SUSTAINING IRRIGATED AGRICULTURE IN THE 21ST CENTURY : OPTIONS FOR PAKISTAN

By

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ABSTRACT

Pakistan is also one of those countries that could face severe food shortages in the 21st century, which are intimately linked to water scarcity. It is projected that shortfall of water requirements would be about 32 percent which will result in 70 million tones of food shortages by the year 2025. It is also predicted that after an initial period of high flows in the form of storms due to faster glacial melt there will be a terrifying decrease in inflows of anywhere between 30-40 percent into the Indus river system. Recent estimates suggest that climate change and siltation of main reservoirs will reduce the surface water storage capacity by 30% by 2025. This reduction in surface supplies and consequent decreases in groundwater abstraction will have serious effect on irrigated agriculture, which produces more than 90 percent of the total agricultural production in Pakistan. This situation has threatened the food security of 170 million people living in Pakistan. It is, therefore, imperative that Pakistan should invest soon in increasing storage capacity, improving water use efficiency, managing surface water and groundwater resources in a sustainable way to avoid problems of soil salinization and water-logging. Current low productivity in comparison to what has been achieved in other countries under nearly similar conditions points to the enormous potential that exists. Of course, building capacity of individuals and organizations and strengthening institutions are key elements for achieving these targets.

BACKGROUND

Indus Basin Irrigation System (IBIS)

The Indus Basin Irrigation System (IBIS) commands a gross irrigable area of 16.85 million hectares (Mha), of which 14 Mha is culturable command area (CCA) to which water is allocated. The perennial canal supply is available to 8.6 Mha while the remaining area is entitled to irrigation supplies only during the summer (Kharif) season. The Indus River and its tributaries, on an average, bring 175 billion cubic meters (BCM) of water annually. This includes 165 BCM from the three Western Rivers (Indus, Chenab and Jehlum) and 10 BCM from Eastern Rivers (Ravi, Beas and Sutlej). Most of this, about 128 BCM, is diverted for irrigation, 35 BCM flows to the sea and about 12 BCM is wasted as the system losses (Zuberi, 1997).

The average safe groundwater yield is estimated to be about 63 BCM, whereas the extraction for agriculture, domestic and industrial sectors is of the order of about 52 BCM. Thus the remaining groundwater potential is about 11 BCM (PWP, 2001). While these figures may suggest some potential for further exploitation of groundwater, other evidences such as increasing salinity in the groundwater due to redistribution of salts in

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the aquifer and declining groundwater levels confirm that potential for further groundwater exploitation is very limited.

Increasing Gap in Supply and Demand

The water requirements for irrigation in the Indus Basin are estimated at 250 BCM in 2025 against the availability of 185 BCM. Even by exploiting the full groundwater resources, the water availability will not be more than 190 BCM. Considering the reduction in present storage capacities due to siltation and non-availability of additional storage facilities, the shortfall of water requirements would be about 32 percent by the year 2025 (ADB, 2002). In the "business as usual" scenario, shortfall of water will result in serious food shortages in the years to come and will severely hurt the national economy and livelihood of millions. Estimated requirements of the agricultural commodities for the project population in 2025 are given in Table 1.

Table 1: Projected food requirements and productions for the year 2025 (Million Tons).

Crops	Requirement	Production	Shortfall
Food-Grains	50	31.5	18.5
Sugarcane	82	46.4	35.4
Cotton (lint)	3.5	2.7	0.8
Pulses	1.9	1.4	0.5
Oilseed	3.3	1.5	1.8
Vegetables	14.3	9.0	5.3
Fruits	16.1	9.0	7.1
Total	171	102.8	69.4

Source: ADB water Sector strategy for Pakistan, 2002.

Low System Efficiency and Crop Productivity

Pakistan has a large stock of water infrastructure with an estimated replacement cost of about US$ 60 billion (World Bank, 2006). Much of this infrastructure is very old and operating beyond their designed life. The services provided by this infrastructure are very crucial for sustainable irrigated agriculture and the national well being. However, these services can only be available if the structures are well maintained and, when their useful life is over, replaced.

The overall irrigation efficiency in the Indus basin is about 30% (Bhutta and Smedema, 2007). In addition to water shortage, lack of inputs and poor irrigation practices, soil salinization are the other major factors for low crop yields. The average yields in Pakistan are low for wheat and rice, being 2276 kg ha^{-1} and 1756 kg ha^{-1}, respectively. There is a great variability in crop yields with some farmers achieving yields of 3874 kg ha^{-1} for wheat and 3545 kg ha^{-1} for rice (Qureshi, 2004).

Inequity in Water Distribution

Conceptually the major task for water managers in the Indus Basin is to provide water in a predictable and timely manner to those who need it and have a right to it. This task is done less and less satisfactorily due to monoply, discretion and corruption in the water sector. The water bureaucracy has yet to make the vital mental transition from that of builder to that of manager. The "warabandi" distribution system favors head-enders and discriminate tail-enders, which has serious implications for equity and crop productivity. Within watercourses, tail-enders get 20% less water than middle-enders, who in turn get 20% less water than head-enders. Similar trends are seen in the productivity levels of head, middle and tail-enders of the same watercourse.

Degrading Water Infrastructure

Pakistan benefited immensely from the major water infrastructure built in the Indus Basin. The benefits from Tarbela dam substantially exceeded those which were predicted at the time of construction (World Bank, 2007). Through forward and backward linkages in the economy, the total benefits were probably about twice those of the direct power and irrigation benefits. However, with age and neglect, much of the water infrastructure is in poor shape resulting in huge system losses and low performance in carrying water to the tail reaches of the canal commands. Many elements of the vast hydraulic system are now reaching the end of their design lives, and have to be rebuilt/rehabilitated. There is an enormous backlog of deferred repair and maintenance. Most of the recent irrigation and water supply "investments" have been for the rehabilitation of poorly maintained systems and not for the construction of new infrastructure.

Degradation of the Resource Base-soil Salinization

There is abundant evidence of wide-scale degradation of the natural resource base. The Indus Basin is faced with a considerable salt balance problem. The salts are brought in by rivers and their tributaries. On an average, about one ton of salts is added to each hectare of irrigated land. This accumulation is the main cause of land salinization. Salt-affected soils have become an important ecological problem in the Indus Basin—an estimated 4.5 million ha are already afflicted, about half of which are located in irrigated areas (Qureshi et al., 2004). Of course, the scale of the problem of salt accumulation in the root zone would be even greater if saline groundwater is used for irrigation.

Figure 1 shows that problems of salinity are more serious in the Sindh where about 54% area is saline. The main reason for higher salinity in the lower parts is low rainfall, high evapo-transpiration rates with shallow and saline groundwater. Groundwater is used for irrigation both in isolation and in conjunction with the canal water. The conjunctive use of surface water and groundwater is now practiced on more than 70% of the irrigated lands of Pakistan resulting in soil salinity problems.

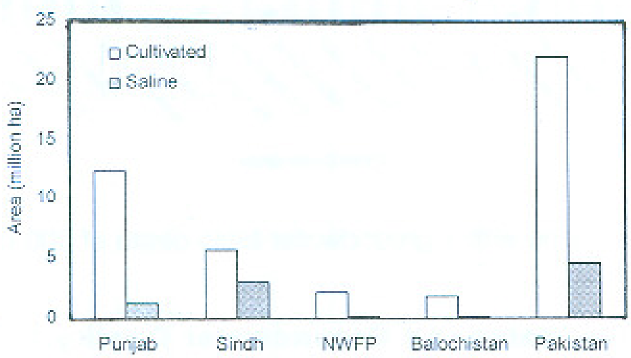

Figure 1: Province-wise distribution of cultivated area and salt-affected area (WAPDA, 2007).

Over-exploitation of Groundwater

Over the past three decades, farmers have largely taken the problem of surface water scarcity into their own hands, and "solved it" by sinking hundreds of thousands of tubewells to feed their thirsty crops. The number of private tubewells have increased from 10,000 in 1960 to about 0.6 million in 2002 (Qureshi et al., 2003) and about 0.8 million in 2006 (World Bank, 2007). The total groundwater abstraction from these tubewells is estimated at 51 x 10^9 m^3 against a recharge of 40-60 x 10^9 m^3. The management challenge is to stabilize the groundwater table at levels where the cost of pumping is affordable. Over-exploitation of groundwater has already caused severe water table decline in most canal command areas of Punjab and Sindh provinces (Figure 2). The average decline in groundwater table is about 1.5 meters per year. The excessive use of groundwater in cities has also led to falling water levels and contamination.

