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**ROLE OF WATER RESOURCES DEVELOPMENT
IN THE ECONOMY OF PAKISTAN**

**M. Mushtaq Chaudhry, Dr. Muhammad Siddique, Dr. Allah Bakhsh
Sufi**

ROLE OF WATER RESOURCES DEVELOPMENT IN THE ECONOMY OF PAKISTAN

M. Mushtaq Chaudhry¹, Dr. Muhammad Siddique², Dr. Allah
Bakhsh Sufi³

ABSTRACT

Water is the major driving force and engine for the irrigated agriculture and economy of Pakistan, which uses over 90% of water and contributes 24% of GNP and employs 80% of labour force in the rural areas and almost 50% at the national level. Water sector of Pakistan is the largest enterprise contributing to the tune of over Rs. 20 billion per annum to the national economy. The importance of water sector development can be seen from the respective allocations for the water sector in the Ten Year Perspective Plan (2001-2011), the total of which is estimated at Rs. 25.40 trillion.

The total canal supplies were 85 MAF during 1960-61 and the irrigated area was 25.7 MA. At present the irrigation system of Pakistan annually is utilizing a total of about 105 MAF of water to irrigate an area of 36 MA. The increase is attributed to the multipurpose storage reservoirs of Mangla, Chashma and Tarbela. Tarbela and Mangla till 2005 have provided 294 and 163 billion Kwhs of energy to Pakistan grid, and have released 175 and 255 MAF of water respectively. The controlled water supplies enhanced water diversions that have contributed to increase agricultural production.

Population growth, rapid urbanization, industrialization and environmental degradation are now imposing pressure on water resources. The growing imbalance in supply and demand of water for agriculture and other sectors is felt acutely. The spatial and temporal variations in river flows across seasons/years necessitates additional construction of reservoirs to optimally use available flows for agriculture and other competing sectors. To meet these challenges and recognizing the importance of water and power development in "National Economy", WAPDA has launched a comprehensive Integrated Water Resources and hydropower development Mega – Plan known as "Vision 2005". This aims at the development of new storages (big and small) and generation of hydropower on large scale.

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INTRODUCTION

Geographically, Pakistan lies between latitudes 24° to 37° North and longitudes 61° to 76° East. In general, the climate of Pakistan is described as predominantly desert or near desert with approximately half of the country receiving less than 250 mm (10 inches) average annual rainfall. The distribution of rainfall is sporadic and highly uneven.

Pakistan, which has the mighty Indus River with its tributaries, has a great amount of variability in terms of water availability in time and space. The Indus is more a snow fed river, while its other tributaries viz. Jhelum, Chenab, Ravi and Sutlej rivers basically depend on rainfall and snow melt in their catchment areas for their flows. Most of the annual flow may come during summer months following snowmelt and heavy rains. Unless captured by reservoirs, the surplus water flows to the Arabian Sea, causing seasonal flooding in the plains, later in the year, the same or other areas may suffer droughts.

Out of a total geographical area of 79.3 Mha (196 Ma), the suitable area for agriculture in Pakistan is estimated about 31.2 Mha (77.1 Ma). Currently almost 18.0 Mha (44.4 Ma) of land is irrigated by all sources. Supplemental source of irrigation water in most cases and primary source in some cases is groundwater. It is estimated that about 9.1 Mha (22.5 Ma) of land could be made productive if sufficient assured water supplies are made available. Figure 1 presents the land use of Pakistan.

Pakistan has superb agricultural resources. About 80% of the cropped area is irrigated and 90% of the agricultural output is from irrigated land. Due to favourable “lay of land” and surface flows of the Indus river system and irrigation developments over the last 150 years or so, Pakistan now has world’s largest contiguous canal network. This is popularly known as “Indus Basin Irrigation System”. Salient features are summarized in Box-1 (Schematic Diagram Figure 2).

Box-1		
Indus Basin Irrigation System		
Sr. No.	Item	Quantity
1.	Reservoirs <ul style="list-style-type: none"> • Number • Designed – Storage Capacity 	3 18.37 MAF
2.	Barrages/Head works	23
3.	Link Canals	12
4.	Main Irrigation Canals <ul style="list-style-type: none"> • Number • C.C.A • Length (including distribution system) 	45 36 MA 38000 Miles
5.	Water Courses <ul style="list-style-type: none"> • Number (approximately) • Length (approximately) 	107000 1 Million miles

In post Tarbela period (1976-2004) an annual average of over 35.2 MAF escaped below Kotri (Figure 3). During the last 27 years a total flow of 1,164 BCM (951 MAF) has flowed into the sea. This is equivalent to more than 9 years of average Indus Basin canals withdrawals, Part of this water can be effectively utilized for supplementing the irrigation water, hydropower generation and meeting the agreed environmental needs, through multipurpose storage reservoirs.

When river flow is variable, then storage is required so that the supply of water can more closely watch water demands. Relative to other arid countries, Pakistan has very little water storage capacity. The United States and Australia have over 5,000 cubic meters of storage capacity per inhabitant, and China has 2,200 cubic meters, Pakistan has only 150 cubic meters of storage capacity per capita. Figure 4 shows the storage capacity available in some of the major arid basins in the world. The dams of the Colorado and Murray-Darling Rivers can hold 900 days of river runoff. South Africa can store 500 days in its Orange River, and India between 120 and 220 days in its major peninsular rivers, whereas Pakistan can barely store 32 days of water in the Indus Basin (Figure 5).

National demand for electricity has been and would keep on growing rapidly. Based on the present generation capacity, the hydel: thermal mix in the country is 32:68, which is almost the reverse of an ideal hydel-thermal mix, which should be 70:30 for overall economic development of Pakistan. Though induction of thermal generation initially helped in overcoming load shedding, it resulted in substantial increase in power tariff. Therefore, a sizeable injection of cheap hydropower through multipurpose storages is a viable option to keep the cost of electricity within the affordable limits.

In developing countries, increasing agriculture production is a major means of overcoming poverty. Most of the poor live in rural areas where more poverty problems are found. Properly managed water resources play an important role in achieving full potential of development.

