Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 5, No. 1, January, 2019

Socio-Economic Impact Assessment of Small Dams Based on T-Paired Sample Test Using SPSS Software

Nabi Bux Bhatti [a*], Altaf Ali Siyal [a], Abdul Latif Qureshi [a], Imtiaz Ali Bhatti [b]

[a] *U.S.-Pakistan Center for Advanced studies in Water (U.S-PCAS-W), Mehran University of Engineering and Technology, Jamshoro, 76062, Pakistan.*

[b] *Faculty of Civil and Environmental Engineering Universiti Tun Hussein Onn Malaysia Parit Raja, Johor, 86400, Malaysia.*

Received 03 October 2018; Accepted 08 January 2019

Abstract

A dam is a barrier/structure that impounds water and retains it for later use. Thus, it plays an important role and offers a reserve stock of water for rural communities in remote areas. The present study was conducted to assess the socio-economic impact of small dams on local communities. The impact was analyzed based on descriptive statistics and t- paired sample tests using SPSS software to study and analyze the Nagarparkar area, Sindh, Pakistan. Primary and secondary data were used for collecting the data. The data was collected randomly from 250 people through interviews and group discussions Also, 104 sets of data were obtained through a questionnaire survey. The overall results summary of the parameters revealed that a significantly positive variation occurred in the study area after construction of the dam. The number of the packa houses and water depth were increased. The distance to collect water and water-fetching time were decreased 6% and 5.61 % respectively. The overall average area cultivated with crops was increased by 26.55%. The average yield of almost every crop in both Rabi and Kharif seasons were increased by 55% in the areas surrounding the dams. The overall number of livestock was increased by 18.08%, while the number of horses decreased by 1.5% after construction of the dam. The income, expenditure, and savings have increased significantly to 36.16%, 17.68%, and 32.15%, respectively, while the migration rate has decreased19.09% since construction of the dam. The choice of crops has also changed from inferior crops to superior and market-oriented crops. The water table and quality have improved, and wells have been recharged.

Keywords: Impact Assessment; Before and After; Dam Construction; Nagarparkar; T-Paired Samples Test.

1. Introduction

Nowadays, most of the world countries are facing a water supply problem which does not fulfil the demand of human in terms of either quantity or quality; Pakistan is also one of them. Basically Pakistan is an agricultural country and once was a water-surplus country; it is now a water shortage country [1-3]. Pakistan has two main water resources and five climatic zones [4, 5]. The water resources are classified into two main classes: primary and secondary. Primary resources consist of precipitation, glaciers, and snowmelt; secondary resources consist of surface and subsurface water. Climatic zones include (Zone A, B, C, D, and E) humid, semiarid, coastal, arid and hyper-arid. Nagarparkar is classified as an arid zone; in the arid zone irregular and insufficient rainfall occurs. Consequently, the annual rainfall is less than 250 mm [4, 5].

In fact, most advanced countries have constructed numbers of the large water-development projects to enhance economic and social development. Moreover, dams are regarded as one of the important structures for water transfer and resource systems. These countries include China (Three Gorges Dam), South Korea (Andong Dam) and India

* Corresponding author: nabibuxbhatti76@gmail.com

http://dx.doi.org/10.28991/cej-2019-03091233

(Srisailam Dam). No doubt, these projects have had many positive and negative effects. The largest infrastructure project provoked the largest resettlement of people and produced the greatest negative environmental impacts [6]. It led to rapid population increase [7], expansion of the urban area, and changes in the landscape [8]. The largest projects met strong opposition from indigenous groups and from members of the regional population who were concerned with the negative social and environmental impacts of a large dam [9]. Then researchers try to find out a more optimum solution to accelerate economic and social development; after extensive research, a better solution was found. Small dams are among the most long-lived infrastructure projects, and social impacts can be considered over the entire operational timeframe; dams may operate effectively for over 100 years. Various stages of dam construction had various impacts; when dam construction was complete, water bodies increased considerably upstream and decreased downstream. These big changes in water bodies may have long-term impact on ecosystem functions, land-cover changes, socio-economics and environments. This research provides new insights on the impact of dam construction, which will be valuable for making better decisions about water and land resources [9]. Currently, the pattern has changed from the construction of large dams to construction of smaller dams. The number of small dams has increased due to their reduced cost, low negative and high positive impact on settled communities and the environment, the availability of many favourable locations, and their easy access due to proximity [10]. Small dam's play very important role in the development of rural economy and offer a lifeline to rural settled communities during the dry season, which enhance water availability, improve the living standard and food security of inhabitants in direct and indirect ways [11]. Water harvesting structures are beneficial in water-scarce areas for supplying the required water for domestic, agricultural and livestock uses [11]. Water harvesting structures help to reduce the shortfall in the water supply [11]. The basic purpose of these dams is to harvest every drop of available rainwater for multi purposes [11]. Large numbers of small dams/reservoirs are constructed in remote areas for multiples purposes, such as domestic use, raising livestock, agricultural, brick making and to increase groundwater storage capacity [11-13]. It was not cleared that whether the sources have used on these dams are beneficial or not. Currently, studies are being conducted throughout the world and also in Pakistan, to determine the socio-economic and environmental impact assessment of the development of small dam construction [14 -16]. Various researchers have assessed and reported differently, based on the different parameters

