Water Use for Agriculture in Priority Rivers Basins

CONTENTS

1 IWMI PROJECTIONS FOR SOUTH ASIA

In the period following the 1980s the South Asia region has been able to keep its production surpluses or deficits within 5 per cent of the region's consumption needs, even under extreme climatic conditions. This is largely due to the fact that rice is grown under irrigation, leading to yields per hectare that are 172 per cent of yields under rain-fed conditions. For this reason it is foreseen that rain-fed cultivation areas will be brought under irrigation in the future.

Table 1.1 IWMI projections for South Asia

Factor	**Units**	**1995 value**	**2025 projection**	**Annual growth 1995–2025** %
Population	million	1,233	1,762	1.2
Cereal demand	m mt	227	356	1.5
Cereal production				
- Total	m mt	229	344	1.3
- Irrigated	m mt	170	289	1.8
- Rain-fed	m mt	58	55	-0.2
Growth in total irrigated area	m ha	101	128	0.8
Primary water supply	km^3	615	754	0.7
PWS, % of PUWR	%	45	55	
Water diversion				
- Total	km^3	866	1,117	0.9
- Irrigation	km^3	831	988	0.6
- Domestic	km^3	16	50	3.9
- Industrial	km^3	19	80	4.9
Water-scarcity level	No water scarcity (Total PWS <60% of PUWR, and total growth in PWS <25%			

Source: Molden 2000
PUWR = Potential utilizable water resource
m mt = million metric tonnes
m ha = million hectares

The major conclusions for South Asia are:

- A small deficit of cereal production is projected by 2025 (3% of total demand) from a small production surplus of 1 per cent of the 1995 demand. The region as a whole is projected to be self-sufficient.
- The region as a whole is not water scarce because of the substantially high water endowment of a few countries such as Bangladesh. The region can be split into two broad categories: a substantial part of South Asia, including Pakistan and the arid regions of India, which are physically water scarce; and other parts which are economically water scarce.
- In the physically water-scarce regions sustainable increases in the productivity of water in agriculture are a key focus. In other regions there remains considerable scope for water resources development.

Issues of importance are:

- Most parts of South Asia are categorized as water-scarce; other parts have high potential for water resources development
- Competition between sectors (e.g. domestic, industrial, agricultural) is projected to increase in water-scarce areas

- Opportunities for groundwater development exist in high-potential areas
- Risk of groundwater over-development in water-scarce areas
- Deteriorating water quality
- Concerns for environment and human health.

2 THE INDUS RIVER BASIN

The Indus River Basin covers an area of 1,068,000km^2 (Wolf 2000) and drains four Asian countries: Pakistan (56%), India (26%), China (10.2%), Afghanistan (6.7%) and an additional area, control of which is disputed by India and China (1%).

The 3,180km long river originates in Lake Ngangla Ringco, 6,714m above sea level on the Tibetan plateau, and traverses Jammu, Kashmir and Pakistan before emptying into the Arabian Sea. The drainage area contributes to an average annual inflow of 226km^3. The flow of the Indus fluctuates seasonally, with melting Himalayan glaciers accounting for almost 90 per cent of the water in the upper Indus Basin. Although most of the basin lies in a zone of low rainfall (<250mm annually), abundant flows occur during the monsoon season (July–September), which accounts for 51 per cent of the annual flow.

Owing to the importance of irrigation in the Indus plain, the water balance in the Indus Basin has been carefully studied. The mean annual inflow into Pakistan from the western rivers (the Indus, including the Kabul tributary, the Jhelum and the Chenab) amounted to 170.27km^3 in 1995. The mean inflow from the eastern rivers (the Ravi, the Beas, and the Sutlej) is estimated at 11.1km^3, but this is reserved for India under the 1960 Indus Waters Treaty, established to enable exploitation by Pakistan and India of the Indus Basin's economic potential.

Figure 2.1 Location of Mangla and Tarbela Dams in the Indus River Basin

Under this treaty (regarded as one of the few successful settlements of transboundary water basin conflicts), India was granted water from the three eastern tributaries in return for the cost, to Pakistan, of "replacement works" (i.e. water storage infrastructure) amounting to

GBP62 million. This included construction of two additional dams in Pakistan (Mangla and Tarbela) and new link canals and barrages to develop and sustain agricultural activities. The new infrastructure has enabled agricultural production in the Indus Basin to increase by 33 per cent.

2.1 Ecoregions in the Indus River Basin

The headwaters, tributaries, floodplains, delta, and marine coastal zone of the Indus River Basin represent a complete range of ecosystems and unique geographical and geological features. The delta and near-shore waters, in particular, provide habitat for important freshwater and marine fisheries.

Two important freshwater lakes, Haleji and Kinjhar (Kalri), lie within the basin and have been classified as Ramsar sites. Haleji supports a variety of flora and fauna and 103,000 waterfowl have been counted during the winter. Kinjhar, one of the largest freshwater lakes in Pakistan with a surface area of 13,468ha, supports about 150,000 waterfowl. These lakes are the source of drinking water for the city of Karachi. They also serve as flood control and support major fisheries.

Four WWF Global 200 Ecoregions lie in the Indus River Basin: Western Himalayan Temperate Forests, Rann of Kutch Flooded Grasslands, Tibetan Plateau Steppe, and Indus River Delta.

