The table shows that 77(46%) were categorized as usable, 41(24%) marginal and 51(30%) hazardous waters.

The water quality of each tubewell was depicted on the map. After contouring, the area was calculated into usable, marginal and hazardous which is given below in Table-12.

Table-12: **Area alongwith percentage falling under different categories based on EC, SAR and RSC in un-commanded Area of Thal Doab.**

(Million Acres)

Name of Doab	G.A.	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		Area	%age	Area	%age	Area	%age
Thal Doab	3.703	1.687	46	0.898	24	1.118	30

It is evident that 46% area was underlain by usable, 24% marginal and 30% hazardous waters.

3.8 Geo-Chemical Classification

Under this classification, seven types of geo-chemicals were established in the groundwater underlain in the area which is presented below in Table-13.

Table-13: **Number of tubewells alongwith percentage falling under different Geo-Chemical types of un-commanded Area of Thal Doab.**

No. of T/Wells Sampled	Geo-Chemical Types													
	$NaHCO_3$		NaCl		Na_2SO_4		$Ca(HCO_3)_2$		$CaSO_4$		$Mg(HCO_3)_2$		$MgSo_4$	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
169	37	22	28	16	93	55	7	4	1	1	2	1	1	1

The table indicates that majority of tubewells 93(55%) produced Sodium sulphate, 37(22%) Sodium bicarbonate, 28(16%) Sodium chloride, 7(4%) Calcium carbonate and Calcium sulphate, Magnesium bicarbonate and Magnesium sulphate 1% each geo-chemical type.

3.9 Groundwater Quality in D.G. Khan Area

Groundwater quality in D.G. Khan Area based on EC, SAR and RSC was categorized as usable, marginal and hazardous waters and is reported in Table-14.

Table-14: **Number of samples falling under different water quality categories based on EC, SAR and RSC.**

Source of Water Samples	Total Number Sampled	Shallow Ground Water Quality based on EC, SAR and RSC					
		Usable		Marginal		Hazardous	
		No.	%	No.	%	No.	%
Handpump	19	1	5	5	26	13	69
Tubewell	13	4	31	5	38	4	31
Total	32	5	16	10	31	17	53

The above table reveals that hazardous water was dominant followed by marginal and usable in case of handpumps. In case of tubewells same trend i.e. hazardous water followed by marginal and usable, was followed.

The water quality of each tubewell/ handpump was depicted and after contouring, the area was calculated into usable, marginal and hazardous which is given in Table-15.

Table-15: **Area alongwith percentage falling under different categories based on EC, SAR and RSC in un-commanded Area of D.G. Khan.**

(Million Acres)

Name of Un-commanded Area	Source of Water Samples	G.A.	Shallow Ground Water Quality based on EC, SAR and RSC					
			Usable		Marginal		Hazardous	
			Area	%	Area	%	Area	%
D.G. Khan	Handpump	0.112	0.006	5	0.029	26	0.077	69
	Tubewells	0.076	0.023	30	0.030	40	0.023	30
	Total	0.188	0.029	16	0.059	31	0.100	53

The table shows that out of the total area, 16%, 31% and 53% was underlain by usable, marginal and hazardous waters respectively.

3.10 Geo-Chemical Classification

Under this classification, 5 types of Geo-chemical were established and reported in Table-16.

Table-16: **Number of handpumps and tubewells alongwith percentage falling under different Geo-Chemical types.**

Source of Water Samples	No. of Samples	Geo-Chemical Types									
		$NaHCO_3$		Na_2SO_4		$CaSO_4$		$Mg(HCO_3)_2$		$MgSO_4$	
		No.	%	No.	%	No.	%	No.	%	No.	%
Handpump	19	-	-	17	89	2	11	-	-	-	-
Tubewell	13	1	7	8	62	2	15	1	8	1	8
Total	32	1	3	25	78	4	13	1	3	1	3

The data reveals that in case of handpumps, two types (Sodium sulphate and Calcium sulphate) and in case of tubewells five types (Sodium sulphate, Calcium sulphate, Magnesium bicarbonate, Sodium bicarbonate and Magnesium sulphate) waters were observed.

CONCLUSIONS

Based on the study conducted by SMO, WAPDA, Lahore following conclusions have been drawn:

BARI DOAB

1. Water Quality based on salinity as well as sodicity as EC, SAR and RSC collectively indicates that usable quality was 44% whereas marginal and hazardous quality are 27% and 29% respectively.

2. Major geo-chemical types of groundwater underlain in the un-commanded area of Bari Doab are Sodium bicarbonate by 81% and Calcium bicarbonate by 19%.

RECHNA DOAB

1. Water Quality based on salinity and sodicity as EC, SAR and RSC reveals that usable quality was dominant by 61%, whereas marginal and hazardous quality was 32% and 7% respectively.

2. Major geo-chemical types of groundwater underlain in the un-commanded area of Rechna Doab were Sodium bicarbonate by 65% and Magnesium bicarbonate by 32% and Calcium bicarbonate by 3%.

CHAJ DOAB

1. Water quality based on salinity and sodicity as EC, SAR and RSC shows that usable quality was 42(59%), marginal 23(32%) and hazardous 6(9%).

2. Major geo-chemical types of water underlain by the un-commanded area were Sodium bicarbonate and Calcium bicarbonate.

THAL DOAB

1. Water quality based on salinity and sodicity as EC, SAR and RSC indicates that usable quality was dominant by 46% whereas marginal and hazardous quality was 24% and 30% respectively.

