# Future Threats for the Sustainability of Groundwater: Evidence from Buchiana, Irrigation Sub-division, Rechna Doab, Pakistan

**Abdul Hamid, Nazim Ali and Asad Sarwar Qureshi,** *Social Scientist, Agncultum Economist and Acting Director, International WaterManagement Institute, 12 Km Multan Road Thokhar Niaz Baig Chowk Lahom, Punjab Pakistan, Ph 0092 42 5410050-3, Fax. 0092 42 5410051, email a.hamid@cgiar.org*

## ABSTRACT

The paper presents the case study of groundwater in Buchiana irrigation sub-division. The International Water Management Institute (IWMI) collected the data about tubewell density, share of groundwater and surface water in inigation and its historical trends. Similarly, the farmers' perceptions were observed regarding the future threats of ground water and preventative measures taken by them. The result shows that the groundwater play significant role in the irrigated agriculture of Pakistan. Use of groundwater is directly linked with cropped area. But on the other hand, people are exploiting the ground water resource by ignoring its consequences. Unintentionally they cause both deterioration and conservation of groundwater, keeping in view their financial benefits. Through the data, we can communicate to the policy makers over the alarming situation of groundwater, which may be threat on irrigated agriculture, so as the measures, could be taken for the sustainability of the groundwater resource.

**KEYWORDS:** Future Threats of Grounwater, Exploitation of Grounwater, Conjunctive Water Management, Water Quality and Sustainability of Groundwater

## SUMMARY

The water resources in Pakistan are decreasing day by day due to it extensive utilization and improper management. Although Pakistan has one of the largest irrigation systems yet it is facing the water shortage both for irrigation and domestic use. To deal with this situation farmers are looking for alternate sources, like groundwater and wastewater etc. Most of the groundwater used in agriculture is marginal to hazardous but still its use is very common. Groundwater provides about 40 to 50 percent of total irrigation supplies in irrigated agriculture. This contribution is increasing with the passage of time depositing salts in root-zone. The intensive use of the ground water may affect the sustainability of irrigated agriculture by increasing secondary salinization. Similarly, it may cause up coning of fresh groundwater. Although, the end users have realized over the critical situation and un-intentionally doing the preventive measures for the sustainability of the groundwater. But still there is need to highlight the issue at policy level.

## 1. INTRODUCTION

Agriculture plays a pivotal role in the economy of Pakistan and livelihoods of its growing population. Agriculture production accounts for **24.6%** of the country's GDP, employs 50% of its labor force and provides about 70% of export earnings including processed agricultural exports (Government of Pakistan 1998). Some 90% of agricultural production is contributed by irrigated agriculture. Major parts of the agriculture depend on surface irrigation. But, in spite of having one of the largest irrigation systems of the world, the water is not sufficient to meet the crop water

requirements. Because water demand is growing day by day due to over-population, continues drought, multiple use and improper water management. The people are looking alternatives to fulfill the gap between the demand and water supply. One of the best, demand based and possible alternatives is the use of ground water, which has become a major supplement to surface water supplies.
The use **of** groundwater is long history in Pakistan. Initially, the people used the ground water through dug wells for irrigation but later in the decade of sixty, development was made and thousands of deep tubewell were installed with the launching of Salinity Control and Reclamation projects ***(SCARPs).*** During last **25-30** years, these large capacity public tubewells were followed by the private shallow tube wells with the approximate capacity of 30 lit/sec. The development of private tubewell received a boost when subsidized power supply and prelusion of locally manufactured diesel engine, resultantly ***2.5*** million farmers were estimated the groundwater users (Qureshi et al 2002) which used 60 billion cubic meters of groundwater annually.

The groundwater offers better insurance against drought because of the time lag between changes in recharge and responses in groundwater levels and yields. Under certain condition, the irrigation with groundwater may be more productive as compared to surface water irrigation because farmers tend to economize its use thus maximizing application efficiency, which leads in enhancing the people reliance over the ground water.

