ROLE OF ENGINEERS IN ECONOMIC DEVELOPMENT AND POLICY FORMULATION

By

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Abstract

Arranging tree branches to create shade or throwing log across a stream to use as a bridge are examples of primitive engineering. Basically human beings have in-built sense of engineering to create convenience and to improve the quality of life. It were the engineers who built the city of Harappa and Mohenjo Daro and these civilizations flourished from agriculture produce providing food and fibre. Engineers at that time had built inundation canals for agriculture and boats for navigation. As the civilizations developed and scientific progress was made in the electrical and mechanical fields, generation of energy became equally important for development of economy. Pakistan has abundance of resources available ready to be harnessed in the field of hydropower, thermal, solar and wind energy.

This paper highlights the challenges faced by Pakistan in development of water and agriculture resources of the country and opportunities available for the engineers to play a lead role to harness the untapped resource and revive the national economy.

1. GENERAL

The civilizations have progressively developed over the centuries and man has learnt to adapt with changing needs and environment. In the beginning man used to live in caves eat whatever food was available in the wild. With the ever accumulating experience his mental abilities increased and soon he learnt to live in communities and produce food by rain fed agriculture. With further progress these agricultural farmlands were supplied water through inundation canals using tools and techniques developed in a parallel home industry. Later on as knowledge about land, water and crops grew, essential infrastructure was developed to control and transfer water for agriculture to enhance production. Agriculture and the related industry thus developed side by side supporting the backbone of communities. The infrastructure requirement was fulfilled by engineers who conceived, prepared and implemented these projects. This is how over time, engineers have played their role in the economic development of their countries. This should be true even today for Pakistan.

2. ECONOMY

2.1. According to the Oxford Dictionary, 'Economy' is defined as the state of a country or region in terms of the production and consumption of goods and services and the supply of money. A given economy is the result of a set of processes that involves several factors including, technological evolution, social organization, political structure legal systems, as well as its natural resources.

2.2. Gross domestic product (GDP) is an important indicator of a country's economy. It is the market value of all officially recognized final goods and services produced within a country in a given period of time. GDP per capita is often considered an indicator of a country's standard of living. Higher growth in GDP improves the economy. Global ranking of some countries on the basis of GDP and GDP per capita is shown in Table-1 below.

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TABLE-1: GLOBAL RANKING ON THE BASIS OF GDP & GDP PER CAPITA

GDP			GDP PER CAPITA*		
Rank	**Country**	**GDP (US$ Billion)**	**Rank**	**Country**	**US$**
1	United States	16.2	1	Luxembourg	106,400
2	China	8.2	2	Qatar	104,800
3	Japan	6.0	3	Norway	99,200
4	Germany	3.4	9	Singapore	52,100
5	United Kingdom	2.5	10	United States	51,700
10	India	1.8	23	United Kingdom	39,200
16	Indonesia	0.9	34	South Korea	22,600
17	Turkey	0.8	63	Malaysia	10,300
35	Malaysia	0.3	138	India	1,500
36	Singapore	0.3	142	Pakistan	1,300
44	Pakistan	0.2			

* rounded to the nearest hundred Source: Wikipedia - A list by IMF (2012)

United States, China and Japan top the list of World's largest economies. Pakistan ranks at No.44

Since the GDP per Capita figure is greatly influenced by population the ranking of Pakistan on this basis drops to 142 with India at No. 138. Malaysia ranks 63, USA at No. 10 and Singapore at No.9 on GDP per capita global standing. It is notable that most of the countries have raised their per capita GDP through industrial growth and efficient management of resources. The President of Indonesia and the Prime Ministers of Malaysia, Singapore and Turkey were engineers when these countries, made maximum progress.

2.3. Pakistan's economy grew at a fairly impressive rate of 6% per year through the first four decades of the nation's existence. Per capita incomes doubled, inflation remained low and poverty reduced from 46% down to 18% by the late 1980s. Pakistan became one of the four fastest growing economies in the Asian region during 2000-07 with its growth averaging 7.0 per cent per year for most of this period. As a result of strong economic growth, Pakistan succeeded in reducing poverty by one half, creating almost 13 million jobs restoring investors' confidence.

2.4. Why is it that Pakistani economy has done well under military governments and performed poorly when led by politicians? Dr. Mahbub ul Haq explained the corrosive impact of political patronage on economy in Pakistan as quoted in a recent book "Pakistan-A Hard Country" as follows;

"Every time a new political government comes in they have to distribute huge amounts of state money and jobs as rewards to politicians who have supported them and short term popular measures which leaves nothing for long term development. That is why only technocratic, non-political governments in Pakistan have ever been able to increase revenues. But they cannot stay in power for long."