Western Himalayan Temperate Forests
The middle elevation forests of the Western Himalayas, including places such as the Palas Valley of Pakistan, contain numerous plant species found nowhere else on Earth. The Palas Valley is the most floristically rich area in Pakistan.

General threats: The remaining forests are threatened by increased logging, conversion for agriculture, and fuelwood collection. Hunting pressure is also high.

Rann of Kutch Flooded Grasslands
These seasonally flooded saltmarshes represent the only flooded grasslands in the Indo-Malayan region. Expanses of mangroves and desert vegetation also make up portions of this ecoregion. Some of the endemic and endangered plant species include *Tamarix kutchensis*, *Ziziphus williamsii* and *Cyperus dwarkensis*. These habitats support a number of threatened mammals and a rich diversity of birds, including many migrants. Salt and brackish lakes include Shah Bunder, Jafri Lake, Hadero, Nurri Jubo (a Ramsar site), and Mahboob Shah Lake. They are all important wintering grounds for waterbirds, particularly flamingos, ducks and shorebirds, and up to 19,000 waterfowl have been counted in these areas.

General threats: Despite the fact that areas in the Rann of Kutch remain largely intact, it is considered vulnerable to development pressures. In addition, large portions of the Indus delta have been destroyed as a result of fuelwood collection – the only source of firewood for local people – and fodder collection, on top of other activities related to grazing. Construction projects, water diversions, and logging all pose further threats.

Tibetan Plateau Steppe
The Tibetan Plateau is situated at the juncture of two zoogeographic realms, the Palearctic and Oriental. Due to its size and its position near the tropics, the Tibetan Plateau is one of the most ecologically diverse alpine communities on Earth. Habitats range from gravelly, wind-blown periglacial environments, to moist alpine pastures and scrub.

General threats: Despite low population density, hunting threatens many species of mammals and large birds.

The Indus River Delta

The waters of the Indus are home to one of the few species of freshwater dolphin, the Indus River dolphin (*Platanista minor*) and numerous species of distinctive fish, many of which live in or migrate through the waters of the delta. Important food species, like large freshwater shrimps (*Macrobrachium* spp), are part of the delta's abundant aquatic life.

The Indus delta extends over 600,000ha and is characterized by 17 major creeks and innumerable minor creeks and extensive mudflats. Classified as the sixth-largest delta in the world, an estimated 160,000ha are occupied by mangrove vegetation. These mangroves are unique in the sense that they are the world's largest arid mangrove forests. Where once eight species were recorded, only four still exist, *Avicennia marina, Aegiceras corniculatum, Ceriops tagal* and *Rhizophora mucronata*. The forests are used for fuelwood, fodder for cattle and browsing areas for more than 20,000 camels.

Around 100,000 people, mainly fishing communities, live along the delta and use the creeks and estuaries as fishing grounds. The creeks support a variety of marine life, such as *Hilsa ilisha*, known locally as *Palla*, which swims up from the Arabian Sea to spawn in fresh water. Many species of marine dolphin, including Indo-Pacific humpback dolphin and bottle-nose dolphin, occur in the creeks.

General threats: Dams on the Indus River reduce flows in lower stretches of the system and limit the transport of fertile sediments downstream into the delta. They also pose a serious threat to the survival of the Indus River dolphin, as the remaining dolphins become isolated in smaller groups. Water extraction for irrigation, chemical runoff into the rivers, and introduced species also threaten the delta's freshwater species.

2.2 Pakistan

Pakistan, covering 796,100km^2, is located in southern Asia and is divided into the four provinces of Punjab, Sindh, North West Frontier, and Balochistan.

The country can be divided into five physiographic regions:

- The Himalayan mountain ranges in the north-western part on the border with India and China; the highest peak is Choghori (or K2) at 8,611m
- The Hindu Kush and the Western Mountains in the north on the border with Afghanistan; the Tirichmir, at 7,690m, is the highest peak in the Hindu Kush range
- The Potwar Plateau, south of Islamabad, where elevation varies from 300 to 600m; south of the Potwar Plateau lies the Salt Range
- The Indus Plain, stretching from the Salt Range to the Arabian Sea, consisting largely of alluvium to a depth of 300m or more, deposited by the Indus River and its tributaries, and
- The Balochistan Plateau in the south-west of the country, which rises to about 600m; dry hills run across the plateau, north-east to north-west and a large part of the north-western area is desert.

In 1990, the total cultivable area was estimated at 29.9 million ha – 37 per cent of the total area – mainly concentrated in the Indus plain. Of this, the total area actually under cultivation was estimated at 16.6 million ha, or 55% of the cultivable area, of which 16.1 million ha consisted of annual crops.

2.2.1 Climate and water resources

Most of Pakistan's climate is semi-arid. June is the hottest month in the plains and July in the mountainous areas, with temperatures over 38ºC, while the mean monthly minimum is only 4ºC in December/January. Average annual precipitation is estimated at 494mm, but is uneven over much of the Indus Basin. It reaches up to 1,500mm in the north. Most of the rainfall in Pakistan originates from summer monsoons.