On the other hand, the farmer's reliance is causing the exploitation of ground water and they did not bother about the water quality and its long-term impacts on the land and aquifer. Although there is limit in the use of groundwater even in the fresh water zone, otherwise uncontrolled situation may lead the abstraction of groundwater quality, even in the sweet zone. It is due to that this problem has emerged in many area of Indus basin (Kijne, 1999). Despite the alarming situation, nobody takes care, either in the public or private level, which is the big threat for the sustainability of the groundwaier resource.

It is often neglected until undesirable effects start to develop. One of the reasons for this is that the processes in a groundwater aquifer are very slow and invisible compare to surface water. Secondly groundwater resource does not belong to specific farmer or group of farmers. Therefore, there is little tendency to conserve a common resource. Thus, the proper ground water management is imperative for the sustainability of this precious resource. The study aimed is to understand thoroughly the use of groundwater and farmers behavior towards its use misuse and conservation so as the measure could be taken to keep its natural balance on sustainable basis. Keeping in view the objective, following hypothesis could be tested,

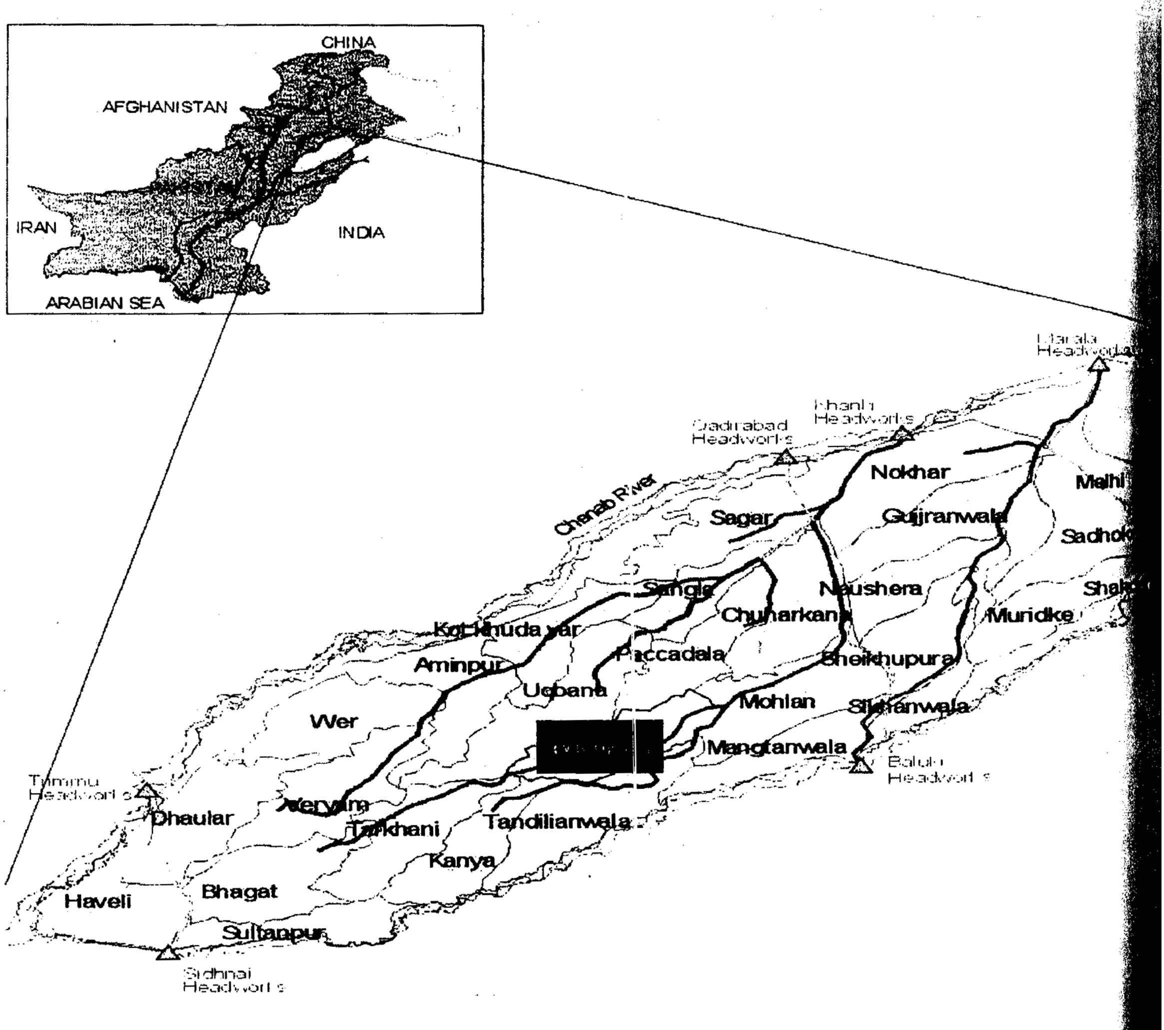
1. Inequity in surface water distribution and high cropping intensity causes the exploitation of groundwater
2. Use of ground water increases tremendously in the brackish water zone
3. Farmers get realized over the future threats of ground water use
4. Farmers are taking preventatives measures for the sustainability of the groundwater