2. The groundwater of Thal Doab is mainly affected by salinity and to some extent sodicity also.

D.G. KHAN

1. Water quality based on salinity and sodicity as EC, SAR and RSC shows that usable quality was 16%, marginal 31% and hazardous 53%.

2. Major geo-chemical types of groundwater underlain by the un-commanded area of D.G. Khan was Sodium sulphate by 78%.

3. Like Thal Doab, the groundwater underlain by D.G. Khan Area is associated with high value of salinity.

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MANAGING WATER SCARCITY AND QUALITY DETERIORATION IN PAKISTAN: CHALLENGES AND OPTIONS

By

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ABSTRACT

Integrated water resources management is based on the concept of water being an integral part of an eco-system, a natural resource and a social economic good, whose quantity and quality determine the nature of its use (Agenda 21, United Nations, 1992). A water resource that is reliable, in terms both of its quantity and its quality, is a pre-requisite for the survival of human civilization and socio-economic development. Water scarcity, gradual deterioration, aggravated pollution and infra-structure development has increasingly created conflicts over the uses of this resource. If we consider the maintenance of adequate access to and supply of good quality water, we need to look at how this is to be achieved beyond the provision of safe drinking water and sanitation. Maintaining a safe water supply means that overall river basin management, agriculture practices and other works are important. Ultimate need is to make certain that river basins and ground waters are managed in their entirely. Steps need to be taken to make provision for environmental flows for healthy river systems as healthy functioning of river systems and groundwater are essential for people, plants and animals.

1. INTRODUCTION

Water is precious and eternal source of life on earth. It has direct bearing on almost all sectors of the economy. The increasing population pressure & industrialization has placed a great demand of water with an ever increasing number and intensity of local and regional conflicts over its availability and use. Availability of water in Pakistan has alarmingly declined from 5000 cubic meters per capita in 1950 to nearly 1,000 cubic meters in 2010, because of increase in population, inefficient irrigation, mismanagement and unequal water rights. Increasing deterioration and pollution, depleting biodiversity, desertification, over exploitation of natural resources, receding glacial phenomena, water scarcity and degrading economic system are posing a huge challenge to sustainable farming and economic development.

Nearly 75 percent of population or some 125 million people have no access to clean drinking water. The situation is worse in rural areas. Water crisis has several serious health, social and political implications. Water borne diseases such as cholera, gastro, diarrhea, hepatitis and typhoid cost the national exchequer 2 percent of GDP (Rs. 125 billion) annually because of poor access to safe drinking water and better sanitation. The situation is becoming precarious with the passage of time. Over 60% of the population gets their drinking water from hand or motor pumps, with the figure in rural areas being over 70 percent. Areas, where underground water is brackish, use of surface water for

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domestic purposes is a serious issue. Links between water quality & health risks are well established. According to UNCEF, 20-40 percent of hospital beds in Pakistan are occupied by patients suffering from water borne diseases.

In 1960s and 70s it was proclaimed that the "Green Revolution" would solve all the food problems. However, the new mode of cultivation, due to use of chemical fertilizers, herbicides, pesticides have destroyed bio-diversity, killed fish in the rivers, created salty soils and polluted rivers and source of drinking water. Over exploitation of groundwater and climate change phenomenon is another upcoming bound to complicate the situation further. Good quality water offers assurance against famine for food security and sustainability. Pakistan is a country with large arid & semi-arid regions where rainfall is sparse and insufficient for crop water requirements. Globally 40% of food production is produced from irrigated land. That is just 17% of cultivated land. But in Pakistan where annual rainfall is about 240 mm, 95% of food production comes from irrigated areas. Pakistan's canal irrigation system operates largely in a water-short environment. Although agricultural scientists have been doing remarkable job to cope with this situation, it is time to review the current situation, co-ordinate the individual efforts and develop a national workable strategy for sustainable water resource development & management.

TABLE-1
WHERE DOES PAKISTAN STAND IN
WATER AVAILABILITY vis-à-vis POPULATION

Year	Population (Millions)	Growth Rate	Total Water Availability		Per capita water availability (m^3)
			Billion cubic meter	MAF	
1951	34	0	178.8	144.9	5260
1961	43	2.38	178.8	144.9	4159
1971	63	3.89	178.8	144.9	2838
1981	84	2.72	178.8	144.9	2129
1991	111	2.83	178.8	144.9	1611
2001	143	2.60	178.7	144.9	1250
2010	172	2.10	178.6	144.7	1038
2020	204	1.70	178.9	145	877
2025	221	1.60	178.9	145	809
2030	238	1.50	178.7	144.8	751
2040	273	1.40	178.7	144.8	654
2050	311	1.30	178.8	144.9	575

Population Censuses Record					
Year	1951	1961	1972	1981	1998
Population	34	43	65	84	131

In future there are two kinds of challenges: One is the quantity of agricultural production and other is quality as well. The quality of agricultural product is a major concern for the WTO challenge. Thus it is very much required to develop crop production technology for sustainable production & increase the cropping intensity by bringing additional land under cultivation. Breeders should breed high yielding varieties. Similarly agricultural engineers will have to concentrate their efforts to modify and improve the existing irrigation techniques that are economical and well suited to our farming community and environment, especially to increase the overall water efficiency and salt balance issues upcoming through surface and groundwater application.

1.1 Present Situation

- Pakistan's current population of 168 million is expected to grow to about 221 million by the year 2025. This has a direct impact on the water sector for meeting the domestic water requirements of the people and for meeting the needs of agriculture to support increasing food requirements and produce an exportable surplus for earning foreign exchange. Over time per capita water availability and land use in Pakistan is shown in Fig. I and Fig. II respectively.

