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SOCIO-ECONOMIC IMPACT AND MIGRATION DUE TO WATER SHORTAGE IN DISTRICT BADIN SINDH PROVINCE OF PAKISTAN

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ABSTRACT

The agriculture sector is the backbone of Pakistan's economy. It contributes 18.9 percent to the national GDP (Gross Domestic Product), and 43.5 percent to the national labor force. The term 'water scarcity' depicts, the water demand that could not fulfill the human need. Some of the factors that cause water scarcity include dry spells, shortage of irrigation water, climate change, drought, excessive storage, and weather extremes. Another critical factor that causes scarcity is excessive population growth. Water stress directly impacts human migration because it affects the human lives and socio-economic conditions of the migrants. This study aimed to examine the impact of water shortage on the socioeconomic condition of growers in the study area. To examine how water scarcity is behind the migration and to analyze the impact of water shortage on agricultural production. The analysis of the data reveals that migration occurs due to the shortage of water in the last five years of Taluka, Tando Bago. The current scenario of the study depicted that Tando Bago is suffering from the worst condition of water shortage and about 60 percent of farmers were not in a condition to use the freshwater resources. According to the farmer's perception (88%), the quality of underground water is seen to be low as compared to taluka Matli. It is a big threat to the agriculture sector in terms of productivity, soil degradation, and fallow land. The study further reveals that per acre yield of crops is low that signifies the impact of water shortage on agriculture production. In taluka Matli, the net return of wheat crop and per-acre value of land (RS: 795,858), is high as compared to Tando Bago (RS: 225,428). The results of the study favours' the significant impact of water shortage on socioeconomic and migration of the people in district Badin.

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INTRODUCTION

The agriculture sector is the backbone of Pakistan's economy. It contributes 18.9 percent to the national GDP (Gross Domestic Product), and 43.5 percent to the national labor force (GoP, 2020). Water is a vital natural resource for human beings to survive, to maintain biodiversity, and economic development (Walter *et al*., 2011). Water is an essential need for human beings as well as development (Guppy and Anderson, 2017). Water scares is a global problem (Lenzen *et al*., 2013). Water shortages create a threat for society to survive and it is important for socioeconomic conditions (Veldkamp *et al*., 2015). It provides the basic need of life; without water there is no life. Water provides the foundation stone for livelihood and cultural progress (Adams *et al*., 2009).

Water scarcity directly affect human live and societies and their impact on human migration (Black *et al*., 2011). The term 'water scarcity' depicts the water demand that could not fulfil the human need. Some of the factors that cause water scarcity include dry spells, shortage of irrigation water, climate change, drought, excessive storage, and weather extremes. Another important factor that causes scarcity is excessive population growth. Water stress directly impacts human migration because it affects the human lives and socio-economic conditions of the migrants. There are three main causes of water shortage which are rapidly growing population, unproductive agriculture sector, and lack of management for the development side (Madani, 2014). In some previous years, the water demand is going high day by day because population, urbanization, and industries are rapidly increased. According to social experts, water is directly interlinked with peoples' lives in the shape of living standards and their needs (Yin *et al*., 2017). Pakistan has been shifted to water-stressed and faces inadequate water scarcity because it is a limited resource. Mismanagement of water distribution is a big issue and it directly hits water scarcity (Khair *et al*., 2011). Rural people directly depend on the agriculture sector. This sector is directly interlinked with the rural people and the water resource is the life of the agriculture sector without water, it is nothing. Water scarcity probably rises, which affects the agriculture sector and the farming community, as well as their health issues (Grewal and Ahmed, 2011).

Most people living in rural areas are unaware of the quality of water for agriculture and their health. Water scarcity and polluted drinking water cause a lot of water-borne diseases. Rahman *et al.* (2018) said that still, no epidemiological facts of alternate drinking water, arsenic poisoning, and wellbeing involvements are present to the individuals in danger, unfortunately. Guglielmi (2017) indicates that in Pakistan, around 60 million individuals are at risk of being affected by high concentrations of arsenic in drinking water; the biggest mass poisoning in history. Arsenic poisoning can be the reason for restrictive pulmonary disease, cancer, diabetes mellitus, skin lesions, gangrene, cardiovascular problems, neurological impairments, and problems in immunity, liver, kidney, bladder and endocrine glands and as well as socioeconomic risks. Nabi *et al.* (2018) mentioned that local biodiversity, ecology, and deprived water supply would probably disturb agriculture destructively. The natural world has even now arrived in the red zone and can perhaps go into a humanitarian disaster with the harm of large-scale area migration of individuals because of drought-like conditions. Some recommendations have been suggested that it could conceivably provide the benefit to the people of Pakistan to get rid of pollution, shortage of water and to preserve an ecology, save local biodiversity, and recover agriculture (Shaikh, 2018).