Malekhoseini and Mirakzedeh (2014) have studied different types of dams in various parts of the world and suggested that more than half of the dams, especially in Africa and Asia, have been developed for irrigation and agriculture, and reported that dam construction has potential for improvement and some limitations. Potential improvements include agricultural boom, cropping pattern changes, migration, and other parameters [17]. Scudder (2012) reported that dam construction has social impacts, which may be positive or negative [18]. Mudzengi (2012) reported that the creation of dams has caused general socioeconomic impact on the population. Similarly, Kamayama et al. (2013); Mudzengi and Chazireni (2017) have noted that the construction of dams has both positive and negative impact [19]. Many other researchers investigated the socio-economic impacts of dams on migration and resettlement, changes in the rural economy, employment structure, infrastructure and housing, cultural aspects, health and health relations in various parts of the world. Pakistan also felt dire need for a more impact assessment of small dams on settled communities in rural area. Hence an attempt made to investigate the socio-economic impact of small dams on settled communities in study area Nagarparkar, Tharparkar, Sindh, Pakistan.

The socio-economic survey is one of the most important tools and plays a very important role in research work and is used to design methods for collecting information about the executed project and resources as a means of improving understanding of local resource management systems, resource use, and their impact (Malekhoseini & Mirakzedeh, 2014). A socio-economic survey is regarded as one of the most important sources of statistical data on household expenditure and income as well as other data. The socio-economic impacts of the dam on the settled communities were evaluated based on the community livelihood profiles, health, education, water level, water quality, houses, agriculture, livestock, income, expenditure, saving and migration rate of the population, and social impact on the communities. Socio-economic impact provides a foundation for assessing the cumulative impacts of a development undertaking on the community's social and economic resources. The assessment of such impacts can help to promote sustainable development strategies settlements for future [20-23].

2. Study Area

Nagarparkar is in Tharparkar District, Sindh, Pakistan. The demographic features of the District head quarter are explain and presented in Tables 1 and 2 and Figure 1. It is located 129 km from Mithi, in Sindh, Pakistan. It is located between latitudes 24^0 14' N to 24^0 33' N and longitudes 70^0 36' E to 71^0 03'E, and it covers an area of approximately 313.63 km^2. It is connected by road with Karachi, Hyderabad, and Badin via Mithi and Islamkot. It is situated in the south-east corner of Sindh Province [24].

Table 1. General Information of Tharparkar District

S#	Parameter	Description
1	Area	19638 Square Kilometer
2	Demographic information	7 Talukas, 64UC ,172 Deh, 26 Circle and 56Tapa
3	Population	914291
4	Livestock population	3656933 (TRDP)
5	Birth rate	38.8 Crude birth rate and 5.5 fertility rate
6	Mortality rate	87 Infant mortality rate/ 1000
7	Literacy rate	18.32 % for male and 6.91 % for female
8	Main livelihood sources	Agriculture and livestock
9	Health	1 CH, 3 THQHs,2, 2 RHCs, 30BHUs and 40 Dispensaries
10	Climate	Tropical, deserted and consist of a barren tract of sand dunes
11	Minerals	Coal, Granite, China clay and salt mines

Table 2. Local Government Setup of Tharparkar District

S. No	Taluka	MC	TCs	UCs	Circles	Tapa	Deh
1	Mithi	1	1	9	5	10	27
2	Islamkot	-	1	10	5	9	21
3	Diplo	-	1	5	2	4	26
4	Kaloi	-	-	7	2	6	18
5	Chachro	-	1	10	5	10	19
6	Dahli	-	1	11	3	7	23
7	Nagarparkar		1	13	4	10	38
8	**Total**	**01**	**6**	**64**	**26**	**56**	**172**

Note: MC is Municipal committee, TC = Town committee, UC = Union council.