- Pakistan is now essentially at the limit of its water resources. There is some potential for additional storage but this is limited and, at present, the lack of consensus on storage between the provinces hampers its development. Additional water must be derived through conservation, especially in irrigation, where over 95% of water is used.

- While there has been continuous improvement in agricultural yields they remain significantly lower than their potential. Hence water for irrigation is not being utilized as effectively as it could with regard to crop production.

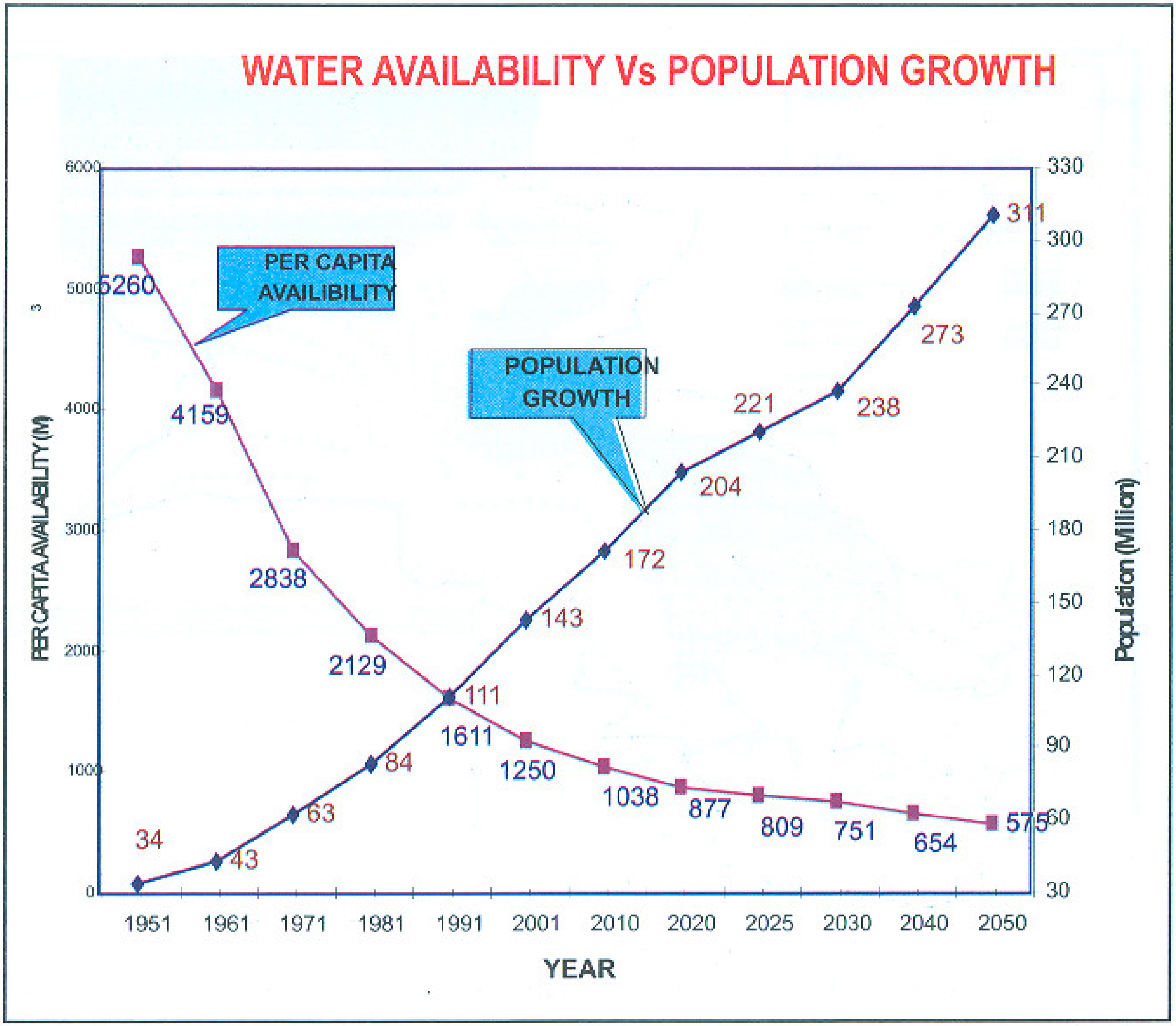
- Water quality in the rivers and other surface waters is low and deteriorating because of unchecked disposal of untreated municipal and industrial wastewater. Water quality monitoring and information management is lacking and yet is crucial to any water quality improvement programme.

- Information on water resources and, especially, water use is limited and not very accessible.

- Public awareness and understanding of water issues is lacking and needs to be addressed in order to garner public support for the changes in water management that will be needed in the immediate and longer term future.

- Access to clean domestic water in the urban and rural sub-sectors is low and significant investment will be required to improve service and keep up with the population growth.