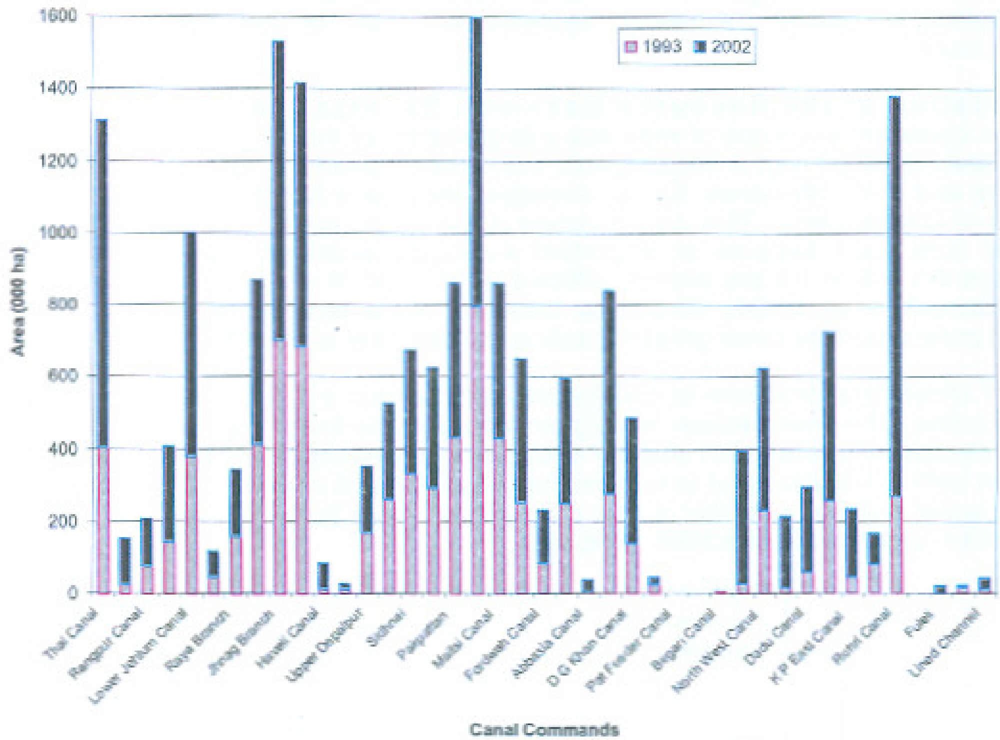

Figure 2: Increase in area with a groundwater table depth of 300 cm between 1993 and 2002.

Deteriorating Surface Water and Groundwater Quality

There is large-scale uncontrolled pollution of surface water and groundwater from the increasing quantities of pesticides and fertilizers used in agriculture and by rapidly growing cities and industries. Major cities have inadequate sewage treatment plants. Many are either non-functional or working poorly. And there is only one industrial common effluent treatment plant working in the whole of the country. The result is the presence of heavily degraded surface water around all cities and towns.

The quality of groundwater in the Indus Plains varies widely, both spatially and with depth and is related to the pattern of groundwater movement in the aquifer (Qureshi et al., 2007). The salinity of the groundwater generally increases away from the rivers and also with depth. In Punjab 23 percent of the area has hazardous groundwater quality, while it is 78 percent in Sindh (Haider, 2000).

An Inadequate Knowledge Base

The Indus Basin is a single, massive, highly complex interconnected ecosystem, upon which man has left a huge footprint. In a system so massive and complex, the generation and smart use of knowledge are the keys to adaptive management. But there has been very little investment in Pakistan in building this knowledge base and the accompanying institutional and human systems. This is going to be a major constraint in the future when we seriously embark on implementing our strategy. In the past Pakistan has relied heavily on outside knowledge, especially in sciences. Now Pakistan needs to develop its indigenous capacity and make a major push to establish and nurture a new set of institutions that will provide the scientific, technical and policy support for the management of increasingly scarce water.

Non-development of Areas Outside the Indus Basin

The food insecurity-poverty nexus is also pervasive in Pakistan. Poverty in Pakistan, as is the case with most developing countries, is linked to overall growth performance of the agricultural economy. In Pakistan, poverty in irrigated areas is usually attracted by non-irrigated areas. In earlier days of irrigation people migrated from water poor areas to the basin to settle and develop lands. Limited water availability now no longer allows for such migration. The alternate is to develop water resources in those areas outside the basin and offer more livelihood opportunities in their own environment. It is worth mentioning that about 20% of the total water resources of Pakistan are located outside the Indus basin. Therefore it is important to invest in spate irrigation structures in these areas to improve water access for agriculture.

The Way Forward-Key Areas to Focus

The problems of water resources management in Pakistan are complex and a straightforward solution seems impossible. In order to increase agricultural production and ensure sustainability of irrigated agriculture, the overall strategy should be to increase water capital and make better use of water. For quick response to water and food security needs, issues of increased water and land productivity, water delivery efficiency and environmental and ecological sustainability, the following options can be considered:

Increasing storage capacity and modernizing irrigation infrastructure

Relative to other arid countries, Pakistan has very little water storage capacity that is hardly 15% of the annual river flow. The per capita water storage capacity in Pakistan is only 150 cubic meters as compared to over 5,000 cubic meters in USA and Australia and 2,200 in China (Figure 3). The dams of the Colorado and Murray Darling rivers can store 900 days of the river runoff, South Africa can hold 500 days in the Orange River and India between 120-220 days in the Peninsular Rivers. In contrast, Pakistan can hardly store 30 days of water in the Indus Basin (World Bank, 2006). If no new storage is built in near future, canal diversions will remain the same and the shortfall will increase by 12 percent in the next decade. The Pakistan Water Sector Strategy estimates that Pakistan needs to raise its storage capacity by 22 BCM by 2025 in order to meet the projected requirements of 165 BCM.

In the past few years, government is emphasizing more and more on the construction of small dams to provide irrigation facilities to the small scale irrigation schemes. The small

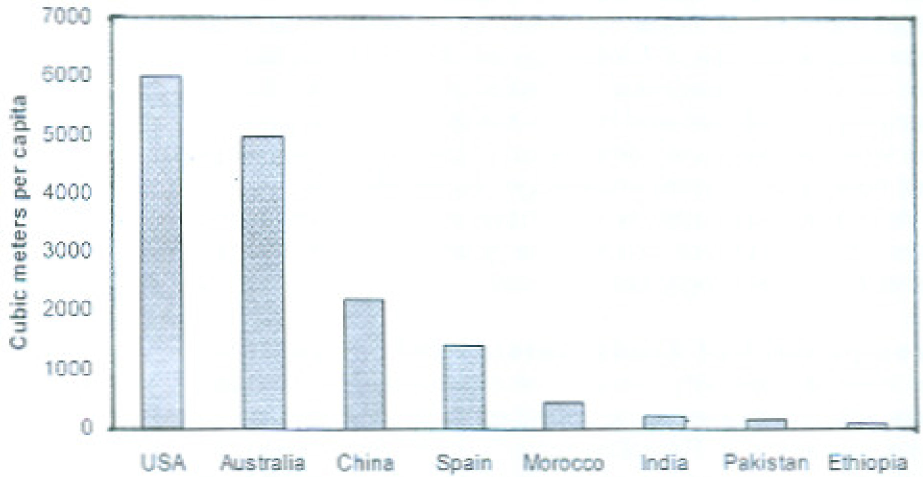

Figure 3: Storage per capita in different semi-arid countries.

dams may address to some extent the poverty issues in selected villages but would not help in eradicating poverty in large areas. The envisaged small dams will have a storage capacity of about 1850 cubic meters, which is good to meet the requirements of small scale irrigation and meet domestic water requirements. But in no way can they be considered as true replacement for large dams. For instance, to store water equivalent to Kalabagh dam we would need to construct 750 small dams, and that too will be exclusive of power generation. Therefore, where it is necessary to build small dams, the importance of large dams should not be ignored as they are imperative for sustained national economic growth.

Another area which is linked with the agricultural development and needs immediate attention is the construction of farm to market roads so that farmers can bring their produces directly to the competitive markets. Pakistan's post harvest storage and processing industry is also very weak and need to be strengthened. More than 20% of the agricultural products are wasted due to non-availability of proper storage and post harvest processing facilities. Construction of grain storages close to larger markets will greatly help in providing farmers security in the post harvest period. With these storages there will also come about financing arrangements for sustaining and increasing their holding capacity, which today with its absence leads to disproportionate profits for the middleman.

Improvements in the water use efficiencies

The productivity of water in Pakistan is about the lowest in the world. For wheat for example it is 0.5 kg/m^3 as compared to 1.0 Kg/m^3 in India and 1.5 Kg/m^3 in California (IWMI, 2000). The maize yields in Pakistan are very low and there is a tremendous scope for substantial improvements in the maize yields. In terms of water productivity, maize has a factor of nine between lowest in Pakistan (0.3 Kg/m^3) and highest in Argentina (2.7 Kg/m^3). The flip side of current low water productivity is that Pakistan can get much more product – crop, jobs and income – per drop of water. Introducing improved cultural practices such as precision land leveling, zero tillage, bed and furrow planting can help a great deal in improving water productivity.