To test the hypothesis, the International Water Management Institute (IWMI) selected an irrigation sub-division Buchiana, where the study was conducted in the year 2001-***02.***

## 2. SITE CHARACTERIZATION

The study area is the part of Lower Chenab Canal (LCC) system, which originates from the Chenab River at Khanki Headwork. LCC canal bifurcates into Upper Gugera and Main Line lower at head Sager after a distance of 46 Kilometers. The Upper Gugera, which is part of LCC east system furthers, bifurcates into Lower Gugera and Burala canal at Buchiana head after distance of 86 Kilometers. The Buchiana irrigation sub-division is covering the Reduce Distance

(RD) 0-190 of the Lower Gugera branch. The gross area of sub-division is 81,151 hectares (ha) of which 79 percent is Cultureable Command Area (CCA) and is being irrigated by the seventeen distributaries and six direct outlets with an authorized discharge of 15.06 $m^3$ / sec.




The Buchiana sub-division is one of the mediums to large subdivisions in Punjab province. It is a first irrigation sub-divisioii in the lower Gugera division, which receives the water supply based on its position in the rotational schedule, which is a priority-based system that runs subject to the availability of supply. The possibility of receiving water depends on the availability of water in the main system. Buchiana sub-division is the first of the three sub-divisions of the lower Gugera. The branch traverses the entire length of the sub-division on its way to the Tarkani sub-division further south. Its irrigation network, off taking from either side of the lower Gugera canal, consist of 302 sanctioned outlets for an average of nearly 212 hectares of cultivated land per watercourse. Total length of distribution network is approximately 195 kilometers corresponding to a density of about 3 kilometers per 1000 hectares (Rehman et al 1997).

The morphology of the sub-division is characterized by well-defined clustering of coarse to medium soils. The soils are well drained and suited for the growth of sugarcane and wheat. The topographic relief across the Buchiana Sub-divisions is 15 meters from head to tail, for which the average slope is 0.00033. The main crops grown in the command area are wheat (48.3%), cotton (7.7%), sugarcane (26%), and rice (3.2%), as well as fodder during the winter (13.6%) and summer (12.6%) seasons (Rehman et al 1997).

The climate in the area is hot and arid. Based on 25 years, precipitation data from the meteorological institute in Faisalabad, the average rainfall per year is about 398.4 millimeters. Average temperatures range from 19.5 to 40.4 Celsius in June and 27.3 to 4.2 in January. The rural life in the Punjab province is very hard indeed, mostly due to scarce canal irrigation resources, unfit ground water, and the so-called twin menace of waterlogging and salinity.

The people of the area usually possess the mixed background, Local, Mohajir (migrants) and settlers. Similarly, mixed castes, Rajput, Gujjer, Arian and some poor castes, are existing (Field observation). The groundwater quality is usually poor, But, it is found good along the canals, perhaps this is the reason mostly the tubewells are located there.

## 3. METHODOLOGY

### 3.1 Data Sources

Following information were collected,

**3.1.1** Literature Review
**3.1.2** Primary Data
**3.1.3** Secondary data

#### 3.1.1 Literature review

Literature review contributed to an understanding of the history and existing status of groundwater and it importance in irrigated agriculture. Similarly it gave an insight about the status of preventative measures, if there are happening, for the management of groundwater resource.

#### 3.1.2 Primary Data

Two types of the data were collected from the field.