- At a time when Pakistan is in dire need of investment in the water sector, there have been considerable delays in project implementation. There have


WATER AVAILABILITY Vs POPULATION GROWTH
PER CAPITA AVAILIBILITY
POPULATION GROWTH
PER CARTA AVAILABILITY (M3)
Population (Million)
YEAR
6000
5000
4000
3000
2000
1000
0
330
300
270
240
210
180
150
120
90
60
30
1951
1961
1971
1981
1991
2001
2010
2020
2025
2030
2040
2050
5260
4159
2838
2129
1611
1250
1038
877
809
751
654
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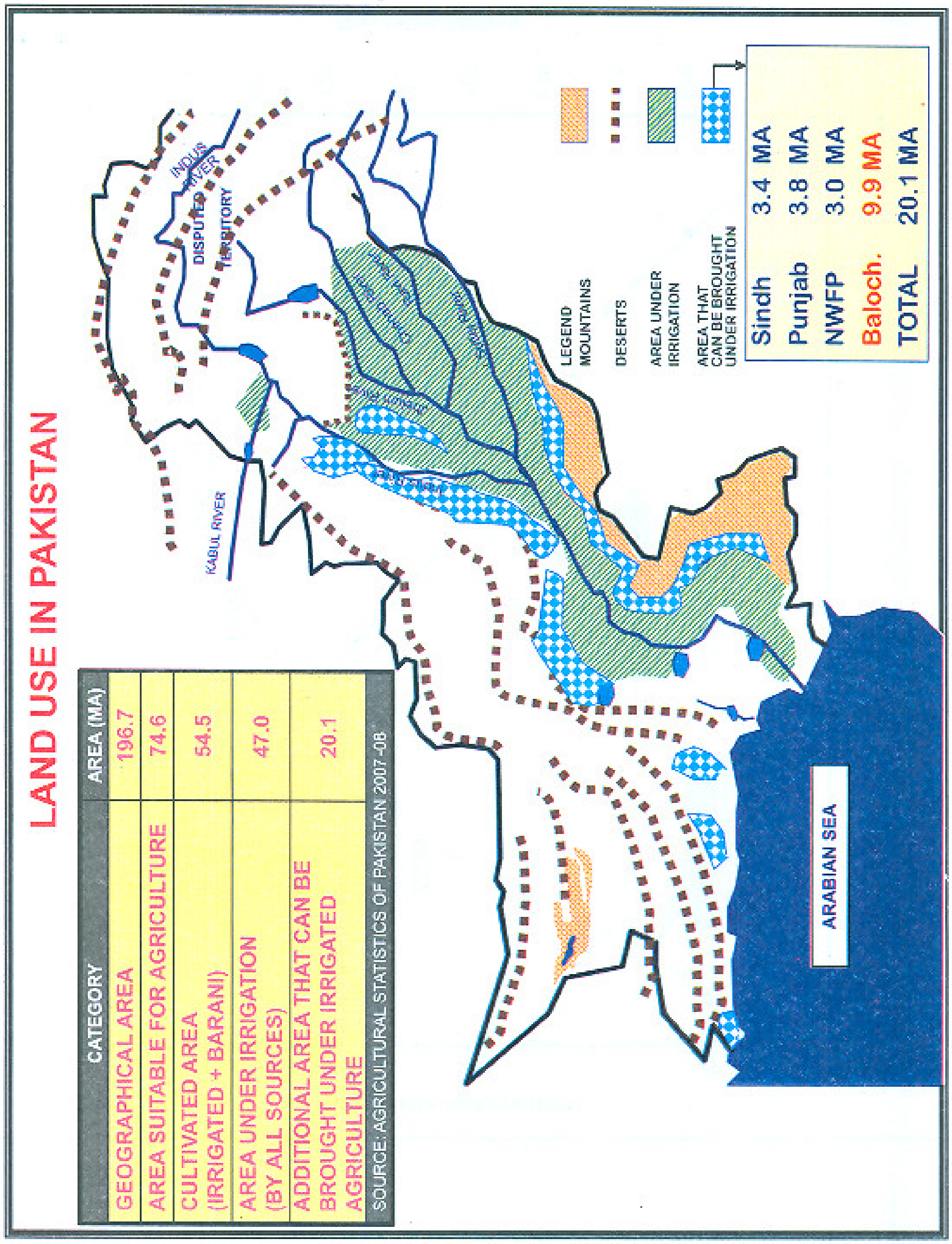

CATEGORY	AREA (MA)
GEOGRAPHICAL AREA	196.7
AREA SUITABLE FOR AGRICULTURE	74.6
CULTIVATED AREA (IRRIGATED + BARANI)	54.5
AREA UNDER IRRIGATION (BY ALL SOURCES)	47.0
ADDITIONAL AREA THAT CAN BE BROUGHT UNDER IRRIGATED AGRICULTURE	20.1

SOURCE: AGRICULTURAL STATISTICS OF PAKISTAN 2007-08 been several causes for this, but most result in some way with lack of ownership on the part of the implementing agency.

2. Uses of Water

2.1 Water Availability

The average annual inflow of the Western Rivers during post Tarbela period 1975-2001) at the rim stations (Indus at Kalabagh, Jhelum at Mangla and Chenabat Marala) is 143.18 MAF (176.63 BCM). 82% of the total inflow is in the Kharif season (April – September) and 18% of the total-flows during the Rabi season (October – March).

The three eastern rivers, Ravi, Sutlej and Beas, have been allocated to India for its exclusive use, but un-utilized flows enter Pakistan. Allowing for the reduction in the contribution from the eastern rivers and the allowable uses by India on the western rivers the total long term surface water available in the Indus Basin is effectively equal to the inflow of the western rivers i.e. 143.18 MAF (176.63 BCM).

2.2 Irrigation

Irrigated agriculture is the major user of both the surface and groundwater resources of Pakistan. The average annual river diversions for irrigation in the Indus Basin are of the order of 103.84 MAF (128.10 BCM) for irrigating over 36 million acres (14.6 million hectares). Out of this 66.83 MAF (82.44 BCM) on average are diverted during the Kharif period, while 37.01 MAF (45.01 BCM) are diverted during the Rabi period.