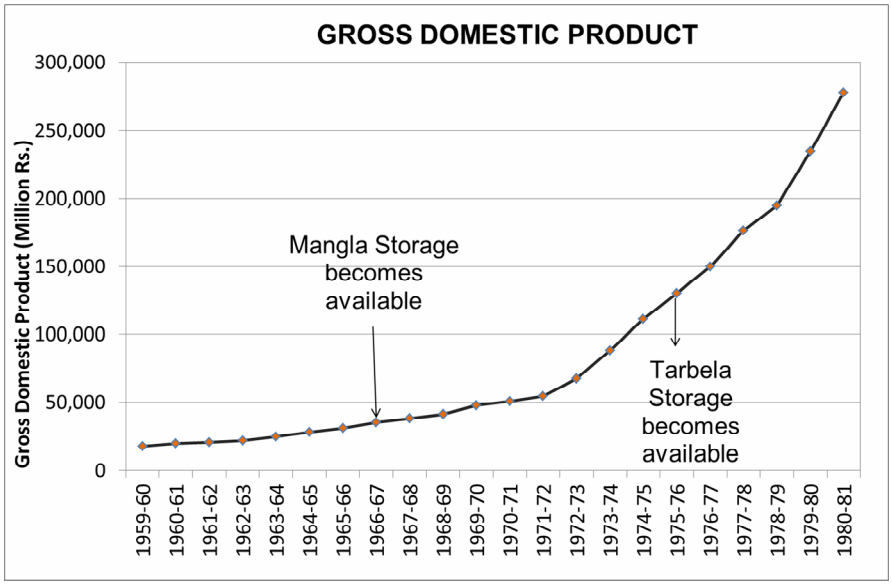
2.5. Despite peaceful elections in 2008 and a smooth transition to a new government, political instability persisted. A crisis of confidence intensified as Investors and development partners started to walk away. The stock market nosedived, foreign exchange reserves plummeted and the Pakistani rupee lost one-third of its value. While the country was moving rapidly towards the IMF, the economy suffered yet another major jolt from the widespread devastation caused by recent floods in the year 2010.

3. NATIONAL DEVELOPMENT CHALLENGES

3.1. During 1960s and 1970s the multipurpose projects of Mangla Dam and Tarbela Dam were built and important infrastructure of irrigation system was rehabilitated, modernized and supplemented and engineers played a vital pivotal role in this. These projects provided additional water supply of 17 MAF for agriculture. Power generation increased by 7,500 MW during this period. Resultantly, the production of industrial goods increased which enhanced economic progress and improved the quality of life. This is also reflected in GDP growth. (See Figure below)

Construction of additional storage facilities would boost the economy further. The proposed projects of Diamer Basha Dam, Kalabagh Dam and Shyok River Dam should be implemented without further delay.

3.2. With the population growing at a fast rate of over 3%, the demand for food & energy has been increasing at much accelerated pace which could not be adequately addressed during 1980s and 90s. By the year 2001 the Vision-2025 Program was prepared for building new projects in the Water & Power sectors. It was planned to store 58 MAF water and produce 40,000 MW of electricity by the year 2025. Soon after its approval this program was taken up by launching several Fast Track Projects in the first phase. Because of the shortage of funds, the second phase of the program has not been implemented as per envisioned schedule. There is urgent need to review this program and decide fresh ranking of projects for implementation. WAPDA has identified 33 hydropower projects and four canal projects for implementation in the coming decades. Feasibility reports are ready for 14 projects. Proper sequencing and ranking of these projects for construction is very important for maximizing the benefits. This ranking should consider the project readiness for implementation, its contribution of water and power supply to the national networks, conjugate operation with its upstream and downstream projects along with its geologic difficulties and sedimentation impacts. For these considerations the engineer has a greater role to make decision for project rankings.



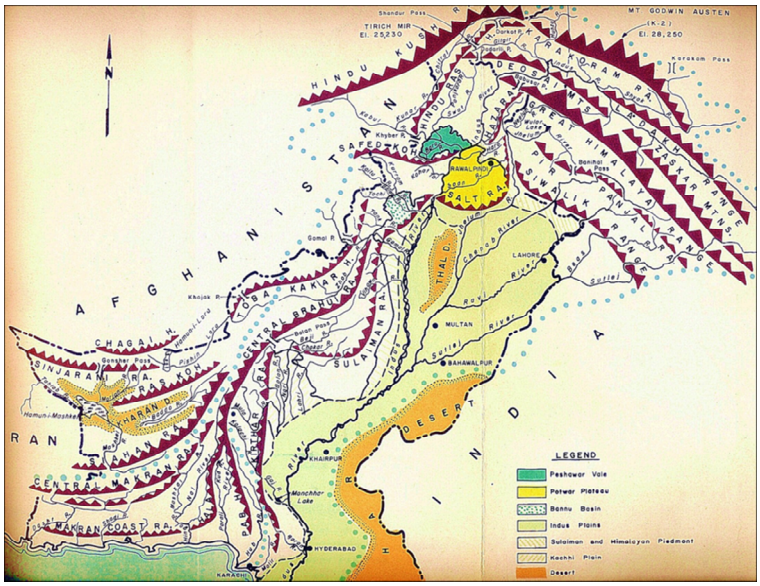
It is prudent that Engineers should plan and decide the ranking for construction of future projects and the politicians should rigorously work for the procurement of needed foreign funds and for the removal of domestic hurdles and taking stake holders into confidence.

4. IRRIGATED AGRICULTURE

The Indus Basin has the soils, topography and climate that make it suitable for multi-seasonal agriculture. Major agricultural areas lie within the Indus Plains which run in a general North-East/South-

West direction. The system is like a funnel (see figure below) with numerous sources of water at the top converging into a single stream which flows into the Arabian Sea.