Pakistan can be divided into three hydrological units:

- The Indus Basin, covering more than 566,000km^2 (71% of the country's territory), comprising the whole of the provinces of Punjab, Sindh and North West Frontier and the eastern part of Balochistan. The Indus River has two main tributaries, the Kabul on the right bank and the Panjnad on the left bank. The Panjnad is formed by the flow of five separate rivers: the Jhelum and Chenab, known as the western rivers, and the Ravi, Beas, and Sutlej, known as the eastern rivers.
- The Kharan Desert, lying in the west of Balochistan (in the west of the country), a closed basin covering 15 per cent of the territory. The Mashkel and Maijen Rivers are the principal sources of water in the basin. The water is discharged in the Hamun-i-Mashkel Lake, in the south-west on the border with Iran.
- The arid Makran coast along the Arabian Sea covering 14 per cent of the territory in its south-western part (Balochistan province). The Hub, Porali, Hingol, and Dasht are the principal rivers of this coastal zone.

Dams and hydropower

In 1986, there were 40 dams with a height of over 15m in Pakistan. By 1992, 12 additional dams were under construction. The two major dams are Tarbela (with 13.7km^3 of maximum reservoir capacity and 12.0km^3 of active reservoir capacity) and Mangla (7.2km^3 and 5.9 km^3 respectively); both are equipped for electricity generation. In 2000, hydropower represented 49.9 per cent of total installed capacity, and 28 per cent of total energy generation. Tarbela dam alone represents 36.7 per cent of the total. The gross theoretical hydropower potential was estimated in 1991 at 150,000GWh/year.

Water withdrawal

Total water withdrawal in 1995 was estimated at 178km^3, of which 97 per cent was for agricultural purposes. Groundwater abstraction for agriculture has been estimated roughly at 55km^3/year, which is approximately the volume of renewable groundwater resources. However, in some areas development appears to have reached the point where groundwater is being mined. Most urban and rural water is supplied from groundwater. Over 50 per cent of village water supply is obtained through hand-pumps installed by private households. In areas where groundwater is saline, irrigation canals are the main source of domestic water.

Table 2.1 Water demand forecast for Pakistan

IWMI characteristics	Units	1995	2025	Annual growth (%)
Population	million	122	215.5	1.9
Total cereal consumption	m mt	21.8	41.5	2.2
Cereal production	m mt	22.7	36.2	1.6
Irrigated cereal area	m ha	10.3	12.17	0.6
Rainfed cereal area	m ha	0.00	0.00	0.0
Total cereal area	m ha	10.3	12.17	0.6
Net irrigated area	m ha	16.0	16.0	0.0
Gross irrigated area	m ha	17.6	20.8	0.6
Primary irrigation supply	km^3	172.1	188.1	9
Total water withdrawals	km^3	177.7	203.3	0.5
Total primary water supply	km^3	177.7	203.3	Total growth
Total PWS as % of PUWR	%	89.3	102.2	14
Scarcity level	Physical			

Source: Molden 2000

From Table 2.1 it can be seen that Pakistan was already using 89 per cent of its potential utilizable water resources (PUWR) in 1995 and will require more than 100 per cent by 2025. This is impossible and Pakistan will face serious problems in providing sufficient food for its population. It is expected that Pakistan will have to import more than 10 per cent of cereal consumption by 2025 (Molden 2000).

2.2.2 Irrigation and drainage development

The area of managed water in Pakistan was estimated at 16,960,000ha in 1990, and can be divided according to the following classification:

- *Regular irrigation schemes,* covering 14,327,000ha comprising the Indus Basin Irrigation System (IBIS), which is by far the largest irrigation system in Pakistan, covering areas in all provinces. In 1993, irrigated areas in the IBIS were estimated at 13,972,500ha. In North West Frontier province, about 7,800ha are irrigated through pump lifts maintained by the Provincial Irrigation Department (PID). In northern parts of North West Frontier province, irrigation is done by means of contour channels drawing water from local water sources, often steep-sided streams or springs. Most of these schemes, which cover about 26,700ha, are owned and operated by the beneficiaries through traditional social organizations. In Balochistan, about 50,000ha are irrigated from about 540 *karez* (tunnels or underground channels tapping an aquifer) and perennial springs. They are generally small group-operated schemes ranging in size between 50 and 400ha. And also in Balochistan, about 130,000ha of small group-operated schemes are irrigated from infiltration galleries or small weirs in rivers.

- *Spate irrigation,* covering 1,402,448ha. These areas are known as *Rod Kohi* in North West Frontier and Punjab, or *Bandat* in Balochistan, and are often called flood irrigation. This kind of irrigation relies on the flood runoff from hillside torrents. Wherever possible the runoff is harnessed for irrigation by weirs or temporary diversion structures. Farmers divert the spate flow onto their fields by constructing earthen bunds (called *gandas)* across the rivers, or by constructing stone/gravel spurs out into the centre of the river. Captured water flows from field to field, and when the soil profile is saturated, the lower bund is breached to release water into another field. The annual average cropping intensity is 20 per cent.

- *Flood-recession cropping areas,* covering 1,230,552ha. In Pakistan these areas are known as *Sailaba* and are often called 'falling flood' irrigation areas. *Sailaba* cultivation is carried out on extensive tracts of land along rivers and hill streams, subject to annual

inundation. The method utilizes the moisture retained in the root zone after the flood subsides, together with sub-irrigation due to the capillary rise of groundwater and any rain.