Managing groundwater in irrigated and rain-fed (barani) areas

Over the last few decades, the water economy of Pakistan has survived largely due to the tapping of the unmanaged groundwater by millions of farmers. It is clear that this era of "productive anarchy" is now coming to an end. There is an urgent need to develop policies and approaches for bringing water withdrawals into balance with recharge. Because the longer it takes, the greater would become the depth of the groundwater table, and the higher would be the costs of the "equilibrium" solution. Also reform in water allocation process to the canal commands is urgently needed if benefit of conjunctive use is to be derived in the basin. Managing the aquifer will require a well thought-out, pragmatic, patient and persistent strategy. In rain-fed areas, farmers have invested in rainwater harvesting structures for supplemental irrigation and for recharging aquifers. Therefore supporting these initiatives of farmers and helping them to sustain them will be crucial to produce more food and increase current levels of water use efficiency.

Maintaining the resource base—salinity management

Pakistan lacks a good network of drainage system which is essential for evacuating salts from the system. Therefore there is a need to invest in the rehabilitating the existing drainage systems and construction of new drainage system for salinity management in the Indus Basin. This is a major piece of essential infrastructure needed for sustainable irrigated agriculture in the basin and requires to be put in place in the coming decade or so. In the past, too much emphasis has been given to engineering solutions, with very little on the management front. Although engineering solutions help increase cropping intensities and yields, they fail to stop emergence of similar environmental problems in adjacent areas. There is also a need to focus on action programs for the most seriously affected areas, capacity building for farmers, introduction of groundwater extraction regulations, and promotion of saline agriculture.

Building capacity of individuals and institutions

We need to build a strong natural, engineering and social scientific cadre capable of working with all users in defining the problem, developing solutions, monitoring, assessing and adjusting. This is a capacity which requires a wide range of disciplines –

those necessary for understanding climate, river geomorphology, hydraulic structures, surface and groundwater hydrology, sediment management, hydraulics, conflict management, politics, economics and financing. A major emphasis will need to be on developing a better understanding of salinity and formulation of salt management strategies; groundwater recharge; and flood flows. The impending challenges of climate change make it even more urgent to have these institutions in place and satisfactorily performing so that Pakistan can become more self reliant in managing its scarce land and water resources.

Strengthening institutions for change

Agriculture in Pakistan is changing fast. Contract farming is increasing, more progressive and commercial farmers are emerging, high value crops are displacing food grains and increased prices of agricultural commodities are attracting people towards agriculture. But all this can not happen without assured water supply. For this to happen, Pakistan needs to invest in institutions to enable them to take on the future challenges of water management. The capacity of institutions should be developed to undertake systematic sets of legislation and organizational changes to solve entitlement, pricing and regulatory issues. Reforms should aim at solving the management issues as well as delivering benefits to the people because without these strings chances of success will be very limited.

Conclusions and Recommendations

The viability of irrigated agriculture in the Indus basin is threatened by multitude of factors, including seepage from unlined canals, inadequate provision of drainage resulting in water logging and soil salinization in irrigated areas, poor on-farm water management practices, insufficient canal water supplies and use of poor quality groundwater for irrigation and lack of robust policies for the management of land and water resources in the basin. On the other hand, it is estimated that to feed the increasing population, 40 percent more food would be required by the year 2025. It is also perceived that due to decreased investments in the water sector combined with shortage of good quality water and environmental and ecological threats, scope of expansion of irrigation areas will be very limited.

Pakistan needs to boost production from existing farm lands. This will be possible by increasing the performance of existing irrigation systems and, wherever possible, developing new storage and irrigation systems. In order to increase productivity and sustainability of the irrigation systems in the basin, an integrated water management approach could be useful to manage available water resources with respect to quality and quantity in view of increasing demands, limited resources, rising groundwater tables and soil salinization. This paper suggests following potential solutions:

- Increase water availability (*develop new storages*)
- Save irrigation water (improve irrigation efficiencies)
- Grow more food with limited amounts of water (improve productivity of water)

- Manage salts in fields and basin (control soil salinization and disposal of excess salts to the sea)
- Improve irrigation water distribution and allocation (enhance reliability, equity and adequacy)
- Institutional and policy changes to support more productive irrigation (accelerate reforms process).
- Increase knowledge base (build capacity of individuals and organizations).

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RAINWATER HARVESTING POTENTIALS FOR RAWALPINDI AND ISLAMABAD

By

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Abstract

In most urban areas, population is increasing rapidly and the issue of supplying adequate water to meet societal needs and to ensure equity in access to water is one of the most urgent and significant challenges faced by decision-makers. Among the various alternative technologies to augment freshwater resources, rainwater harvesting and utilisation is a decentralised, environmentally sound solution, which can avoid many environmental problems often caused in conventional large-scale projects using centralised approaches. Collecting water from roofs via traditional guttering and through down pipes to a storage tank. It can then be used for a variety of uses such as watering gardens, reduce urban flooding and reduce erosion. In Rawalpindi and Islamabad main source of the water supply is surface water. Groundwater table is rapidly decreasing. On the other hand only in urban area (545.40 KM^2) of the cities approximately 610 million cubic meters of rainfall occur annually. This sufficient amount of water can be utilized for variety of the purposes specially for watering the gardens, neighborhood parks and city parks. Moreover it can reduce the dependency on the groundwater and can be a potential source of drinking water.

1. Introduction

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams and cistern. The techniques usually found in Asia and Africa arise from practices employed by ancient civilizations within these regions and still serve as a major source of drinking water supply in rural areas.

Rainwater harvesting is also effective in reducing storm water runoff pollution. When rainfalls, it is clean, but it immediately picks up pollutants from rooftops and pavement. This pollution is carried into storm drains and then into streams. Collecting storm water from rooftops and directing it to storage tanks so it can later be used for irrigation or flushing decreases the volume and rate of runoff.

The installation of rainwater harvesting systems (i.e., the use of rainwater collected on-site) has been increasing throughout the US and Canada. Different advantages of rainwater harvesting are listed below.

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i. Provide a source of free water—the only costs would be for storage,
ii. Treatment and use;
iii. Provide water if there is no other source of water;
iv. Augment or replace limited quantities of groundwater;
v. Provide good-quality water if groundwater quality is unacceptable;
vi. Provide water if tap charges are too high for water supply connection;
vii. Reduce storm water runoff;
viii. Reduce non-point source pollution;
ix. Reduce erosion in urban environments;
x. Provide water that is naturally soft (no need for water softeners);
xi. Provide water that is pH neutral/slightly acidic;
xii. Provide water that is sodium-free, important for those on low-sodium diets;
xiii. Provide good quality water for landscape irrigation;
xiv. Provide water for non-potable indoor uses;
xv. Provide safe water for human consumption, after appropriate treatment;
xvi. Help utilities in reducing peak demands in the summer;
xvii. Help utilities in delaying the expansion of water treatment plants;
xviii. Provide water for cooling and air-conditioning plants;
xix. Reduce the demands on groundwater;
xx. Provide water for fire protection; and
xxi. Save money for the consumer in utility bills.

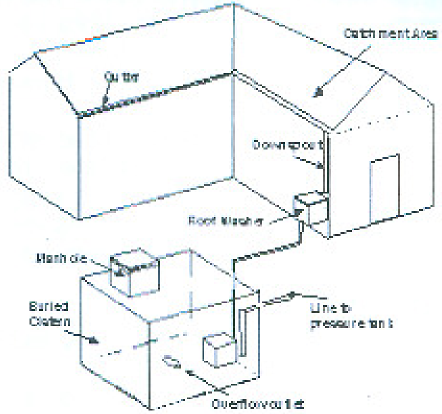

Figure 1. Basic rainwater harvesting system

There are several component of the rainwater harvesting system.

These components are rainwater catchments, conveyance, purification, and storage and distribution network. Component of the rainwater harvesting system are shown in the figure -1.

2. Statement of the Problem

As the world's population continues to grow, now at a rate of about 10,000 per hour, our same finite water resources are going to have to go farther and be treated wisely. In order to meet our future water needs, solutions are needed that are both economical and environmentally friendly.

In case of Rawalpindi and Islamabad, groundwater level is very much low. As groundwater is the main source of potable water other main source of potable water in these cities are Rawal Dam and Khanpur Dam. In Islamabad the drop in the water table has been 50 feet from 1986 to 2001.

On the other hand, adequate rainfall occurs in these cities, which is not being capitalized in any way. In these cities, rainwater harvesting can be a potential source of potable water supply and other uses. Moreover, this sufficient amount of precipitation falls and many contaminates into Nala-Lai and Sawan River subsequently and polluting the surface water rapidly. There is an emergent need to carry out study to identify the potentials of rainwater for the beneficial uses of the cities.

Groundwater is becoming scarcer in large urban areas due to reduced water infiltration. The decrease of groundwater recharge in the cities is directly proportional to the increase in the pavement and roof area. In addition, high population density has brought about high groundwater consumption. Recognising, the need to alter the drainage system and to harvest the rainwater.

3. Objectives

The objectives of the study are as followings

1. Spot the sustainable potential uses of rainwater harvesting for Rawalpindi and Islamabad.
2. Quantify the total volume of the precipitation by using GIS, occurred in the last few years in these cities.
3. Suggest the recommendations for the potential uses of the rainwater.