### 3.1.2.1. Questionnaire data

Semi-structured questionnaires were developed for the interviews from sample farmers. The sample farmers were selected from Buchiana subdivision taking 3-7 farmers randomly from each of the village depending upon size of the village so that entire command of the village could be covered. This data consists of number of tubewells, perception of farmers about groundwater use, threats and measures to conserve the depleting aquifer and land use pattern.

### 3.1.2.2. Physical data

It was quite difficult to collect data about water resources from entire subdivision. Therefore, Khanuana Distributary was selected from Buchiana subdivisions for detail study about water availability. Buchiana Distributary is about 37 kilometers long with discharge of about 2.89 cumec serving 12585 hectares of area by its **64** irrigation outlets. Distributary was divided into three reaches i.e. head middle and tail reaches of about 12 km each.

Out of 64 outlets, 9 outlets were selected for water measurement; ***6*** from head middle and tail reaches and 3 from its minors off-taking from this distributary. Data collected from sampled outlets of Khanuana system include cropped area, discharge of the outlets, tubewell installation, their discharge and operational hours. This data was proctssed to calculate availability of surface and groundwater for one hectare of command area of sampled outlets.

### 3.1.3 Secondary data

The secondary data about the canal flow was collected from the Punjab Irrigation office Faisalabad. The gauge reader of irrigation department da ly recorded the data, which comprised daily discharge of seventeen gauge points of Buchiana sub-division for the last ten years.

All above data was processed in MS Office, 97 software.

### 3.1.4 Data Processing

Availability of canal water resource at distributary level was calculated by multiplying discharge of outlet and duration of its operational while availability of tubewell water was calculated by multiplying pumping capacity of tubwells in command of sampled outlets with their operational hours. To check historical trend in water resource in canal water at sub-divisional level, secondary data for discharge was used and for groundwater, primary data about tubewells was extrapolated at sub-divisional level.

## 4. RESULTS AND DISCUSSIONS

### 4.1 Water and land resource availability

The data was collected about daily discharge of canal outlets, pumpin capacity and tubewell operational hours of sampled outlets for the complete crop year. But data about water resources was presented here for Kharif (summer), 2002 because dernand rises to its maximum and farmers use the ground water intensively to supplement their canal water supplies. In Rabi (winter) season only the canal water can fulfills the water demand so farmers occasionally use groundwater. Availability of water per hectare in command area of each of sample outlets was presented below.

| Location | Canal water | Ground water | Total water | Share of GW (%) |
|---|---|---|---|---|
| Head | 2.94 | **2.89** | **5.83** | 50 |
| Middle | 2.74 | **0.73** | **3.47** | **21** |
| Tail | 2.73 | **0.43** | **3.16** | **14** |

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| | (000) m3/ha | **CCA (ha)** | **Cropped Area** (ha) | **Cropped area as** percentage of **CCA** |
|---|---|---|---|---|
| Head | **5.83** | **568** | **543** | **96** |
| Middle | 3.47 | 576 | 450 | 78 |
| Tail | 3.16 | 667 | 424 | 64 |

LCC (East) irrigation system was designed to irrigated about **35** percent of the command area in each season but due to population pressure cropping intensity increased about 64 to 96 percent in different reaches as its is evident from table 2. For this additional cropped area, farmers use groundwater to supplement their canal water supplies, therefore more would be the groundwater higher would be the cropped area in each season. Table 2 shows a strong correlation between water resource and cropped area. Although farmers prefer to use canal water as source of irrigation due to better quality and low cost but groundwater, despite its inferior quality and high cost, is essential to sustain this much cropping intensity.

Canal water supplies are unre iable, less flexible and supply based unlike groundwater that is demand based with flexible water supply, therefore dependency of farmers on groundwater to boost their cropping intensity is increasing. This increased dependency and high pumpage causing a threat to sustainability of groundwater. Because over pumpage not only deteriorates quality of groundwater but also lower the groundwater table making it out of reach of shallow tubewells and hand-pumps.

Dependency on groundwater as source of irrigation is increasing day by day due to increased water demand not only for agriculture but also for domestic and industrial use too. Less surface water diversion and drought have aggravated the problem. To visualize the future scenario, it is necessary to see the development of groundwater resource during last decade, which was presented in following section.

