Pak. J. Agri. Sci., Vol. 58(1), 275-281; 2021
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI: 10.21162/PAKJAS/21.263
http://www.pakjas.com.pk

A QUALITATIVE INSIGHT INTO THE FACTORS BEHIND WATER SCARCITY IN PUNJAB, PAKISTAN

Muhammad Awais Ali Khan[1,*], Khalid Mahmood Ch.[1], Ijaz Ashraf [1] and Muhammad Tahir Siddiqui[2]

[1]Institute of Agricultural Extension, Education and Rural Development, UAF, Pakistan;
[2]Dept. of Forestry and Range Management, University of Agriculture, Faisalabad, Pakistan
***Corresponding author's e-mail: m.awais925@gmail.com**

This study was conducted for the exploration of different factors contributing to future water scarcity. For this qualitative study, 370 farmers were selected from the study area. The literature regarding the assessment of factors involved in water scarcity in Pakistan is scanty, which is producing a research gap. Few of the studies available were local, had a narrow scope, and were quantitative. Conversely, this study adopted a thematic analysis technique, which is a qualitative approach to analyze data collected through face to face interviews. Empirically, this study identified and discussed some important and explanatory themes striking water scarcity, i.e., inadequate institutional role, the conventional approach of farmers, inappropriate policies, ignorance of future water crises, and conflicts. The results gave a deep insight into how water scarcity is looming over and what measures are key to implement in order to alleviate water scarcity. The results also provide a significant generalization and recommendations to conserve water resources in an entire country.
Keywords: Thematic analysis; qualitative; conflicts; water scarcity; harvesting; agriculture.

INTRODUCTION

Over half (65%) of Pakistan's total population lives in rural areas, with a large majority of them being dependent on agriculture for their livelihoods (GOP, 2019). Pakistan has an agriculture-based economy; agriculture provides raw material to the industry, such as cotton for the textile industry and sugarcane for the sugar industry. Moreover, Pakistan is 5th most populous country in the world, and if the population growth rate continues, it is projected to double by 2050, which will make Pakistan 4th most populated country in the world (United Nations, 2019). With the projected increase in population, there will be a corresponding rise in food and fiber demands which need to be fulfilled by agriculture. Agriculture is also the main contributor to the national economy, with a share of 18.9% in national GDP (GOP, 2019). Agriculture is the largest employer in Pakistan, with 42.3% of the country's total labour force. Therefore, strengthening the agriculture sector would not only alleviate poverty through sustainable development but also create more jobs. However, during 2018-19 the performance of agriculture in Pakistan was passive. The agriculture sector remained refrained to 0.85%, much lower than the target of 3.8% (GOP, 2019). Of the various reasons behind this under performance, poor availability of water was prominent. This scarcity of water significantly reduced the cultivated area and inhibited the growth of cultivated crops. As a result, the crops showed a negative (-4.43% against the target of 3.6%). A total -6.55% reduction in crop production was the witness. Of the various major crops' sugarcane, cotton, and rice embarked decline of -19.4, -17.5, and -3.3%, respectively. Maize production increased by 6.9% and wheat production by 0.5%, away from lower than the target. Cotton ginning was squeezed to -12.74% due to a reduction in cotton crop (GOP, 2019).

The agricultural sector is a major beneficiary of available water receiving through a canal system for irrigation known as the Indus Basin Irrigation System (IBIS). Out of the total water in the IBIS, 69% is consumed by agriculture, 23% is used by industry, and 8% is used by the domestic sector. Due to climate change and other challenges, such as water mismanagement and water wastage, Pakistan is experiencing a decline or fluctuation in water availability in the IBIS canal network, which results in greater unreliability in water availability for farmers to grow their crops. According to their needs, small landholders who receive less canal water could face severe problems as the result of canal water scarcity as they cannot afford the operational and installation cost of groundwater pumps. Out of the total farmers, almost 86% of farmers in Pakistan are small landholders (Acquiring land less than 12.5 acres) (GOP, 2019).