4. Scope

Scope of the study may be divided into two broader parts. First is geographical scope, and geographical scope of the study is municipal limits of the cities. Second is theoretical scope, and theoretical scope of the study is to figure out the potentials of rainwater harvesting for the cities.

5. Methodology

Following steps was followed to carried out this study

Objective	Method Employed	Target Achieved
Download satellite images of the cites and mosaic them to form a single image	***Google Earth Professional*** for image downloading and ***Erdas Imagine 8.7*** for Mosaicing of images.	Map of the cities
Geo-reference the image	***Erdas Imagine 8.7*** ***Arc GIS 9***	Scaled Map of the cities
Plot Precipitation Data	Coordinates of the Rain gage stations was obtained then plotted on scaled map of the cities by using ***Arc GIS 9.*** Isohyets were drawn on the map.	Isohyets Map of the cities
Quantify the Volume of Precipitation	Municipal limits of the cities was earmarked and total area would be found by using ***Arc GIS 9.***	Volume of Precipitation
Digital Elevation Model (DEM) of the cities	DEMs was obtained from internet and simple map of the city was converted into topographical map by using ***Arc GIS 9.***	Topographical map of the city
Treatment of rainwater and other potential uses of rainwater	Treatment train of the rainwater would be designed and other potential uses rainwater would be identified.	Harvesting of rainwater

In short span of time it was not possible to conduct entire study. But the aim of this practice is to familiar student with this technique and about the methodology, how would go for it. Although, municipal boundaries of the cities and precipitation data of some stations were assumed in order to complete this task. But still it was good practice to make student understand about this technology. Methodology is briefly described in a flow chart below. (Figure 2)

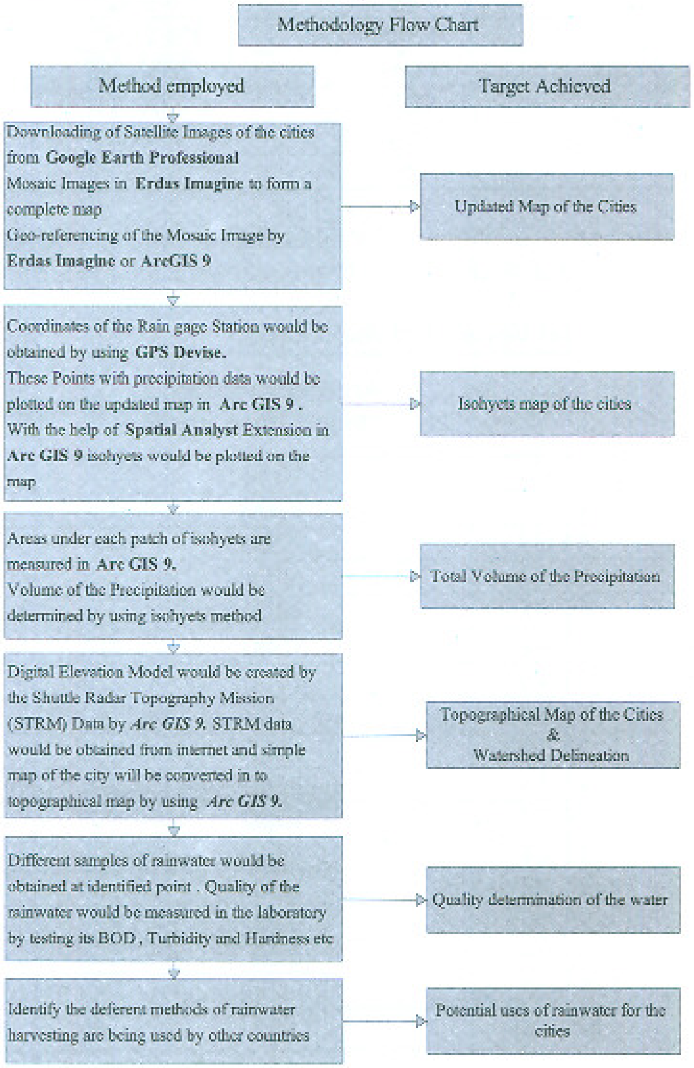

Figure 2: Flow Chart of the Methodology

6. Results & Discussions

Precipitation data from the Meteorological department was obtained unfortunately data for all the stations were not available because those gauge stations were not classified. Anyhow seven rain gauge stations were plotted on the map of GIS, location and annual average precipitation are shown in the table below.

Table 1: Location and Annual Average Precipitation of Rain gauge

Name of Rain gauge	Annual Average Precipitation (mm)	Location of Rain gauge	
		Easting	Northing
G - 11/1	1200	72°59'43.99"	33°39'20.76"
Arid University	979	73°5'8.92"	33°38'48.11"
Airport	1247	73°6'2.94"	33°36'38.70"
Meteorological Deptt.	1180	73°3'57.16"	33°40'53.08"
OPQS Qasim	900	73°1'59.41"	33°33'36.06"
B. Town	1000	73°10'0.41"	33°32'11.81"
Park	1050	73°10'28.71"	33°44'18.07"

It is estimated that the total urban area of Rawalpindi and Islamabad is about 545.20 KM^2. Mean annual average precipitation in these cities about 1172 mm/year.

Table 2: Mean Annual Volume of the Rainfall

Sr. No.	Area	Annual Average Precipitation (mm)	Volume of Precipitation (Million M^3)
1	3.27	1650	5.40
2	21.23	1300	27.60
3	41.37	1250	51.71
4	10.89	950	10.35
5	12.52	1050	13.15
6	17.42	1550	27.00
7	23.40	1450	33.93
8	28.30	1350	38.21
9	35.38	1250	44.23
10	46.81	1150	53.83
11	74.57	1050	78.30
12	15.24	750	11.43
13	27.22	850	23.14
14	38.10	1050	40.01
15	99.06	950	94.11
16	50.62	1150	58.21
Total	**545.40**	**1172[1]**	**610.58**

[1] Mean Annual Average Precipitation

From the calculation it is depicted that the volume of the precipitation for the area of Rawalpindi and Islamabad is approximately 610 million cubic meters annually. Figure – 3 showing the isohyets of the cities.

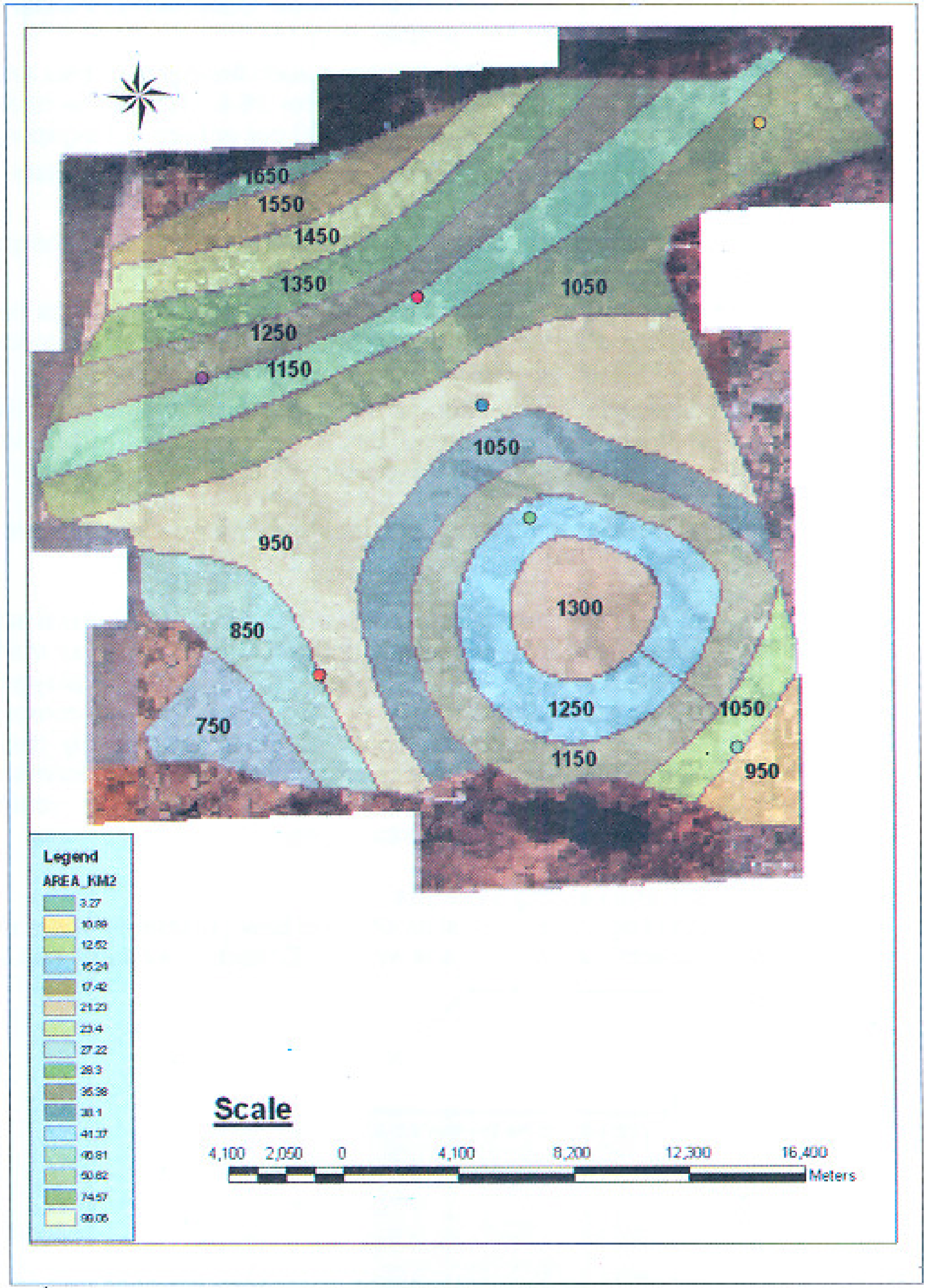

Figure 3: Isohyetal Map of Rawalpindi and Islamabad

7. Practices of Rainwater Harvesting

Some of the examples of rainwater harvesting are mentioned below.

