Paper No. 187

FOOD SECURITY AND GROUNDWATER INVESTMENT

Ghulam Nabi, Muhammad Masood, Muhammad Rashid, Umar Masood

FOOD SECURITY AND GROUNDWATER INVESTMENT

By:

Ghulam Nabi[1], Muhammad Masood[1], Muhammad Rashid[2], Umar Masood[2]

Abstract:

Groundwater irrigation plays a vital role in boosting agricultural production and livelihoods of rural communities in many parts of the world. For example, the area in South Asia equipped for irrigation has tripled since 1950. India, Pakistan, and Bangladesh are the largest groundwater users in South Asia, with an estimated annual extraction of about 320 billion m^3 (BCM), (India 230 BCM, Pakistan 60 BCM, and Bangladesh30 BCM). More than 85% is used for agricultural purposes, compared to 40% in the rest of the world.

Groundwater, is basic source for agriculture, industrial, and economic growth. The Green revolution in the 1970s contributed considerably to increasing food production in Pakistan through the development of groundwater-based irrigation, which resulted in an expansion of irrigated area and a rapid rise in the number of electric and diesel pumps.Groundwater pumping for irrigation remains the primary driver of groundwater depletion, which can further affect food and water security in Pakistan under climate change.Groundwater depletion threatens global water and food security. Despite local successes in reducing ground- water extraction, the potential for transitioning currently irrigated systems to rain fed systems to address both production and groundwater use problems remains poorly understood at the national level. There is dire need for heavy investment for groundwater conservation, development and replenish.

Key words: Food Security, Groundwater, Agricultural Growth, Groundwater Investment

Introduction:

Food security is a basic human right. In fact, having access to at least an adequate amount of nutritious food could be seen as the most basic of all human rights.

However, for hundreds of millions of people, this right is not being met, usually for reasons entirely out of their control. In this article, we will discuss why this is happening, the impact that food insecurity has on those affected, and what we can do, both as individuals and collectively, to right these wrongs(Fahy, 2019).Climate change and population growth have significantly affected the global water resources in the 20th century and are likely to pose more challenges in the future(Dangar et al., 2021). With rapid globalization, the number of immigrants worldwide has tripled from approximately 84 million to 272 million in the past(Dou et al., 2022).

1 Associate Professor Assistant Professor, Centre of Excellence in Water Resources Engineering, UET, Lahore.

2 Post graduate students, Centre of Excellence in Water Resources Engineering, UET, Lahore.

Water scarcity is an imbalance between demand and availability and exists when the demand for water exceeds the supply. It can be defined either in termsof existing and potential supply of water or in terms of present and future demands for water or both. It can also be defined as a relative concept and therefore be regarded partly as a Social construct because determining water scarcity varies from country to country and region to region in a country and within the social construct, the scarcity is determined both by the availability and consumption pattern(Period, 2021).

International Food Security Assessment 2021-31 by the United States Department of Agriculture found out that 38 percent of Pakistan's population is food insecure. In Nepal, 13.6 percent of the population is food insecure; Sri Lanka 19.4 percent, Bangladesh 25.7 percent and India 25.8 percent.

Pakistan's current water availability as 1,090 cubic meter per capita per year. On the other hand, water scarcity is estimated to be 850 cubic meters in 2013 and will go on declining to 659 cubic meters per annum in 2025. The shortage has been estimated at 29 percent for the year 2010 and 33 percent for 2025(International news 2021, n.d.).

Groundwater development in Pakistan-historical perspective

The Indus Basin is underlain by an extensive unconfined aquifer covering about 16 million ha of surface area, of which 6 million ha are fresh and remaining 10 million ha are saline. The aquifer receives its direct recharge from natural precipitation, river flow, and the continued seepage from the unlined canals, distributaries and watercourses and application losses from the irrigated fields. The safe groundwater yield is estimated to be about 68 BCM, whereas the extraction for agriculture, domestic and industrial sectors is already approaching to about 56 BCM.