POPULATION GROWTH AND FOOD REQUIREMENTS

Population of Pakistan was 33.7 million in 1951. The census during 1972 indicated the rate of increase of 3.2 percent with the population as 65.2 million. The population increased to 83.8 million in 1981 and 130.6 million in 1998 showing an increase of 2.64 percent from 1981 to 1998. It has been estimated that rate of increase of population during the last few years has dropped to 2.2 percent which is likely to further decrease with time. The anticipated population by the year 2010 would be 178 million and by 2025 would enhance to 225 million with an average annual increase of 1.81 percent. It has been estimated by FAO that over 20 percent of Population of Pakistan is living under malnutrition. If redressal measures are not adopted for increasing food production, the problem of malnutrition will further aggravate. Presently, 90 percent of the food is being supplied by the irrigated area. Nearly 80 percent of water in the irrigation sector is used for four major crops i.e., wheat, rice, sugarcane and cotton, while remaining is used for minor crops, fruits,

fodders and forests. It has been estimated that agricultural production would have to be increased by over 60 percent by the year 2025 to meet food and fiber requirements of the country. Figure 6 presents population growth vs. water availability and canal water diversions.

WATER REQUIREMENTS

Water requirements of the country are increasing to meet the needs of the growing population, water supply and sanitation; industry etc. Irrigated area of Pakistan from all sources has increased from 20.75 Ma to 44.4 Ma during 1947 to 2003. Cereals production increased from 5.2 Mt to 28.5 Mt during the same period. The area under cereal crops increased by about 250 percent. The maximum rise was in case of rice and sugarcane where the increase was 318 percent and 544 percent respectively, which are high delta crops. Thus, both horizontal expansion (increase in area) and vertical expansion (increase in yield) have contributed in the higher production of agriculture. Under future scenario for the increase in food and fiber production, there is scope for both vertical and horizontal expansion. Horizontal expansion would require additional land and water resources development while vertical expansion would entail better seeds, fertilizer, improved field management practices etc. Yield of cereal production in Pakistan is about 1/3rd of the potential production with the same environment setting. It has been anticipated that future needs of food and fiber would be met both by horizontal and vertical expansion, with about 50 percent contribution by each source.

It has been estimated that additional water requirements under different sectors upto 2025 would be as:

- | | |
|-------------------------------|-------------------------|
| • Agricultural Sector | 37 MAF (at canal heads) |
| • Water Supply and Sanitation | 06 MAF |
| • Industry, Environment etc. | 02 MAF |

If groundwater and rainfall harvesting can meet the requirements of water supply, sanitation, industry etc; the river flow development to the tune of 37 MAF would be required under the optimistic scenario of 50 percent increase in agriculture through vertical expansion.

AVAILABILITY OF WATER RESOURCES

Water is a critical resource for sustainable economic development of Pakistan. The growing imbalance between supply and demand has led to the shortages and competition. Inadequacy in the availability of surface flows has led to excessive and lopsided exploitation of groundwater. The unsymmetrical groundwater pumping has created a number of adverse interactions like; (i) Persistence of waterlogging in certain areas and continuously lowering of water table levels in others, making further use of groundwater about 10 percent area, which is likely to increase with time and (ii) Intrusion of saline water into fresh groundwater resources due to vertical upconing of saline interface or horizontal movement of saline aquifer.

It is estimated that groundwater storage capacity is about 56.7 MAF. About 50.3 MAF of groundwater is pumped for irrigation use and drinking water supplies. Groundwater use is nearing the upper limit and the groundwater table is falling in most parts of country. Therefore, the potential of groundwater exploitation is very limited. Major exploitable water resource of Pakistan is River flows. Indus Basin flows are highly variable on seasonal and yearly basis. Advent of high variability dictates that river flows be conversed and managed to optimally meet agricultural requirements. The analysis of inflow record of the three Western Rivers from the year 1976-77 to 2003-04 indicates that annual flow varies from 172.1 MAF (1991-92) to 97.17 MAF (2001-02), Kharif flow variation is from 157.24 MAF (1978-79) to 84.7 MAF (1974-75). Average annual availability of river flows in Kharif is nearly 85 percent, while balance water is available during Rabi season as against requirements of nearly 60 percent and 40 percent during Kharif and Rabi respectively. Magnitude of variation between maximum and minimum Kharif flow is over 75 MAF. Existing storage capacity is about 13.48 MAF (2004). Thus, in order to optimally, utilize and transfer surplus Kharif flows to Rabi, additional/largest storage capacity of dams would be needed.

GLOBAL PERSPECTIVE FOR WATER CONSERVATION THROUGH STORAGE DAMS

Water storage through dams has made an important and significant contribution to human development and the benefits derived from them have been considerable. Specifically, the large dams have emerged as the most significant and variable tools for the optimal management of water resources. More than 800,000 dams have been constructed of which 45,000 are more than 15 meter (m) high. Total storage capacity of dams and fresh water ponds is nearly 8,000 MAF and is the principal source of water for 280 Mha of irrigated area on this globe which produces more than 2/3 of the global rice and 1/3 of the wheat. These dams have also played major role in helping communities and economies for food production, energy generation, flood control and water supply by harnessing water resources. These dams are producing nearly 20 percent of the world electricity, equivalent to about 5 million barrels of oil per day. Following paragraphs indicate how the dams have helped the countries in achieving high rate of economic development in food security, flood control etc.

- a) La Grande River (Canada): 7 large capacity dams have been constructed with a gross storage capacity of 329 MAF. The aggregate storage capacity of dams constructed in Canada is 694 MAF which have made Canada as one of the large exporters of cereal and other agricultural products in the world.
- b) High Aswan Dam (Egypt): The capacity of high Aswan Dam on Nile with an average annual flow of 38 MAF is 132 MAF. The study conducted by WK Shenouda about this multipurpose dam indicate that during the last 30 years, the dam has fulfilled all its objectives of protecting the country from droughts, flood losses, agricultural

expansion for a bigger area than planned and hydropower generation which encouraged the development of heavy industries and rural electrification. The dam has virtually saved Egypt from the long continuous drought of nine years that afflicted most of the African Continent during the late 1980s (1988-97).