1. Light roofing is placed on the roofs to act as catchments. Collected roof water is kept in separate cisterns on the roofs for non-potable uses.
2. The water is used primarily for non-potable functions such fire-fighting drills and toilet flushing. Such collected and treated water accounts for 28 to 33% of the total water used, resulting in savings of approximately S$ 390,000 per annum in Singapur.
3. In Tokyo, rainwater harvesting and utilization is promoted to mitigate water shortages, control floods, and secure water for emergencies.
4. Storing rainwater from rooftop run-off in jars is an appropriate and inexpensive means of obtaining high quality drinking water in Thailand.
5. Indonesian government introduced a regulation requiring that all buildings have an infiltration well. The water deficit of 53% by the year of 2000 would be reduced to 37%, which translates into a net savings of 16% through conservation.
6. In Bangladesh, rainwater collection is seen as a viable alternative for providing safe drinking water in arsenic affected areas. Since 1997, about 1000 rainwater harvesting systems have been installed in the country, primarily in rural areas.

Similarly, there are many more examples around the world. Many countries are using rainwater sustainable.

Rainwater harvesting systems can provide water at or near the point where water is needed or used. The systems can be both owner and utility operated and managed. Rainwater collected using existing structures (i.e., rooftops, parking lots, playgrounds, parks, ponds, flood plains, etc.), has few negative environmental impacts compared to other technologies for water resources development. Rainwater is relatively clean and the quality is usually acceptable for many purposes with little or even no treatment. The physical and chemical properties of rainwater are usually superior to sources of groundwater that may have been subjected to contamination.

8. Types of Rainwater Harvesting Systems

Typically, a rainwater harvesting system consists of three basic elements: the collection system, the conveyance system, and the storage system. Collection systems can vary

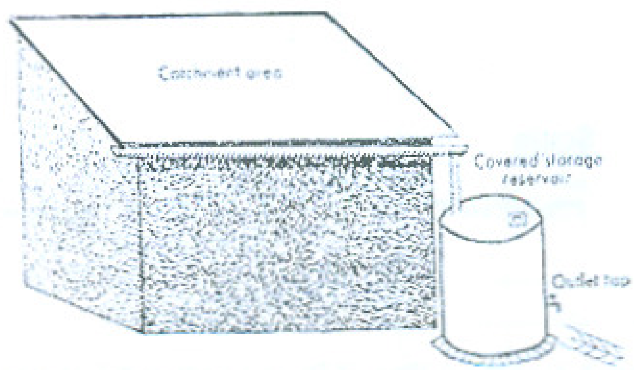

Figure 4: Example of a roof catchment system.

from simple types within a household to bigger systems where a large catchment areas contributes to an impounding reservoir from which water is either gravitated or pumped to water treatment plants. The categorisation of rainwater harvesting systems depends on factors like the size and nature of the catchment areas and whether the systems are in urban or rural settings. Some of the systems are described below.

8.1 Simple roof water collection systems

While the collection of rainwater by a single household may not be significant, the impact of thousands or even millions of household rainwater storage tanks can potentially be enormous.

The main components in a simple roof water collection system are the cistern itself, the piping that leads to the cistern and the appurtenances within the cistern. The materials and the degree of sophistication of the whole system largely depend on the initial capital

Figure 5: At Kokugikan sumo wrestling arena in Tokyo, Japan, rainwater collected from the arena's 8,400 square meter rooftop is used for non-potable purpose.

investment. Some cost effective systems involve cisterns made with ferro-cement, etc. In some cases, the harvested rainwater may be filtered. In other cases, the rainwater may be disinfected.

8.2 Larger systems for educational institutions, stadiums, airports, and other facilities

When the systems are larger, the overall system can become a bit more complicated, for example rainwater collection from the roofs and grounds of institutions, storage in underground reservoirs, treatment and then use for non-potable applications.

8.3 Roof water collection systems for high-rise buildings in urbanised areas

In high-rise buildings, roofs can be designed for catchment purposes and the collected roof water can be kept in separate cisterns on the roofs for non-potable uses.

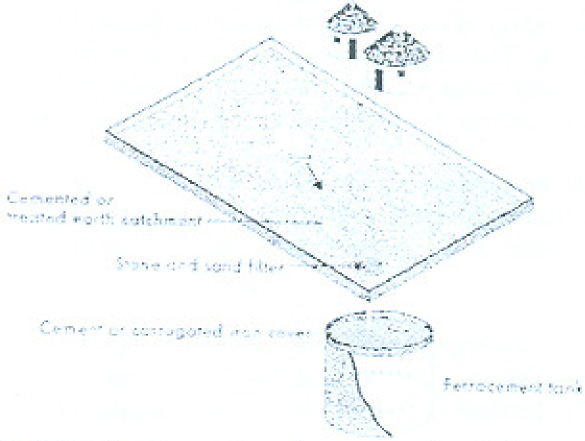

Figure 6: Example of a ground catchment system.

8.4 Land surface catchments

Rainwater harvesting using ground or land surface catchment areas can be a simple way of collecting rainwater. Compared to rooftop catchment techniques, ground catchment techniques provide more opportunity for collecting water from a larger surface area. By retaining the flows (including flood flows) of small creeks and streams in small storage reservoirs (on surface or underground) created by low cost (e.g., earthen) dams, this technology can meet water demands during dry periods. There is a possibility of high rates of water loss due to infiltration into the ground, and because of the often marginal quality of the water collected, this technique is mainly suitable for storing water for agricultural purposes.

8.5 Collection of storm water in urbanized catchments

The surface runoff collected in storm water ponds/reservoirs from urban areas is subject to a wide variety of contaminants. Keeping these catchments clean is of primary importance, and hence the cost of water pollution control can be considerable.

9. Conclusion

Rainwater can meet many needs and many designs can be used to capture and store and reuse rainwater. All rainwater harvesting systems have a similar set of functions and components though they vary in complexity and efficiency. A simple process focused on understanding use needs, rainfall patterns and resources can contribute to an appropriate system. Annually, there is 610 million cubic meters of rainfall occurring in the urban area of the Rawalpindi and Islamabad. If 50% of the total rainfall volume would be used for beneficial purposes than our ground and surface water resources can preserved. Water resources are getting depleted day by day it is required to preserve them by using wisely rainwater.

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APPLICATION OF FISCAL MEASURES FOR SECURING ACCESS TO SAFE DRINKING WATER- AN ANALYSIS OF COMMUNITY PERCEPTIONS IN ABBOTTABAD DISTRICT

By

Saadullah Ayaz* and Mahmood Akhtar Cheema**

Abstract:
Secure access to water is linked to poverty in many ways, as it affects income and health as well as education, and exacerbating gender disparities and social exclusion. Secure access to safe and reliable drinking water is a key social, health and environmental challenge being faced by inhabitants of Abbottabad. Currently, 88% of Abbottabad's urban population and 62% of rural residents have access to some form of water supply.

An increasing trend in water use is expected to continue resulting in over exploitation of water resources that is resulting in scarcity of available water. The issue is further aggravated because of institutional constraints, declining quality, in- equalities in access and lack of resources and poor governance. Fiscal instruments must be promoted for ensuring sustainable use, prevent infrastructure deterioration, generate revenues for betterment of water supply schemes. Such instruments are also essential for protection of water resources from pollution and management of water utilities and infrastructure in Abbottabad.

This paper presents an analysis of community perceptions regarding application of fiscal measures for improved access to safe drinking water in Abbottabad, district. The results of the study indicate that there is high degree of un- satisfaction with the quality and quantity of available drinking water and people are willing to pay for improved access to safe drinking water in Abbottabad.