During the Kharif seasons, on average basis of supplies Punjab used 34.3 MAF (42.3 BCM) annually on average, while Sindh & Balochistan used 31.4 MAF (38.7 BCM) and NWFP used 2.35 MAF (2.9 BCM). During the Rabi periods of the same period, average withdrawals by Punjab, Sindh & Balochistan and NWFP were 19.87 MAF (24.5 BCM), 16.06 MAF (19.8 BCM) and 1.46 MAF (1.8 BCM) respectively.

An estimated 41.6 MAF (51.3 BCM) are pumped annually from the groundwater reservoirs. Most of the groundwater abstraction is in the Punjab, estimated at 34.0 MAF (41.94 BCM) in 1999-2000, followed by Sindh at 5.0 MAF (6.17 BCM), Balochistan at 0.5 MAF (0.62 BCM) and NWFP AT 2.1 MAF (2.59 BCM). More than 90% of groundwater abstracted is used for irrigation.

The recent drought has caused considerable reduction in irrigation supplies. As a result there was a negative growth in agriculture. This has impacted on the growth of GDP.

It is interesting to note that there have been yield increase in some crops, notably wheat, despite, or in fact, because of the drought. The increases are in the areas of Punjab and Sindh which are normally waterlogged and have saline groundwater problems. The increases are attributed to a reduction in Waterlogging due to lower levels of water use as canal diversions have decreased. It remains to be seen whether the lesson here will be taken on board once the drought ends and water allocations are back to normal.

It is not possible to meet all future agricultural requirements with existing water resources alone, even with the development of additional storage. Much of the future requirements will have to be met through increased crop yields, increased water use efficiency, use of saline water for agriculture and recycling of effluents etc.

Table-2 WATER DEMAND

Population	**2010** **2025**	**168 million** **221 million**
Urban Population	Currently 2025	35% 60%
Total Area	196 M Acres	
Cultivable	73 MA	
Cultivated	52.5 MA	
Remaining	21.5 MA Needs Add. Water	
To increase the crop yield requires additional water		
Net Water Requirement	2010-11 2024-25	89 MAF 114 MAF
Domestic Demand	Currently 2025	4.0 MAF 10.5 MAF

2.3 Domestic and Industrial Water

The present water use for municipal supplies in the urban sector is of the order of 4.3 MAF (5.3 BCM). Most urban water is supplied from groundwater except for the cities of Karachi and Hyderabad and part of the supply to Islamabad. The increased population will exert additional pressure on the already strained water supply and sanitation facilities. The demand for municipal and industrial supplies in urban areas is expected to increase to about 7.1 MAF (8.7 BCM) by 2011 and 12.1 MAF (14.0 BCM) by 2025.

The total water requirement for non-irrigation use is estimated at 8.96 MAF (11.0 BCM) in 2011 and 15.3 MAF (18.9 BCM) in 2025. Irrigation water use will face increased competition from the municipal and industrial water supply sector.

2.4 Competition Between Uses

Irrigation dominates water use in Pakistan and is expected to continue as the major user of both surface and groundwater into the future. The existing reservoirs are operated with priority for the irrigation uses of the provinces as stipulated in the Water Accord. Hydropower generation is a secondary benefit from the reservoirs. Compared to irrigation the current demand for urban and rural water supply is minimal. However, as development proceeds and the population as well as country's economy grows, competition for water resources will become a major concern.

With the expected increase in the demand for supply of water for urban and rural domestic and industrial use, plus the needs of the environment, coupled with the limited overall water resources, it is likely that some water will need to be diverted from irrigation to these other uses. Currently, the irrigation system runs with overall efficiency of about 40%. There is some scope for conservation of water through increasing irrigation efficiencies to ensure water for all users, as well as ensuring adequate supply for irrigation itself. Urgent action is required for reducing losses from the irrigation system.

Disposal of effluents from agricultural drainage, municipal waste and industrial effluents into the canals, rivers and other water bodies are a major issue due to their effect on other water users. The disposal of untreated municipal and industrial effluent from all cities is already having significant negative impacts on downstream water quality.

Table-3
Competing Water Uses: Interaction

	Sanitary Control	*Hydro-power*	*Irrigated agri-culture*	*Domestic water supply*	*Industrial water supply*	*Waste water disposal*	*Naviga-tion*	*Aqua-culture*	*Recreation / Fisheries*
Salinity Control	2	*C*	*C*	*1*	*1*	2	*0*	2	2
Hydro-power			*1*	*0*	*0*	*0*	*0*	2	2
Irrigated agriculture				*3*	*3*	*3*	*0*	*C*	*1*
Domestic water supply					*1*	*C*	*0*	*0*	*0*
Industrial water supply						*C*	*0*	*2*	*2*
Waste water disposal							*0*	*2*	*2*
Navigation								*0*	*0*
Aqua-culture									*C*

O: no competition 1: minor competition 2: moderate competition 3: severe competition C: complementary use

3. Groundwater Quality

3.1 Irrigation Waters

The Indus Basin is formed by alluvial deposits carried by the Indus and its tributaries and is underlain by an unconfined aquifer covering about 15 million acres (6 million ha) in surface area. In the Punjab about 79% of the area and in Sindh about 28% of the area is underlain by fresh groundwater, which is mostly used as supplemental irrigation water and pumped through the tubewells. Some groundwater is saline and water from the saline tubewells is generally put into drains and, where this is not possible, it is discharged into the canals for use in irrigation after diluting with the fresh canal water.