Out of the total annual available water, 97% of water is used for agricultural practices in Pakistan. An economic transaction is continuing in Pakistan, so its struggle for water resources with agriculture is expected to rise (Briscoe and Qamar, 2008). Studies have shown that the gap between water supply and demand is increasing according to United Nation's estimates, with water demand increasing by 10 percent per

annum in Pakistan (Shah *et al.*,2018). Considering the increase in demand by 2025, Pakistan will require 274 Million Acre Feet water supply to meet its needs. Whereas estimates based on studies also suggested that the availability of water by 2025 is not expected to change from the current 191 MAF availability, the gap could worsen (Akhtar, 2010). The widening gap between demand and supply is expected to continue as per capita water availability in Pakistan was 5260 cubic meters in 1951, which reduced to 1040 cubic meters in 2010, a decline of more than 400% (Sharif *et al.*, 2016). According to Rijsberman (2006), 50 liters is the minimum per capita domestic water requirement, whereas to grow food for one person per day requires 2600-3500 liters. In this case, Pakistan is running short of the water to grow food. Falkenmark Indicator, presented by Falkenmark *et al.* (1989), delivers an association between water availability and the human population. Any country having less than 1700 m^3 water is declared as a water-stressed country. When per capita availability of water falls under 1000 m^3, the country is a water-scarce, and when availability falls less than 500 m^3 per person, the country experiences an absolute-water scarcity. Taking this indicator into account, Pakistan has crossed the water scarcity line during 2005 and, if the situation persists, it will touch the absolute water scarcity line by 2025 (Ashraf, 2012). In Pakistan, 90% of food is produced in irrigated areas, whereas 10% comes from arid areas (World Bank, 2006). In this scenario, pertaining to water scarcity food production process seems to become sluggish in the future if proper measures are not taken. In this context, this study was planned with a vision to identify those areas seeking attention in order to conserve water. The major objective of the study was to determine the different factors causing water scarcity at the farm level in the Punjab region. This study augments, identification of critical factors that can help institutions to diversify their role and line of action in order to conserve water resources. This study is significant in many ways. The literature related to the exploration of factors behind water scarcity in Pakistan is scanty. The available literature is mainly of local genre and quantitative in nature. This study is perhaps the first qualitative attempt to explore different factors through discussions with the farmers.

MATERIALS AND METHODS

The research was targeted in the Punjab region, which was selected through purposive sampling on the basis of having the largest provincial population and a high dependence on water to support irrigated cultivation (Fig.1). Punjab has an area of 50.9 million acres, of which 54% is cultivated. This extensive area requires a substantial amount of irrigation (Alam *et al.*, 2000). The study was conducted within the Faisalabad district, which was selected through the lottery method of sample selection. The Punjab province comprises 36 districts - tickets bearing each district name were prepared. One ticket was chosen; this was Faisalabad. This lottery method gave each district an equal chance of selection and has been used in previous studies (Thakur, 2003). Faisalabad is known for its agricultural potential and the Lower Chenab Canal (LCC), which is the main source of irrigation used for supplying 80% of cultivated land in the district. The most common method is surface or flood irrigation in the study area. The soils in the region are mainly loamy, with a significant proportion of silt (Ahmad and Rasul, 2008).

Figure 1. Map of Pakistan showing the Faisalabad study area located within the Punjab region.

Faisalabad comprised of six tehsils, with an area of 5856 km^2 and 7.87 million population. The district is also known as Manchester of Pakistan, having a tremendous potential for the industry. Faisalabad is also known a very productive with respect to agro-production. Wheat, sugarcane, rice, and maize are the major crops of the area. The Lower Chenab Canal (LCC) is the main source of irrigation in Faisalabad, providing water to 80% of the cultivated lands. The LCC contains Rakh Branch, Jhang Branch (Upper), Jhang Branch (Lower), Gogera Branch, and Bhowana Branch Canals.
Through a system of 67 distributaries, the LCC supplies water to 485622 hectares of productive lands into other districts such as Hafizabad, Nankana Sahib, Jhang, Toba Tek Singh, and Chiniot districts along with Faisalabad. The details regarding distributaries, outlets, and benefiting farmers are tabulated in Table 1.

Table 1. Detail regarding distributaries, outlets, and benefiting farmers from LCC branches.