Key Words:
Fiscal instruments, drinking water, community perceptions, Abbottabad

Introduction:
The North West Frontier Province (NWFP), where Abbottabad is situated, currently ranks second only to Balochistan as the province with the poorest drinking water supply in the country Abbottabad ranks third in the NWFP in terms of piped water Provision. Currently, 88% of Abbottabad»s urban population and 62% of rural residents have access to some form of water supply, primarily from public stand posts (GoP 2006). But only 32.73% of households have access to drinking water inside the home, while the remaining 67.27% rely on an outdoor source. Findings revealed that overall only 8% of

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households have their own water source. In urban areas, 88% of households depend primarily on government tanks, while 46% of rural households depend on springs and wells (IUCN 2009).

Access to safe and reliable water is a growing concern throughout the district Abbottabad with many areas now facing increasing levels of water pollution and decreased quantity of available water. Like all other basic utilities, the cost of provision of drinking water is the combined result of the management of upstream waterways, large-scale investment in infrastructure, as well as their day-to-day management and maintenance.

Management of water supply systems and infrastructure is a key issue faced by secured access to safe and reliable drinking water in Abbottabad. The fiscal instruments have not been adopted for this sector including; revenue shortfalls, low fees paid by consumers that does not reflect the economic cost of managing and improvement of water supply services, that barely cover 16% of maintenance and repair costs of the available infrastructure (IUCN 2004b: ix).

Currently, only about 92 percent households in urban and 65 percent of household in rural areas on Abbottabad obtain piped supply of water from public sector schemes. While people in these areas pay a very nominal 'service fee' in levy of the supplied water except Nawanshehr Union Council, where users pay 'bill' as per consumption of water from water being supplied through extensive network of supply pipes and overhead storage tanks (IUCN 2004b: ix). Under project being implemented by International Union for Conservation of Nature (IUCN), the tariff revision in being proposed as to cover administrative charges through revised 'progressive block tariff system of water billing' and subsidy to poor households (beneficiaries of Zakat and Bait ul Maal), with a purpose to bring pro- poor fiscal component in sector of drinking water supply.

Application of fiscal measures represents an important way of addressing water issues in the context of secured access, environmental sustainability and better management for available water resource. For Abbottabad, the underlying logic for this is to increase fiscal revenues through water price revision while furthering purposes for resource sustainability, prevent access and promote social and development related dimensions associated with water use.

Objectives of Study:

The objectives of this study are:

1. To conduct an analysis of the community perceptions regarding application of fiscal instruments for secured access for safe and reliable drinking water in the district Abbottabad,

2. To suggest application of appropriate fiscal measures for improved quality and secured access to drinking water in district Abbottabad.

Material and Methods:

Material: Abbottabad is a city located in the North-West Frontier Province of Pakistan, lying between 34°09□N latitude and 73°13□E longitude being the third-largest city in the province. The city is situated in the Orash Valley, 150 km north of Islamabad and 200 km east of Peshawar at an altitude of 4,120 feet or 1,260 m (Wikipedia 2010).

Abbottabad can be accessed from Karakoram highway which passes through urban centre of the city. Neighboring districts are Mansehra to the north, Muzaffarabad to the east, Haripur to the west and Rawalpindi to the south. The city is bounded at all four sides by the Sarban hills.

Abbottabad's climate is cold during winters and mild during summers with humid temperatures during June and July. During the winter, the temperature may drop to below 0°C and snowfall is common, especially in January. Most rainfall occurs during the monsoon season in summer, stretching from May to August, and can sometimes cause flooding.

According to the 1998 Census, "Hindko" was spoken by 94.26% of the population, followed by "Potohari" at 2.30%, "Pashto" at 2.22% and "Urdu" at 1.05%.[9] Although the first language of most people in Abbottabad is Hindko, Urdu is understood and spoken fluently by majority of the residents and commonly used in the markets, offices and formal functions. English is widely used in business and education.

Methods: A detailed review of literature was carried out before undertaking the research work.. Relevant publications were gathered on similar studies by making use of libraries, relevant web- sites. A detailed survey was conducted in order to assess the community perceptions on application of fiscal instruments on the drinking water sector in Abbottabad through frequent visits and personal interviews with target stakeholders.

The gathered information was analyzed using software tools to present an analysis on the community perception of application of fiscal instruments for securing access to safe drinking water in Abbottabad.

Results:

Results obtained from the study are presented below:

1. Degree of satisfaction with drinking water quantity and quality

   Response was obtained from people both from rural and urban households regarding degree of satisfaction with available drinking water quantity and quality in district Abbottabad. The results show that among the surveyed respondents, 60 percent of household in urban area showed satisfaction, while in rural household only 36 percent showed satisfaction with the quantity and quality of available drinking water. These results are graphically shown in Figure 1.

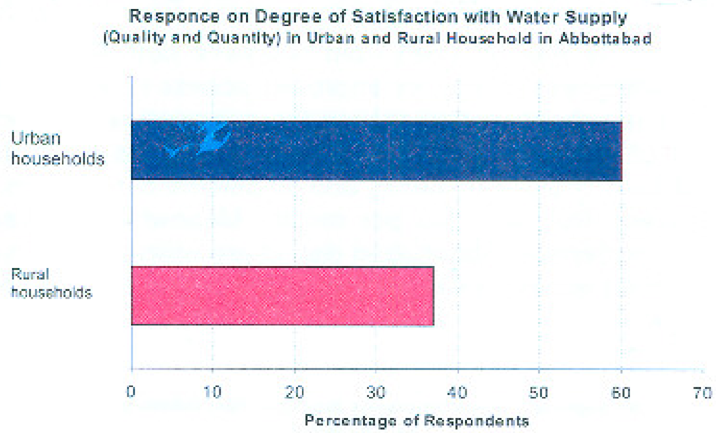

Figure 1.

2. Key Priority among respondents regarding supplied water

During the survey, response was obtained from residents both from rural and urban households regarding parameters/ key priorities for quantity and quality of water in district Abbottabad. The results show that among the surveyed respondents, "regular supply" of water was identified as key priority by 34 percent of urban and 50 percent of rural household. Similarly, "convenience" for obtaining water was identified as a priority by 20 percent of rural and 4 percent of urban household. Meanwhile, "improved quality' of water was identified as key priority by 34 percent of urban and 40 percent of rural household. These results are graphically shown in Figure 2. below:

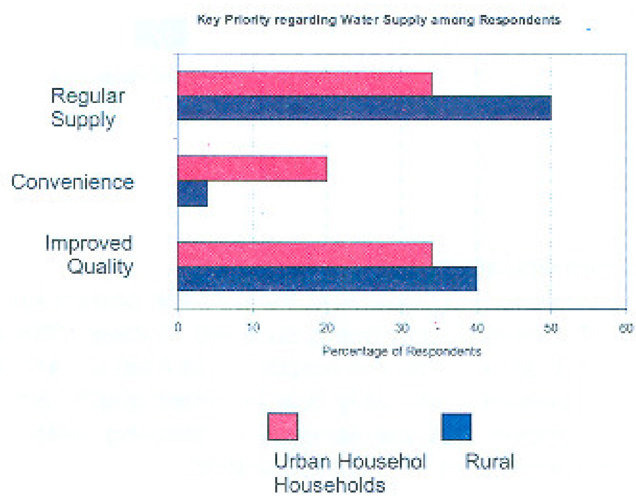

Figure 2.

3. Willingness to pay for improved access to safe drinking wate

During the survey, response was obtained from residents both f al and urban households regarding willingness to pay for improved access to s ıking water in district Abbottabad. The results show that among the surveyed re ents, 9 percent of rural and 3 percent of urban household are ready to pay be' Rs. 1 - 50 per month. Similarly, 19 percent of urban residents and 55 percent of r ts of rural areas are willing to pay between Rs. 50 - 100 per month. Meanwhil oercent of rural residents and 49 urban residents of Abbottabad district are willing higher than Rs. 100 per month for improved access o safe drinking water. These are graphically shown in Figure 3. below:

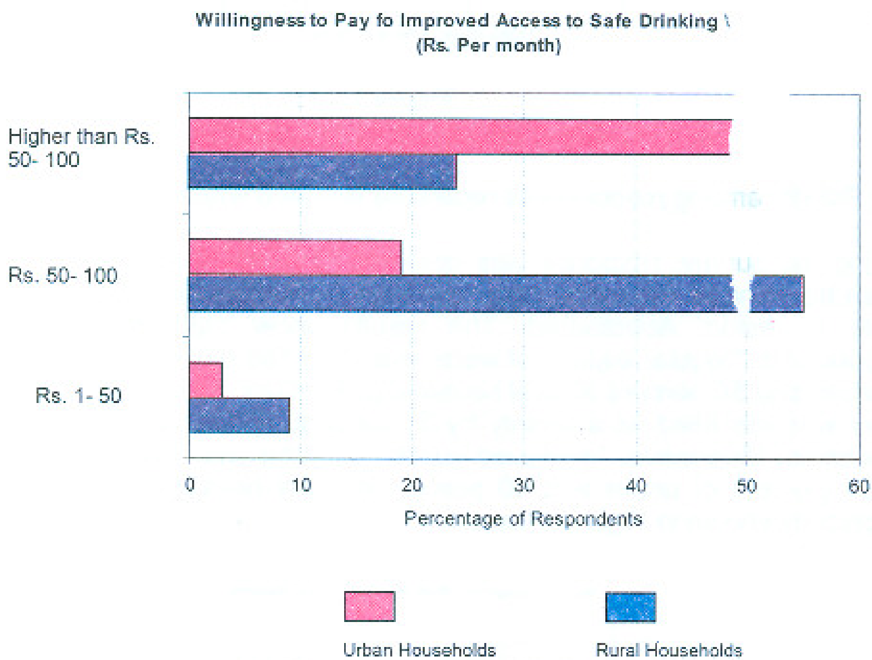

Figure 3.