### 4.2 Historical trend in the use of water resources

Data were collected from entire command of Buchiana sub-division in the year 2002 about tubewell installation, their types and capacity. Surface water supplies were calculated from secondary data of gauges and discharges. While tubewell data was extrapolated from sample data collected from field. Data were analyzed for the last decade (1991-2000) but for the sake of simplicity data from selected years is being presented in following table.

**Table 3: Number of Tube wells and it contribution in total available water (Million $m^3$)**

| Year | No. of TW | TW water | Canal water | Total Water | TW water % |
|---|---|---|---|---|---|
| 1991 | 413 | 11.74 | 609.88 | 621.62 | 1.89 |
| 1995 | 1138 | 32.38 | 586.91 | 619.29 | 5.23 |
| 2000 | 4034 | 114.51 | 474.35 | 588.86 | 19.45 |

Table 3 shows that there is tremendous increase in the tube wells installation within the period of ten years. The tubewell density increased from 6.4 to 62.92 per 1000-hectares of the CCA, which is almost ten-time increase within the period of ten year, Surprisingly, this increase was observed in an area where there is brackish groundwater that means this growth can be even higher in fresh water zone. The data also indicates the reduction in surface water supply with the passage of time: which compelled farmers towards the use of ground water resource. According to Federal Bureau of Statistics, the surface water availability reduced to 26 percent during the cropping year of 2000-01 when compared with 1996. During this period, the population of private tube wells increased by 59 percent. This steep increase in number of private tubewell with uncontrolled pumpage poses a serious threat to groundwater balance in Buchiana subdivision. This threat may be further lower quality and quantity in aquifer. The real concern is do farmer realize these threats about future use of groundwater? For this farmers were interviewed and results of data were presented in subsequent section.

### 4.3 Threats to Groundwater

The interviews based data is presented in the under mentioned table. The data was collected from the farmers' community. As being the big users of the ground water, their responses may be valuable.

**Table 4: Future Threats Regarding Use of Groundwater**

| Indicators | Respondent | Percentage(%) |
|---|---|---|
| Poor quality: | 215 | 44 |
| Lowering Water table | 25 | 5 |
| Land degradation | 203 | 42 |
| High pumping Cost | 45 | 9 |
| Total | 488 | 100 |

The above table 4 indicates the future threats regarding the use of groundwater. Majority of the respondent think the water quality as the biggest threat. Farmers think that deteriorating groundwater quality may stop use of groundwater for agriculture. This may be because they think that there is no remedy for this problem if it occurs. The second main issue for the farmer is land degradation through secondary salinity. Secondary salinity not only hardens the soil but also lower yield, which is direct economic loss for them.

Few also responded the high operational cost and lowering of water table but still it is not big issue. Perhaps, the high cost is compensated with the output in the shape of crop production. Surprisingly, despite the visible threats, there is tremendous increase in the use of groundwater. This is due to lack of proper monitoring of groundwater pumpage.