PHYSIOGRAPHY OF PAKISTAN



5. IMPORTANCE OF AGRICULTURE IN NATIONAL ECONOMY

Agriculture has been, and continues to be the most vital sector of the economy of Pakistan, despite the fact that the share of agriculture in gross domestic product (GDP) has fallen from 53% in 1947 to about 23% in 2012. Irrigated agriculture covers 85% in terms of total cultivated area and provides for 90% production of food and fiber.

Agricultural exports account for about 70% of total foreign exchange earnings, while agricultural imports constitute about 30% of the total foreign exchange earnings. Furthermore, it remains the (i) principal source of income for about 70% of the total population (ii) major supplier of raw materials for industry and (iii) the biggest consumer of production of non-agricultural sectors.

The industries like textile, sugar, oils and food items all need agricultural produce as basic resource. The energy is equally important. All industrial units need electricity but it is continuously in short supply. The country is hard pressed under the burden of load shedding. Only an intelligent planning and speedy implementation of large size water storage and power projects can save the nation out of prevailing turmoil and provide a reasonable quality of life.

6. IMPORTANCE OF WATER RESOURCES DEVELOPMENT IN THE NATIONAL ECONOMY

6.1. In view of the importance of irrigated agriculture, the water resources development scene has been dominated, to the exclusion of all others by the needs of irrigated agriculture. Adequate and timely water supply is the prime most need. For the post Indus Water Treaty period (1961-2013) combined average annual flow of Western rivers is 130.5 MAF. Since the year 2000 (upto 2011) the average annual rim-station inflows have been lesser i.e. 120 AF (Table-2).

TABLE-2

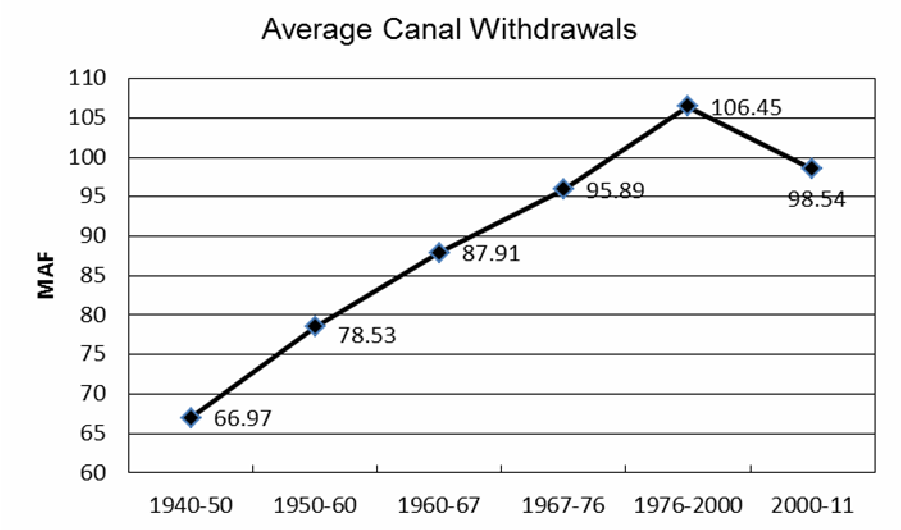
INFLOW AT RIM STATIONS AND CANAL WITHDRAWALS

Year	Inflow at Rim Stations (MAF)	Canal Withdrawals (MAF)	Additional Storage
1961-62	134.77	82.86	
1962-63	108.95	85.78	
1963-64	132.79	89.45	
1964-65	138.53	89.90	
1965-66	136.10	91.23	
1966-67	140.15	95.54	Mangla
1967-68	145.46	95.22	
1968-69	139.66	98.28	
1969-70	139.80	98.22	
1970-71	112.06	89.26	
1971-72	106.61	89.26	Chashma
1972-73	129.57	103.22	
1973-74	166.86	98.62	
1974-75	94.69	89.03	
1975-76	136.33	100.90	
1976-77	130.27	99.29	
1977-78	122.12	105.18	Tarbela
1978-79	150.10	99.14	
1979-80	124.27	107.58	
1980-81	125.85	109.91	
1981-82	130.49	104.37	
1982-83	112.62	105.81	
1983-84	139.40	103.03	
1984-85	125.51	103.61	
1985-86	109.79	98.84	
1986-87	136.26	108.35	CRBC Stage I
1987-88	131.46	111.63	
1988-89	149.85	107.62	
1989-90	124.09	104.59	
1990-91	153.64	112.26	
1991-92	161.70	112.48	
1992-93	159.34	103.92	
1993-94	119.40	110.59	

1994-95	152.86	97.47	CRBC Stage II
1995-96	146.13	105.36	
1996-97	149.72	114.10	
1997-98	130.44	106.16	
1998-99	138.70	113.70	
1999-2000	117.68	109.71	
2000-01	96.22	89.21	
2001-02	91.24	82.63	
2002-03	111.68	96.45	
2003-04	131.06	106.11	CRBC Stage III
2004-05	108.37	90.78	
2005-06	141.83	109.44	
2006-07	136.05	102.66	
2007-08	119.74	107.47	
2008-09	113.37	100.05	
2009-10	117.69	101.93	
2010-11	152.39	97.22	
Average	***130.47***	***100.71***	
Maximum	***166.86***	***114.10***	
Minimum	***91.24***	***82.63***	

Source: WRMD, WAPDA

6.2. The post Water Accord (1992) average canal head withdrawals have been about 103 MAF which is 79% of annual Average River flows. The canal withdrawals progressively increased over the last 60 years but during the last decade there has been a significant decrease. It is considered that this decrease is mainly due to climate change and drought conditions (see graph). One can apprehend future repetition of low flow periods for which there is compelling need to appropriately plan the sharing of deficits among the provinces.