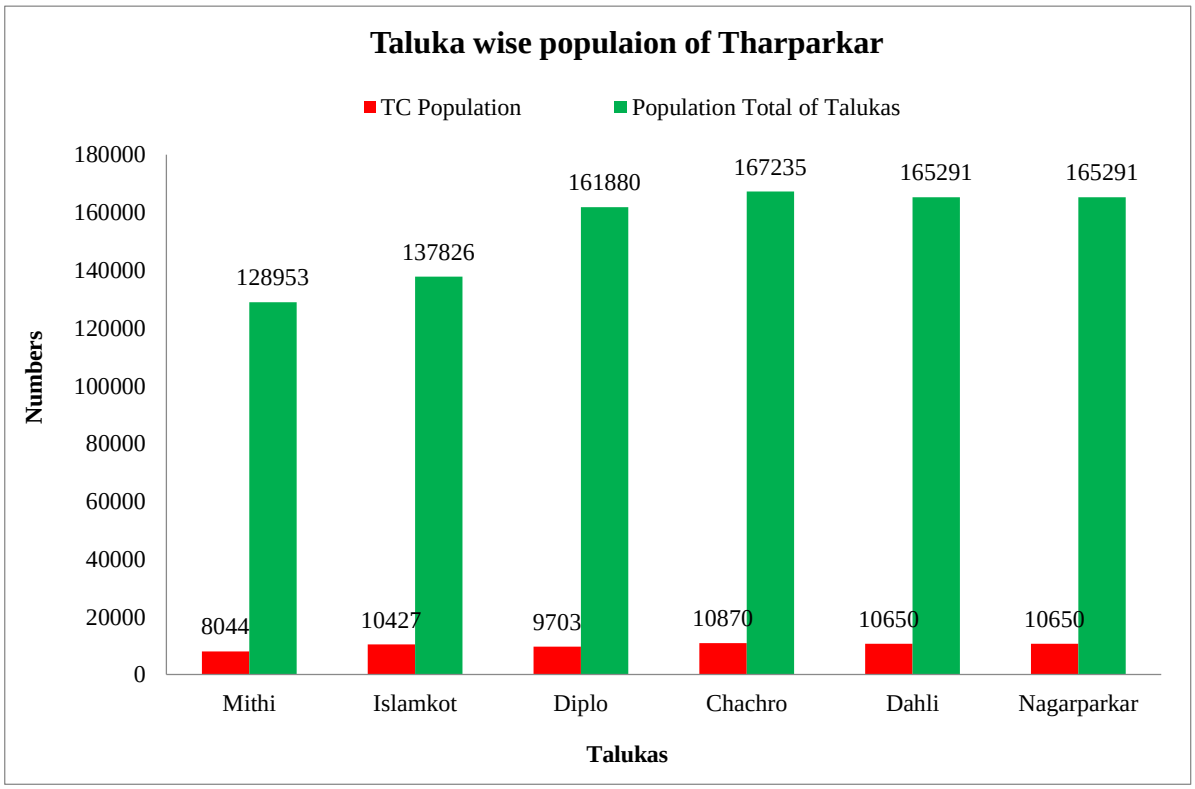


Figure 1. The Taluka-Wise Population of Tharparka

2.1. General Field Conditions

Nagarparkar region is divided into two categories based on geomorphology. Area one is the Thar Desert, and an area two is the hilly Thar (Nagarparkar) region shown in Figure 2. The Thar Desert consists of an area of high sand dunes, composed of fine, coarse sand with silt. The drainage system of the Thar rainwater that comes from the sand dunes and accumulates into the low- lying areas. The hilly Thar (Nagarparkar) is mostly flat land. The drainage system of the hilly Thar area consists of fifteen streams and rivers, locally called Nai. These seasonal Nai drain the rainwater from the plain and Karonjhar hills to Ran Kutch. In that region, there is no functional irrigation system; the only available source of water is from underground sources. The rain is the only source of groundwater recharge, and aquifers entirely rely on the rain. Even a short drought adversely affects groundwater recharge. The rainfall that occurs in that region is mostly irregular and undependable. Annual average rainfall in the region varies from 4 to 6 inches, whereas Nagarparkar receives 13 to 15 inches or more. The hilly Thar region also consists of mountains in which some granite matter is present. The Granite Mountains covers the central part of the hilly Nagarparkar, and they extend for approximately 80 square kilometers. The elevated peaks vary from 114 to 360 meters above a sea level, [24]. The salient features of the Nagarparkar and its UCs wise population status are explained and presented in Table 3 and Figure 3.