Apart from these water managed areas, some attempts have been made to develop water harvesting, known in Pakistan as *Khuskhaba*.

According to the usual Pakistani classification, irrigation consists of:

- Government canals: amounting to 11,310,000ha in 1990, of which 74 per cent are in the Punjab and 20 per cent are in Sindh province
- Private canals: 430,00ha, of which 86 per cent are in North West Frontier province;
- Tube-wells: 4,260,000ha, of which 92 per cent are in Punjab province
- Open wells: 280,000ha, of which 82 per cent are in Punjab province
- Tanks: 60,000ha, all of them in the Punjab, and
- Other means: 620,000ha, of which 73 per cent are in Sindh province.

The total managed water area of 16.96 million ha is higher than the total cultivated area (16.56 million ha), due to the fact that not all the managed water areas are actually cultivated. This is especially the case for spate irrigation and flood-recession cropping areas. The main irrigated crops are wheat, rice, cotton, and sugarcane. Due to inadequate availability of water in winter (when storage capacity is too small) and at the beginning and end of summer, cropping intensity is exceptionally low.

The Indus Basin Irrigation System (IBIS)

Development of irrigation in the Indus Basin has progressed in the form of discrete barrage-controlled systems. With water rather than land the main constraint, the irrigation systems were generally designed to use the available river supplies to bring the largest possible area under cultivation, with minimum water provided to bring the crops to maturity.

IBIS is characterized by its supply-based structure, designed to distribute water with minimum human interference. There are few structures to regulate canal flow. No escapes are provided at the tail-end of the system and surplus flows have to be absorbed within the systems. Drain construction has not kept pace with requirements, while infrastructure development has often obstructed natural drainage flows.

Covering almost 14 million ha, IBIS is the largest contiguous irrigation system in the world. It consists of an extensive network of barrages, canals and watercourses. There are some 61,000km of canals and a further 1.6 million kilometres of communal watercourses, farm channels, and field ditches. In the Indus system, river water is diverted by barrages and weirs into main canals and subsequently branch canals, distributaries and minor arms. The flow to the farm is delivered by the watercourses (of which there are over 107,000) that are supplied through outlets *(moghas)* from the distributaries and minors. The *moghas* are designed to allow a discharge that self-adjusts to variations in the parent canal. Within the watercourse control areas (which range from 80 to 280ha), farmers receive water proportional to their land holding. The entire discharge of the watercourse is given to one farm for a specified period or a seven-day rotation. The rotation schedule – termed *warabandi* – is established by the Provincial Irrigation Department, unless the farmers reach a mutual agreement.

Table 2.2 Irrigation and drainage data for Pakistan

Irrigation potential	1990	16,960,000ha
Irrigation		
1 Area equipped for irrigation	1990	14,327,000ha
- surface irrigation		
- sprinkler irrigation		
- micro-irrigation		
% of area irrigated from groundwater	1990	37%
% of area irrigated from surface water	1990	63%
% of equipped area actually irrigated		
2 Spate irrigation	1990	1,402,448ha
3 Equipped wetland and inland valley bottoms		
Total irrigated area (1+2+3)		
4 Flood recession cropping areas	1990	1,230,552ha
Total Water Managed Area (1+2+3+4)	1990	16,960,000ha
- as % of cultivated area		102%
- increase over the last 10 years		14%
- power irrigated area as % of water managed area		
Full or partial control schemes		
Large schemes		
Medium schemes		
Small schemes		
Total number of households in irrigation		
Irrigated crops		
Total irrigated grain production	2000	24,581,000T
As % of total grain production		100%
Harvested crops under irrigation		
- wheat	2000	7,544,000ha
- cotton	2000	2,955,000ha
- rice	2000	2,419,000ha
- sugarcane	2000	1.059,000ha
- other cereals	2000	865,000ha
- fodder	2000	916,000ha
- pulses	2000	893,000ha
- fruits/citrus	2000	572,000ha
- vegetables	2000	273,000ha
- rapeseed	2000	262,000ha
Drainage environment		
Drained area	1992	5,100,165ha
As % of cultivated area		31%
Drained Areas in full or partial control irrigated areas	1992	5,100,165ha
Area salinized by irrigation		

Source: FAO 1997a, FAOSTAT

The data presented in this table are taken from the FAO AQUASTAT database as they are more extensive than the data provided by the Pakistani Ministry of Food, Agriculture and Livestock (as used in Table 2.3 for agricultural production). This also permits a better comparison between the different river basins covered by this study.

Operation and maintenance

The public sector operates the irrigation systems above the *moghas*. Each season, the federal government's Water and Power Development Authority (WAPDA) estimates water availability for the following season. Provincial Irrigation Departments (PID) inform WAPDA of provincial water demands at specific locations. WAPDA releases water from the reservoirs to meet demands as closely as possible. The country's water resources are distributed and regulated under a Water Apportionment Accord by the Indus River System Authority (IRSA). The limited reservoir capacity does not allow the full regulation of rivers for irrigation.