The canal withdrawals for post Mangla and post Tarbela period show increases because of the availability of additional capacity from storages. This trend was halted by about 1990 where the progressively increasing storage losses due to sedimentation over took the net effect of Mangla and Tarbela storages. The latest (2012) value is only about 98.5 MAF. To increase the canal withdrawals, construction of additional storage dams is necessary where engineers' role is of paramount importance.

6.3. It is estimated that by the year 2025, total requirement for urban, rural domestic, commercial, industrial and livestock will increase from the present 8% to around 12% of river flows. This will further adversely impact the water availability. Currently and for the foreseeable future, irrigation demands shall dominate the water demand.

7. NATIONAL CHALLENGES

7.1. Population

The population of Pakistan nearly doubled over the first half of this century, from 16.6 million in 1901 to 32.5 million in 1947 and has increased to 184 million by 2013. Increasing population demands more food and hence more intensive irrigated agriculture which in turn requires planning and provision of more storage both from surplus seasonal flows and surplus yearly flows. Wheat production has hardly kept pace with population growth. The canal withdrawals which facilitate wheat production have shown a declining trend during the last decade. This negative impact was compensated by progressively increasing the irrigation supplies from tubewells but the number is now approaching its ceiling. Only additional storages can help arrest this trend.

7.2. Rainfall

Pakistan is an arid country. The rainfall over most of the agricultural area of the Indus Plains averages only 9 inches per year. In the Northern Area, the Kohe-Sufaid zone and windward slopes of the Himalayas including the Murree Hills, receive 30 to 40 inches of rain. In the Indus Plains the annual rainfall decreases from the foothills of Himalayas to the south with 32 inches at Sialkot, 25 inches at Lahore 6 inches at Multan and 3.5 inches at Nawabshah. Further south, it increases towards the coast with 7 inches at Hyderabad to 12 inches near the south west coast.

Balochistan is the driest part of Pakistan fed by food produced in the Indus plains with an average annual rain of only about 2 inches and has to be fed by food grains produced in the Indus plains.

7.3. Snowfall

The bulk of snow fall, nourishing the glaciers in the Hindu Kush, Karakorum and Himalayas derives its moisture from westerly winds, during the winter. However, even in summer large quantity of precipitation falls as snow. Topography largely determines where snowfall occurs. Two outstanding factors are; the great variation of snowfall with altitude and the altitudinal migration of melting temperatures over the hydrological year. These two factors combine to ensure that only a fraction of whole Upper Indus Basin probably less than 30% contributes an estimated more than 80% of the river's flow.

In essence, all the hydrological action takes place in the zones above 8,200 ft (2,500 m) above mean sea level. Below 8,200 ft. there is generally little precipitation and high evaporation.

Much of the snow in area extent disappears before the rivers show an appreciable increase in flow. This reflects thinning of the cover below 11,500 ft. (3,500 m) above sea level. This means that much of the melt here is lost to evaporation. The main summer period of river flows commences as melting reaches the ablation zones. Monitoring of annual changes in snow and ice cover is therefore very important for Pakistan.

7.4. Glaciers

The upper Indus catchment has numerous glaciers. Those exceeding 6km have an aggregate length of 1,800 km, and represent only a third of the glaciers in the watershed. They are great natural storage reservoirs that feed and regulate the Indus and its tributaries. Because cloud cover restricts snow melt, the more it rains or snows, the more they conserve, but when the weather changes, the moving glaciers and the dynamic avalanches release the stored waters.

Other large glaciers such as Siachen 72 km, Hispar 62 km, Biafo 60 km, Braldo 56 km and the numerous smaller glaciers and extensive ice fields may be holding, in aggregate, more than a billion acre feet (1.233 Billion m^3) of water. Tarbela and Mangla reservoirs with a total live storage of about 15 MAF (18 Billion m^3) are miniatures compared to these natural reservoirs.

7.5. Characteristics of the River Flows

The Jhelum river rises early and at a fast rate compared to the Indus. The rise in the flow of Chenab river is at a slower pace than the Jhelum and Indus. All the rivers are in spate during July and August, the snow-fed because of summer temperatures, and the rain-fed due to the monsoon rains. The flows in the western rivers (at rim station) are quite variable from year to year and against the longer average annual figure of 139 MAF the maximum recorded in 1959-60 was 186.79 MAF and the minimum in 2001-02 was only 97 MAF.

The variability in the river flows is equally marked during both the Kharif (Summer) and Rabi (Winter) season. There is also a great imbalance between the Kharif and Rabi flows. The Kharif inflow averages about 115 MAF which is over 5 times the Rabi inflows at about 22 MAF. Most canals are designed to divert and convey irrigation supplies available from summer flows. Much of this capacity becomes redundant in low flow periods of winter and can only be utilized by storage of surplus summer flows to be released in winter season for Rabi crops.