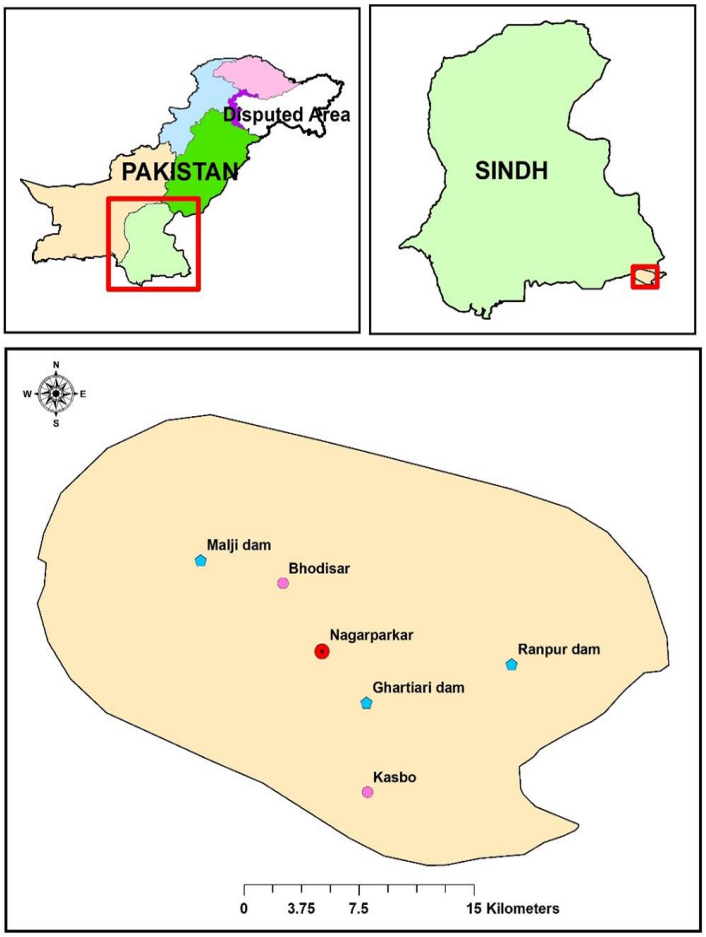


Figure 2. The Study Area [24]

Table 3. The Salient Features of Study Area Nagarparkar

1	UCs	13 (RR)
2	Deh	51 (RR)
3	Villages	584 (RR)
4	Houses	27406 (TRDP)
5	Voters	85407 (RR)
6	Population	165291(RR) 205545TRDP