The water shortage in the agriculture sector is another issue.Agriculture has features that make it a unique instrument for development. Agriculture can work in concert with other sectors to produce faster growth, reduce poverty, and sustain the environment. Agriculture contributes to development as an economic activity, as a livelihood, and as a provider of environmental services, making the sector a unique instrument for development.Pakistan's 92 percent land area is considered to be arid and semiarid. The productivity of this land area depends largely on the irrigation. Around 25 percent of the total land is covered by the Indus plain and 65 percent population subsisting on agriculture draw water by irrigation.This irrigated area accounts for 80 percent total area under cultivation in Pakistan; estimated to produce above 90 percent food and fiber requirement of Pakistan. The irrigated area, which is about 80 percent of the country's total cultivated area, produces 90 percent of Pakistan's food and fiber requirements.

According to the analysis of total demandi.e. demand of all the commodities, of last decade it showed an increase in demand by 57.5 % which portrays the increase in food demand according to rising population by the end of this decade will be 141.13%. The increment of food demand in last decade in all commodities and total demand of these commodities is depicted in figure 1 and figure 2.

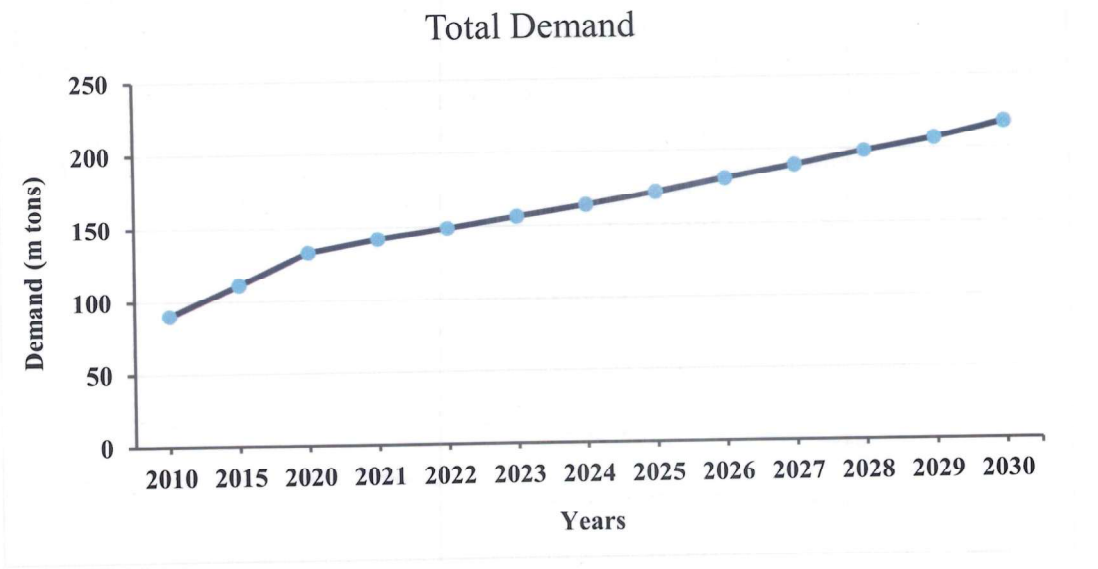

Figure-1: Total Years wise Food Demand (http://www.pidelms.com/pphs/)