7.6. Groundwater

Groundwater in Pakistan is an important resource for irrigation as well as domestic and industrial supplies. The Indus plain comprises alluvium predominantly silts and sands to depths in excess of 1,000 feet in Punjab and Upper Sindh tapering down to some 200 ft in lower Sindh.

Groundwater under the Indus irrigation system is plentiful, however quality is a constraint. About 81% of this area is in Punjab. Development of this resource, mainly by private tube wells (now about 1.075 Million) accounts for a gross annual abstraction of about 50 MAF (Table-3).

TABLE-3
GROUND WATER USAGE FROM TUBEWELLS

(Million Acre-Feet)

Year	Ground Water			
	Public T.Wells	Private T.Wells	Scarp T.Wells	Other Private T.Wells
1992-93	12.56	33.92	-	-
1993-94	12.66	34.79	-	-
1994-95	12.76	35.66	-	-
1995-96	12.86	36.53	-	-
1996-97	12.96	37.40	-	-
1997-98	1.93	38.27	-	-
1998-99	1.93	38.63	10.51	0
1999-00	1.93	38.27	9.71	0
2000-01	1.93	39.35	9.27	0

2001-02	1.93	39.71	8.65	0
2002-03	1.93	40.08	8.01	0
2003-04	1.93	40.08	8.01	0
2004-05	1.93	40.08	8.01	0
2005-06	1.93	40.38	8.01	0
2006-07	1.93	40.38	8.01	0
2007-08	1.93	39.98	8.01	0
2008-09	1.93	39.98	8.01	0.4
2009-10	1.91	40.50	7.00	0.8
Average	**4.94**	**38.56**	**8.43**	**0.10**

Source: Agricultural Statistics of Pakistan (2009-10) GoP, Ministry of Food & Agriculture (Economic Wing) Islamabad.

Over the past 20 years groundwater use has been a major factor in raising agricultural production. Groundwater tube wells not only supply additional water but have provided flexibility to match surface water supplies to crop water requirements. Because of uncontrolled (and rapid) private sector development of groundwater (6% annual growth) there is a danger of excessive lowering of water tables and intrusion of saline water into fresh-water aquifers. Control and regulation of ground water mining is urgently required.

In most areas the development has reached the equilibrium point between mining and recharge with very little potential for further development. Specific studies are required to define this potential more accurately.

There is also some potential for recovery of irrigation losses in saline groundwater areas by means of interceptor drains, scavenger wells and other special means.

In certain areas lining of canals and water courses has been taken up to enhance water conveyance efficiency and reduce seepage losses but this has negative impact on water recharge for the groundwater reservoirs.

7.7. Water Accord 1991 Allocations

There is a long history of management of river flows for irrigation uses, starting from Tripartite Agreement in 1920 to the Fazal-e-Akbar Committee report in 1970.

Following the Fazal-e-Akbar Committee Report the Government of Pakistan took the first decision of adhoc distribution of storage water from Chashma Barrage completed in 1971. Later when Tarbela Dam was completed in 1974, its reservoir storage was also included in the Adhoc distribution arrangement.

Adhoc distribution arrangements continued till resolution of the water dispute among provinces through Water Allocation Accord (WAA) 1991. This also envisaged establishment of an Indus River System Authority (IRSA) for implementation of the provisions of WAA among the four provinces. Under an Act of the Government of Pakistan, IRSA was established in January 1992 and has since assumed the basic responsibility of overseeing the distribution of river waters among the co-sharers in accordance with WAA. During water short years, conflicts arise among the provinces over sharing of deficits and IRSA engineers have to face the challenge of providing fair and equitable solutions. The IRSA should be strengthened to meet these challenges.

7.8. Gradual Siltation

On completion of Mangla Dam in 1967 its live storage capacity of 5.34 MAF was made available for sharing by the provinces. In 1971 the Chashma Reservoir provided an additional 0.72 MAF and when Tarbela Dam was completed in 1976 another 9.68MAF was added to the annual storage capacity. As such a total storage capacity of 15.75 MAF was available at the time of construction of these reservoirs (Table-4).

TABLE-4
REDUCING STORAGE CAPACITY
DUE TO RESERVOIR SEDIMENTATION

RESERVOIR	LIVE STORAGE CAPACITY (MAF)		STORAGE LOSS (MAF)	
	ORIGINAL	YEAR 2012	YEAR 2012	YEAR 2025
TARBELA	9.69 (1976)	6.58 (68%)	3.11 (32%)	4.16 (43%)
MANGLA	5.34 (1967)	4.49 (84%)	0.85 (16%)	1.16 (20%)
CHASHMA	0.72 (1971)	0.26 (36%)	0.46 (64%)	0.64 (89%)
TOTAL	**15.75**	**11.33 (72%)**	**4.42 (28%)**	**5.96 (37%)**

* Post raising capacity of Mangla Dam shall be 8.24 MAF in 2013.
Source: WAPDA 2013

The live storage capacity created at these three reservoirs has been constantly depleting due to deposition of sediments which is a natural phenomenon. The available live storage has reduced from 15.75 MAF to 11.33 MAF in 2012. An additional storage of 2.9 MAF by raising of Mangla Dam has changed this figure to 14.23 MAF.

This loss in water availability for agriculture has to be compensated by construction of new storage dams on a continual and well planned basis. The additional storages created off line in post-Tarbela period and those online are as shown in Table-5.The Diamer Basha Dam has already been announced and approved by the government and should be urgently taken up for construction.