- c) Colorado River USA: Average annual flow of river (1895-2003) is 12.40 MAF with a minimum flow of 3.8 MAF. 3 large dams with a storage capacity of 59.62 MAF have been constructed. This capacity is around 5 times the average annual flow. During the last few decades, the flow has never gone to the sea. More than 20 million people who depend upon the river flow and industry have benefited from the dams which have saved the Basin States from the adverse interaction of drought that inflicted the area a number of times, since the construction of dams.
- d) Columbia River (Canada/USA): This river originates in Canada and outfalls in the Pacific Ocean after traversing the North Western States of USA. There was only one dam site available in USA, where a dam (Grand Coulee Dam) with a storage capacity of 11.79 MAF was constructed. Two potential dam sites were also available in Canada. In order to utilize a surplus flow that was outfalling into the sea, USA made an agreement with Canada for the construction of two dams and for purpose of water and hydel power from Canada. Mica Dam with a storage capacity of 25 MAF and Revalstoke Dam a storage capacity of 5.2 MAF have been constructed and USA is purchasing water and hydel power as per agreement. Through the construction of these dams, all potential water and hydel power resources of the river have been utilized by USA.
- e) In 1950s, India was deficient in food to the tune of about 2-3 Mt. India started the management and development of river flows through the construction of dams. So far, it has constructed 4,636 dams with a storage capacity of 245 MAF. It has not only made India self sufficient in food to meet the requirements of population of over 1.15 billion, but has also an exporter of cereals in the world.
- f) China has constructed more than 22,000 dams with a storage capacity of 2,280 MAF including fresh water ponds. Management of water resources through dams has largely helped China in meeting growing cereal requirements of the country and to create grain storage of over 200 Mt.

Large number of dams constructed in various parts of the world indicates that storage capacities of dams on various rivers are many times more than the average annual flow, which greatly helped in conservation of flows of high peak flood events. Large capacity dams serve to utilize stored water as a cushion against drought and low flow periods/years.

PAKISTAN'S PERSPECTIVE OF WATER STORAGE

In the Indus Basin Irrigation System, average canal head diversions at the time of independence were about 67 MAF. During 1960-77 the gigantic Indus Basin Project was implemented. Besides three storage reservoirs at Mangla, Tarbela and Chashma, IBP entailed construction of five barrages and about 620 kms of inter-river link canals to divert water across the upper. Indus plain (Punjab Province) to feed irrigation system hither to dependent on the three eastern rivers (Sutlej, Beas and Ravi) assigned to India under IWT. IBP enabled Pakistan to acquire significant capability of river flow regulation through an integrated system as shown in the Schematic Diagram of IBIS (Figure 2).

By the dint of river regulation-cum-storage facilitate of IBP and other irrigation developments on the Indus River main stem, canal head diversions progressively increased till 1990 as depicted in Box-2.

Box-2 Indus Basin Irrigation System – Canal Head Diversion		
Year	Canal Diversion (MAF)	Remarks
1949-50	67	Just after independence
1959-60	85	Just before Indus Water Treaty
1967-68	95	Just after Mangla storage commissioning
1975-76	101	Post Tarbela
1977-82	105	Post Tarbela average
1996-97	114	Post Tarbela peak
1999-2004	109-103	Declining post – Tarbela trend due to non-addition of a new storage

It can be noted from Box-2 that in the post-Tarbela period an average (1977-82) canal head diversion of about 105 MAF was achieved. This peaked to about 114 MAF in 1996-97 and then started declining. This trend was now persisting and basic reason for this could be almost complete moratorium on surface water development in post-Tarbela period and significant loss of online storage capacity through sedimentation. The original live storage capacity of 18.37 MAF has decreased by 4.73 MAF by the year 2002, which is anticipated to further decrease to 6.03 MAF and 7.27 MAF by the year 2010 and 2020 respectively (Box-3). With the help of Chashma, Mangla and Tarbela Reservoirs seasonal carry over capacity from Kharif to Rabi was increased from 12% to 21%. Due to sedimentation of these reservoirs this capability has now reduced from 21% to 19% (Figure 7).

The available supplies for canals in critical Rabi and Kharif sowing/ maturing period are thus progressively reducing. Creation of more storages is an imperative need in the present situation.

BOX -3 SEDIMENTATION OF RESERVOIRS

RESERVOIR	Original Storage Capacity (MAF)	Storage Loss by Year 2005 (MAF)	Storage Loss by Year 2010 (MAF)	Storage Loss by Year 2015 (MAF)	Storage Loss by Year 2020 (MAF)
TARBELA	11.62 (1976)	3.25 (28%)	3.95 (34%)	4.43 (38%)	4.98 (43%)
MANGLA	5.88 (1967)	1.27 (22%)	1.60 (27%)	1.63 (28%)	1.79 (30%)
CHASHMA	0.87 (1971)	0.39 (43%)	0.48 (55%)	0.50 (57%)	0.50 (57%)
TOTAL	18.37	4.91 (32%)	6.03 (33%)	6.56 (36%)	7.27 (40%)

IMPACT OF EXISTING RESERVOIRS ON THE NATIONAL ECONOMY

The Agriculture sector is the major user of water and its consumption will continue to dominate water requirements. The major user of water for irrigation is the Indus basin irrigation system. The total canal supplies were 85.0 million acre feet (MAF) during 1959-60 and the irrigated area was 25.7 million acres (Ma). The construction of storage reservoirs enabled Pakistan to acquire significant capability of river flow regulation. By dint of river regulation-cum-storage facilities, canal head diversions progressively increased. At present the irrigation system of Pakistan is utilizing a total of 105 MAF to irrigate an area of about 36 Ma. The increase is attributed to the storage reservoirs of Mangla, Chashma and Tarbela which become operational in 1967, 1971 and 1976 respectively. The annual storage releases of Mangla and Chashma averaged 5 MAF and with addition of Tarbela, it has gone upto 15 MAF during the last 15 years.

Tarbela and Mangla are multipurpose water projects of great importance for promoting economic development of Pakistan. Beside power generation and irrigated agriculture, these projects facilitating water supply to the many riparian villages, towns, and cities. Tarbela and Mangla till 2005 have provided 293.965 and 162.472 billion Kwhs of energy respectively to Pakistan grid. Upto the year 2005 Mangla, Chashma and Tarbela reservoirs have released 174.56, 55.73 MAF and 255 MAF of water respectively. The greater control on the water supplies coupled with enhanced water diversions have contributed to increased agriculture production. Water released from storages through hydropower plants returns to the river system. Most of the annual storage is released as priority for irrigation and not for hydropower generation.

Water productively in Pakistan is very low as compared to various other countries of the World with similar land and agro-climatic environments. Generally water is deficient during critical periods of crop growth, while construction of storage reservoirs provided some flexibility in meeting crop needs as per requirements. In some countries the large storage facilities have provided flexibility which helps in pre-determined agronomic practices and water requirements. This has largely facilitated in managing and providing water as per actual requirements, thereby achieving higher water productivity. This is primarily due to non-availability of optimal quantities of water during critical growth periods. Various

studies carried out by national and international experts have indicated that in Pakistan crop yields of farmers who can ensure availability of water through tubewells or other sources, are much higher (150 to 200 percent) as compared to farmers who can not meet optimal crop water requirements and depend only on inadequate rotational canal supplies.