Discussions and Recommendations:

The results of the study show a clear view that most of the people are not satisfied with the quality and quantity of drinking water being supplied. A clear difference can be seen in rural and urban household shown that the respondents from urban area show a higher degree of satisfaction (60 percent), probably due to better quality and quantity of water being supplied. This also shows that the services of drinking water supply are not as good as in rural areas (36 percent) of Abbottabad district.

Similarly, the results regarding parameters/ key priorities for quantity and quality of water in district Abbottabad show that "regular supply" has been highlighted as priority by rural residents in higher number (50 percent) as compared to resident of urban areas (34 percent). These results also show that "convenience" for obtaining water is a higher priority for urban residents showing a marked higher percentage, due to higher water demands in urban areas, where as only 4 percent of rural resident consider it a priority. While, "improved quality' of drinking water is also considered a priority almost equally by urban and rural residents showing that the quality of drinking water is equally considered a priority in these areas.

Based on the results of this study, the following recommendations are made for application of fiscal instruments to secure access to drinking water in Abbottabad district:

1. In light of depleting quality and reduced quantity of drinking water, there is a need to apply fiscal measures for improving access to both urban and rural residents of Abbottabad. Such measure could be regular billing system for drinking water supply, higher tariffs and user charges.

2. Since people are willing to pay for secured access to drinking water, application of proper fiscal instruments will be beneficial for improvement of services, through better system management, infrastructure development and resource management.

3. Application of proper fiscal instruments can serve as a mean for taxation that can contribute to exchequer and also will help in resource development and environmental conservation.

4. Pro- poor fiscal measure needs to be initiated like subsidy or exemption for poor of Abbottabad district (beneficiaries of Zakat and Bait ul Maal). The margin for such investments could be met for implementation of "progressive block tariff system' in which users to be charged as per progressive use of water and separate tariff for commercial users.

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GROUNDWATER MANAGEMENT AND RECHARGE POTENTIAL AS AN ALTERNATE TO MEGA SURFACE STORAGES

By

Muhammad Basharat[1] and Danial Hashmi[2]

ABSTRACT

Pakistan is an agrarian country where irrigation is used on 75 % of agricultural land, mainly in Indus Basin. There is much variability in river flows and crop water requirement round the year, surface water reservoirs were constructed under Indus Basin replacement works to reduce temporal gap between water availability and requirement. However, the long halt in surface storage development in the country since the completion of Tarbela reservoir in 1976 and silting up of storages therein with passage of time has diverted increasing demand for canal water towards groundwater development. The alluvial aquifer that underlies the Indus Basin Irrigation System (IBIS) had unintentionally stored huge quantities of water (about 40 ft rise) after inception of irrigation system within about 40-50 years time. This huge storage has provided a big boom for increasing cropping intensities, but it has surpassed the safe limits of groundwater use and sustainability of existing agriculture is at alarming risk. Currently this storage is being depleted at a rate of about 1.2 ft/year in many of the areas, which means it will not last longer.

There is therefore a dire need to rehabilitate the groundwater potential of the Indus basin in the form of underground storage of surplus surface water. Analysis of below Kotri escapages for 1976-2008 shows that 31.47 MAF annually is escaping below Kotri Barrage. Exceedance chance is 87.1 % for 6.55 MAF proposed for groundwater recharge in Punjab and below Kotri releases to check sea intrusion for four months. Maintaining river flows in dry reaches for 4 months have groundwater recharge potential of about 5.35 MAF in Punjab in addition to suppressing below Kotri seawater intrusion in Sind. Additional benefits will further accommodate the needs of fisheries and environmental sustainability in river channels.

1. INTRODUCTION

The world's fresh water resources are unequally distributed both in time and space. Until recently water resource management focused on reallocating river water to demand centers i.e. when and where it was required, a supply-side or fragmented approach. Nowadays there are signs that water resource availability is dwindling – due to both population growth and increased per capita water use – and ecosystems are being damaged. To face this challenge, new holistic approaches well matched with local challenges are being devised and implemented in most of the countries all over the world. This approach includes the integrated or conjunctive use of surface and groundwater resources at system level. It takes account of social, economic and environmental factors along with the importance of water quality issues within the system.

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Indus Basin Irrigation System (IBIS) encompasses arid to semiarid climate and annual canal diversions are less as compared to evapotranspiration. It was originally based on the objective of irrigating the maximum area possible. The system was designed for an annual cropping intensity of about 75 percent with the intention to spread the irrigation water over as large an area as possible to expand the settlement opportunities (Jurriens and Mollinga, 1996). Now the increasing demand for food to cope with the ever increasing population has caused the annual cropping intensities to rise to 150 to 180 percent in different canal commands. This has become possible only with increasing contribution of groundwater for meeting additional water requirement, but has resulted in increased concentration of salts in groundwater. This change in groundwater environment needs to be tackled on scientific and long term basis rather than short term perspective otherwise the situation may not be reversible. A study undertaken in 1990 (NESPAK/SGI 1991) pointed out that in Punjab the volume of groundwater extracted significantly exceeds the volume of water recharged. The study estimates the difference to be as much as 27 % on a provincial basis, but this overexploitation is concentrated in a number of fresh groundwater areas. This is in line with that as reported by Steenbergen and Oliemans (1997), that the share of groundwater in the supply of irrigation water has been rising from 8 % to 40 % from 1960 to 1985. Also Halcrow (2006) reported that the groundwater use by farmers has increased from 8% in 1960 to 60% at the start of 21st century.

Current rate of over exploitation of groundwater can be very devastating to the environment and economic well being of the populace of the area. Current trends has induced water level drawdown to the levels where existing depths of wells do not support pumping and re-drilling of majority of wells is being implemented by the farmers in many depleted groundwater areas of IBIS. This has increased the investment of farmers and will not serve the purpose in the long run. If the present trend of groundwater depletion continues, after few years there will be need of lowering the wells again and change of pumping technologies from centrifugal to submersible, thus increasing the cost of investment and pumping to many folds. The time is fast approaching that groundwater may become out of reach of small/poor farmers. According to PPSGDP (2000) the areas with deeper groundwater levels generally are located in tail reaches of the canal system. This increasing depth to groundwater across the commands has caused considerably decreasing net income of farmers in head to tail direction as reported by Latif and Ahmad (2009).

In the absence of additional surface storages, groundwater recharge and management is a viable choice as it is already contributing about half of the crop water requirements. Unfortunately there is no concerted effort to manage this precious resource. The government agencies are only concerned with management of canal water. There exists no systematic groundwater investigation, evaluation and development plan accompanied with monitoring so as to keep an eye on the possible overdraft and deterioration of the resource. The institutional or strategic level groundwater management does not exist at all. This has created a wide gap between a planned, regulated, scientific and sustainable use of groundwater resources and current practice of mushrooming of tubewells as shown in figure 1. Therefore, a technically feasible, socially acceptable and economically viable groundwater management system concentrating both aspects i.e. groundwater governance and recharge is the need of the day.

During preceding many decades (1960s – 1990s) surplus water was available in the Indus River System, but exceptionally low quantity is available during the current decade as shown in figure 2. The preceding many decades, therefore presented a condition where canal water was available in excess to the crop water requirements due to low cropping intensities. This generated a situation where recharge component from seepage surpassed the abstraction from groundwater and as a result groundwater levels rose to near to ground surface. As the cropping intensities increased and drought conditions prevailed for many years, crop water requirements were met through pumping of groundwater. This steadily induced declining trends in depth to watertable (DTW) as is currently being observed since many years resulting not only in the elimination of waterlogging but now groundwater depletion is a fact in most of our canal commands. The danger in current scenario is over pumping causing groundwater mining and secondary salinity caused due to poor quality of groundwater. The major aim of our irrigation system management should be to keep an eye on this issue and chalk out strategic plan assuring sustainability of our groundwater irrigation.

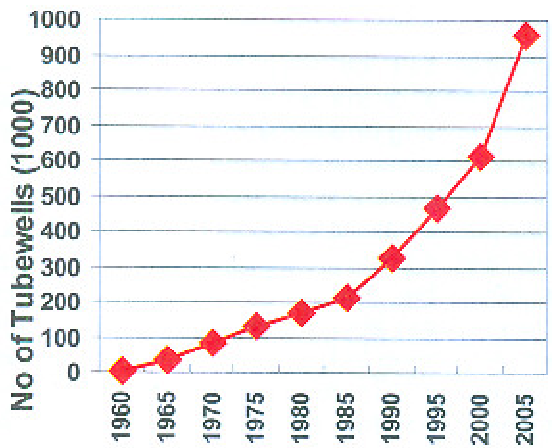

Figure 1: Growth of private tubewells in Pakistan.