About 42 MAF (52 BCM) of groundwater is pumped for irrigation use and for urban & rural drinking water supplies. Province-wise the groundwater usage is 34 MAF (42 BCM) in Punjab, 3.5 MAF (0.6 BCM) in Balochistan. Both the groundwater potential and use is very limited in AJ&K as compared to other provinces. In Northern Areas the potential for groundwater exploitation is virtually none.

Groundwater use is nearing the upper limit in most parts of Pakistan. The groundwater table in most of the fresh water areas is falling, therefore the potential of further groundwater exploitation is very limited. For future projections it is estimated that the additional contribution by groundwater may increase at best by 1-2 MAF (1.2 – 2.4 BCM).

The quality of groundwater ranges from fresh (salinity less) than 1000 mg /L TDS) near the major rivers to highly saline farther away, with salinity more than 3000 mg/L TDS. The general distribution of fresh and saline groundwater in the country is well known and mapped as it influences the options for irrigation & drinking water supplies. In the country some 14.2 million acres (5.75 Mha) are underlain with groundwater having salinity less than 1000 mg/L TDS, 4.54 million acres (1.84 Mha) with salinity from 1000-3000 mg/L TDS and 10.57 million acres (4.28 Mha) with salinity more than 3000 mg/L TDS.

Table-4 Water Quality Standards

Water Class	Electrical conductivity dS/m	Salt concentration mg/1	Type of water
None-saline	<0.7	<500	Drinking and irrigation water
Slightly saline	0.7-2	500-1500	Irrigation water
Moderately saline	2-10	1500-7000	Primary drainage water and groundwater
Highly saline	10-25	7000-15,000	Secondary drainage water and groundwater
Very highly saline	25-451	5,000-35,000	Very saline groundwater
Brine	>45	>45,000	Seawater

Punjab

About 79% of the area in Punjab province has access to fresh groundwater. Some 9.78 million acres (3.96 Mha) are underlain with groundwater of less than 1000 mg/l TDS, 3 million acres 1.22 Mha) with salinity ranging from 1000 to 3000 mg/l and 3.26 million acres (4.32 Mha) are underlain with groundwater of salinity of more than 3000 mg/l TDS. In the province, saline waters are mostly encountered in Central Doab areas. Cholistan area in the southern Punjab is well known for highly brackish waters, which can not be used for drinking as well as irrigation purposes.

3.1.2 Sindh

Around 28% of the area in Sindh province has access to fresh groundwater suitable for irrigation. Close to the edges of the irrigated lands, fresh groundwater can be found at 20 to 25 m depth. Large areas in province are underlain with groundwater of poor quality.

Indiscriminate pumping has resulted in contamination of the aquifer at many places where salinity of tube well water has increased. The areas with non-potable, highly brackish water include Thar, Nara and Tharparkar.

3.1.3. N.W.F.P.

In NWFP abstraction in access of recharge in certain area such as Kark, Kohat, Bannu and D.I. Khan has lowered the water table and resulted in the contamination from underlying saline water.

3.1.4 Balochistan

The Makran coastal zone and several other basins contain high brackish groundwater. As there is no alternative, local communities use groundwater for drinking purposes with TDS as high as 3000 mg/l.

It is apparent from the above discussion that as is the case with the quality of surface water, the quality of ground water in many areas is deteriorating due to contamination from industrial and municipal wastes and also due to salt water intrusion as a result of over pumping. Water quality of both surface and groundwater is becoming one of the major water resources issues.

For each of the % ages indicate whether stable, increasing or decreasing

Condition	Severe Impact	Moderate Impact	Slight Impact	No Impact
Area of aquifers where watertables are drawn by pumping	6.4% (Increasing)	3.6% (Increasing)	2.4% (Increasing)	87.6% (Decreasing)
Area of aquifers where chemical water quality is adversely affected by human activity.	12% increasing	9% increasing	9% increasing	70% decreasing
Area of aquifers where biological water quality is adversely affected by human activity	Negligible	Negligible	Negligible	99%

3.1.5 Estuarine & Coastal Zones

The coastal and estuarine zone of Pakistan is mainly affected by human activities in deltaic region except for small fishing villages scattered on the shoreline in Sindh & Balochistan. The kind of impacts generated by human activities include:

Estuarine

- Decrease in fish and other aquatic species.
- Depletion of mangrove system.
- Hyper-salination of creek system & depletion of habitat.
- Pollution through municipal sewerage and industrial effluent
- Sea water intrusion.

Coastal

- Loss of habitat
- Eutrophication
- Bio-accumulation of toxic substances
- Traffic & oil pollution in harbour areas.
- Smothering of inter-tidal flora & fauna
- Marine pollution due to port and harbour

The Indus estuarine area was once well known for its shellfish, Oyster, window pans oysters, shrimps and small pearls from species in the creek system. The catches of these landings have declined or completely ceased due to changes in hydrographic regions and environmental degradation. Traveling has also destroyed species in estuarine areas, which act as breeding and nursery grounds for several fish species. Traveling in the estuarine areas should be either banned or controlled and monitored.

3.1.6 Industrial Impacts

More than 60% of the industries of the country are located in five industrial complexes near the coast in Sindh and Balochistan. Sindh Industrial Trading Estate (SITE), Hub Industrial Trading Estate (HITE), Landi Industrial Trading Estate (LITE), Korangi Industrial Trading Estate (KITE) and the Port Qasim/Steel Mill Complex , Karachi, with an estimated population of 13-14 million generates more than 262 MGD (499.3 MCP) of untreated domestic and industrial waste water. The disposal of periodic Oxygen deficient water in the proximity of coastal region has resulted in many important fish species moving farther away from the fishing zones.