Inefficient Use of Irrigation Water

International Monetary Fund (IMF) states that Pakistan has been ranked third among the countries which are bearing a highly severe shortage of water. The Pakistan Council of Research in Water Resources (PCRWR) declared in May 2018 that by 2025, the availability of water would be very short and not clean in the country (Shukla, 2018). The pollution in water is responsible for around 30 percent of deaths and 80 percent of all diseases (Daud *et al*., 2017). World Health Organization (WHO) stated that waterborne diarrheal illnesses are blameable for approximately 2 million deaths yearly globally, with the top happening in children under five years (WHO, 2018).

Sound National Water Policy: National water policy is required to improve and save their water resource, because of environmental threats faced by every country, and Pakistan is one of them.

Switch to Bottled Drinking Water: It is a luxury choice, those people have the affordability power to drink it (Guglielmi, 2017). Bacteria and other germs are consumed in water that's why people avoid open water and prefer to purchase safe drink water (Sahoutara, 2017).

Building Dams: This time, Pakistan needs large as well as small dams because without a dam's water storage facility is not possible and it is beneficial for ecology. More dams support an ecosystem, dams are favorable to any country because there are many benefits, like electricity, agriculture, fisheries, and the environment. Biodiversity is a significant factor for an environment; without it, life could not survive happily (Qureshi and Akıntug, 2014).

Reforestation: Pakistan misses almost 2.1 percent of its forestry annually. If this proportion remains the same, Pakistan will be without forests within the coming 50 years (Randhawa, 2017).

Artificial Rain: Pakistan needs a rainmaking system throughout the country, likewise China. This will probably benefit us in resolving the difficulties of shielding the ecology, shortage of water, saving biodiversity, and reducing the natural calamity, China is emerging as the world's biggest weather-operating system encompassing tens of thousands of fuel-burning compartments. This scheme will raise rainfall over a range of almost 1.6 million square kilometers (Chen, 2018).

Specific objectives of the study are as under: to examine the impact of water shortage on the socioeconomic condition of growers in the study area, to examine how water scarcity is behind the migration in the study area, to analyze the impact of water shortage on agricultural production.

Natural scarce resources are threatened by increasing population and growing urbanization. Water plays a major role in environmental migration. The current migration due to water in the Middle East and Africa was identified. Specifically, water is the main driving force for migration and a geographical region, it was examined by a potential statistical correlation. Nawrotzki *et al*. (2017) states that in agriculture dominated area; there is a lack of knowledge to alleviate stress on migration- the speedy rural-urban migration can be reduced by making a public investment in the agriculture sector.

Paulsen (2015) examines that fresh water and migration are both interlinked with each other and consider them as a global issue of the twenty-first century. The impact and potential linkages are aimed to explore one after other. Veldkamp *et al.* (2015) observed the worst risk for society is the shortage of water. However, the world is suffered from socioeconomic and changing hydro-climatic conditions day by day which can cause problems of scarcity of water in society. Hermans (2012) argues that water plays an additional role in the migration of people in a society. The current migration pattern is frequently influenced by a direct correlation in the hydrological factor. The most challenging for migrating decisions is the push and pull factor. Walter *et al.* (2011) Said that water is life for the whole nature its worth is always countable in every aspect of life as economic development, biodiversity, and a way forward for sustainable development. Water policy is taking an important consideration as becoming a water trade and a globally scarce resource. Khair *et al.* (2011) said that water shortage due to poor management and maintenance; Pakistan is underneath faster depletion of water and contributing much more to a crisis of water scarcity. Hamdy *et al*. (2003) concluded that water availability and agriculture production is directly proportional to each other in terms of rainfall as well as irrigation and also known to be the largest global water user.