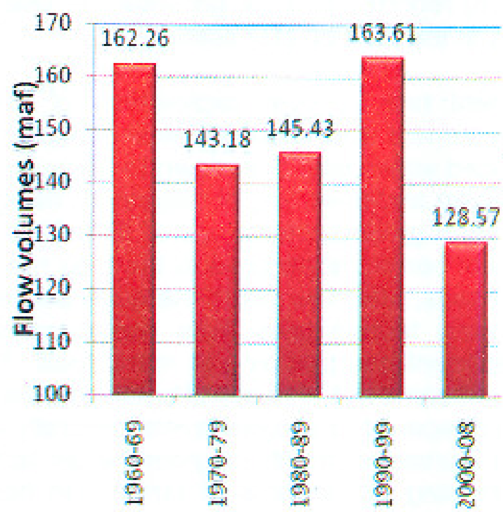

Figure 2: Annual average (10 yearly) flows in Indus River System.

1.1 Degradation of River and Groundwater Environment

Groundwater depletion should also be looked into as an environmental concern because it provides a cushion for meeting crop water requirement in drought periods which are cyclic in nature. So, water resource management should also focus to preserve or enhance the groundwater environment's buffering capacity to withstand unexpected stress or negative long-term trends in the form of droughts. As the environment's carrying capacity is put under increasing pressure, due to the growing needs of the population and over use of its resources, environmental vulnerability has increased too.

Also the degradation of our river environment is increasing day by day. Several river reaches of the order of hundreds of kilometers has become municipal waste carriers. In this context, mismanagement of water resources, not paying any attention to the environment but only lip service to irrigation needs particularly in Rabi season, has led to water scarcity and water pollution which is threatening security and the quality of human life. Giving proper regard to this unsustainable trend, the need is to acknowledge the pivotal role that integrated water resource management can play in the process of sustainable water resources management. This new approach must take into account of social, economic and environmental factors and comprehend surface water, groundwater and the ecosystems through which they flow.

Among the ADB member countries, Pakistan has the highest rate of utilization of the total available freshwater resources at 61%. In terms of groundwater withdrawal, Pakistan's annual rate of 489.5 m^3 per capita is also the highest by a wide margin (Raymond and Husaini 2006). This information clearly indicates (i) the high reliance that Pakistan has on its available water resources for irrigation and (ii) the importance of increasing the efficiency of water use when there is limited scope for increasing the supply due to internal political division between the provinces for construction of dams for storage. The above diminution coupled with degradation of water resources base of IBIS is also leading to environmental hazards in all the four provinces particularly the Punjab and Sind. So the selection of most appropriate development and management options on strategic lines needs to be the principal planning concern.

1.2 Irrigation and Groundwater Development

After the introduction of weir-controlled irrigation in 1871 (Ahmed 1993), the groundwater table started rising due to poor irrigation management, lack of drainage facilities and the resulting additional recharge from the canals, distributaries, minors, water courses and irrigation fields. On the other hand, the extensive use of groundwater for irrigation started with the installation of public tubewells in 1960's, followed by the explosive development of tubewell installation by private farmers (about one million at present and still growing at annual rate of 1-2%). The total groundwater extraction from private tubewells for Punjab has been estimated to be 43.4 BCM (35 MAF) for 2002 (Qureshi and Akhtar 2002), whereas, average canal diversions (1977-82) to Punjab were 54.4 MAF. Where as, on Pakistan basis, the annual groundwater abstraction under the latest drought conditions (1999-2002) has been estimated to be about 55 MAF. This high groundwater use in recent decades shows that farmers are only left with the groundwater development choice for coping with any increased water demand due to increasing cropping intensity and other competing uses such as domestic and industrial as a result of population increase.

1.3 Changing aquifer behaviour over one century

Before the introduction of widespread irrigation, the groundwater table in the Indus Basin varied from about 40 feet in depth, in Sindh and Bahawalpur areas, to about 100 feet, in Rechna Doab. Seepage from irrigation systems, some of which have been in operation for more than 150 years, was the principal cause of rise in water levels. Geologic studies have shown that virtually the entire Punjab is underlain to depths of 1000 ft or more by unconsolidated alluvium, which was saturated to within a few feet of land surface due to seepage as shown in figure 3 (Greenman et al. 1967). The alluvium complex consists principally of fine to medium sand, silt and clay. In the natural environment that existed before the inception of perennial canal irrigation, the groundwater hydraulic system was in dynamic equilibrium i.e. recharge to groundwater reservoir almost balanced discharge and there was no long term rise or fall of the watertable as shown in figure 4 by early parts (1910-14) of groundwater level hydrographs for Lower Bari Doab Canal (LBDC) area. Groundwater was derived from under flow from the upstream areas and from local precipitation. Evidently underflow form upstream and recharge from precipitation did not quite balance underflow downstream and evapotranspiration losses; so equilibrium was maintained by small component of recharge from the rivers to groundwater reservoir as shown by pre-irrigation groundwater regime in figure 3.

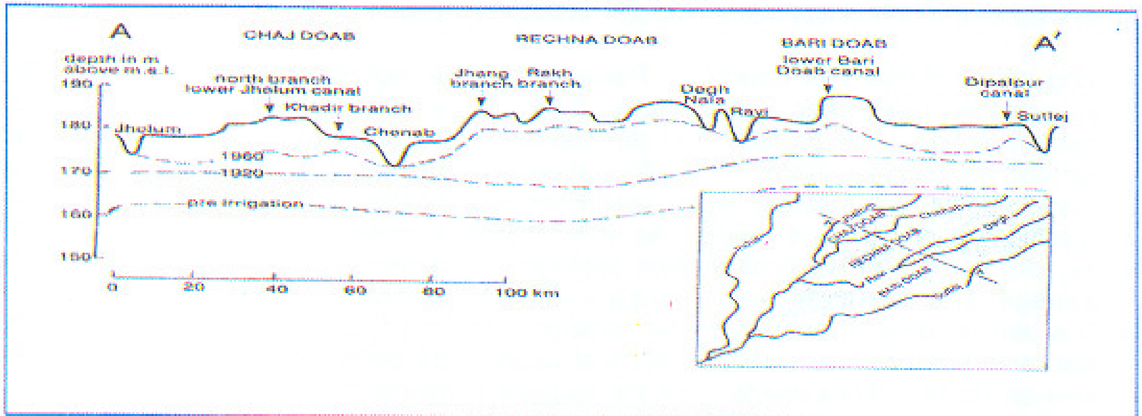

Figure 3: History of Groundwater rise in Punjab (Source Greenman et al., 1967.)

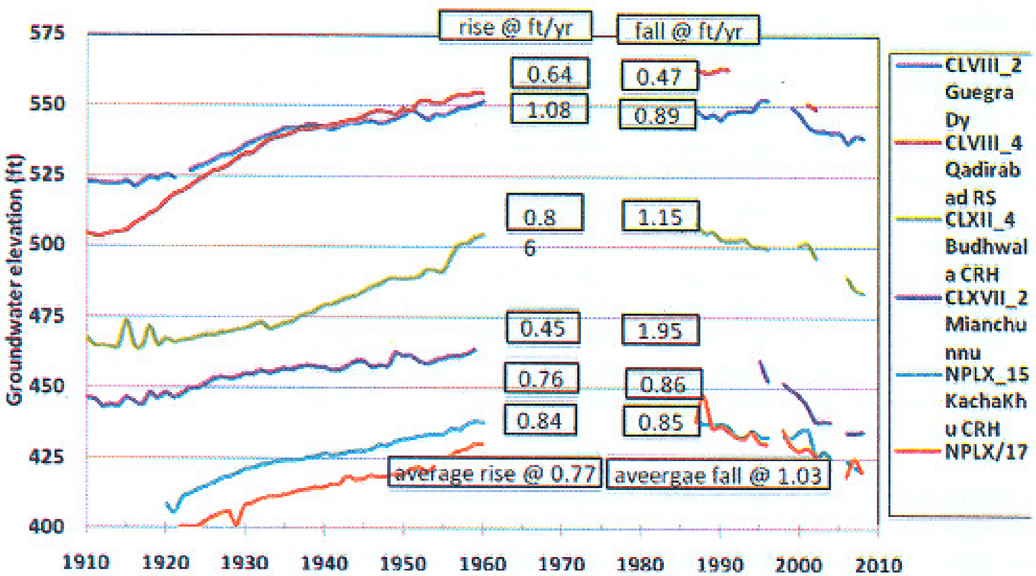

Figure 4: Groundwater hydrographs spanned over one century, showing reservoir filling and depletion in LBDC command.