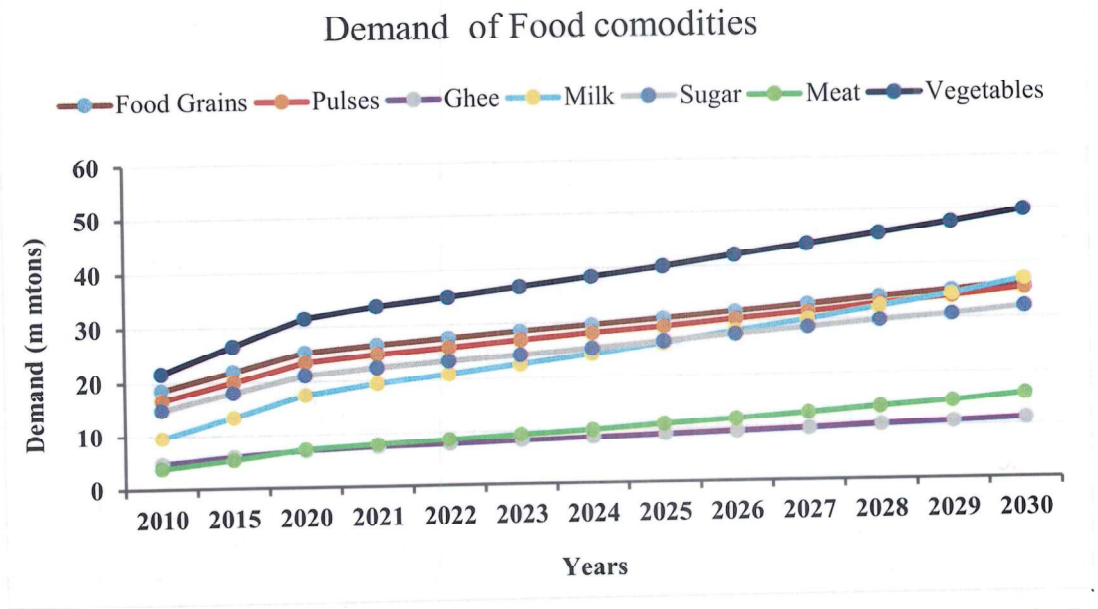

Figure-2: Food Demand of different Commodities (http://www.pidelms.com/pphs/)

The agriculture sector's performance during 2020-21 broadly stands encouraging as it grows by 2.77 percent against the target of 2.8 percent. The growth of important crops Pakistan Economic Survey 2020-21 (wheat, rice, sugarcane, maize) during the year is 4.65 percent. The production of major Kharif crops 2020, such as sugarcane, maize and rice indicated considerable improvement compared to last year and surpassed the production targets. The production of sugarcane increased by 22.0 percent to 81.009 million tonnes from 66.380 million tonnes, rice by 13.6 percent to 8.419 million tonnes

from 7.414 million tonnes and maize by 7.4 percent to 8.465 million tonnes from 7.883 million tonnes(2021, n.d.). The production of food decreased 7.5 percent in 2012-2013 and 9.1 percent in 2013-2014. And in 2016-2017 and 2018-2019 crop reduced 12.7 to 15 percent. These reduction values are shown the decline production of wheat crop in the graph below. Almost wheat production is small in 2018-2019. Decrease trend of production crop in figure 3.In year 2019-2020, Sugarcane production (66379.6 M Tons) was observed to be maximum than rest of the crops like rice (7413.7 M Tons), wheat (25247.5 M Tons) and maize(7883 M Tons).

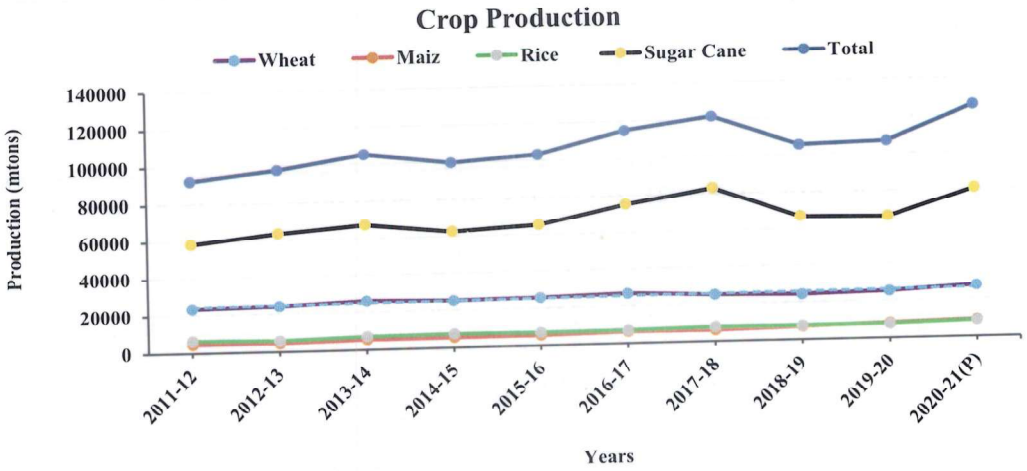

Figure-3: Years wise Crop Production of Food Crops(http://www.pidelms.com/pphs/)

