Country Paper: Pakistan

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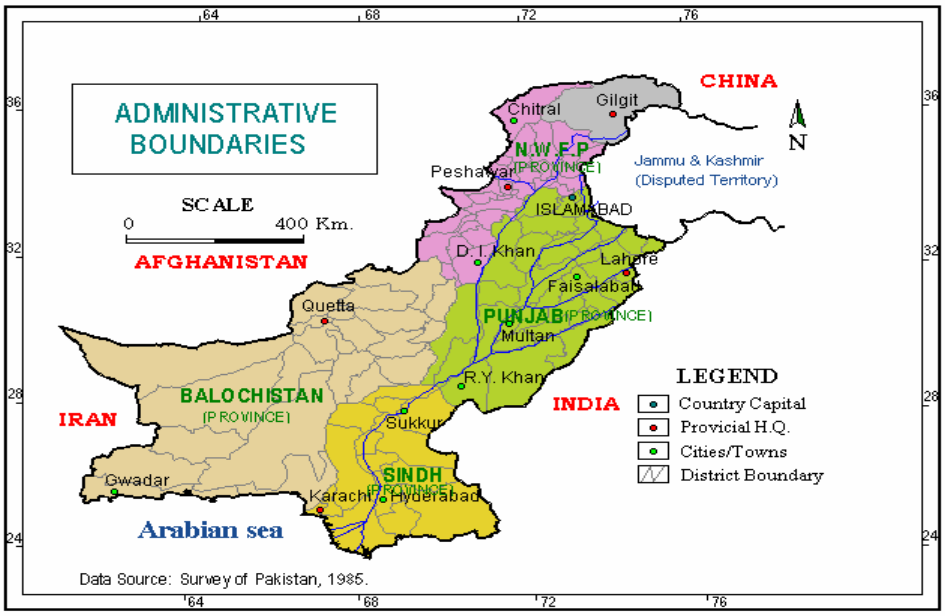
1. Introduction

Pakistan basically is an agricultural country blessed with immense natural resources like favorable climate, fertile plains, vast irrigated land and considerable manpower. Pakistan has arid and semi-arid conditions with a total area of 79.61 million hectares. Pakistan is administratively divided into four provinces viz Punjab, Sindh, NWFP and Baluchistan.



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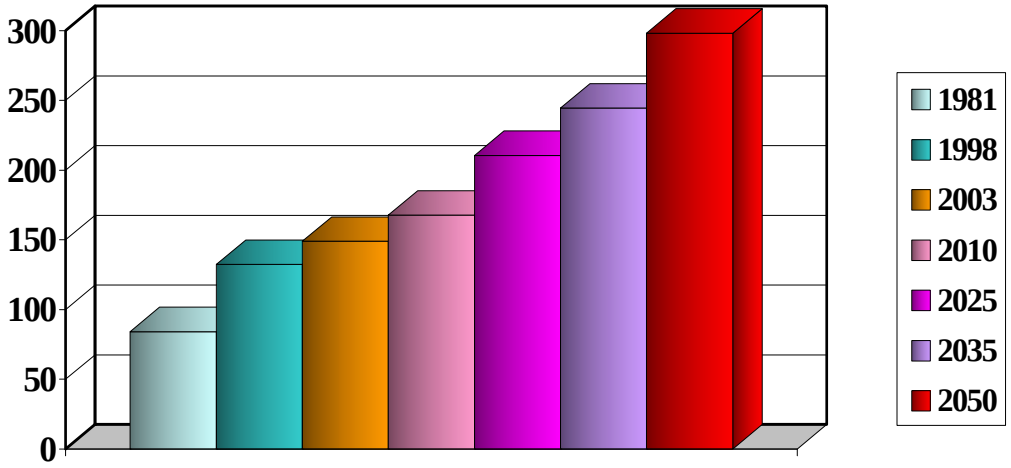
2. Population

The total population of Pakistan is 160.00 million, out of which about 95.00 million live in the rural areas. Agriculture provides employment to about 52% of the labour force. The increased population and the decreasing water resources are the challenges to meet the food requirement at present as well as in future.