METHODOLOGY

Study Area

The Badin is the coastal district and has a strategic location in Sindh province. This district is full of natural resources. According to the population census 2017, the area of district Badin is 6,726 square kilometers, and the total population is 1,804,516. From all five talukas, two were selected namely Matli and Tando Bago.

Sampling Procedure and Data Collection

The questionnaire was developed with the help of a literature review and research supervisor, it is pretested in the field. Primary data was collected through a random sampling technique. The total sample size was 120 respondents, 60 respondents from each taluka. Furthermore, 24 villages were selected 12 villages from each taluka for data collection.

Data Analysis

Data were arranged in the coding system in SPSS, analyzed likewise mean, maximum, minimum, percentage, net income, and cost-benefit ratio.

Percentage:

Calculated under this formula: $P = \frac{f}{n} * 100$

f = number of respondents

n = total number of respondents

Average or Mean:

Sum of all amount divided by the total amount.

Calculated it as; $\bar{X} = \frac{\sum \text{xi}}{\text{n}}$

$\bar{X}$ = means

$\sum xi$= sum of all amount

n = number of observations

Net Return/ Income:

Net Return means total revenue minus total cost.

NR = TR-TC

NR= net amount

TR= total revenue

TC= total cost

Benefit Cost Ratio= BCR = NR/ TC

RESULTS AND DISCUSSION

In this research section, the results of different variables are described that are interlinked with the objective of the study, like the impact of water shortage on socioeconomics condition, agriculture production, and migration. Those were analyzed and identified.

Impact of Water Shortage on Socioeconomics Conditions

Table 1 shows the impact of water shortage on socioeconomic conditions during the last ten years. The data reveals that the socioeconomic conditions are not looking better since the last decade due to water shortages. Regarding the house structure, most people were living in mud houses and some of them were

living in katcha house and very few were living in semi pacca and pacca houses. The source of drinking water was not favorable because the quality of underground water was not efficient that's why they do not use it; they are using water channels and other sources for drinking purposes.

Table 1. Perceptions of respondents about impact of water shortage on the socio-economic condition during last ten years (Tando Bago).

Particulars		Numbers	Percent
House structure	Pacca	11	18.33
	Semi Pacca	9	15.00
	Kutcha	15	25.00
	Mudhouse	25	41.67
Source of drinking water	Hand pump	12	20.00
	Pounds	24	40.00
	Supply water	3	5.00
	Canal	21	35.00
Condition of drinking water	Improved	3	5.00
	Same	12	20.00
	Declined	45	75.00
Monthly income	Increase	9	15.00
	Same	19	31.67
	Decrease	32	53.33
Living standard	Increase	6	10.00
	Same	11	18.33
	Decrease	43	71.67
Job opportunities	Increase	5	8.33
	Same	7	11.67
	Decrease	48	80.00
Livestock production	Increase	13	21.67
	Same	20	33.33
	Decrease	27	45.00
Farmers losses from agriculture	Increase	31	51.67
	Same	18	30.00
	Decrease	11	18.33

Especially in the Kharif season, water is concise. According to the farmer's perception, the monthly income is low and the livestock production was high because most people depend on the livestock sector. However, it is directly interlinked with the agriculture sector. Most of the respondents responded that since last decades they faced a lot of agriculture heavy losses due to water shortage and untimely rainfalls.

Table 2. Socioeconomic condition and disease.

Particulars		Numbers	Percent
Hepatitis	Yes	78	65.00
	No	19	15.83
	Don't know	23	19.16
Malnutrition	Yes	97	80.83
	No	13	10.83
	Don't know	10	08.33

Table 2 shows the diseases that occur in the study area. According to the respondent's perception about Hepatitis disease, the majority of the people (65%) suffering from it, and some of them were not aware of hepatitis. It is directly linked with drinking water; if they do not use clean water, the more chance of diseases will

occur. Malnutrition problem is a very serious issue seen in the study area, most of the peoples (80.83%) suffering from it. This is a food and malnutrition issue, it can be occurred due to not using plenty of food. Most peoples have not a proper growth rate because of a very low nutrition problem.

Table 3. Respondent's family structure and marital status (Percent).

Particulars	Numbers	Percent
Male	120	100.00
Female	00	00
Marital status		
Married	67	55.83
Single	53	44.16
Total	120	100.0

Table 3 shows the respondent's family structure and their marital status. The results indicate that the majority means of all respondents were male and their marital status shows that most of the respondents were married (55.8%) and some were single (44.1%) in the study area.