Irrigation water withdrawal and water losses

Over the past 20 years, groundwater use has been a major factor in increasing agricultural production. Groundwater tube-wells not only supply additional water, but have provided flexibility in meeting crop water requirements where surface-water supplies are unable to meet full demand. However, because of uncontrolled and rapid private sector development of groundwater (6% annual growth), there is a danger of excessive lowering of water tables and intrusion of saline water into freshwater aquifers in certain areas. With IBIS, total water availability at the farm gate has increased significantly in the last 15 years; its composition has changed slightly with a higher use of groundwater extracted by tube-wells. The Water Resources Section of the Planning and Development Division has estimated average water losses from canal head to outlet at 25 per cent, and from outlet to farm gate at 15 per cent.

Waterlogging, drainage, salinity, and flood protection

Increasing diversion of river flows has significantly changed the hydrological balance of the irrigated areas over the past century. Initially, irrigation systems were developed without any provision for drainage. Seepage from irrigation canals and watercourses, and the deep percolation of this water, have gradually raised the groundwater table, causing waterlogging and salinity.

In June 1989, it was estimated that about 2.39 million ha had water tables within 1.5m of the land surface (which resulted in flooding of 4.92 million ha in October 1989, shortly after the monsoon). Such areas are being considered as disaster areas by government and given high priority for drainage. Since the 1960s, strenuous efforts have been made to provide drainage in irrigated areas. In 1992, the total drained area was estimated at 5.10 million ha.

According to the Soil Survey of Pakistan (1985–1990), 1.78 million ha are considered as severely saline and 0.18 million ha as very severely saline – but the survey does not indicate which part is due to irrigation. Since 1959, about 50 Salinity Control and Reclamation Projects (SCARPs) have been initiated to provide a lasting solution to the problem of waterlogging and salinity through sub-surface drainage.

There are about 5,200km of flood control works, the maintenance of which falls under the responsibility of the PID.

Trends in water resources management

Irrigation is central to Pakistan’s economy. In the irrigation sub-sector, measures are expected to be taken to increase water availability, water reliability, equity of water distribution, and irrigation efficiency, in order to reduce waterlogging and salinity, to limit over-exploitation of fresh groundwater resources, and to improve cost recovery.

River flows are almost fully utilized, except during the monsoon flood period. The utility of flood water is very marginal unless additional storage is provided in the system to broaden the supply period. Additional storage would also be necessary for providing the flexibility needed by the shift from a supply-based operation system towards a demand-based one. Several sites have already been identified, and plans drawn up for one of them (Kalabagh dam).

For most of the multi-purpose reservoirs priority is given to irrigation. The recent increase in thermal generation capacity has reduced potential conflicts between water releases from reservoirs for hydropower generation and irrigation. Most of the annual storage is required for irrigation, not for hydropower, but conflicts do still occur at times.

Waterlogging and salinity have been identified by the authorities as one of the main issues to be addressed in the near future. The elimination of waterlogging in disaster areas was one of the main targets for the 8th Five-Year Plan (1993–1998). Under the Salinity Control and

Reclamation Projects, attempts were made to meet the sub-surface drainage needs through deep tube-wells.

Groundwater extraction by tube-well may cause serious environmental problems. In certain areas, increasing exploitation by tube-wells has caused water tables to fall at a rate of about 0.3m per year.

2.2.3 Agriculture

Over the last decade, agriculture grew at an average annual rate of 4.5 per cent, with some sizeable year-on-year fluctuations. For example, severe drought in 2000/2001 caused a widespread shortage of irrigation water, resulting in negative growth of 2.5 per cent, as against an impressive 6.1 per cent growth in 1999/2000.

Wheat is the staple crop, providing about half of the daily calorie intake, with rice providing only 8 per cent. Unlike in other South and South-East Asian countries, rice is not considered a subsistence crop in Pakistan, but a cash crop grown for export. Rice is the third major crop, after wheat and cotton, contributing 13 per cent of GDP; wheat and cotton each contribute around 30 per cent.

Wheat is commonly grown in the north-western parts of the Indo-Gangetic Plains, in rotation with rice or other crops such as cotton, using traditional methods of flat sowing and flood irrigation. The unplanned irrigation methods lead to leaching of native and applied nutrients, aeration problems, and restriction of plant root and shoot growth due to the development of hard soil. Clearly, these factors are threatening the sustainability of the rice-wheat cropping systems in the region. The high water requirements of rice have greatly aggravated the declining groundwater tables and freshwater aquifers, and it is estimated that the water table is falling at a rate of 20cm every year, while tube-wells are sunk ever deeper.

Rice occupies about 25 per cent of the cultivated area in the summer monsoon season and 10 per cent of the total cropped area. Wheat, being the staple food, occupies 75 per cent of the cultivated area in the winter season and about 38 per cent of the total cropped area.