Quantitative estimates of oil pollution on the Karachi creeks are lacking. However, observations indicate considerable amounts of oil and tar balls from shipping traffic washed up on the coast. This is probably due inadequate flushing water. The influence of pollution from Karachi Harbour and Gizri-Korangi creek system is noticeable to a radius of 10-20 Km' offshore. Flotsam and oily wastes are visible to a radius of 5 Km. Bottom sediments show sings of organic pollution to a distance of 15 – 20 Km offshore from Korangi – Phitti creek opening

3.2 Domestic Waters

Poor microbial quality of drinking water supplies is by far the dominant water quality issue for health in Pakistan. In most of the cities the municipal water is unsafe to drink and does not meet WHO guidelines. In cities the quality of the water is generally compromised with the distribution system by inadequacy or lack of chlorination, cross-connections from sewage lines, poor maintenance and illegal connections. Many surface water treatment plants do not observe basic procedures to ensure water quality. It is estimated that 90% of the country's population is exposed to unsafe drinking water. There is an increasing trend in cities and urban areas on the use of costly bottled drinking water. Several bottling companies have started operating but a recent survey, reported in the Press, showed that the quality of water supplied by a number of these companies also did not meet WHO standards for drinking water.

For water in rural area across Pakistan, there is simply no system in place to assess the quality of drinking water. The availability of drinking water in rural areas where groundwater is saline is a serious problem.

For each of the % ages indicate whether stable, increasing or decreasing

Condition	Severe Impact	Moderate Impact	Slight Impact	No Impact
%age (by length) of coastal line whose aquatic eco systems are affected by human activity	11.5%	15.3%	8.8%	64.4%
%age (by area) of estuaries in which the salt water interface has advanced in land as a result of human activity	90%	10%	0 %	0 %
%age (by area) of estuaries whose aquatic eco systems are adversely affected by human activity	90%	10%	0 %	0 %

3.2.1 Sindh

In Karachi the tap water is not fit for drinking. Almost 95% of shallow groundwater supplies are faecally contaminated and surveys suggest that similar pollution occurs elsewhere in the province of Sindh. The presence of chlorinated pesticides in shallow groundwater sources in Karachi has also been reported. Many rural areas of the province (in particular Mirpur Khas and Thar) are also faced with high fluoride content in the drinking water.

3.2.2 NWFP

The quality of drinking water in NWFP is often low due to the aging distribution system, the lack of treatment facilities and contaminated water sources in some urban areas. Drinking water in Peshawar is generally unfit for human consumption due to faecal contamination. In certain saline areas in Nowshera, Kohat and D.I.Khan, water is unfit for drinking due to a high salt content. Nitrate concentrations as high as 946 mg/l have been reported from rural areas around Gadoon.

3.2.3 Punjab

The drinking water quality in major urban centres of the Punjab seldom meets WHO Guidelines. Samples obtained from Lahore, Rawalpindi and Islamabad is reported to be unfit for human consumption due to faecal contamination. High concentrations of nitrates have also been detected in drinking waters in Islamabad, Rawalpindi, Gujar Khan, Kahuta, Murree and Taxila. Nitrate leaching from heavy fertilizer use is known to be an issue in southern Punjab. Many areas near Lahore have very high fluoride content in drinking water supplies, which resulted in ailments in the consumers.

3.2.4 Balochistan

In Balochistan, the main environmental health problems arise from higher levels of faecal coliform, viruses and pathogens in water supplies obtained even from deep wells. The problem is specially acute in Quetta. Some of shallow aquifers are contaminated by sewerage & other pollutants. An additional problem is that of hyperfluorosis. Drinking water in Jafarabad, Dera Bugti, Mastung & Bolan areas have been found to contain high fluoride content.

4. Areas to be addressed urgently at Public & Private Levels

4.1. Water Storage

To meet future water requirements, it would be necessary to create large storages on Indus River. The Federal Government through WAPDA has launched a comprehensive integrated water resource and hydropower development Mega Plan Vision 2025 for development of water reservoirs and hydropower generations. Under this programme water storage/reservoir sites of about 65 MAF total capacity and power potential sites of 35,000 MW in the whole of Pakistan including Northern Areas & AJ&K have been identified. The Vision Programme envisaged a comprehensive portfolio for undertaking feasibility studies, detailed engineering designs and preparation of tender documents of a number of projects. Under Vision 2025 Programme, implementation of such projects as Raised Mangla Dam, Gomal Zam Dam, Hingol Dam and Mirani Dam etc. has been undertaken on fast track basis. Basha Diamer, Akhori, Munda dams have been taken up already or would be taken up in future.

4.2. Environment

Through out the country river and stream behaviour is changing due to increased diversions, construction of reservoirs and deforestation of catchments. Silt loads, particularly in the wet season, create a problem in all sub-sectors using surface water. Suspended matter in the water creates a greater rate of component wear on pumps and turbines and increases filtration problems in any situation requiring clean water. Sedimentation of reservoirs is resulting in reduction of capacity and other irrigation infrastructure poses an ongoing maintenance problem in an environment where attention to maintenance is not given a high priority.

Environmental use of water has not received recognition in the past. For future development of storage reservoirs allocations may be made for the environmental use so that the downstream adverse effects are mitigated. Significant further investment is required in public awareness and education, farmer training and institutional strengthening.

Pakistan is likely to face acute problems in near future, as its water resources will not be adequate to supply water to cities, towns and rural areas, or to produce enough food crops to meet the requirements of an increasing population. The most environmental concern is the low quality of surface water, which should be addressed through improved wastewater treatment in both the urban water and industrial sub-sectors.