Pakistan is facing water scarcity which has its roots in water shortage. Critical factors such as Rapid population growth, climate change, reductions in the ice and snow areas of the Himalayas, Urbanization, industrial growth, poverty, distribution inequalities, unsustainable water consumption Practices, loss of ecosystems, more rapid runoff and bad management of water resources by the Government have caused degradation of the resource base and laid huge stress on the quantity and Quality of water resources. The population of Pakistan is 170 million in 2010, 200 million in 2020 and increases in 2030 up to 250 million. All values of population increase per year shown in figure 4.

The world population has increased in the previous century. There were 1.8 billion people on the planet in 1915. According to the most current UN estimate, there are 7.3 billion people today, with a possible increase to 9.7 billion by 2050. This expansion, along with increased affluence in emerging nations (which results in dietary changes such as consuming more protein and meat), is pushing up global food consumption.(Elferink Maarten & Schierhorn Florian, 2016).

The issue of population expansion has long been linked to the issue of food security. Since the 1960s, worldwide agricultural output growth has exceeded population growth.

The coronavirus disease 2019 (COVID-19) pandemic had a dramatic impact on individuals, families, and the economy in early 2020, including interruptions in food access. Food production and supply were hampered by the spread of disease among

staff and food outlet closures, resulting in global staple food shortages(Hollis-hansen et al., 2022).

Rate of Population in Pakistan has increased significantly that increase the food demand. Crop production has also increased but the rate of crop production as compared to the rate of food demand and population has decreased. Figure 4 has shown the increasing trend of population in Pakistan.

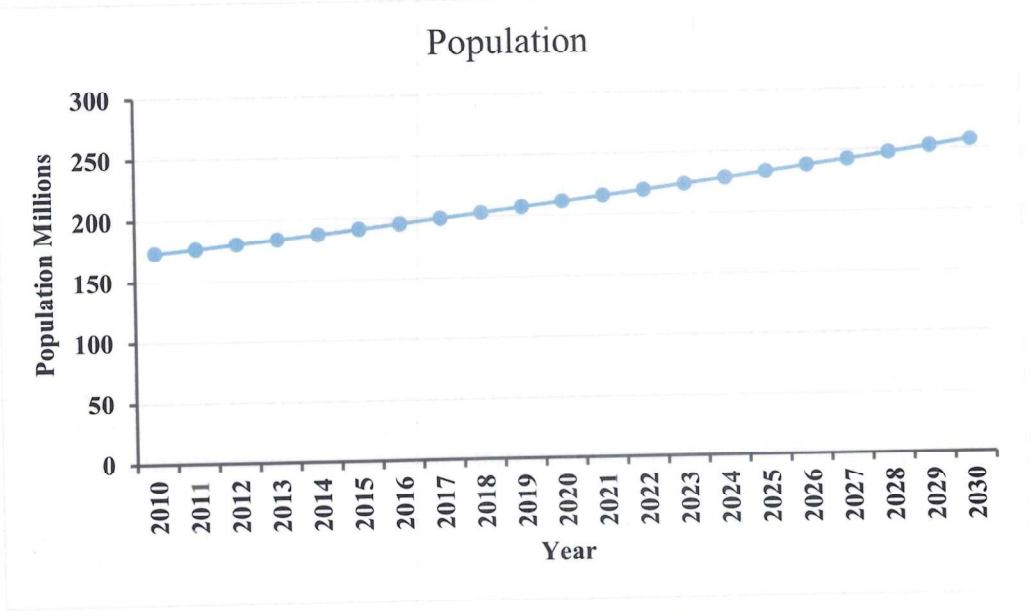

Figure-4: Rate of Population in Pakistan

Wheat Demand – Supply Situation

Wheat is the most important crop of "Rabi", which showed growth of 8.1 percent and reached record high production level of 27.293 million tons compared to 25.248 million tons last year.