Table 4. Age distribution of growers according to their age in the study (Percent).

Age (Years)	Numbers	Percent
Up to 20	09	0.75
21-33	23	19.16
31-45	34	28.33
46-60	43	25.83
61 & above	11	0.91
Overall	120	100.0

Table 4 shows the age category of respondents available in the study area. The majority of the respondent category was 46 to 60 years, while some were 31 to 60 years. Furthermore, the third category was 21-33 years of the farmers. Only 1 percent of the respondents were 61 and above years age in the study area.

Table 5. Respondent categories according to their education level, farming experience, and working occupation.

Education Level	Numbers	Percent
Illiterate	28	23.33
Primary	30	25.00
Middle	19	15.83
Matriculation	23	19.17
College	12	10.00
Graduate	08	6.67
Total	120	100.0
Farming experience		
No experience	23	19.16
1-15	37	30.83
16-30	46	38.33
31 & above	14	11.66
Overall	120	100.00
Working occupation		
Agriculture	78	65.00
Government services	19	15.83
Private services	23	19.66
Overall	120	100.00

Table 5 indicates the respondent's category according to their education, farming experience, and working occupation. The results depicted the educational level of the respondent in the study area, the majority of the respondents has primary education. While others were illiterate, matriculation, middle and college level respondent that shows the percentage 28, 19, 15 and 10% respectively. The respondents' farming experience in the study area shows that the majority of farmers' knowledge was 16-30 years because it is their ancestral property and cultivating it since childhood. The other category has 1-15 years of farming experience. The third category of the table is the occupation of the respondent that is divided into three categories. The majority of the respondents (60%) were interlinked with the agriculture sector, some (28%) of respondents have government jobs and 11 percent had private jobs in the study area.

Table 6. Perception of respondent's regarding the education level current and previous 10 years scenario.

Particulars	Numbers	Percent
Previous 10 years	52	43.33
Previous 5 years	45	37.50
Current	23	19.16

Table 6 shows the perception of the respondent regarding the currents and past status of educational level. The majority of the respondents (43.3%) indicate that the education level was delighted in the last decade. Some of the respondents (37.5%) mentioned that the education level was satisfied due to increased purchasing power in the people and currently (19.1%) respondent indicates that education is just satisfactory because the expenditure is very high. Income is low that causes hurdle in getting an education and mostly, poor people cannot afford it.

Water Scarcity and Migration in Study Area

Table 7 discusses the scarcity of water and migration in the study area. Water scarcity is a common problem in Pakistan. The majority of the respondents (93%) were facing water shortage problems. The majority of the farmers (60%) responded that the migration has occurred due to a shortage of water. Agriculture productivity is going to be low day by day in the study area due to water scarcity, while 85 percent of the respondent were agreed to agriculture productivity going down. Most of the respondents said that underground water quality is deficient, so they do not use it. The value of agricultural land is decreasing day by day. About 65 percent of respondents were agreed to prices are going down and 20 percent said that they don't know about the costs of agricultural land in the study area.

Table 7. Perception of farmers about water scarcity and migration status (Tando Bago).

Particulars		Numbers	Percent
Facing a shortage of water	Yes	53	88.33
	No	5	8.33
	Don't know	2	3.33
Shortage of water behind the migration	Yes	36	60.00
	No	16	26.67
	Don't know	8	13.33
Does people migrates from your village to anywhere?	Yes	22	48.33
	No	29	36.67
	Don't know	9	15.00
Agricultural productivity is reduced due to water shortage?	Yes	51	85.00
	No	6	10.00
	Don't know	3	5.00
Underground water uses in agriculture	Yes	1	1.67
	No	53	88.33
	Don't know	6	10.00
Do you think the price of agricultural land day by day decreasing?	Yes	39	65.00
	No	13	21.67
	Don't know	8	13.33

Table 8. Water shortage.

Particulars	Matli	Tando Bago
	Mean	Mean
Since how many years water shortage problem is faced	1.75	12.81
How many household migrate from your village	0.79	2.24
Any relative home migrates from here	0.12	1.23

Table 8 shows the data on the water shortage problem. It is a severe issue in Pakistan, but all over the world, it is faced. For the last 13 years, the water shortage problem has occurred in the Tando Bago. Averagely 2.24 homes had migrated from the villages. In the answer against any relative have migrated from here to any other city of place, respondents answered that, averagely, 1.23 homes were migrated in the study area. Furthermore, Matli taluka's condition was good as compared to the Tando Bago.