Table 2.3 Agricultural production in Pakistan, 1995/96 to 2000/01

Crops	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
Total area sown (000ha)	22,590	22,730	23,040	22,860	22,760	22,760
% of cropped area to:						
- Food grains	55	53	55	55	56	55
- Cash crops	18	18	17	18	18	18
- Others	27	29	28	27	26	27
Total cereals*						
- Area (000 ha)	12,473	12,112	12,617	12,598	12,734	12,184
- Production (000t)	22,968	22,960	25,161	24,774	28,380	24,581
Wheat						
- Area (000ha)	8,376	8,109	8,355	8,230	8,463	8,430
- Production (000t)	16,907	16,630	18,694	17,857	21,079	18,735
Rice						
- Area (000ha)	2,162	2,251	2,317	2,424	2,515	2,060
- Production (000t)	3,966	4,305	4,333	4,673	5,155	3,900
Cotton						
- Area (000ha)	2,997	3,149	2,959	2,923	2,983	2,560
- Production (000 bales)	10,595	9,374	9,184	8,790	10,600	9,700
Sugarcane						
- Area (000ha)	963	964	1,056	1,155	1,010	860
- Production (000t)	45,229	41,998	53,104	55,191	44,000	35,000
Fruit						
- Area (000ha)	622	629	640	646	657	596
- Production (000t)	6,091	6,187	6,295	6,345	5,846	5,564
Fodder crops						
- Area (000ha)	2,715	2,651	2,680	2,646	2,556	1,917
- Production (000t)	60,383	60,518	61,300	60,500	58,414	43,810
Livestock production						
- Meat (beef, mutton, poultry)	588	602	617	633	649	510
- Milk (000 litres)	28,577	29,930	30,126	30,948	31,804	24,976
- Eggs (millions)	5,927	5,757	6,015	8,261	8,464	6,660

Source: Ministry of Food, Agriculture and Livestock, Agricultural Statistics of Pakistan, 1999/2000
* Includes minor cereals such as sorghum, millet, maize and barley

Figure 2.2 Pakistan crop calendar

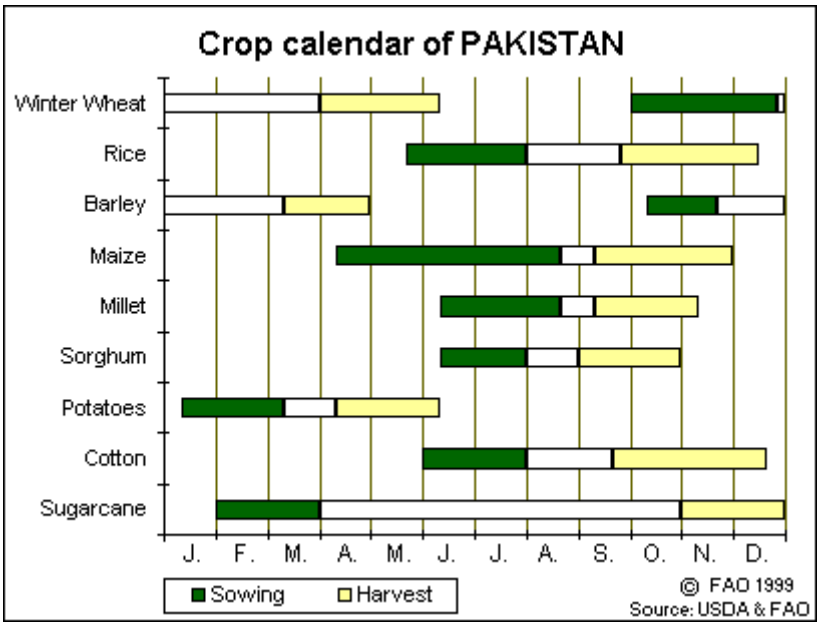
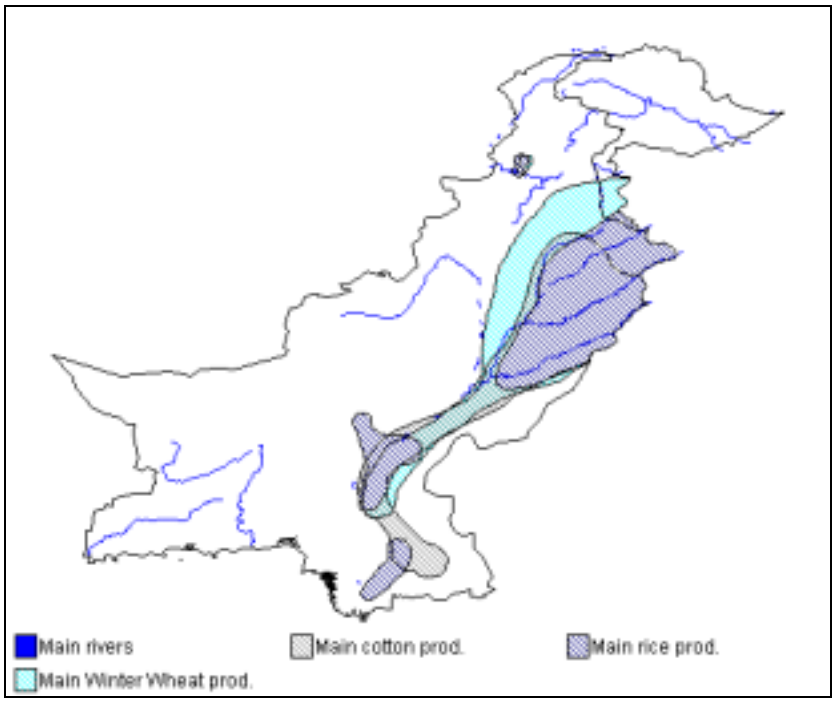
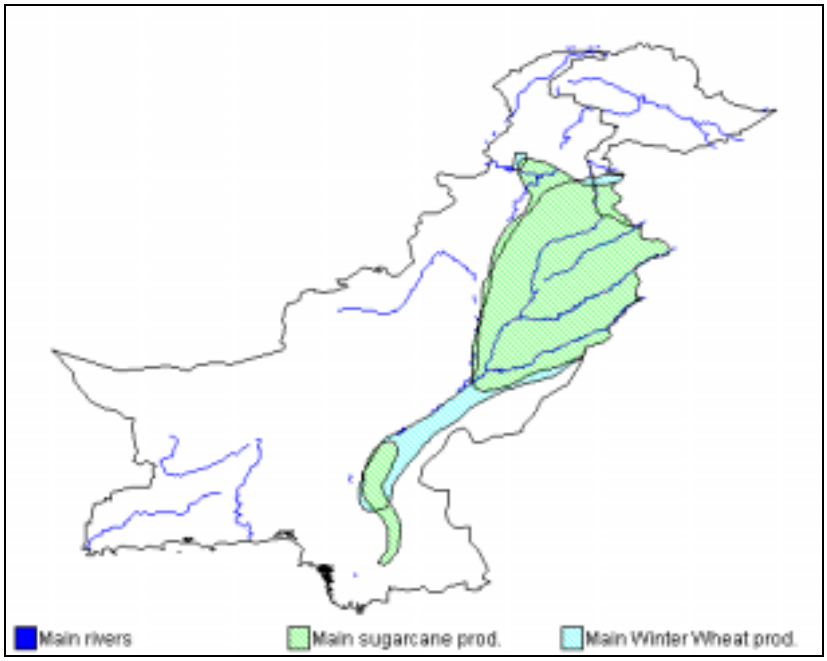