TABLE-5
ONLINE AND OFF-LINE STORAGES IN POST TARBELA PERIOD

Project Name	Live Storage Capacity (MAF)	Date of Completion	River	Remarks
Mangla Dam Raising	2.90	2009	Jhelum River	Online
Mirani Dam	0.15	2007	Dasht River	Off line
Sabakazi Dam	0.02	2009	Zhob River	Off line
Satpara Dam	0.06	2009	Satpara Lake	Off line
Gomal Zam Dam	0.89	2011	Gomal River	Off line
Total	**4.02**			

Source: WAPDA 2013

Kalabagh Dam was a project to be built after Tarbela but it was engulfed in controversies. The government announced that Kalabagh Dam will be built after developing a consensus among the provinces. Development of consensus needs careful planning and needs to be carried out a project. Time and again the hot 'surface issues' related to Kalabagh have been discussed with stakeholders and their reservations have been addressed through meetings, seminars, newspaper and TV programs but the real problems lay hidden beneath the surface issues and have not been tackled in a mature manner. The misconceptions have been created among the people by certain sections of the society having their own vested interests.

7.9. Irrigated Agriculture and its Difficulties

The cropped area of Pakistan was 21.82 M. Hain 1990-91. By 2008-09 the cropped area increased to 24.12 M. Ha and since then has decreased a little to 22.45 M. Ha in 2012. This decrease may be attributed to rapid urbanization and development of housing societies on cultivable lands.

Pakistan's irrigation and drainage system is now in dire state and suffering from severe and worsening operational problems.

Pakistan's problems are common to many irrigation systems like waterlogging and salinity, over-exploitation of fresh groundwater, low efficiency in delivery and use, inequitable distribution, unreliable delivery, and insufficient cost recovery.

Crop water requirement is influenced by various factors such as cropping pattern, crop varieties, crop duration (sowing and harvesting time), weather and climatic conditions of the area, type of soil, irrigation methods, amount of availability of water, non-water inputs used, size of land holdings etc.

Due to rigid and un-flexible irrigation system, there is a general shortage of water and irrigation supply which do not suffice for meeting the annual crop water requirements of most crops, especially during hot summer months when evaporation is high.

IRSA estimates the water availability for every following season. Provincial Irrigation Departments (PIDs) inform IRSA of their respective water demands at specific locations. WAPDA on receiving the indents from IRSA releases water from reservoirs to meet demands as closely as possible. Limited reservoir capacity of the system does not allow full regulation of rivers for irrigation.

7.10 Operation and Maintenance of Infrastructure

The efficiency of delivery of the canal system is low, ranging from 30% - 60% from canal head to the farm gate. With inefficient water delivery and water use the canal water does not reach users towards the tail-end of the system. Inequity in the distribution of surface water-due to deliveries less than designed levels, poor O & M and even illegal diversion is a major concern. The gap between O & M expenditures and recoveries through water charges is high (44 %) and increasing which is another major concern.

Construction of irrigation system in the Indus Basin was started by the British engineers in the middle of the 18th century. The system has progressively deteriorated because of aging, inadequate maintenance and overstressing of the channels and structures. In most cases the canals have been run beyond their designed capacities in order to meet the enhanced water demand. This affects the channel regime and operational safety of hydraulic structures. The projects for the rehabilitation of canals and ancillary structures should be prepared and implemented preferably in the next two decades.

Many of the hydraulic structures have outlived their useful life and are now susceptible to serious damages. Recent surveys have revealed that many important structures including barrages and canal head works are in precarious state and need urgent rehabilitation. Some projects (Sukkur, Taunsa and Jinnah barrages) have already been taken up whereas others await funding.

7.11 Water Escapages wasted to the Sea below Kotri

A Study entitled "Water Escapages below Kotri Barrage to check Seawater Intrusion," was carried out by a Joint Venture of MWH of Chicago, ACE, and NESPAK Lahore in September 2004.

From the detailed analyses made for this study and historic irrigation uses and distribution of water, the study concluded and recommended the following;

Season	Volume in MAF		
	Dry Year	Average Year	Wet Year
Rabi	0.53	2.11	3.61
Kharif	2.56	3.35	3.63
Annual	3.09	5.46	7.24

Barrages to control sea water intrusion have been built in coastal areas in several countries. Construction of a barrage is therefore considered workable to address seawater intrusion in Indus delta. The present flow scenarios obviate its construction in the near future. A proper feasibility study should be carried out for construction of the project when funds are available.

8. Opportunities

8.1. High Efficiency Irrigation System

In the wake of current and impending future water shortages it is prudent to adopt high efficiency drip irrigation (HEIS) wherever possible in Pakistan. It will not only save on water usage but will also enhance the agricultural production. In this regard, WAPDA has planned the Irrigation Network System adaptable to HEIS for selected Command Areas of some under construction medium size dams. The Provincial Governments should create Directorates of High Efficiency Irrigation System to acquire skill and excellence for operation of the system in the ongoing and future projects. Heavy investments are required for installation of HEIS and its operation. Engineers have to bring down the cost by using indigenous materials.

8.2. Water Transfers from High River Flow Periods to Low Flow Periods

Three storages have been created at Mangla, Chashma and Tarbela to provide seasonal carry over from Kharif to Rabi.