Table 9. The average price of land per acre.

Years	Matli	Tando Bago
	Per acre price	Per acre price
At present	795,858.85	225,428.85
5 Years Before	632,943.50	295,987.50
10 Years Before	512,438.98	339,928.98

Table 10. Migration status during last 10 years in comparison to the current period (Tando Bago).

Particulars	Average households migrate
10 years back	0.21
5 years back	1.01
Current	2.34

Table 11. Purposes of migration in percent (Tando Bago).

Particulars	Nearby town	Nearby city	Out of country	Overall
Job	75.00	22.00	3.00	100
Daily wages	79.00	19.00	2.00	100
Education of children	68.00	30.00	2.00	100

Table 9 shows the price of land per acre is compared with the last few years in the study area. The current price of Matli was 795,858 rupees, while in Tando Bago was 225,428 rupees and five years ago, the same land was sold in 295,987 rupees per acre. If it is looked at two decades ago, the land price was 339,928 rupees—the taluka Matli as good as compared to Tando Bago because Matli taluka rarely faces water shortage problems. Table 10 shows the comparison between the current and the last decade migration status. During the last decade, 0.21 percent of homes were migrated and in the previous half-decade, 1.01 homes were migrated, but currently, the migration ratio is very high as compared to the past. The current ratio of migrants is 2.3 percent. Table 11 shows the purposes of migration; there were three primary purposes educations of children, duty, and daily wages in the study area. For education purposes, nearby town migration was 68 percent and nearby city migration was 30 percent. While meager rate migrates were out of the country for education purpose (2%). For job purposes, nearby town migration was 75 percent, the nearby city was 22 percent, and the out of the country is 2 percent. For daily wages, the nearby town migrants were 79 percent, nearby city migrants were 19 percent and 2 percent was out of the country.

Table 12 indicates the migration-related issues in the study area. In the last ten years migration occurs due to a shortage of water, about 23 percent, the education purpose and conflict is almost 93 and 4 percent respectively. In the last five years, the migration occurs due to a shortage of water is 57 percent, the education purpose and conflict are 51 and 12 percent respectively. Furthermore, the current scenario of migration depicts, 81 percent due to shortage of water, education purpose and conflicts is 28 and 11 percent respectively in the study area.

Table 12. Migration related issues (Percent).

Particulars		Homes migrate from village
Previous 10 years	Water shortage	23.00
	Education purpose	93.00
	Conflicts	04.00
Previous 5 years	Water shortage	57.00
	Education purpose	51.00
	Conflicts	12.00
Current	Water shortage	81.00
	Education purpose	28.00
	Conflicts	11.00

Impact of Water Shortage on Agricultural Production

Table 13 indicates the distribution of growers according to their farm size in the study area. The small farmers of taluka Matli, are 43.3 percent, while in Tando Bago are 63.3 percent, which is the highest ratio. Ultimately, the large farmers have the most influence in the society, 23.3 percent in taluka Matli, while 15 percent in Tando Bago. Table 14 clearly shows the average status of fallow land in the study area. In the last ten years, fallow land was 1.24 acres and in the previous five years, it was 2.34 acres. While currently, 3.01 acres was fallow land in the study area.

Table 15 indicates the perception of farmers regarding agriculture production in the study area. Sixty-five percent of farmers mentioned that agriculture production was good in the last ten years, while 19 percent mention that in the previous five years, agriculture production was just satisfactory. Even more current 10 percent of farmers mentioned that their agriculture production was not very adequate. Most of the farmers said surface water is a severe issue because the shortage of water impacts livelihood and livestock as well as in the study area.

Table 13. Distribution of growers according to their farm size.

Farm Size	Matli		Tando Bago	
	Nos.	%age	Nos.	%age
(Up to 15) Small farmers	26	43.33	38	63.33
(16-30) Middle farmers	20	33.33	13	21.67
(31 > Above) Large Farmers	14	23.33	9	15.00
Overall	60	100.00	60	100.00

Table 14. Status of fallow land in (Acres).