Figure 2.3 Wheat, cotton and rice cultivation areas in Pakistan



Source: FAO GIEWS

Figure 2.4 Wheat and sugarcane cultivation areas in Pakistan



Source: FAO GIEWS

The locations for which crop water requirements have been calculated were selected along a north-south line. It is noteworthy that annual crops in the south (Hyderabad) require almost double the volume of water than crops in the north (Lahore). As land preparation is the main water-consuming component in rice cultivation, the difference is not as extreme with this crop.

Table 2.4 Water requirements for major irrigated crops in Pakistan

Crop	**Location**	**(Trans)planting date**	**Total cultivation requirements** (mm)	**Irrigation requirements** (mm/ha)
Wheat	Nawabshah	15/11	417	417
	Jacobabad	15/11	402	402
	Lyallpur	15/11	245	193
	Lahore	15/11	255	191
Cotton	Hyderabad	1/7	1028	975
	Jacobabad	1/7	922	870
	Multan	1/7	778	513
	Lahore	1/7	597	363
Rice	Hyderabad	15/6	1497	1372
	Jacobabad	15/6	1439	1376
	Multan	15/6	1325	1221
	Lahore	15/6	1030	718
Sugarcane	Nawabshah	1/2	2768	2675
	Multan	1/2	2249	2156
	Lahore	1/2	1787	1408

Source: FAO CROPWAT

Table 2.5 Irrigated crop area in Pakistan

	Irrigated area (1,000ha)	**Crop area as % of the total area equipped for irrigation, by month**											
		J	F	M	A	M	J	J	A	S	O	N	D
Wheat	7,554	48	48	48	48	48						48	48
Rice	2,419						15	15	15	15	15		
Maize	720						5	5	5	5	5		
Barley	100						1	1	1	1	1		
Millet	105						1	1	1	1	1		
Sorghum	240						2	2	2	2	2		
Potatoes	90						1	1	1	1	1		
Sugarcane	1,059	7	7	7	7	7	7	7	7	7	7	7	7
Pulses	893						6	6	6	6	6		
Vegetables	273						2	2	2	2	2		
Citrus	197	1	1	1	1	1	1	1	1	1	1	1	1
Fruits	374	2	2	2	2	2	2	2	2	2	2	2	2
Rapeseed	262	2	2	2								2	2
Cotton	2,955						19	19	19	19	19	19	19
Fodder	916	6	6	6								6	6
All irrigated crops	18,157	66	66	66	58	58	60	60	60	60	60	85	85
Equipped for irrigation	15,729												
Cropping intensity	115												

Source: FAO AQUASTAT

Table 2.6 Agricultural water withdrawal in Pakistan

Total Renewable Water Resources (TRWR)	418km^3
Irrigation water requirements	71.18km^3
Water use efficiency percentages	44%
Water withdrawal for agriculture	161.84km^3
Water withdrawal as % of TRWR	39%

Source: FAO AQUASTAT

The calculations in Table 2.7 are based on the assumption that for each crop 33 per cent of the irrigated area is located in the south of Pakistan and 67 per cent in the north. This is based on Figures 2.3 and 2.4 (above) which give the irrigated areas for the four major irrigated crops (wheat, rice, sugarcane, and cotton).