Sr.	LCC	Distributaries	Outlets	Farmers
1	Gogera branch	7	42	3838
2	Jhang branch	11	140	13270
3	Rakh branch	14	159	14559
4	Total	32	346	32667

Being widespread over large area, more distributaries, outlets and a large number of farmers, Rakh branch canal was selected purposively on the basis of a larger irrigation area in Faisalabad in order to select study respondents (Table 1). Further distribution of outlets and farmers benefited from Rakh branch distributaries are shown in Table 2.

Table 2. Distributaries of Rakh branch canal.

Sr.	Distributaries of Rakh branch canal	Outlets	Farmers
1	Butti	13	1616
2	Chukri	7	914
3	Dubwala	1	122
4	Dhubi	3	215
5	Dijkot	40	4732
6	Gatti	11	615
7	Kalangri	6	681
8	Gatwala	2	241
9	Khairali	10	814
10	Lakhuana	30	2029
11	Siawala	7	936
12	Taror	19	1429
13	Tulwala	8	566
14	Lathiawala	2	92

Of the total distributaries, Butti, Dijkot, Lakhuana, and Taror distributaries were selected through a purposive sampling technique taking into account the larger area of irrigation. With the help of surveysystem.com, a sample of 370 was selected through a proportionate sampling technique. Of the total respondents, 60 farmers from Butti, 178 from Dijkot, 76 from Lakhuana, and 53 came from Taror distributary.

As the study was qualitative: hence, the interview guide consisting of open-ended questions was prepared. Respondents were interviewed face to face. Each interview lasted for 30-40 minutes. The responses were recorded electronically for assistance during analysis. Data were then categorized and analyzed thematically. Thematic analysis was used to analyze the collected data. The thematic analysis approach is the globally renowned and adopted approach for qualitative investigations (Nowell *et al.,* 2017). Thematic analysis technique intricate specific steps (1) getting familiarity with the data through thorough reading and re-reading filled questionnaires, (2) categorizing and coding of the material collected, (3) identification of themes, (4) identification of explanatory acquaintances, (5) interpretation of the findings. A software, nvivo helped researchers to complete the thematic analysis. Codes, Basic themes, and organizing themes of this study are given in Table 3.

In Table 3, the codes refer to the points raised by the respondents during the discussion. These points were found most repeated during the interviews. The points were summarized, and related points were categorized, and as a result, basic themes were generated from the codes by the authors. Furthermore, the basic themes were grouped as organizing themes in order to give results a meaningful interpretation.

RESULTS

Water is imperative for profitable farming. Availability or the shortage of water may have direct effects on the production level of different crops. Water shortage can bring drought and acute food shortages. Thus, the importance of judicious use of water resources becomes of great worth. Pakistan is graced with the largest irrigation system in the world, but despite the water shortage is becoming alarming with each passing day. This study sought different factors behind water scarcity in the study area. As the study is qualitative, the responses generated from the respondents are grouped into four organizing themes (i) inadequate institutional role, (ii) conventional approach of farmers, (iii) ignorance to the future water crisis, and (iv) conflicts pertinent to water.

Institutions across Pakistan are accountable for regulating irrigation water and ensuring each farmer had equal access tow water. However, respondents had bitter thoughts regarding the institutional role. It was perceived that institutions failed in regulating the water and stabilizes equality in the distribution of water. One of the respondents argued:

Institutions did not maintain equality. The availability of water is going down each day, and farmers access to water is shrinking as well. The respondents specifically highlighted Rakh Branch, which was A category canal, and Jhang branch of B category. This implies there would be water flowing in A category canal throughout the year, whereas, in B category, it would not. But it is happening inverse now as A category canal did not have the availability of water throughout the year, but B category has. This indicates a non-competency of the department and involvement of the elite to gain maximum benefits.

Another farmer cited:

Since the Rakh Branch is not getting water throughout the year, more or less 35000 farmers are affected badly. Wheat, sugarcane, and different fodders were the key crops being irrigated through this canal, but now the loss is unprecedented. The groundwater is not fit for irrigation; if crops are irrigated with the groundwater it causes acute crop burning.

Water for irrigation is provided to the farmers under warabandi system. Warabandi system refers to canal water distribution among farmers. It was introduced by the British before partition and is still operational in the country. For most farmers, this system has become a major problem though the farmers had no clue about its possible replacement. One of the respondent arbitrated:

We are bound under warabandi system. Each farmer awaits his turn to use canal water, but the farmers in tail are

Table 3. codes, basic themes, and organizing themes.