Country Population in Millions



Source: National Institute of Population Studies

3. Land Availability

Total geographical area of Pakistan is 79.61 million hectares. Out of which 22.15 million hectares is reported as cultivated including 6.97 million hectares area sown more than once. The forest area is 4.01 million hectares. Details are as under:

Geographical area & Province wise land classification

(Million Hectares)

Province	Geographical area	Total area reported	Forest Area	Not available for cultivation	Culturable waste	Cultivated area Col (8+9)	Current fallow	Net area sown	Area sown more than once	Total cropped area Col (9+10)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Punjab	20.63	17.67	0.50	2.97	1.63	12.57	2.16	10.41	6.27	16.68
Sindh	14.09	14.09	1.00	6.00	1.49	5.60	2.86	2.74	0.99	3.73
NWFP	10.17	8.34	1.33	3.90	1.21	1.90	0.56	1.34	0.55	1.89
Baloch.(R)	34.72	17.12	1.36	9.83	4.00	1.93	0.91	1.02	0.07	1.08
Total	**79.61**	**57.22**	**4.19**	**22.70**	**8.21**	**22.00**	**6.49**	**15.51**	**7.88**	**23.39**

Source: Agricultural Statistics of Pakistan 2006-2007

Land irrigated at various sources

Province	Total	Canals		Tube wells	Wells	Canal Tube wells	Canal wells	Tanks	Others
		Govt	Private						
1	2	3	4	5	6	7	8	9	10
Punjab	14.57	3.58	-	2.88	0.14	7.71	0.22	-	0.04
Sindh	2.74	1.87	-	0.47	0.40	-	-	-	-
NWFP	1.00	0.40	0.34	0.07	0.05	0.07	-	*	0.07
Baloch.(R)	1.28	0.51	0.08	0.47	0.08	-	-	-	0.14
Total	**19.59**	**6.36**	**0.42**	**3.89**	**0.67**	**7.78**	**0.22**	**-**	**0.25**

* = Nominal Source: Agricultural Statistics of Pakistan 2006-2007

4. State of Agriculture in Pakistan

Agriculture presently contributes 25% to national income and provides employment to 50% of the labour force. About 60% of the country's exports are directly or indirectly based on agriculture. The country's area is divided into 10 broad agro-ecological regions considering physiography. These regions are: a) Indus delta; b) Southern irrigated plain; c) Sandy deserts; d) Northern irrigated plain; e) Barani lands; f) Wet mountains; g) Northern dry mountains; h) Western dry mountains; i) Dry western plateau; and j) Sulaiman piedmont. The ecology and resources in these regions vary considerably. The main limitation for development of agriculture is water shortage because of arid climate and insufficient rainfall. The development of agriculture is therefore dependent on water, which is much more capital intensive than any other development. The sedimentation in rivers and channels, erosion of soil, waterlogging, salinity, desertification and over-grazing are examples of leaky agricultural systems.

Pakistan's agricultural production system is complex because it consists of a mix of crop, livestock and vegetation. Four major cropping patterns are in practice, which include: a) rice-wheat; b) cotton-wheat; c) sugarcane-wheat; and d) maize-wheat. There are 81% farms under 5 ha size, which constitute about 39% of the farm area. About 12 percent farms lie between 5-10 ha and covering farm area of about 22%. Only 7% farms are over 10 ha but covering 40% of the farm area. The variability in land holdings demands appropriate land use and cropping systems considering the investment capacity of farmers.

The country is also importing edible oils of around 1 billion US$ annually and the per capita demand is increasing due to changes in income levels and dietary habits of the people. In addition, the country is importing tea, dry milk, coffee, wood and wood products. Country was able to develop an effective national agricultural research system consisting of national and provincial research institutions and agricultural universities. The agriculture extension is a provincial responsibility. All the four provinces have established networks of agriculture extension.