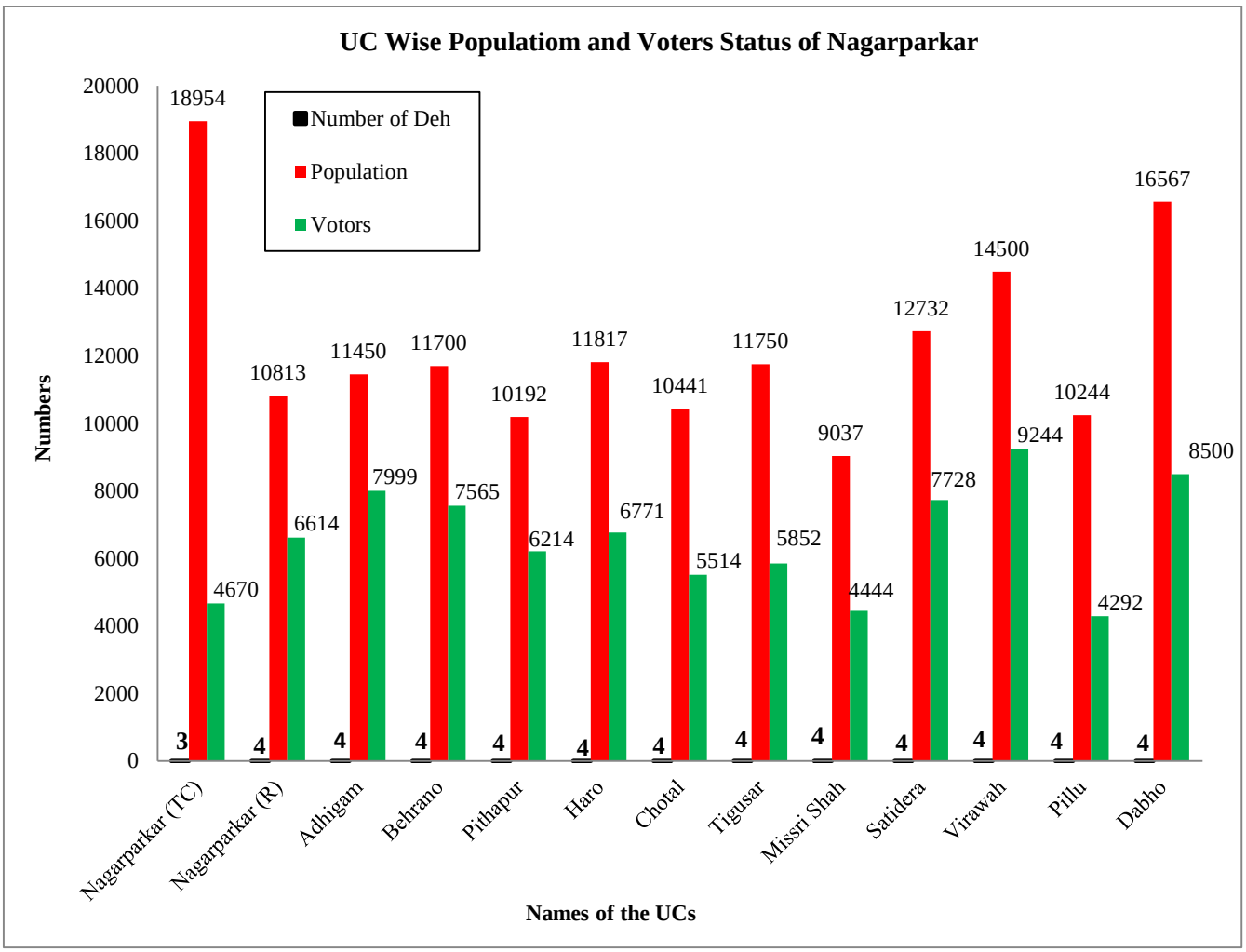


Figure 3. UC-wise population and voters status of the Nagarparkar

Table 4. Salient Features of The Selected Dams

S. No	Name	Type	Location	Cost (M)	Height (ft)	Spillway width (ft)	Capacity (ft^3)
1	Ranpur	Storage	Bhimara	115.312	10	150	3570
2	Bhodesar	Storage	M.jo w	53.831	7	111	763
3	Malji	Recharge	Khipora	119.711	8	270	7397
4	Ghartiari	Recharge	Ghartiari	167.690	11.5	115	753