The overall crops sector, having a share of 35.81 percent in agriculture value addition and 6.87 percent in GDP, witnessed a growth of 2.47 percent. Water availability during Kharif 2020 remained at 65.1 million acre feet (MAF) showing a slight decrease of 0.2 percent compared to 65.2 MAF of Kharif 2019. Rabi season 2020-21 received 31.2 MAF, showing an increase of 6.9 percent over Rabi 2019-20 (Seminar Report 2021, n.d.). Following are some demand and production trends of wheat in Pakistan.

Groundwater depletion threatens global water and food security(Liu et al., 2022).Pakistan faced with a growing population of 165 million of which at least 25 percent live below the poverty line and, 98 million rely on agriculture, 50 million does not have access to safe drinking water, and 74 million do not have sanitation and hygiene. Facing poverty, growing population, system losses, distribution inequalities and ecosystem degradation Per capita water availability in Pakistan has decreased from 5,000 cubic meters per annum in 1951 to 1,090 in 2005. It witnesses a further decline and is just at around the benchmark of 1000 at this time.

Groundwater Potential in Punjab

The main source of groundwater in the Punjab lies in the four hydrogeological zones, namely Potohar plateau & salt range, Piedmont areas, alluvial plains and Cholistan desert. Indus River and its tributaries drain the province. In Punjab a lot of work has been carried out on seepage from the irrigation system and the resulting recharge to the groundwater. The groundwater potential is based on rainfall recharge, groundwater recharge and recharge from irrigation system. The rainfall recharge of 9.90 MAF (15% from 380 mm/year) in different SCARP areas was worked out during the period 1987-97. The recharge from return flow, irrigation application, and sub-surface inflows was assessed 7.08 MAF (22.5% of 31.5 MAF). Canal seepage varies from 2 to 8 cfsdepending on the size of canal and drainage characteristics. A delivery of 24 large canals for the irrigation year 1990-91 was with an average of 54 MAF. The recharge from these canals was estimated 21.70 MAF (40% of 54 MAF). The recharge from rivers was 3.5 MAF and return flows from domestic and industrial use were assessed as 0.57 MAF (22.5% of 2.52 MAF). The total available groundwater resource of the Punjab Province was estimated 42.75 MAF(Amin, 2004).

Groundwater Potential in Sindh

The most important feature is the Indus River, the sole source of surface water for the Province. The groundwater lies in the three hydrogeological zones namely Eastern (Thar) desert, Western mountain and Indus valleys. Useable groundwater in the Province is mainly found in the Indus Plain, which is recharged from the meandering river and from the irrigation network that has been developed in the area. The other source of recharge - rainfall, is quite scanty and its contribution to the resource is limited. The

Recharge from return flows (22.5% of 38.2 MAF), irrigation returns (22.5% of 3.5 MAF) was assessed 8.58 MAF and 0.79 MAF respectively. In the Sindh, canal water losses have been taken as 15 % of the total average canal supply of 45 MAF for the period 1988-2000.