5. Problems of Agriculture Sector

The cultivated area is classified as canal command, tubewell command, *Sailaba* (runoff farming) and *Barani* (rainfed). The total culturable area is around 23.57 million hectares (mha), whereas, 11.82 mha are under forage and forests. This makes 35.39 mha suitable for agriculture and forestry. The rest of 44.22 mha is not suitable for agriculture and forestry within existing framework except for rough grazing in certain places.

Salinity is one of the major problems in the Indus basin. According to Water and Power Development Authority (WAPDA), 1981 surveys, about 26 and 39% area is affected by

surface and profile salinity, respectively. There is a decrease in the salinity due to Salinity Control and Reclamation Projects (SCARP).

Waterlogging is another problem affecting the irrigated agriculture. Within 100 years of the development of the Indus basin irrigation system, the water table has risen from 40 m to within 3 m on about 42% of the area. The situation is worst in Sindh province where water-table is within range of 3 m on about 57% irrigated area of the province. The high water table creates problem of oxygen deficiency, salt build-up in the soil profile and poor workability with soil. However, the high water table in the fresh groundwater zone provides facility for sub-irrigation. It also provides a source of water for irrigation through pumping. Therefore, about 37% of the total irrigation water supplies are met out of groundwater. Furthermore, the high water table is a problem in areas where groundwater is of poor quality. This situation becomes worst due to flat gradient in the Indus basin, which poses a restriction on the natural drainage. The combination of brackish groundwater and soil salinity makes the situation more complex which requires huge investments for reclamation purposes.

Mean annual rainfall varies from around 100 mm in the Sindh to more than 1800 mm in the foothills and northern mountains. About 60% of this rainfall comes during the monsoon period (July to September). Much of the summer rains also not available for crop production because of rapid runoff due to torrential showers. At other occasions, rain may be so light that it evaporates before it can penetrate into the root zone.

Indus basin system in Pakistan is composed of more than 56,127 kms of canals, which covers a total of 16.36 mha of culturable command area. The irrigation water is diverted to watercourse at the canal outlet (*Mogha*) which serves a command area of 60 to 260 hectares. Watercourse is a miniature irrigation project. There are about 110,000 watercourses in the country. The length of a watercourse ranges from fraction of a km to 4 km. The discharge varies between 28-120 litres per second. There are about 50-100 farmers according to size of land holding, availability of water, etc. The canal system is designed to provide water to achieve 70-80% of cropping intensity, whereas there is a potential to achieve a cropping intensity of 200%.

Total annual mean discharge in the Indus river system is 167 billion m^3. About 130 billion m^3 are diverted into the canal system in an average year and the rest flow into Arabian Sea. Moreover, after every second year 167 billion m^3 are not available in the river system and drop every fourth year below 160 billion m^3 and every sixth year below 150 billion m^3. These are important physical properties if the water use reaches the later quantities. The water losses in the canal system are about 25%, which reduce water availability to 98 billion m^3 at the watercourse head.

Water available at the watercourse head is about 158 billion m^3 after having groundwater pumpage of 60 billion m^3. Assuming watercourse losses of about 40%, this leaves only 95 billion m^3 available at the field gate (*Nakka*). The application efficiency is around 75% which leaves 71 billion m^3 available for crop consumptive use requirements. After adding effective rainfall contribution of 17 billion m^3 in an average year, the total net water available for crop consumptive use requirements is in the order of 88 billion m^3.

Crop water requirement for net crop needs have been computed considering cropping intensity of 105% in irrigated areas of Pakistan. Assuming cropping intensity of 110%, the net water requirement comes to around 90 billion m^3, which is almost same as the net availability. The water savings in the Indus basin of 16 billion m^3 are possible through reducing the delivery and application losses. Thus a cropping intensity of around 130% is possible with improved water management practices. Furthermore, to maintain healthy salt

and water balance, it is important to increase the groundwater pumpage. Additional pumping or drainage of 23 billion m^3 is needed to maintain the hydrological equilibrium in the Indus Basin.