WATER STORAGE AND NATIONAL ECONOMY

Storage of water in the reservoirs has played major role in the national economy by transferring surplus Kharif flows to Rabi season and through cheap hydel generation. Another big advantage is that there has been large additional recharge to aquifers. Nearly 50 percent of canal supply is recharged to groundwater reservoir during transit from the canal head to field. The major part of recharge is recovered through pumping, which has been used for bringing new areas under cultivation, to supplement deficient canal supplies and to provide water to crops during stress periods.

After the construction of Tarbela Dam, no major project in water sector was initiated. Only one hydel project i.e. Ghazi Barotha in power sector was undertaken in 1995 and completed in 2004. In view of shortage of power, in early 1990, agreements were made with IPPs, for the installation of thermal generation stations. Although installation of power units through IPPs has helped in meeting the power shortage but abnormally high power rates have badly affected the domestic and industrial consumers. The cost of industrial production has increased which has adversely affected export potential of Pakistan. The additional financial burden to WAPDA for payment to IPPs is over Rs. 120 billion/year which is further compounded by the higher international fuel rates and the base price of Rs. 5,500/Mt at which it has to be supplied to IPPs as per agreement. The additional burden on account of fuel charges alone has increased to about Rs. 40 billion/year. The high power rates and water scarcity are primarily due to the fact that no major storage and hydel generation, Pakistan can become exporter of cereals and competitive in Industrial production. The provincial concerns that arise during late Rabi and early Kharif are bound to increase with time because of progressively higher requirements, which could be avoided by utilizing surplus Kharif flows. It has been estimated that without management of water resources, Pakistan will have to spend about \$ 5.7 billion per year on the import of food by the year 2025.

WAPDA's VISION 2025 PROJECTS

After completion of Tarbela Dam project since 1976, the development of water storages has been at stand still. Although ranking study of all Projects on river Indus & its tributaries was carried out in early eighties and Detailed Engineering Design & Tender Documents of Kalabagh Dam Project were prepared in mid eighties yet no project came up for implementation. Storage capacity of online reservoirs is reducing due to siltation. The present storage capacity is only 11% of total surface flows.

The installed hydropower is only 16% of the total identified potential (40000 MW). In nineties private thermal power projects were inducted in the generation

system. Although this eliminated the load shedding yet disturbed the hydel thermal ratio from 65:35 to reverse (32:68). Fossil fuel being imported the electricity became expensive. The Independent Power Producers (IPPs) which supplied about less than one third of the total power supply of WAPDA had to be paid more than half the revenue of WAPDA.

The drought, which started in 1999 continued for more than three years. Severe water shortages were experienced in the irrigation system. Realizing the situation WAPDA prepared a 25 years programme of development of Water and Power resources of Pakistan to achieve the following objectives;

- To meet the agricultural and urban water demands of the growing population.
- To increase productivity by bringing more area under cultivation.
- To make up the storage lost due to sedimentation.
- To mitigate the effects of drought.
- To inject cheap hydropower in the system to keep the cost of electricity within affordable limit.
- To support economy and poverty alleviation in backward areas.
- To encourage private investment.

Under WAPDA's 'Vision 2025' programme; the following projects are under construction:

Water Sector Projects

- Gomal Zam Dam
- Mirani Dam
- Raised Mangla Dam
- Satpara Dam
- Kurram Tangi Dam
- Greater Than Canal
- Kachhi Canal
- Raineer Canal

Hydro Power Project

- Jinnah Barrage
- Allai Khwar
- Khan Khwar
- Duber Khwar
- Golen Gole
- Neelum Jhelum
- Low Head Hydro Power Project

The following projects are under various phases of study:

- Basha Diamer Dam Project – Feasibility, Detailed Design & Tenders are in progress
- Akhori Dam Project – Feasibility Study completed
- Kurram Tangi – Feasibility Study completed
- Sehwan Barrage – Feasibility

- Chashma Right Bank Canal Lift Scheme – Feasibility and Designs completed
- Bunji Hydro Power Project – Pre-feasibility completed
- Dasu Hydro Power Project – Pre-feasibility in progress
- Skardu Dam – Pre-feasibility in progress
- Nai Gaj – Feasibility Study in progress

Locations of projects shown in Figure 8. Recently Government of Pakistan has announced the construction of 5 large dams i.e. Basha Diامر, Kalabagh, Akhori, Kurram Tangi and Munda upto 2016.