Particulars	Average acres
Previous 10 years	1.24
Previous 5 years	2.34
Current	3.01

Table 15. Perception of farmers related to agriculture production current status and previous 10 years.

Particulars	Numbers	Percent
Previous 10 years agriculture production	90	65.00
Previous 5 years agriculture production	23	19.16
Current agriculture production	07	10.58

Table 16. Wheat inputs quantities and cost per acre (Avg.).

Particulars	Matli			Tando Bago		
	Mean	Min	Max	Mean	Min	Max
Ploughing (No.)	4.34	2.00	5.30	3.37	2.00	5.00
Seed rate in (Kg)	57.89	45.00	62.00	59.79	40.00	65.00
Fertilizer (40/ bags)	4.98	2.00	6.00	4.23	2.00	5.00
Chemical (No/ bottle.)	1.21	1.00	2.20	1.84	1.00	3.00
Surface water (No./ applications)	5.21	3.00	6.00	4.21	3.00	5.00
Rent	12594.09	8039.03	13500.43	7432.65	6340.32	9453.82
Land preparation (Rs.)	5717.08	2600.00	7900.00	4717.98	2400.00	7400.00
Seed (Rs.)	3250.00	2200.00	3700.00	2950.00	2300.00	3500.00
Fertilizer (Rs.)	9088.33	4500.00	12900.00	8088.33	4500.00	11800.00
Chemical (Rs.)	1948.32	800.00	3300.00	1348.17	900.00	3400.00
Irrigation (Rs.)	295.42	260.00	300.00	285.42	250.00	370.00

Table 17. Output of wheat crop per acre (Avg.).

Particulars	Matli			Tando Bago		
	Mean	Min	Max	Mean	Min	Max
Total cost	35,724.47	23,810.00	40,700.00	30,529.23	19,620.00	35,600.00
Yield (40 kg)	35.74	24.00	47.00	29.40	19.50	40.00
Average market price/ 40 kg	1,253.36	1,100.87	1,280.00	1,221.32	1,000.00	1,250.00
Total Revenue (Gross) (Rs.)	44,795.09	26,400.00	55,040.00	35,906.81	19,500.00	56,250.00
Net Income (Rs.)	9,070.62	4,590.00	20650,.00	5,182.34	3210.00	9,650.00
Benefit Cost Ratio =Net Income /Total Cost		0.25			0.16	

Table 16 shows the data related to the input cost of the wheat crop in the study area. The land preparation cost of Matli was 5717 rupees per acre and Tando Bago was 4717 rupees per acre, while the seed cost of Matli was 3250 rupees and Tando Bago was 2950 rupees & fertilizer cost of Matli was 9088 and Tando Bago was 8088 rupees. The overall cost of inputs of Matli was high as compare to Tando Bago taluka in district Badin.

Table 17 indicates the output and total cost of the wheat crop per acre in the study area. The total cost of the wheat crop of Matli was 35,724 rupees and Tando Bago was 30,529 rupees. While averagely yield of Matli and Tando Bago was 35 mds and 29 mds on per acre. Furthermore, the market prices of Matli and Tando Bago were 1253 and 1221 rupees. Due to low yield, net income was meager in Tando Bago taluka. Net income of Matli was 9,072 rupees, while Tando Bago was 5182 rupees. The benefit-cost ratio of both taluks was 0.25 and 0.16 in the study area district Badin.

CONCLUSIONS AND RECOMMENDATIONS

The current study aims to explore and status of migration due to water shortage in district Badin. Most people migrate due to water shortage in the last five years from taluka Tando Bago. Currently, it is suffering from the worst condition of water shortage. About 60 percent of farmers were seriously facing this issue. The underground quality of water in taluka Tando Bago is in an alarming situation. The result revealed that 88 percent of farmers argued that water's underground quality is not very satisfactory in the study area. The agriculture productivity is very low and most farmers leave their lands fallow because of water-scarce. In taluka Matli, the net return of wheat crop and per-acre value of land (RS: 795,858), is high compared to Tando Bago (RS: 225,428). The study results favour the significant impact of water shortage on the socioeconomic and migration of the people in district Badin. It is recommended that proper policy measures should be taken to improve the availability of water in taluka Tando Bago. The quality of groundwater is not good, and therefore mostly farmers leave their lands fallow. It is suggested that detailed studies should be undertaken to know the exact causes and solutions of declining water quality.

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