Agricultural productivity and productions in the Indus basin have been increased during 60s due to the Green Revolution with the introduction of high yielding cultivars and chemical fertilizers. The area and yield of winter (*Rabi*) season crops were increased due to increase in water availability by the completion of the Tarbella dam which helped to increase canal diversions of the *Rabi* season in 25% of the dry years (at 75% probability) with an additional amount of water ranging between 6-10 billion m^3. For example, the *Rabi* season canal diversions were increased from 29 to 42 billion m^3 during the driest year for the pre- and post-Tarbela periods, respectively.

6. Effect of Climate Change on Agriculture

Pakistan is predominantly an arid country and maximum temperature in summer season exceeds 40 °C in central and lower parts of the country. In the hot climate of Pakistan, cereal crops are already on the margin of stress. A small increase in mean temperature will translate into much higher ambient temperatures in the planting and growing periods. Therefore any further increase in temperature due to global changes would affect the potential area of crops and shift in potential boundaries is expected. Growing of *Rabi* crops like wheat, rapeseed, mustard, chickpea, barley and lentils in Pakistan is a gamble in temperature. After the monsoon, the point reached in the gradual cooling of the seedbed regulates the sowing of these crops. Towards harvest, the crops have to ripen under a rapidly ascending temperature when hot dry winds are frequent. At both ends, therefore, the growth period is temperature limited, a fact which not only restricts the choice of varieties to early maturing types, which grow rapidly, but also influences the geographical distribution of the crop. Thus, the increase in temperature, in the semi-arid and arid climates would demand delay in planting of *Rabi* season crops which will result in reduction of growing season length and ultimately affect the yield potential.

The quality and quantity of agricultural yields will be affected by climate change in two ways: a) direct effects from changes in temperature, water balance, atmospheric composition (e.g., CO2 concentrations) and extreme events; and b) indirect effects through changes in the distribution, frequency and severity of pest and disease outbreaks, incidence of fire, weed infestation, or through changes in soil properties. In Pakistan, the temperature and rainfall changes would affect the productivity of agricultural crops. The increase in aridity might lead towards increase in salinity, whereas increase in rainfall and temperature would add towards waterlogging and salinity. The wide variability in climate provides an opportunity to formulate adaptation strategies using sustainable management of land and water resources, improved genotypes and agronomic practices that are more responsive to climate change. However, increase in population at the rate of about 1.8% would force the country to find ways to sustain productivity in the more productive areas and synthesis technologies for fragile environments having little or no negative externalities. Sustained physical and chemical health of soil is an ultimate target in arid environments.

The increase in temperature has direct effect on reference crop evapotranspiration and loss of soil moisture. The increase in reference crop evapotranspiration when combined with decrease in precipitation in the rainfed environments resulted into decrease in actual crop evapotranspiration due to limited availability and use of soil moisture by crops. However, the actual crop evapotranspiration would increase in the irrigated environments, where water is not limiting, because of increase in temperature. The most significant impacts of climate change are likely to be on irrigation and other infrastructure and the effects on agriculture

sector in Pakistan owing to increased variation in the summer monsoon and surface water availability.

The global warming, climatic extremes and CO2 concentrations would lead towards changes in land use systems due to changes in the growing season of various crops. The climatic changes in semi-arid and arid climates of the Indus basin would result in increased salinity and/or waterlogging; which would certainly demand for integration of forestry and aquaculture with the crop based farming systems. Apart from climatic factors, productivity and land use trends in the agriculture sector are strongly influenced by changes in national and international market forces, government policies, trade agreements, the development of new technologies. The shift in land use systems has already been observed in Pakistan where cotton crop is out of cultivation in areas, which now experience problems of high water table due to increased recharge from the irrigation system.

7. Adjustment to the Climatic Changes

As populations have grown, fresh water has become increasingly less available where and when it is needed. Pakistan's agriculture is the single biggest drain on water supplies accounting for about 75% of all water use. The essence of sustainable development and adaptation for climate change is that natural resources must be used in ways that will not limit their availability to future generations. Today most easily accessible renewable freshwater resources like rivers, smaller streams, lakes and aquifers that recharge quickly already have been developed in Pakistan.