Codes	Basic themes	Organizing themes
Water losses Water theft Unequal distribution of water Uncleaned water courses Inadequate trainings Poor awareness Water wastage Poor policies Non-implementation of laws Nepotism Biasness Illiteracy	1. Watercourses are uncleaned, allowing wastage of a lot of water. 2. Policies in regard to water saving are not apparently familiar among people, and implementation of laws is meager 3. The role of institutions in making farmers aware of the importance of water conservation is inadequate	Inadequate institutional role
Non-judicious use Wastage Non-adoption of water-saving strategies Lack of participation in training Inadequate awareness Non-cooperation with institution Mismanagement Corrupt practices such as water theft and selling Over-reliance on canal water Violation of warabandi system Fear Conflicts Landlord system Small landholding Subsistence farming	4. The education level of farmers is lower and usually tend to overuse water while irrigating their farm. 5. The adoption of a high-efficiency irrigation system is sluggish. 6. Pertaining to small landholdings, subsistence farming and affordability issues farmers rely more on canal water irrigation 7. Farmers are victimized to violation of warabandi, mismanagement and political influence from the elite in their areas	Conventional approach of farmers
No storage Seepage Traditional farming Water intensive crops cultivation Inadequate research for less water taking crops Ignorant social behavior Flood irrigation Water harvesting Lining of canal Over irrigation Mismanagement Lower level of groundwater Unfit water for irrigation	8. Farmers are rarely concerned with water harvesting and storage for future use 9. Cropping patterns adopted by the farmers are based on the crops requiring more water to reach maturity. 10. The conventional mode of irrigation, such as flood irrigation, is commonly adopted which not only wastes the water also disturbs the soil. 11. Ground water level is going down at pace but the behavior of farmers is yet right with the over irrigation. 12. Ground water is becoming unfit for the irrigation and canal water remains the sole source to meet irrigation needs	Ignorance of future water crisis
Water theft Political influence Feudal system Barren lands Lower production of crops Chaos Rivalries Migration Abandoning farming Commercialization of land Industrial involvement	13. Water theft has escalated rivalries among farmers 14. Industrial development and commercialization of land, such as lands turning to colonies, had humongous pressure on water resources 15. Farmers on tail did not receive allocated water, and farmers are compelled to abandon farming or migrate to other areas	Conflicts

victimized to acute water shortage. Often, the elite block the water forcefully to irrigate their canals while the farmer on tail suffers a lot from this dishonesty.

One of the farmers suggested that there should be open water instead of the rotation policy. The farmer should have access to the water whenever he feels the need. There should be a worth mentioning management, and water losses should be minimized in order to carry water to the tail farmers.

Some farmers highlighted the issue of unconstructed canals and water channels due to which they experience water losses

as the result of seepage. Few of the respondents maintained that canals are not properly lined and cleaned. Most of the watercourses are damaged and not maintained by the concerned departments. Farmers usually maintain these watercourses through self-help, and it costs farmers a lot, and affordability remains a big question. Many of the respondents witnessed that the watercourses are not cemented and become a source of seepage and a lot of water.

Farmers in the area lack in education and had meager awareness regarding strategies to minimize water wastage. It was observed that most of the respondents had a conventional approach regarding irrigation. For example, most of the respondents had used flood irrigation technique which not only wastes a lot of water but also cost more time and energy. In contrast, the adoption of a high-efficiency irrigation system can conserve water, time, and resources. Pertaining to resources, small landholdings, and affordability issues, farmers had more reliance on canal water for irrigation and showed reservations on warabandi system.

One of the farmer stated;

Warabandi system often disfavors me. More often, water has been closed when my turn is about to come. In this way, I become unable to meet the irrigation needs of crops. Alternatively, I have to purchase water, which increases my cost of production. In my view, there is an urgent need to establish some strategies for future use and confront the water crisis and increasing the cost of production.

Water is an imperative source to sustain farming. It is well documented that water availability is decreasing over time, and coping with the shortage, water-saving techniques, and sustainable agriculture practices are inevitable. The conventional approach for irrigation, as adopted by the farmers, is not in line with the future course of action.