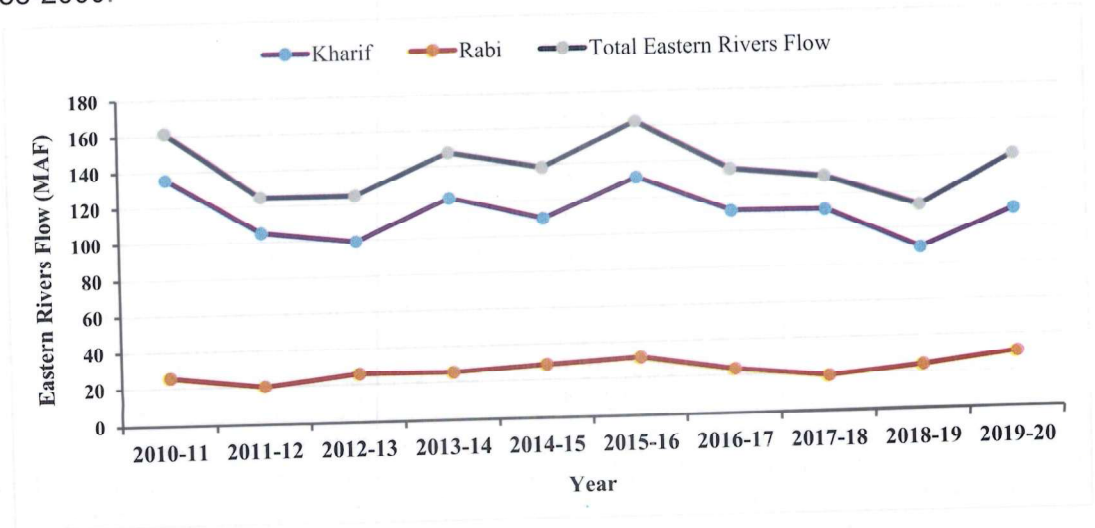

Figure-5: Trend of Western River flows

Groundwater Potential in North West Frontier

The Khyber Pakhtunkhwa (KPK) lies in the four broad geological units namely, metamorphic and igneous rocks of the northern mountains, Mesozoic rocks of the southeastern part, Tertiary rocks of the southeastern part and upper Tertiary. The main groundwater resources in the Province are the alluvial plains and many valleys, which are intermountain basins of tectonic origin. The rainfall recharge was estimated 0.7 MAF (7% of rainfall over a sub-catchment). In this Province, recharges from the canal system were worked out 1.0 MAF (15% of 6.7 MAF). The groundwater recharges include returns from irrigation application, other return flows, sub-surface inflows and recharge from rivers. The recharge from the return irrigation flows was assessed 1 MAF (15% of 6.5 MAF) and other return flows (15% of 0.88 MAF) were worked out to be 0.13 MAF. The total groundwater resource of the KPK was assessed as 3.11 MAF.

Groundwater Potential in Balochistan

The regions of the Province, which are underlain by unconsolidated sediments formed by the deposition of mountainous outwash from the surrounding highlands, have been divided into 12 distinct Basins, flood plains and valleys fills. The Province lies in the five hydrological zones namely, Mountain ranges, Piedmont plains, Valley floor, plains and rolling sand plains. The groundwater, in substantial quantities, occurs in unconsolidated aquifers in almost all basins and sub-basins. The groundwater resources in six basins of the province namely Hamune, Lora, Kachhi Plain, Nari, Pishin and Zhob have been assessed. The effective rainfall coefficient of 20% to the annual rainfall for the mountain areas is used to estimate rainfall of 1.21 MAF.

In Balochistan canal supplies are small in total and restricted to the east of the Province, adjacent to Sindh Province. For the period 1988-2000 the average canal flow was 1.94 MAF and recharge from these canals was assessed as 0.29 MAF (15% of 1.94 MAF). Most of irrigated area of this Province lies in a saline groundwater zone. Other components of groundwater recharge include return flows from irrigation application, other return flows, sub-surface inflows and recharge from rivers. The recharge from return flows of irrigation application was estimated 0.37 (22.5% of 1.62 MAF) and other return flow was 0.08 MAF (20% of 0.45 MAF). The total groundwater resource of Balochistan Province was assessed as 2.13 MAF.

Groundwater pump age and increasing rate of number of tube wells.

Groundwater irrigation plays a vital role in boosting agricultural production and livelihoods of rural communities in many parts of the world. For example, the area in South Asia equipped for irrigation has tripled since 1950. India, Pakistan, and Bangladesh are the largest groundwater users in South Asia, with an estimated annual extraction of about 320 billion m^3 (BCM), (India 230 BCM, Pakistan 60 BCM,and Bangladesh30 BCM). More than 85% is used for agricultural purposes, compared to 40% in the rest of the world.