CONCLUSIONS AND RECOMMENDATIONS

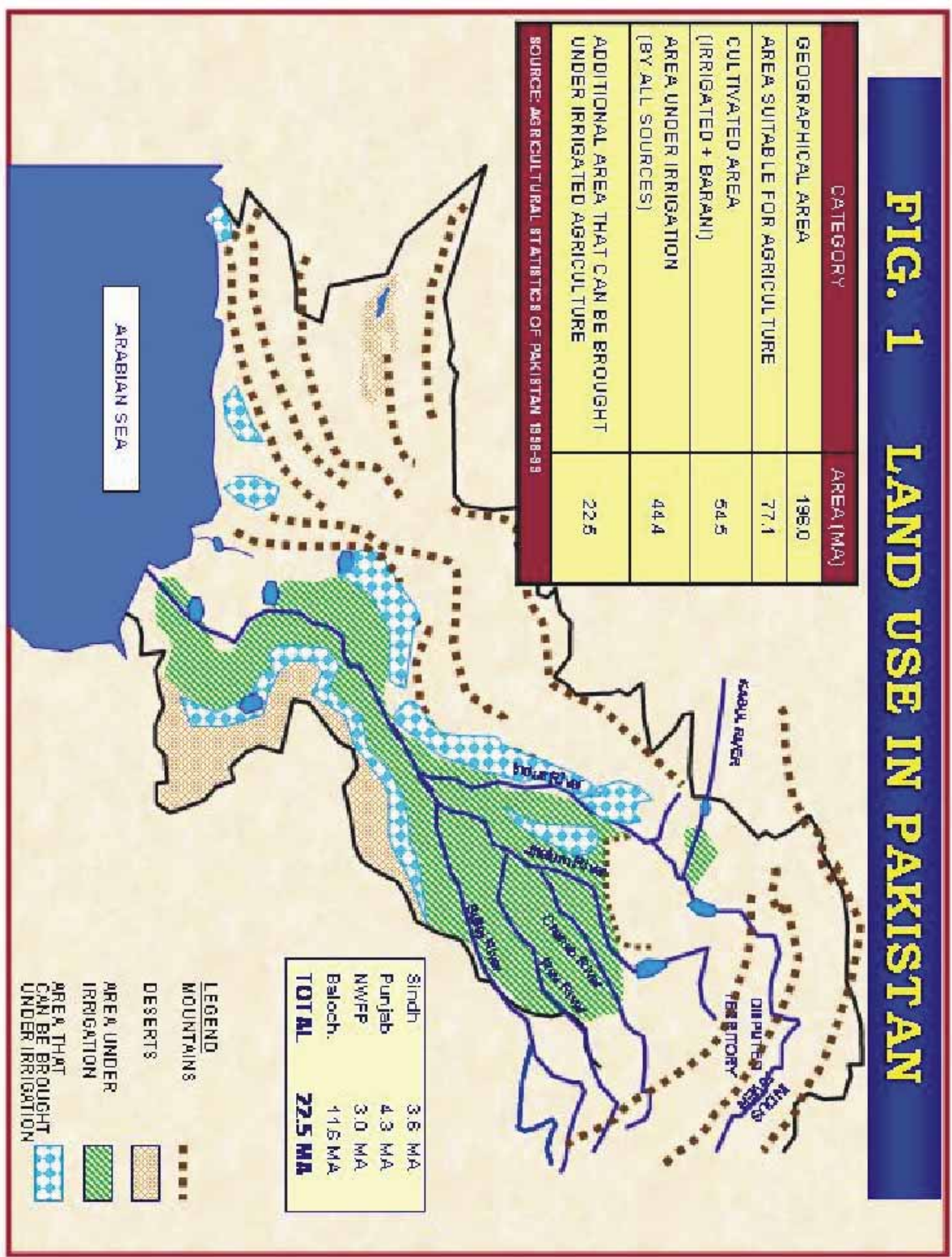
- Existing Dams have greatly facilitated in meeting water requirements for agriculture and cheap hydropower for industry. Existing reservoirs since their construction have supplied 480 MAF of stored water while nearly 951 MAF has gone to the sea below Kotri during the same period, indicating availability of surplus flows for storage.
- Highly skewed availability of river flows dictates that seasonal and annual requirements of irrigation can only be met through storage during surplus flows.
- Pakistan's economy can be propelled into the future only through building new water projects and canals. Timely commissioning of these projects would largely meet the major part of water and power essentially required for sustainability of agriculture and other sectors.
- During low flow period, the farmers resort the excessive groundwater exploitation resulting in pollution of aquifers and abnormal lowering of water table levels. This necessitates that adequate quantity of canal flows be made available to the farmers by constructing additional storages.
- All the feasible projects, identified in WAPDA's Vision 2025 be completed within the stipulated period to combat increasing shortage of water, food and power.

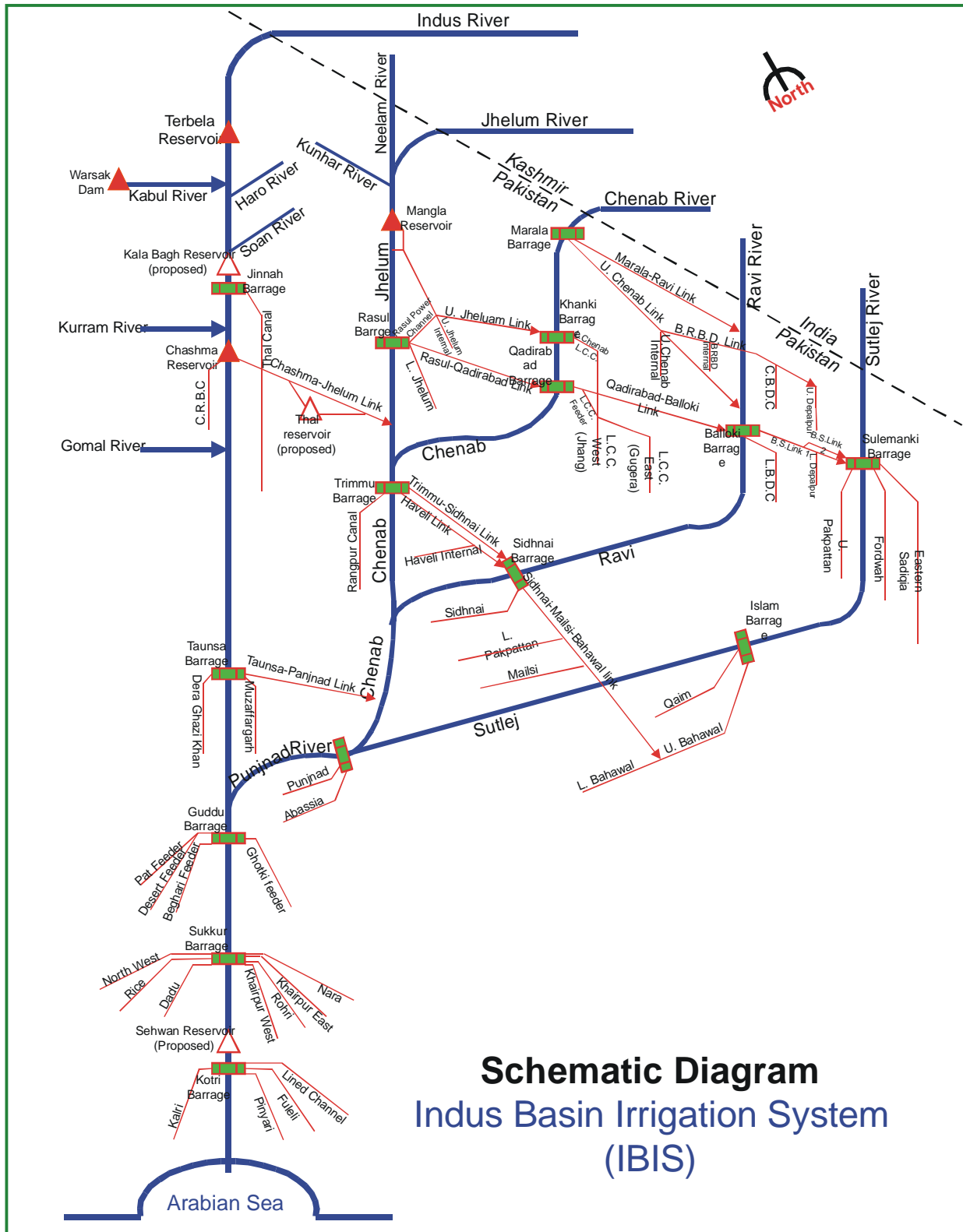
REFERENCES

1. WAPDA Annual Report 2004-05
2. Water Resources and Hydro Power Development Vision-2025 (WAPDA 2002)
3. Kahlowan, M.A. and Majeed, A (2004) Pakistan Water Resources Development and Management, Pakistan Council of Research in Water Sources, Islamabad, September, 2004
4. President of Pakistan Address to the Nation on Jan 18, 2006
5. MINFAL (1998-99) Agricultural Statistics of Pakistan, Ministry of Agriculture, Food and Livestock, Islamabad, Pakistan