### 4.4 Measures for ground water sustainability

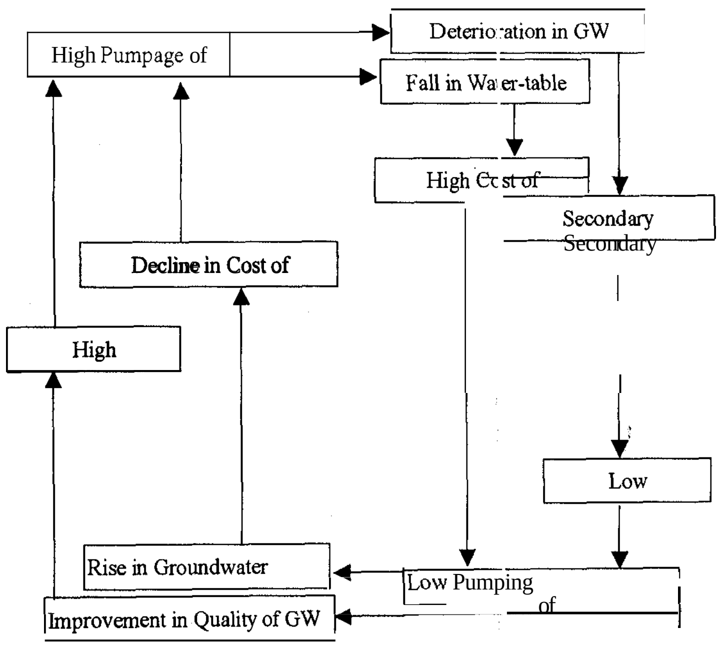
The farmers' community, which is affiliated with the groundwater since their childhood and they usually, experienced over the ups and down of the ground water resource. Therefore, being more practical and experienced users, they were asked about measures to conserve the Grounwater. Unfortunately, farmers did not respond over the preventive measures but told their steps, which were taken to mitigate the secondary salinization. As it is mentioned earlier that groundwater is common resource so fanners think that individual farmer can not do anything to conserve the resource, Therefore he just thinks about profit maximization or cost minimization for his own arm. Any step that a farmer lakes for the conservation of groundwater resource is driven by some economics force. During interview they were asked about steps that they took for the conservation of groundwater resource. They responded about the steps that were taken to control the secondary salinity, but leading to conserve the groundwater resource as well. Therefore, an exercise was made in the study area by the field team and figure out the following data, as mentioned in the table.

**Table 5: Measures for the Sustainability of the Groundwater**

| Responses | Respondent | Percentage (%) |
|---|---|---|
| Less pumping /ground water uses | 70 | 15 |
| Mix with canal water | 378 | 77 |
| Improved irrigation technology | 40 | 8 |
| Total | 488 | 100 |

The above table 5 indicates that majority of the farmers responded that they are mixing the groundwater with canal water, so as to mitigate its effect on land fertility. In central and lower Punjab areas, canal water supplies are limited and groundwater quality is only marginally fit for irrigation. Therefore farmers prefer to use poor quality g:oundwater in conjunction with the canal water. By mixing tubewell water with the good quality canal water, farmers tend to decrease the salinity of the irrigation water in order to reduce the risk of soil salinization. Although evidences exist that blending of saline and non-saline irrigation water is less effective in keeping soil salinity levels lower than applying alternate irrigation (e.g. Hussain et al., 1990; Shalhavet, 1994; Kumar, 1995), this strategy is widely practiced in Pakistim. Few farmers also responded that they saved their land by minimizing the pumpage hours and by introducing the improved irrigation technology. Less pumping hours is very important in the brackish water zone but still few are giving attention over it. Because for the sustainability of groundwater resources, controlling operational hours of tubewell could be a better strategy than restricting the tubewell installations (Qureshi et al **2002).**

The farmer's unintentional action of conserving the ground water resource may leads towards the under-mentioned cycle.




## 5. CONCLUSIONS *AND* IMPLICATIONS OF GROUND WATER RESOURCE

The inequitable surface water distribution is not the strong force that urge farmers to use groundwater rather higher cropping intensities and shortages in surface irrigation supplies compel farmers to use groundwater. Likewise, the climate variability, especially the prevailing of drought condition, provided an opportunity for the farmers of these areas to supplement their irrigation supplies and over the exploitation of groundwater. ***So*** the present uncontrolled and unregulated use of groundwater is causing excessive lowering of groundwater tables and intrusion of saline groundwater into fresh groundwater aquifers, which is serious threat for its sustainability. However, farmers are doing the preventative measures due to fear of secondary salinization that is automatically leading towards the conservation of groundwater. Thus, the farmers' unintentional action of conserving the groundwater could be an encouraging factor for its conservation.

There is required special attention that farmers should encourage over the cultivation of less delta crop and the option of improved irrigation practices, so as the water demand could be minimized. Similarly, the emphasis should be to enhance the coordination among the irrigation and agriculture-related departments. They should come ahead and play their role. Like, if meteorological department forecast the weather well in time, the irrigation department could manage their water supply accordingly. Similarly, the agriculture extension department can motivate the farmers over the cultivation of crop according to the availability of water. There is big question mark, how to enhance the coordination among the various departments. That perhaps could be done through the proper database management. That proper database may serve the requirements of all the departments related to irrigated agriculture.

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