These three countries irrigate 48 million ha (Mha) using groundwater, approximately 42% of the global groundwater-fed cropland. Diminishing surface water supplies and the desire to expand the irrigated area to produce more food for the ever-increasing population are the major factors behind this intensive groundwater use. Furthermore,

supply-driven policies of the governments and subsidized energy and pumps have exacerbated the use of groundwater for agriculture in these countries.

The arid and semi-arid conditions prevailing in most parts of the country make irrigation mandatory for sustainable crop production, as the evapotranspiration is high and rainfall is meager and unreliable. More than 75% of this rainfall is received during the monsoon season (Jul to September). The contribution of rain to agricultural irrigation is about 30 bm^3, which is only sufficient to meet 15% of the crop water requirements and the remaining 85% is met through irrigation. The scarcity and unreliability of surface water supplies left farmers with no other option than to abstract groundwater to fulfill irrigation water demands, regardless of its quality and the pumping cost.

The surface water availability in the Indus basin is 820 mm/ha/year, assuming a total canal supply of 130 bm^3 and a serving area of 16 mha. This water availability is far lower than the evapotranspiration requirements to support a year-round basin-wide intensive cropping system practiced in the Indus basin. This shortfall in surface water supplies is met through the exploitation of groundwater. Groundwater has played a crucial role in thwarting water shortages and ensuring food security for the rising population.

The groundwater use patterns vary in different provinces. For example, groundwater use in Sindh province is minimal due to quality concerns. In the KPK and Baluchistan provinces, groundwater exploitation is costly due to deeper depths and aquifer characteristics. In Punjab, the use of groundwater is widespread due to its existence at shallow depths and relatively good quality. The groundwater use in different parts of Punjab depends on many factors, such as cropping patterns, cropping intensity, agro-climatic conditions, and available groundwater quality. There are three distinct climatic zones in the Punjab province. Upper Punjab has an average annual rainfall of above 500 mm (high rainfall zone), central Punjab receives 300–400 mm (medium rainfall zone), and lower Punjab has 100 to 150 mm rainfall (dry zone). The cropping patterns in these zones differ based on the availability of surface water and groundwater. For high rainfall zones, groundwater use is low compared to small and medium rainfall zones, despite rice being a major crop grown in these areas. In the areas where wheat–cotton cropping rotation is more common, groundwater use is relatively small due to the lower water requirement of these crops. In the sugarcane and fodder-dominant areas, groundwater use is high due to high water demand(Qureshi, 2012).

Deterioration of groundwater quality

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. There are large numbers of saline groundwater pockets in the canal command areas of Punjab. About 77% (4 million ha) of the area in Punjab province has access to fresh groundwater. Saline waters are mostly encountered in central Doab areas. Cholistan area in the southern Punjab is well known for highly brackish waters, which cannot be used for drinking purposes.

Economic and environmental impacts

Declining groundwater tables and land degradation as a result of poor quality groundwater use for irrigation has seriously affected the social fabric of Pakistani

society. Drying up of Karez systems in Balochistan have increased the livelihood burden on women due to immigration of spouses for income supplementation. On average, a woman must carry more than 200 liters of water every day over long distances, which creates an enormous burden on her time and physical capacities. Similar conditions also exist in the Cholistan area of Punjab where women have to walk miles to bring fresh.

Ground water Management

Until recently the management of groundwater in Pakistan did not receive much attention because the resource was in abundance and therefore the focus remained primarily on its development as discussed above. The spectacular expansion of agriculture helped lift millions out of poverty. However, the situation began to turn serious when such unregulated exploitation brought many aquifers under severe stress and threatened the sustainability of this resource.