6. Federal Flood Commission (2002) Annual Report, Federal Flood Commission (FFC), 2002
7. Government of Pakistan (2003) Economic Survey of Pakistan, 2002-2003, Ministry of Finance, Government of Pakistan, Islamabad, 2003

FIG. 1 LAND USE IN PAKISTAN





ESCAPAGE BELOW KOTRI

(HYDROLOGICAL YEAR FROM APRIL TO MARCH)

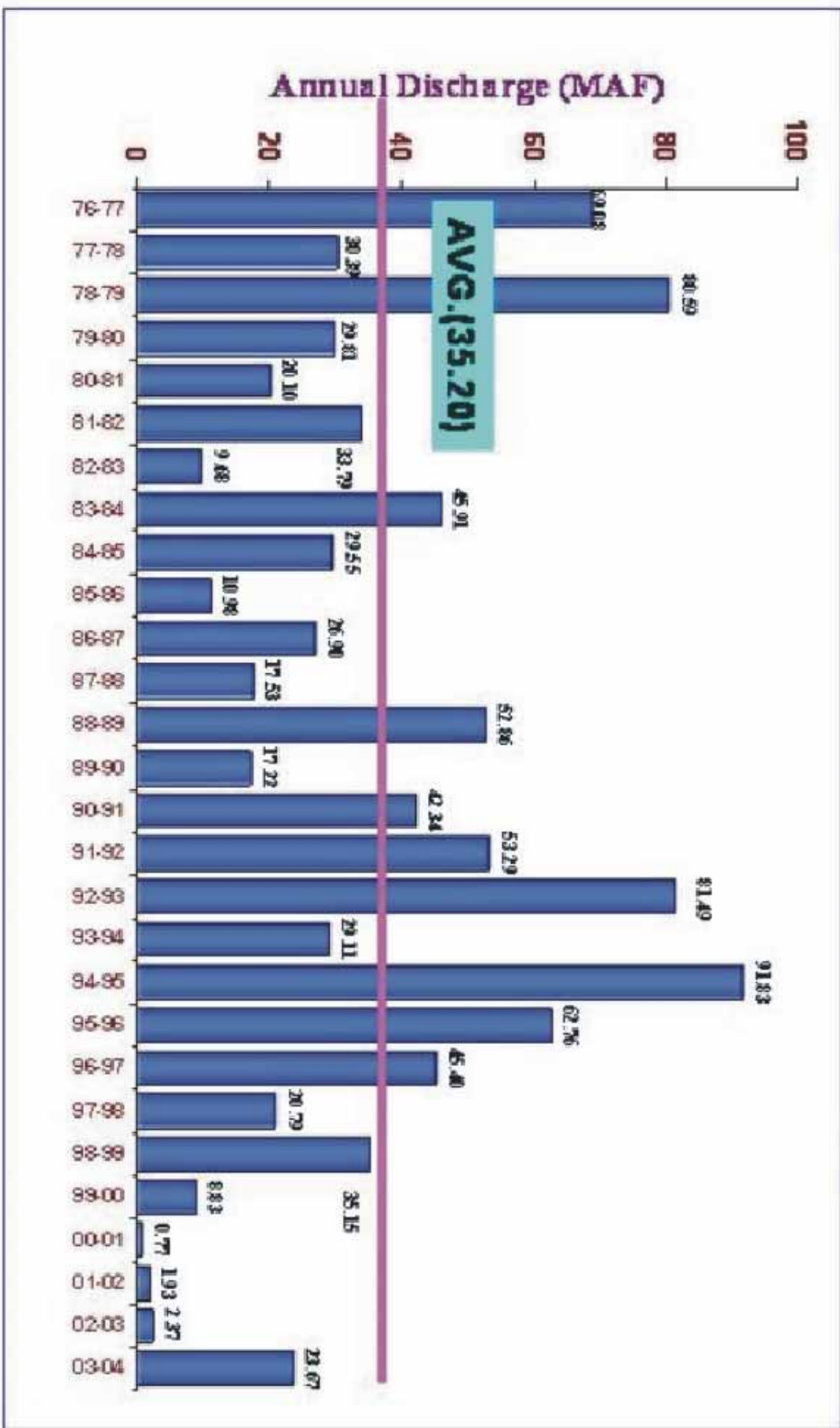
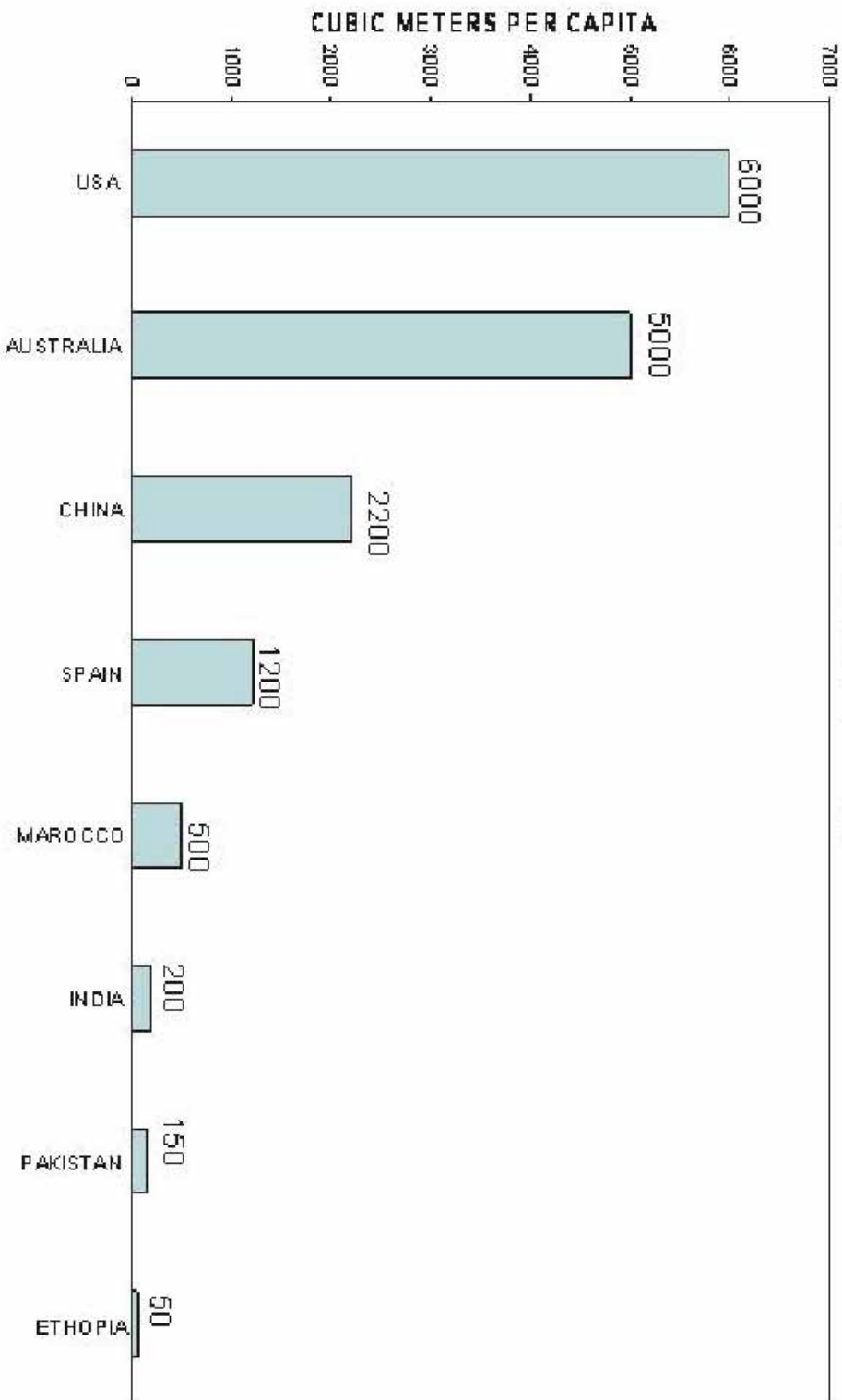