One of the key informant illustrated;

Farmers are irrigating their field through conventional techniques and waste abundant water. There is no implementation of rules regarding water wastage and overuse of water. In order to conserve water for future use, the institutions should materialize the policy for equal distribution of water to each water according to his crop area and crop requirement.

During the informal discussion, it was revealed that farmers understand that if concerned departments such as agriculture extension and irrigation department initiate campaigns and educational programs, farmers can be convinced to adopt those techniques, which are water saving. Farmers can be trained regarding the effective application of water, and even the application of wastewater in case of water shortage can be effectively utilized to meet needs. In those areaswhere groundwater is unfit, farmers are using wastewater. As a result of training and awareness, the use of wastewater can become safe and effective.

One of the respondents who had almost left farming reported;

I had small landholdings but cultivated crops on my own and rented land, but I had faced an acute shortage of canal water. Whenever there was a partial availability more often, it was stolen by the elite groups. It put me under conflicts a couple of times and I was not able to compete anymore with the strong elite group; thus pertaining to these issues, I abandoned farming and adopted livestock farming.

Besides, farmers were observed selling their lands to societies in the wake of water shortage and emerging conflicts pertinent to water theft by the influential farmers. The farmer was perceived satisfied by the commercialization of their lands. Usually, the land colossal to the cities was primarily colonized. In contrast, the lands far from the city are turning to be barren due to water shortage and the unfitness of groundwater. It is summarized that in order to meet future water needs and practice sustainable agriculture to meet future dietary needs, better management is obligatory.

DISCUSSION

This study was mainly focused on the analysis of different factors contributing to water scarcity as perceived by the farmers. The responses from the farmers were recorded qualitatively and analysed using thematic analysis techniques. The responses retrieved from the respondents helped us to construct various factors having a significant impact on water availability in the present and coming times as well. Pakistan is an agricultural country where a major chunk of people practices farming to earn their livelihoods. Irrigation is the soul of farming, and unfortunately, in Pakistan, the use of water by the farmers is anticipated as injudicious. With the passage of time, the availability of water in Pakistan is depleting (Ahmad *et al.*, 2007). At the time of inception in 1947, per capita availability of water was 5,600 cubic meters, and now it has downsized to 1000 cubic meters. By 2025, the non-availability of water may increase to 31% (Husain, 2013). The majority of farmers in Pakistan irrigate their lands through canal water under Warabandi system. Warabandi system is a rotational distribution of the irrigation water allocating fixed duration for irrigation inconsistent with the land size of the farmer within the watercourse command area (Bandaragoda and Saeed-ur-Rehman, 1995). This system is believed ineffective and one of the reasons for water scarcity due to hefty water losses through unlined watercourses and ineffective techniques of irrigation as adopted by the farmers (Iqbal and Ahmad, 2005). Watercourses and channels are poorly maintained, designed poorly, and mishandled by farmers resulting in heavy losses of water (Arshad *et al.*, 2015). Naeem (1991) had reported that one-third of the irrigation water in Pakistan is lost during its conveyance to the field. Conveyance losses of water in Pakistan were recorded 40%, much higher than global countries, where losses range between 25-50% (Anjum, 1993; Badar *et al.*, 2002).

Water conservation has become inevitable, and in order to save water, control over losses is obligatory. In the study area, most of the water channels and watercourses were unlined, causing water losses. The lining of watercourses can significantly conserve water. In a study conducted by Khan *et al.* (1999), a 27% of increases in water delivery and 53% reduction in water losses were recorded in 7 lined watercourses in Khyber Pakhtunkhawa (KPK). Reduction in losses conserve water and ensure availability for future use, which will increase the return for the farmers and country (Anriquez and Valdes, 2006). Awan and Mustafa (2013) had reported that 1% increase in the availability of water could establish a 0.93% rise in agricultural growth. Regarding the future course of action, all over the world efforts are undergoing to save water and introduce water-saving techniques and less water-intensive varieties. Pakistan has the same agenda to feed its mammoth population. Therefore, various efforts are being made, including micro dams, water harvesting, subsidies on high-efficiency irrigation systems, i.e., drip irrigation, and sprinkler irrigation. Though the results coming are meager yet due to the conventional approach of farmers and traditional cropping patterns. For example, farmers often cultivate major crops, including wheat, cotton, maize, and sugarcane, followed by fruits orchards. In this case, the adoption of a high irrigation system remains perplexing for the farmers. Though, the installation of drip irrigation can save 30-40% water and end up with a great increase in the yield of crops. Ashraf (2012) and Yasin *et al.* (2001) had reported that in order to escalate water availability in Pakistan pressurized irrigation system has been practiced for the last 4-5 decades, but the success rate as observed is negligible. Moreover, they had witnessed poor adoption of high-efficiency irrigation system among farmers pertaining to sloppy socio-economic conditions of the farmers. The efficiency of the prevailing irrigation system for surface irrigation is under 40% in Pakistan, indicating a vast room for improvement (Latif *et al.*, 2016).

