
Cropped Area Under Principal Crops & Crop Area Irrigated

Crops	Cropped Area		Cropped Area Irrigated	
	Area m ha	Percent of Total Cropped Area	Area m ha	Percent of Cropped Area
Wheat	8.17	38.2	6.74	83
Fodders	2.76	12.9	2.39	87
Cotton	2.68	12.5	2.68	100
Rice	2.42	11.3	2.42	100
Pulses	1.05	4.9	0.32	28
Maize	0.82	3.8	0.42	51
Sugarcane	0.72	3.4	0.71	99
Vegetable	0.53	2.5	0.49	92
Oil Seed	0.45	2.1	0.26	59
Others	1.76	8.2	N.A	N.A

Source: Census of Agriculture 1990.
Note: Cotton and Rice are known to be all irrigated

Table II.2.3.4
Index of Agricultural Production (1980-81 = 100)

Year	Acreage Index				Quantum Index			
	All Crops	Food Crops	Fibre Crops	Other Crops	All Crops	Food Crops	Fibre Crops	Other Crops
1981-82	104	103	105	107	105	102	105	111
1982-83	105	105	107	103	109	109	115	100
1983-84	105	105	105	96	96	103	69	108
1984-85	105	106	106	100	101	104	141	101
1985-86	105	106	112	91	120	114	170	89
1986-87	109	110	119	86	124	115	185	92
1987-88	103	101	122	88	127	109	206	100
1988-89	111	110	124	96	134	118	200	112
1989-90	112	112	123	93	134	119	204	108
1990-91	113	112	126	97	142	122	230	110
1991-92	112	109	134	98	161	126	306	120
1992-93	113	112	133	95	141	123	216	118

Source: Agricultural Statistics of Pakistan 1993-94, Ministry of Food Agriculture & Livestock

Table II.2.4.1
Pakistan - Access to Safe Drinking Water and Sanitation

	Percent Population with Access to	
	Safe Drinking Water	Sanitation Facilities
1. Rural		
1990		
1990	20	2
	42	12
2. Urban		
1980	72	42
1990	82	53
3. Total		
1970	21	-
1980	35	13
1990	55	25

Source: World Development Report 1994, Infrastructure for Development, World Bank, Oxford University Press, 1994.

Table II.2.5.1
Cost of Supplying Canal Water Per Irrigable Hectare and Recoveries (1988-89)

US $

Province	Cost	Recovery	Recovery as Percent of Cost
1. Punjab	3.82	3.03	79
2. Sindh	4.67	2.74	59
3. NWFP	22.68	4.21	19
4. Baluchistan	5.04	1.71	34

Source: Nationwide Study for Improving Procedures for Assessment and Collection of Water Charges and Drainage Cess, Report prepared for the Ministry of Water & Power by Associate Consulting Engineers ACE (Pvt) Ltd. in association with others, March 1990.

Table II.2.5.2
Cost of Supplying Canal Water During A Sample Year (1988-89)

(In Equivalent US $)

Cost	Punjab*	Sindh	N.W.F.P.	Baluchistan
1. Per Irrigable Hectare	3.82	4.67	22.68	5.04
2. Per Cropped Hectare	3.23	6.48	25.77	5.95
3. Per 1000 m3 of Canal Water	0.47	0,44	2..82	0.25.

Source: Nationwide Study for Improving Procedures for Assessment and Collection of Water Charges and Drainage Cess, Report prepared for the Ministry of Water & Power by Associate Consulting Engineers ACE (Pvt) Ltd. in association with others, March 1990.

* Data relates to 1987-88

* Note:- Convention based on the exchange rate during 1988-89 of US $1 = Rupees 19.21541

Table II.2.5.3
Gross Margins and Water Rates for Principal Crops on Medium Farms in the Rice Wheat Zone of the Punjab

Crops	Gross Margins Rs/ha	Water Rate Rs/ha	Water Rate as Percent of Gross Margins
Rice-Fine	4299.5	79.3	1.8
Rice-Coarse	2226.4	79.3	3.6
Cotton	1848.3	83.3	4.5
Maize	2977.6	46.9	1.6
Wheat	1952.`	53.3	2.7
Sugarcane	6152.8	153.6	2.5

Source: Nationwide Study for Improving Procedures for Assessment and Collection of Water Charges and Drainage Cess, Report prepared for the Ministry of Water & Power by Associate Consulting Engineers ACE (Pvt) Ltd. in association with others, March 1990.

Table II.2.6.1
Depth to Water Table of Less than 5 ft (1.5m) in the Canal Commands of the Indus Basin 1979-94 at 5 year Intervals

(Area in 1000 ha)

Year	April/June		October	
	Area	Percent of Gross Area	Area	Percent of Gross Area
1979	2491.30	15.2	4943.34	30.2
1984	2048.56	12.5	5270.34	32.1
1989	2394.79	14.4	4917.87	29.5
1994	1989.05	11.9	5246.53	31.5

Source: SCARP Monitoring Organization, Planning Division, WAPDA.

Table II.2.6.2
Chemical Status & Soil Profiles in the Irrigated Area of the Indus Basin

Province	Survey Period	Profile Total for	Profiles Affected				Profiles Affected as Percent of Total Profiles
			Saline	Saline Sodic	Non Saline Sodic	Total	
N.W.F.P	1977-79	1935	216	138	28	383	19.7
	1971-75	314	156	71	1	228	72.6
Punjab	1977-79	39707	2803	5757	1813	10373	26.1
	1962-65	23497	1380	6376	2718	10474	44.6
Sindh	1977-79	20398	3430	8677	373	12480	61.2
Baluchistan	1977-79	1402	365	528	12	905	64.6
	1977-79	63442	6814	15100	2226	24140	38.1
Total	1962-65	23811	1536	6447	2719	10702	44.9

Source: Adapted form Soil Salinity Survey Vol. II. Data by Canal Commands Survey & Research Organization; Planning Division, WAPDA, 1981

Note: Chemical Status of Profiles at 1 mile grid, represented by the worst condition of any of the layers 0-6", 6-18", 18-36" and 36-73", Condition defined as:
Saline: Ece > mmhos/cm and SAR < 13
Saline Sodic: Ece > 4 and SAR> 13
Non Saline Sodic: Ece <4 mmhos/cm and SAR> 13
For Sindh & Baluchistan data prior to 1977-79 not available.