FIG. 4 - STORAGE PER CAPITA IN DIFFERENT COUNTRIES



SOURCE: Pakistan Country Water Resources Assistance Strategy Report, World Bank, November 2005

FIG.5 - DAYS OF AVERAGE FLOWS WHICH RESERVOIRS IN SEMI-ARID COUNTRIES CAN STORE IN DIFFERENT BASINS

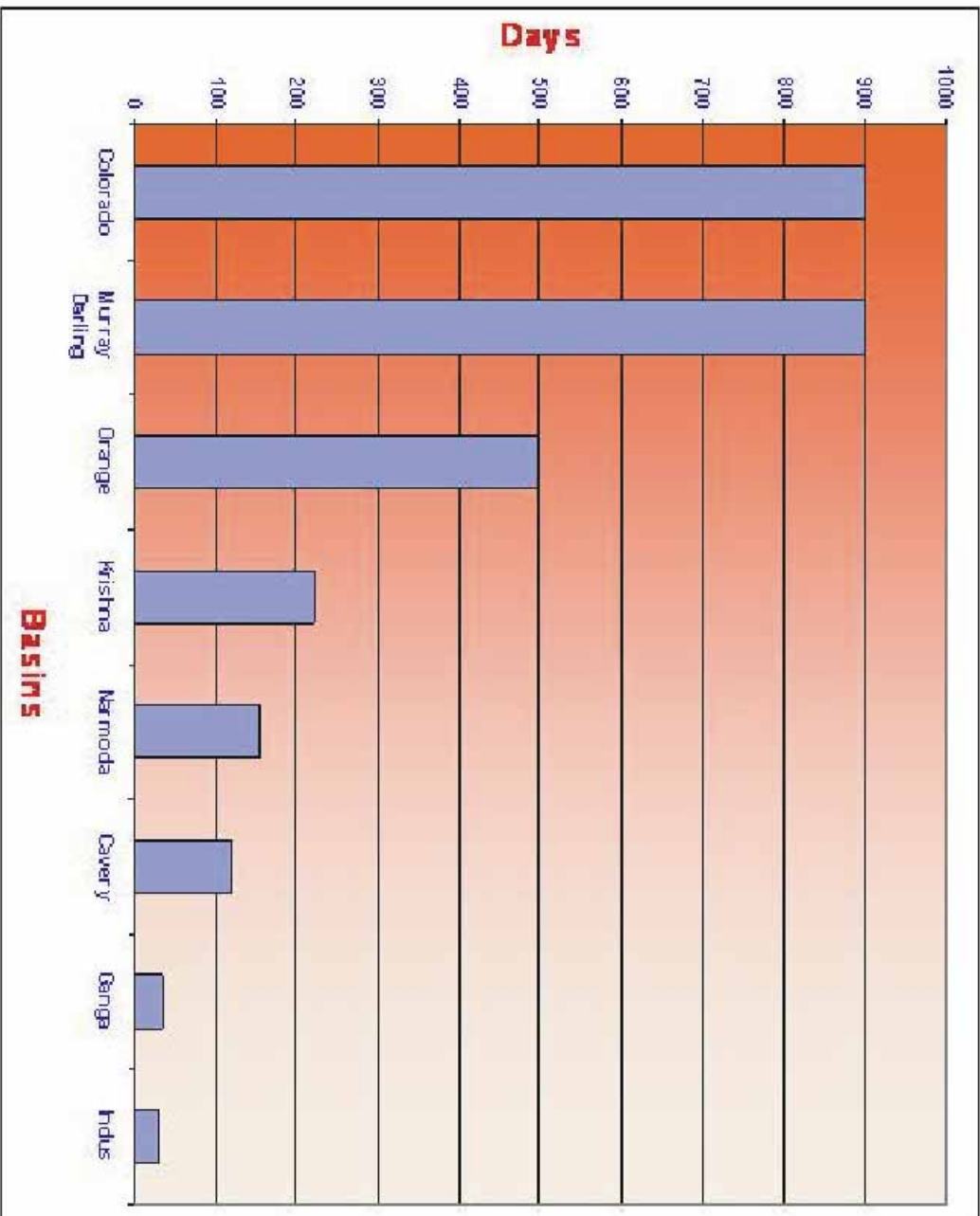
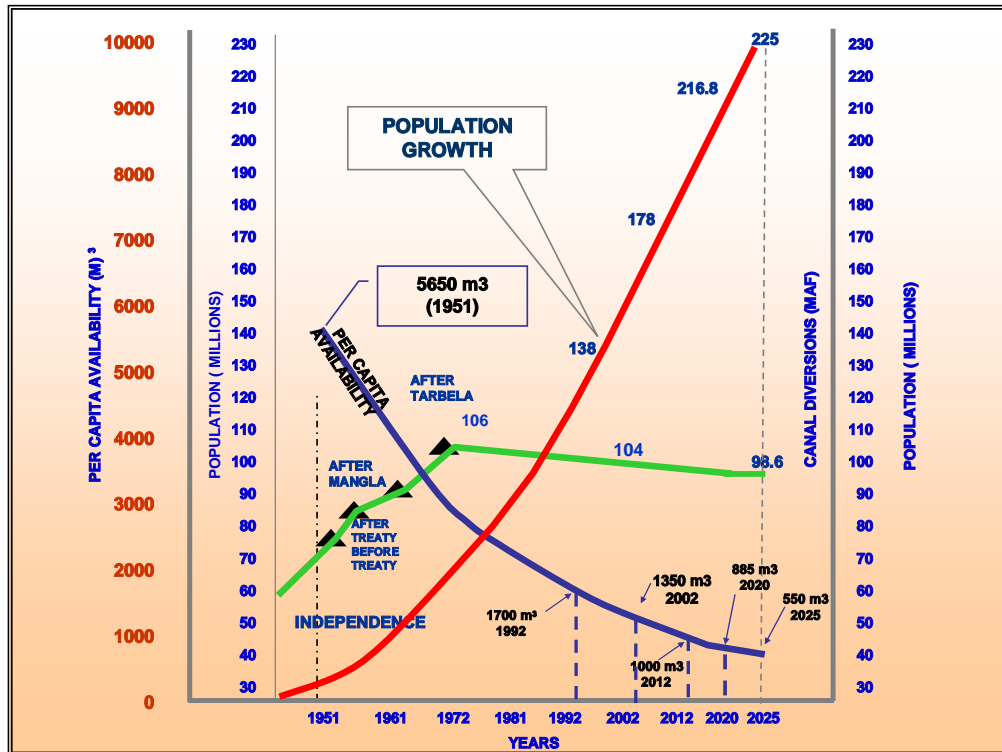