The study area is genuinely industrially known as Manchester of Pakistan. Due to overwhelmed industrial expansion, the water resources are under stress. The industrial effluents had turned groundwater unfit for irrigation, and a major part of freshwater is taken up by the industries to meet their processing needs. In major areas of the study area, farmers have stopped using groundwater. The use of groundwater started ruining the soil quality and health, which eventually left noticeable impacts on the overall yield and health of the crops. This shift also gave birth to conflicts among farmers regarding control over water and getting access to canal water by hook and crook. The elite had more control and pressure over small farmers and accessed more water than the fixed allocation. Pertaining to conflicts, farmers started abandoning farming and decided to commercialize their lands. As a result, the fertile land is converting into colonies. The establishment of residential colonies and industrial zones tend to consume more water and put pressure on available water resources. This implies the share of farmers is likely to shrink in the future, posing serious threats to farming. Many of the farmers had left farming and started practicing livestock farming, which does not require an extensive amount of water. This indicates that future farming is challenged by water scarcity, which is the root cause of several factors. One way, the industrial expansion is hampering water availability and future farming; in another way, the natural resources of the water are under enormous pressure. For example, natural (rainfall, rivers, ponds, lakes, glaciers) and artificial (surface water from rainfall and rivers) are two water resources for Pakistan. Of the total availability of 154 MAF water, 104.73 MAF is used for irrigation purposes in Pakistan. Besides, groundwater potential in Pakistan is regarded as 55 MAF (Pakistan Water Strategy Report) (Ahmed, 2007). However, the situation worsens as the country is turning from a water surplus country to a water deficit country.

***Conclusion recommendations*:** This study unveiled deep insights into the different factors likely to contribute to water scarcity in the future. The results of the study suggest water is inevitable for the sustainability of agriculture and to feed future generations. Water resources are being violated in the country, and farmers have started to witness its bad consequences. Results further augment, this study is novel, and previously the constraints were not explored in order to identify those areas requiring attention. For example, this study augments if measures are not taken timely, there will be chaos among people in the future. The conflicts will rise on the issue of water use, and people will fight each other, building insecurity among people. This insecurity may lead farmers to migrate and abandoning agriculture. The current situation that farmers are facing in the form of low production pertaining to the non-availability of water, adaptive capacities of the farmers are inadequate to adopt high-efficiency irrigation systems. This study concludes, there is an urgent need to work on water conservation and ensuring water availability to sustain farming, alleviate poverty, and hang threats of conflicts. The institutions, such as water and irrigation department, agricultural extension, and research, need to collaborate and bring synergy in the implementation of policies. For instance, the development of less water consuming varieties could help extension agents to convince farmers in order to use water judiciously. The water and irrigation department should expedite their work to improve water storage capacities to harvest more water. There is a need for the policy implementation regarding water use for domestic, agriculture, and industry.