Prior to construction of storages at Mangla and Chashma, the water availability in Rabi & Kharif were 12% and 88% respectively. With storages at Mangla and Chashma, the percentage carry over from Kharif to Rabi was increased from 12% to 16% and after construction of Tarbela Reservoir this percentage further increased from 16% to 21%. The live storage capacity of these reservoirs is constantly decreasing due to sedimentation and the carry over capacity has decreased from 21% to 19% and the live storage capacity has reduced by 4.4 MAF.

The importance of storage reservoirs cannot be underestimated. Data of Canal Head Withdrawals shows that the canal supplies increased with the induction of Mangla, Chashma and Tarbela reservoirs in 1967, 1971 and 1976. In the last ten years alone, an average benefit of about 16 MAF releases from storages have been obtained from these three reservoirs which is more than their combined live storage capacities (see Table-6).

TABLE-6

BENEFITS FROM THE RESERVOIRS

Year	**Releases from the Storage (MAF)**			
	Tarbela	**Mangla**	**Chashma**	**Total**
2002-03	8.58	5.59	3.55	**17.72**
2003-04	8.29	5.30	3.88	**17.47**

2004-05	6.26	3.98	3.82	**14.06**
2005-06	10.11	5.13	3.11	**18.36**
2006-07	8.36	3.97	3.85	**16.18**
2007-08	9.47	5.08	2.32	**16.86**
2008-09	8.42	5.15	3.24	**16.82**
2009-10	8.85	4.69	2.78	**16.32**
2010-11	6.77	4.69	1.71	**13.17**
2011-12	8.01	5.21	1.84	**15.05**
2012-13	6.89	4.39	2.01	**13.29**
Total	**90.01**	**53.17**	**32.11**	**175.29**
Source: WRMD Directorate WAPDA, 2013			**Average Annual**	**15.94**

The average annual releases (2002-13) from the storage were 4.8 MAF at Mangla, 8 MAF at Tarbela and 2.9 MAF at Chashma reservoir.

The overall benefits from these reservoirs after their construction are as follow;

Name / Period	Storage Releases (MAF)	Total Generation Billion Units
Mangla Dam (1967-2012)	209	199
Tarbela Dam (1975-2012)	305	385
Chashma Barrage (1980-2012)	74	-

The above table indicates how storage projects contribute towards the national economy.

9. ALTERNATE SOURCES OF ENERGY

9.1. Pakistan has great potential in harnessing the solar and wind power. These are seldom stand alone projects. The Solar Power project operates during the day when sun is shining and requires storage batteries for power supply in the evening and at night. The battery has short life hence the project requires purchase of new batteries on continual basis. Southern parts of Pakistan have upto 350 sunny days in a year which offers great opportunity to install solar power stations. As a standard 1 Kw panel requires a space of 10 m^2. Lot of inhabited land is available in Sindh, Balochistan and Southern Punjab where large size solar power projects can be established.

The Government has already announced a mega solar project in Cholistan and two large size wind power projects do promise to provide relief in load shedding but not without putting further stress on tariff as both solar and power projects cost higher than hydro and gas power projects. Engineers have the challenging task to bring the costs down.

9.2. Wind Power project works when wind is blowing at its specified minimum velocity. The project therefore has to be supplemented with stabilizers for voltage control. Supplementary thermal project are also required to fill the gaps during low wind flow periods. For wind power projects the coastal areas in Sindh and Balochistan and Potohar areas of Punjab offer big potential.

The engineers should endeavor to develop the alternative energy resources which can contribute to self-sufficiency in power requirement.

10. THAR COAL

At present the total installed capacity of thermal power in the country is 13,794 MW. About half of this generation needs import of furnace oil which is a constant drain on foreign exchange and national economy. World's second largest coal reservoir has been found in Thar desert and awaits extraction and utilization.

Use of indigenous coal for power generation can provide cheaper power and help bring the tariff down. The coal field area is about 140 km long and 5 km wide located east of Mirpur Khas and Naukot in Sindh. The coal seam has thickness of 7 to 36 meters and lies at depths of 115 m or more.

The laboratory analysis has shown that carbon content of coal is about 20%, moisture content about 40-45% and sulphur content about 1 to 1.5%. This type of coal is suitable for running thermal power stations. The extraction of Thar coal and establishment of thermal power stations operating on this coal should be urgently started.

11. VALUE ENGINEERING

11.1 In order to tackle the problems faced by Pakistan we need to address the issues head on by adopting systems and techniques which are being used in the developed countries around the World. One such technique is Value Engineering.

Value engineering is a systematic management technique encouraging creativity and team work to play a key role in selecting the best option and optimizing the project. Value engineering is a process to open the mind to new ideas by breaking down constraints to visualization. It help us break away from old trend and true talent to develop new existing methods, products and intentions to carry us into the future.

Intuitive value engineering can be achieved by very few intelligent and experienced experts but the profession cannot rely on tiny part of the population for creativity and innovation. The engineers try to promote creativity by the synergy of team work. Value methodology is a proven management technique that can greatly help in economic development and policy formulation. Value engineering of large projects can greatly reduce the cost and enhance the benefits. In many countries of the World the project as designed by the project consultants is over viewed by team of expert engineers for its value engineering. The consultancy services for value engineering should be promoted in Pakistan.