FIG. 6 - CANAL WATER DIVERSION Vs POPULATION GROWTH



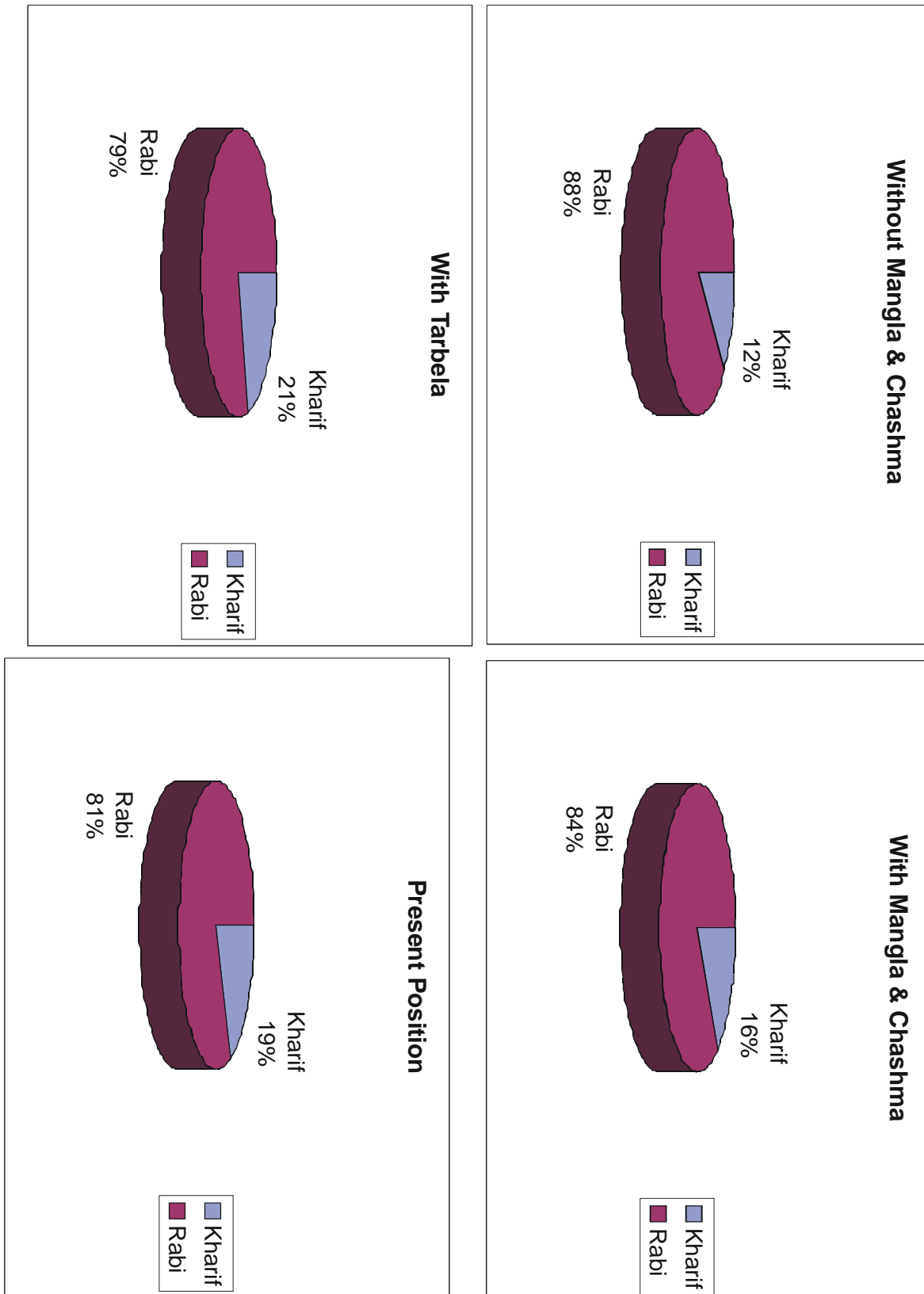


Figure 7: Seasonal carry over from Kharif to Rabi