REFERENCES

Ahmad, M.F. and G. Rasul. 2008. Prediction of soil temperature by air temperature; A case study for

Faisalabad. Pak. J. Meteorology 5:19-27.
Ahmed, A., H. Iftikhar and G. M. Chaudhry. 2007. Water resources and conservation strategy of Pakistan. The Pakistan development review pp.997-1009.
Akhtar, D.S. 2010. Emerging challenges to Indus Waters Treaty. Regional Studies. 28:3-66.
Alam, S.M., S.M. Ansari and M.A. Khan. 2000. Industry and economy: Saline agriculture and Pakistan Nuclear Institute of Agriculture. Tando Jam, Pakistan.
Anjum, M.S. 1993. Marketing Constraints and Development Strategy for Edible Oils in Pakistan. USAID.
Anríquez, G. and A. Valdes. 2006. Determinants of farm revenue in Pakistan. The Pakistan development review pp.281-301.
Arshad, I., M.M. Babar and A. Sarki. 2015. Computation of Seepage Quantity in an Earthen Watercourse by SEEP/W Simulations Case Study: "1R Qaiser Minor"-Tando Jam-Pakistan. Adv. J. Agric. Res. 3:82-88.
Ashraf, M. 2012. Overview of drip irrigation: potential, issues and constraints. Presentation in International Center for Agricultural Research in the Dry Areas (ICARDA), Pakistan on December.
Awan, F. and U. Mustafa. 2013. Key factors contributing to agricultural growth in Pakistan: An application of time series analysis. J. Agric. Eco. Develop. 1:6-13.
Badar, H., M.S. Javed, A. Ali and Z. Batool. 2002. Production and marketing constraints limiting sunflower production in Punjab (Pakistan). Int. J. Agric. Biol. 4:267-271.
Bandaragoda, D.J. and S. Rehman. 1995. Warabandi in Pakistan's canal irrigation systems: widening gap between theory and practice. Colombo (Sri Lanka). IIMI. 1995. 109:96-015026. CIMMYT.).
Bank, W. 2006. Reengaging in agricultural water management: challenges, opportunities, and trade-offs. Water for Food Team, Agriculture and Rural Development Department (ARD) World Bank, Washington, DC.
Briscoe, J. and U. Qamar. 2008. Pakistan's Water Economy: Running Dry.
Falkenmark, M., J. Lundqvist and C. Widstrand. 1989. Macro-scale water scarcity requires micro-scale approaches: Aspects of vulnerability in semi-arid development. In Natural resources forum. 13:258-267.
Iqbal, M. and M. Ahmad. 2005. Science and technology-based agriculture vision of Pakistan and prospects of growth. In Proceedings of the 20th Annual General Meeting Pakistan Society of Development Economics, Islamabad. Pakistan Institute of Development Economic (PIDE), Islamabad, Pakistan. pp. 1-27.
Latif, M., S.S. Haider and M.U. Rashid. 2016. Adoption of high efficiency irrigation systems to overcome scarcity of irrigation water in Pakistan. Proc. Pak. Acad. Sci. B Life Environ. Sci. 53:243-252.
Naeem, A. 1991. Economics of Sunflower Cultivation in Cotton Based Cropping System of the Punjab with Special Reference to Bahawalpur Tehsil. Unpublished M. Sc. Thesis, Dept. of Agri. Econ., Univ. Agri., Faisalabad.
Nowell, L.S., J.M. Norris, D.E. White and N.J. Moules. 2017. Thematic analysis: Striving to meet the trustworthiness criteria. Int.J.Quali.Methods 16:16-47.
Rijsberman, F.R. 2006. Water scarcity: fact or fiction?. Agricultural water management. 80:5-22.
Shah, E., J. Liebrand, J. Vos, G.J. Veldwisch and R. Boelens. 2018. The UN Water and Development Report 2016 "Water and Jobs": A critical review. Development and Change 49:678-691.
Sharif, M., A. Jabbar, M.A. Niazi and A.B. Mahr. 2016. Managing water availability and requirements in Pakistan: challenges and way forward. J. Agric. Res. 54:117-131.
Thakur, D. 2003. Research methodology in social science. Deep and Deep Publications (Pvt.) LTD. Rajouri Garden, New Dehli: 475.
Wing, E.A.S. and D. Finance. 2019. Economic Sur. Economic Survey.pp. 1-16.
Yasin, M., S. Ahmad, M. Aslam and G. Akbar. 2001, October. Adaption of pressurized irrigation in Pakistan. In Proceedings of the International Seminar on "Management of Water Resources for Sustainable Agriculture", Lahore, Pakistan.pp. 29-31.

[Received 17 May 2020; Accepted 15 Sept 2020; Published (online) 11 Jan 2021]