Prospects of Ground water Management

In Pakistan, groundwater is usually used in conjunction with the surface water. While doing so, farmers tend to decrease the salinity of irrigation water in an attempt to avoid soil salinization. In most of the canal command areas, conjunctive use of surface water and groundwater is equally practiced in head and tail ends of the canal system. One of the key disadvantages of this unmanaged conjunctive use is that upstream areas are subjected to rising water tables and water-logging whereas tail-end users are aggravating their salinity problems due to the bad quality of the groundwater.

Improving productivity through resource conservation technologies

Resource conservation technologies such as precision land levelling, zero tillage, bed and furrow planting have also shown considerable reduction in water application at the field level. These studies have found that in the Rechna Doab sub-basin zero tillage and laser leveling technologies for wheat was considerably increased during 2000-2003 from around 15% to above 35%. The area under ZT increased exponentially during 2003-04 with wheat sown on an area of 400,000 ha.

Promoting rainwater harvesting in rain-fed areas

The rain-fed areas of Pakistan contribute about 10% of the total agricultural production. However, production levels of rain-fed areas are very low i.e. 1-1.5 tons/ha. The production potential of these areas can be doubled by providing one or two supplemental irrigations at critical growth stages of the crop. Where farmers are already doing this they are generally relying on groundwater extraction. However, they should be encouraged to harvest rain water and adopt watershed management strategies to both improve the productivity of rain-fed systems and reduce the demands on groundwater.

Introduction of policy reforms

Due to the peculiarities of Pakistan's groundwater socio-ecology, a multi-dimensional policy approach is needed. In Balochistan province, for example, the policy of providing subsidies on electricity needs to be reviewed. Currently, the annual subsidy on agricultural tube wells is Rs. 8.5 billion (US$ 140 million). This subsidy is mainly provided to only 2.5% of the farmers who own deep electric tubewells.

References

2021, S. R. (n.d.). Challenges of Food Security and Performance of Agriculture: The case of Pakistan.

Amin, M. (2004). Pakistan's Groundwater Reservoir and Its Sustainability (pp. 1–7).

Dangar, S., Asoka, A., & Mishra, V. (2021). Causes and implications of groundwater depletion in India: A review. Journal of Hydrology, 596(August 2020), 126103. https://doi.org/10.1016/j.jhydrol.2021.126103

Dou, N., Murray-kolb, L. E., Mitchell, D. C., & Melgar-qui, H. (2022). Food Insecurity and Mental Well-Being in Immigrants: A Global Analysis ~. 000(000). https://doi.org/10.1016/j.amepre.2022.02.006

Elferink Maarten, & Schierhorn Florian. (2016). Global Demand for Food Is Rising. Can We Meet It? In Harvard Business Review. https://hbr.org/2016/04/global-demand-for-food-is-rising-can-we-meet-it

Fahy, A. (2019). What is Food? What Is Food?, 1–13. https://doi.org/10.4324/9780429426100

Hollis-hansen, K., Ferrante, M. J., Goldsmith, J., & Anzman-frasca, S. (2022). ARTICLE IN PRESS Research Brief Family Food Insecurity , Food Acquisition , and Eating Behavior Over 6 Months Into the COVID-19 Pandemic. Journal of Nutrition Education and Behavior, 000(000). https://doi.org/10.1016/j.jneb.2022.04.002

International news 2021. (n.d.). Food insecurity.pdf.

Liu, Z., Bian, Q., Bai, J., He, G., Chen, M., Zheng, H., Batchelor, W. D., Wang, H., Cong, J., Ying, H., Yin, Y., Zhang, Q., Cui, Z., & Zhang, F. (2022). Closing of the yield gap can be achieved without groundwater extraction in Chinese wheat production. Global Food Security, 33(March), 100630. https://doi.org/10.1016/j.gfs.2022.100630

Period, V. (2021). Pakistan: Acute Food Insecurity Situation March - June 2021 and Projection for July - September 2021 in Balochistan and Sindh. September, 2–5.

Qureshi, A. S. (2012). Groundwater management in Pakistan: The question of balance. Centenary Celebration (1912–2012), Paper, 717, 207–217.