Table 2.7 Water requirement per crop

Crop	**Location**	**Season**	**Area** (ha)	**CWR** (mm/ha)	**Eff.** (%)	**Crop per region** (million m^3)	**Crop total** (million m^3)
Wheat	North	dry	5,061,180	250	44	28,756.7	
	South	dry	2,492,820	400	44	22,662.0	51,418.7
Rice	North	wet	1,620,730	1,200	44	44,201.7	
	South	wet	798,270	1,450	44	26,306.6	70,508.4
Maize	North	wet	482,400	320	44	3,508.4	
	South	wet	237,600	886	44	4,784.4	8,292.8
Barley	North	dry	67,000	148	44	225.4	
	South	dry	33,000	316	44	237.0	462.4
Millet	North	wet	70,350	252	44	402.9	
	South	wet	34,650	783	44	616.6	1,019.5
Sorghum	North	wet	160,800	236	44	862.5	
	South	wet	79,200	759	44	1,366.2	2,228.7
Potatoes	North	wet	60,300	376	44	515.3	
	South	wet	29,700	970	44	654.8	1,170.0
Sugarcane	North	wet /dry	709,530	1,800	44	29,026.2	
	South	wet /dry	349,470	2,500	44	19,856.3	48,882.5
Pulses	North	wet	598,310	285	44	3,875.4	
	South	wet	294,690	804	44	5,384.8	9,260.2
Vegetables	North	wet	182,910	304	44	1,263.7	
	South	wet	90,090	785	44	1,607.3	2,871.0
Citrus	North	wet /dry	131,990	729	44	2,186.8	
	South	wet /dry	65,010	1,625	44	2,400.9	4,587.8
Fruits	North	wet /dry	250,580	507	44	2,887.4	
	South	wet /dry	123,420	1,204	44	3,377.2	6,264.6
Rapeseed	North	dry	175,540	144	44	574.5	
	South	dry	86,460	298	44	585.6	1,160.1
Cotton	North	wet	1,979,850	675	44	30,372.7	
	South	wet	975,150	950	44	21,054.4	51,427.1
Fodder (alfalfa)	North	dry	613,720	650	44	9,066.3	
	South	dry	302,280	1,112	44	769.4	16,705.8
						Total	**276,259.4**

From Table 2.7 it follows that rice is the main water-consuming crop (70,508.4 million m^3), followed by cotton (51,427 million m^3), wheat (51,418 million m^3) and sugarcane (48,882 million m^3).

3 CONCLUSIONS FOR THE INDUS RIVER BASIN

3.1 Irrigated agriculture

The Indus River Basin, which is included in WWF's Living Waters Programme, is Pakistan's lifeline. Data were collected (from FAO AQUASTAT) on the major irrigated crops, their water requirements in the wet and dry seasons, and the area under cultivation in each of these seasons. As there is a wide difference in climatic conditions between the north and south of the country, calculations on crop water requirements (CWR) have been carried out for both areas.

Area totals for irrigated crops were assembled from individual country data (FAO AQUASTAT) to detect whether the cropping pattern in Pakistan matched that of neighbouring countries with similar climatic conditions. Countries included in this analysis were Afghanistan, Pakistan, and northern and western India. Wheat occupied the largest area (42.1%), followed by rice (18.7%), cotton (10.6%), and sugarcane (5.8%) (see Table 3.3). For Pakistan the sequence was as follows: wheat (41.6%), cotton (16.3%), rice (13.3%), sugarcane (5.8%), and fodder (5%). The cropping pattern for Pakistan can thus be said to follow the regular pattern for the area.

Table 3.1 Water consumption for four major crops in the Indus River Basin

	Wheat		**Cotton**		**Rice**		**Sugarcane**	
	000ha	million m^3	000ha	million m^3	000ha	million m^3	000ha	million m^3
Pakistan	7,554	51,418	2,955	51,427	2,419	70,508	1,059	48,882

3.2 Future water demand

IWMI Working Paper No.32 *Water for Rural Development* was used collect information on the future water situation. The general conclusion for the South Asia region is that there will be physical water scarcity – i.e. primary water supply (PWS) more than 60 per cent of the potential utilizable water resources (PUWR). From Table 3.2 it follows that by 2025 Pakistan will require 102 per cent of its PUWR to feed the population.

Table 3.2 Water demand forecast for Pakistan

	Irrigated cereal area (million ha)	**PWS** (km^3)	**Rain-fed cereal area** (million ha)	**PUWR** (km^3)
1995	10.30	177.67	0.00	199
2025	12.17	203.35	0.00	
Increase (%)	18	14	0	

Source: Molden 2000

Table 3.3 Irrigated crop areas in north and west India, Pakistan and Afghanistan

	Wheat	Rice	Maize	Barley	Potatoes	Pulses	Vegetables	Fruits	Oil crops	Sesame	Cotton	Fodder	Millet	Sorghum	Soybean	Sugarcane	Groundnut
Afghanistan	1,426	167	179	93	14	25	55	87	34	27	60	115					
Pakistan	7,554	2,419	720	100	90	893	273	571	262		2,955	916	105	240		1,059	
India West	9,994	1,970	523	158	138	1,839	369	417	302		1,671		459	387	268	777	224
India North	6,526	6,786	413	125	147	1,309	394	444	154		1,749		363	305	286	1,650	
Total	**25,500**	**11,342**	**1,835**	**476**	**389**	**4,066**	**1,091**	**1,519**	**752**	**27**	**6,435**	**1,031**	**927**	**932**	**554**	**3,486**	**224**
%	**42.1**	**18.7**	**3.0**	**0.8**	**0.6**	**6.7**	**1.8**	**2.5**	**1.2**	**0.0**	**10.6**	**1.7**	**1.5**	**1.5**	**0.9**	**5.8**	**0.4**