Water quality monitoring and information management is badly lacking in Pakistan. Developing a monitoring system, which would include the establishment of water quality laboratories, and training of personnel for those labs, should be given emphasis in a water sector strategy.

Watershed management, especially the loss of forests in the upper catchments which, among other things, contributes to the sedimentation of reservoirs is a concern. However, at present there is little information on the impact of forest loss. Initial research on this would be warranted. There are several environmental issues which, if unchecked, will make the water use unsustainable. These include:

- Widespread contamination of surface waters due to disposal of agricultural drainage and untreated municipal and industrial effluents causing high incidence of water-related disease;
- waterlogging and salinity;
- over exploitation of groundwater in certain areas;
- limited forest cover and deforestation;
- saline intrusion into aquifers due to over pumping and
- reduction in the capacity of major reservoir due to siltation.

4.3 Federal and Provincial Institutions

At the Federal level Ministries of Water & Power, Food, Agriculture & Livestock, Planning & Development, Environment, Local Government and Rural Development and Ministry of Finance & Economic Affairs deal with water, agriculture and energy related issues. The Principal Institution involved in the planning, design, implementation of irrigation, drainage and power projects at the federal level is the Water & Power Development Authority (WAPDA).

At the Provincial Level Departments of Irrigation & Power, Planning & Development, Food and Agriculture, Physical Planning & Housing Department (Punjab) and Public Health Engineering Departments (Other Provinces) and Finance Departments deal with water and agriculture related issues. The Provincial Irrigation Departments/Provincial Irrigation & Drainage Authorities (PIDAs) are responsible for the planning, design, implementation & operation of irrigation & drainage systems and the flood control infra-structure in their respective provinces. While there is no general concern with the organizational structure of water institutions in Pakistan, there is no body at the federal level which has the responsibility to oversee the water sector as a whole and which has no vested interest in construction or other forms of water sector development.

4.4 Crops Substitution

The types of crops grown need to be rationalized to ensure that the crops grown are efficient in terms of water use and economic productivity. The traditional cropping pattern of rice and wheat has benefited from increased irrigation supplies and these two crops will remain important in Pakistan. However, sugarcane production, for example, has resulted in poor economic allocation of resources and wasteful over production that could not be efficiently marketed, resulting in a break down of support price mechanism and major loss to the producers. Over investment in the sugar industry and increased allocation of land and water to sugarcane has resulted in reducing resource availability to other crops. Modern research has shown several alternative cropping patterns that can raise productivity of existing farm systems. In the intensive agriculture systems of Punjab, Sindh and NWFP, there are ample opportunities to increase farm income from technologies such as zero tillage, introduction of high value crops like sunflower, pulses, vegetables and orchards etc.

4.5 Introduction of Sprinkler and Drip Irrigation

There is potential for reducing water use through introducing sprinkler and drip irrigation for some crops in some areas. Capital investment can be intensive for modern mechanized irrigation. Consideration should be given to introduction and means of financing these modern irrigation system in the scenario of present increasing scarcity of water in Pakistan.

4.6 Recycling of Effluents after Treatment

There is potential to re-use waste water effluent after treatment. However, care must be taken to ensure that the effluent is treated before use for irrigating food crops. Treatment of waste water effluent needs to be given priority from the environmental and water quality concerns.

4.7 Use of Saline Water for Agriculture

The use of saline water for cropping is restricted to growing salt resistant crops. Such crops as grasses for fodder, bushes and trees have proved successful in providing a reasonable economic return from areas affected by saline soils or using saline water for irrigation. This may not have a wide spread benefit, there is likely a potential for local improvements in farmer income.

4.8 Flood Water / Hill Torrents Conservation

One mode of rain harvesting which is used in Pakistan in watersheds of hill torrents and small streams is through construction of check dams to retard the speed of flows and construction of delay action dams to flatten the flood peaks and use the run off either for recharging the groundwater aquifer or to divert it into channels for use in flood irrigation. This technique has become popular in the water scarce areas of Balochistan, NWFP and parts of Punjab. In urban and rural areas rain harvesting can also be introduced in public and community wells situated near slums, draining water from nearby roof-tops and streets into them.

4.9 Conservation and Productivity

Country's productivity is one of the lowest in the world. The future strategy should be to look into enhancing productivity of existing irrigated land with high efficiency irrigation and adopt knowledge based technologies. Similarly in other water related sub sectors, conservation technologies can reduce or at least meet their water requirements more efficiently.

4.9.1 Desalination

Water quality for domestic use is a major problem across Pakistan. There are significant costs associated with the treatment of the raw water. For coastal cities such as Karachi, and inland cities, which have access to brackish groundwater, there is potential to benefit from desalinating water which should be investigated as a possible future source.

5. Conclusions

- Pakistan is presently faced with the situation that all its developed water resources are inadequate to meet the irrigation, power and other water requirements and it will not be able to meet its growing water requirements by 2025.

- Future water needs can be met by using available water resources more efficiently but in many cases it will be necessary to make increased use of low quality water for agricultural production.

- The irrational use of low quality groundwater has resulted into mining & secondary salinization.

5.1 Recommendations

- Impacts of low quality water for agriculture must be assessed at the farm level as well at the regional level.

- Traditional surface irrigation methods should be altered/replaced by properly designed and managed micro sprinkler & trickle irrigation systems.

- Disposal of industrial & sewerage effluents should be brought under strict legal frame work.

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