11.2 For tackling the energy crises, value engineering would be very useful in selecting the optimal solution. Best use should be made of the available resources. God has bestowed Pakistan with abundant natural resources. Hydropower a renewable resource has a potential of about 50,000 MW out of which only 12% has been exploited. Most of the hydropower projects are long gestation and cost intensive. They are planned as long term projects as compared to thermal short term projects. Generally the hydropower projects can recover their cost in six to eight years and after that the electricity is available at a very cheap rate. The storage projects also provide for agriculture use.

Pakistan has a vast deposit of coal in Thar. Power policy needs to be framed such that it encourages exploitation of hydropower as well as indigenous coal. The engineers can play pivotal role in economic development and policy formation.

Pakistan is located at strategic point. It is corridor for trade between the Central Asian States and the rest of the world. Engineers by building the highways connecting the neighboring countries can influence the trade policies of the region.

By upgrading its heavy industry and manufacturing the construction machinery and hydropower equipment the engineers can cut down the imports and make the projects more economical.

By developing the dams and agriculture machinery the engineers can bring a green revolution.

12. RECOMMENDATIONS

12.1 The construction of Mangla and Tarbela Dams provided facility to store surplus water from summer flows and release the stored water during low flow periods for rabi crops. The additional agricultural produce accelerated the economic progress of Pakistan which is reflected in the GDP

growth rates of 1970s & 80s, It is recommended that the proposed dams at Diamer Basha, Kalabagh & Shyok River should be urgently built to boost the economy further.

12.2 WAPDA has identified 33 Hydropower Projects for implementation in the coming decades. The benefits of these projects can be maximized by proper sequencing and ranking. The ranking should consider the project readiness for implementation, its contribution to the water & power supply of the network and conjugate operation with its upstream and downstream projects alongwith geologic hazards and sedimentation impacts. For these considerations the engineer can make better decisions for the ranking of projects. It is prudent that engineers should decide ranking for construction of future projects and the politicians should work for the procurement of foreign funds and for the removal of domestic hurdles.

12.3 Because of uncontrolled mining of ground water, there is a dangerous risk of excessive lowering of watertable and intrusion of saline water in the fresh water aquifer. The control and regulation of ground water is urgently required.

12.4 During water shortage years conflict arises among the four provinces over sharing of deficit from the allocated water supply. IRSA should be strengthened to meet the challenge of providing fair and equitable solutions.

12.5 About 4.4 MAF volume has already been lost in the live storage capacities of Mangla, Tarbela and Chashma Reservoirs due to sediment deposition. To compensate this loss Diamer Basha dam which has already been approved by the Council of Common Interests should be immediately taken up for construction.

12.6 The previous and the present Govt. have announced that Kalabagh dam will be built after developing consensus among the provinces but so far no particular effort has been made in this regard. Development of consensus needs a strategy and careful planning for opinion building. Such a project should be prepared and field work started with due diligence.

12.7 The Irrigation system in Pakistan has deteriorated because of aging, inadequate maintenance and overstressing of the channels and structures. Several important canals particularly in Sindh are heavily silted up. Many of the hydraulic structures have spent their useful lives and now susceptible to serious damages. The operational safety of entire system have to be studied. Projects for the rehabilitation of Canals & Head-works should be prepared to be taken up and completed preferably in the next two decades.

12.8 The construction of a barrage to control sea water intrusion in the Indus delta area is considered feasible and should be carried out after a proper study.

12.9 The provincial irrigation departments should establish Directorates High Efficiency Irrigation System Directorate to acquire skill and experience for operation of these systems in the future and ongoing projects.

12.10 Use of indigenous coal for power generation will provide cheaper power and reduce the burden of furnace oil imports. The extraction of coal from Thar Coal Seams and establishment of thermal power stations utilizing this coal should be urgently started.

12.11 Value Engineering of large size and mega projects can greatly reduce the project cost and enhance benefits. In several other countries the project designed by Consultant Engineer are over viewed by teams of expert engineers for value engineering. The Consultancy Services for value engineering should be promoted in Pakistan.

REFERENCES

1. An Appraisal of Resources and Potential Development by HARZA Engg. Co. Intl., Sep. 1963.

2. Program for Water and Power Development in West Pakistan through 1975 by HARZA Engg. Co. Intl., Jan 1964.

3. Water & Power Resources of Pakistan – World Bank Study, P. Lieftinch, 1967.

4. Report of the Water Allocation and Rates Committee - 1970.

5. Water Sector Investment Planning Study (WSIP), Federal Planning Cell, Dec 1990.

6. Water Resources Management - Pakistan's Experience by Shams-ul-Mulk, Sep. 1993.

7. Water Appointment Accord - 1992.

8. National Water Policy, Volume-II of Final Report, Federal Flood Commission, Jan. 2003.

9. National Workshop on Lining of Water Channels, WAPDA House, Feb. 2003

10. Study on Water Escapages below Kotri Barrage to Check Seawater Intrusion by MWH-ACE-NESPAK JV, Sep. 2004.

11. Water Resources and Hydropower Development Vision 2025, WAPDA, 2004.

12. Agriculture Statistics of Pakistan 2009-10, Ministry of Food & Agriculture (Economics Wing) Islamabad.

13. Pakistan Economic Survey 1986-87 and 2012-13, Finance Division, Islamabad.