With the increase in population of about 1.8% per annum, Pakistan will experience water stress by the end of the year 2020, as per capita water availability will be around 1700 m^3. The most effective long-term strategies for dealing with water scarcity include management and most efficient water use. A "Blue Revolution" in water supply is needed as much as today as the "Green Revolution" in food production was needed after 1950. Without sufficient water, economic development and more specifically the agricultural development becomes virtually impossible and conflicts over scarce resources virtually inevitable in countries like Pakistan. Therefore, options have to be formulated to manage water for sustainable agriculture and further adaptations in future would be required to adjust impacts of climate change. The other non-water management options required are tillage, precision planting, plant nutrition, drainage, salinity management, etc.

8. Government Interventions to Address Impact of Climate Change

The overall irrigation efficiency of the Indus basin Irrigation System is around 36%. The expansion of irrigation to new areas including rainfed, runoff farming and riverine area is essential to add sustainability and profitability to the non-irrigated farming system. To overcome above issues, Government of Pakistan has various plans and programs of Water Resources Development for improved agricultural production and farmer income and to Ensure Food Security for Future". These programs include policies, planning, coordination bringing irrigated agriculture and water resources development projects and proper monitoring of these projects. Beside this, short/medium & long term interventions through participation of stakeholders [farmers] in the form of Water Users Association (WUAs)/Farmer Organizations [FOs] has been initiated by the government. Further, awareness programs & trainings to the technical staff as well as farmers were also undertaken. The details of the programs initiated by the government is given below:

- Augmentation of Irrigation Water
- Incremental gain of 4.6 MAF by 2009
- Efficient water usage for Incremental gain of 8 MAF by 2009
- Drainage Plan Reclamation of 3.0 MA disastrous areas by 2009
- Flood Control and Protection & Controlling water losses in the system
- Embankments (651 km), 178 spur 70 hill torrent structures
- Land Development of 200,000 Acres through bulldozers levelling

i) Short/Mid Term Interventions

- Lining of watercourses
- Laser Land Leveling
- Improved irrigation and Agronomic practices
- Human Resources Development

ii) Long term interventions

A. Augmentation of Irrigation Water by WAPDA Vision 2025

1.	Gomal Zam Dam	(Storage Capacity)	= 1.14 MAF
2.	Mirani Dam	-do-	= 0.30 MAF
3.	Raising of Mangla Dam	-do-	= 3.10 MAF
4.	Satpara Dam	-do-	= 0.02 MAF
5.	Bhasha Dam	(Feasibility study started)	= 5.70 MAF
6.	Sehwan Barrage	-do-	= 0.65 MAF
		Total	**=10.91 MAF**

B. Construction/Remolding of Canals = 4.60 MAF

Construction and remodeling of Canals (Kachi, Pat Feeder, Chasma Right Bank Canal, Rainee, Greater Thal Canal, Irrigation System Rehabilitation & Improvement in Punjab and Sindh) will give incremental gain of 4.6 MAF by 2009

C. On Farm Water Management Program for Efficient Water Usage Incremental Gain = 6-8 MAF

National Programme for Improvement of Watercourses in Pakistan has been started in the country. Under this programme, 86,000 watercourses in all four provinces including AJK and Other areas will be lined within 5 years i.e. till 2010.

D. Construction of Delay-Action Dams

Groundwater re-charge of Pishin, Quetta, Mastung and Mangochar Valleys projects are under way to effective utilization of available water resources

E. Drainage Plan Reclamation of 3.0 MA Disastrous Areas by 2009

National Drainage Programme, Left and Right Bank Outfall Drainage Projects (LBOD/RBOD-I & RBOD-II to the sea, RBOD-III)

F. Modernization of Barrages

Modernization of barrages in Punjab, Water-table control (On-going SCARPs, Tube well, transitioning: Public to community of farmers
Institutional Reforms (Irrigation Departments Replaced by Provincial irrigation & Drainage Authorities, Area Water boards & Farmer's Organization

G. Flood Control and Protection

- Preparation of National Flood Protection Plan-III
- Second Flood Sector Project
- Murri Bugti Hill Torrents Project Emergent Flood Protection Schemes
- Studies and Design for further storages

H. On Farm Water Management Program

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