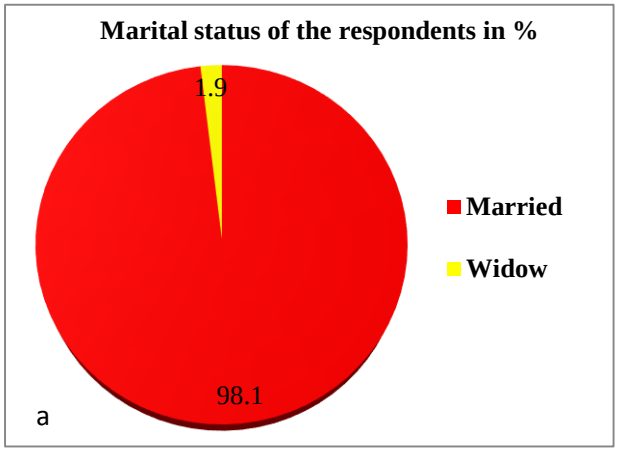
3. Materials and Methods

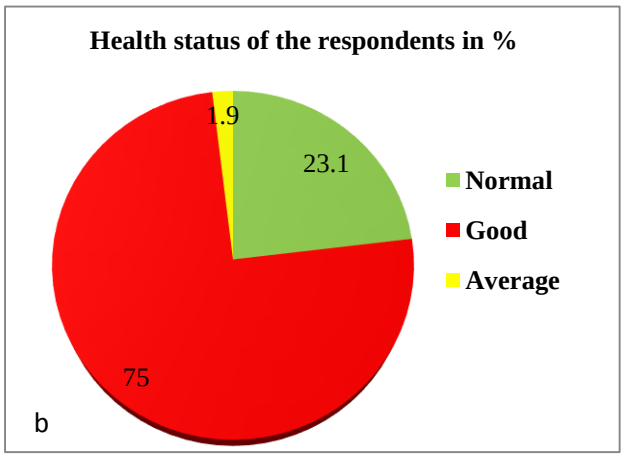
Primary and secondary data were used for collecting the data. Pre-dam construction secondary data were collected from different public private related agencies and also through satellite data, while primary data was collected from randomly-selected local people, including farmers, landlords, shopkeepers, employees, experts and also through satellite data [25]. The data was collected from 250 randomly people through interviews and group discussions, while from 104 through questionnaire survey [26, 27] about these parameters such as: (a) agriculture, water, livestock, house, family size, age, education, health, occupation, Experience, water quality, water level, water distance, water fetching time, land cultivation, crops type, crops yield, livestock, saving, income, expenditure and migration rate before and after dam construction. The collected data were coded and entered in the SPSS data sheet for analysis [28, 29]. Descriptive statistics and paired samples t-test were applied for finding the differences through SPSS Software [30-31]. The satellite data were also used for acquiring the pre and post dam construction data in order to assess the socio economic impact of small dams on settled communities. Total two cloud free images were downloaded through USGS Earth explorer website and two Landsat such as Landsat 5 and 8 were used for downloading the images. The one image was downloaded before the execution of dams and one after the dam's execution. The image classification is done with two main methods that are supervised and unsupervised, these further classified into different methods. Here images were classified based

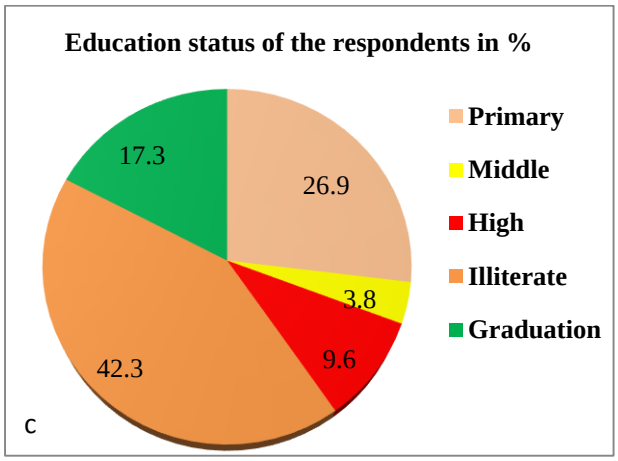
on three classes such as vegetation, soil and water, maximum likely hood supervised classification was applied and analyzed through Envi software.

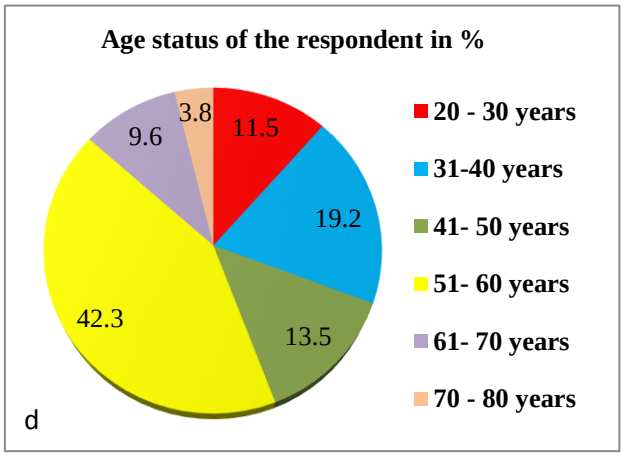
4. Results and Discussion

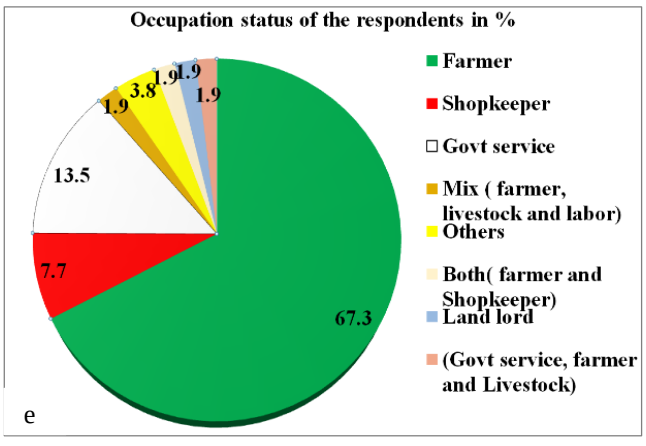
According to Trochim, William (2006) descriptive statistics are very important and useful for describing the basic features of (demographic data) such as age, education, employement status etc, and also show or summarize the data in a meaningful way [32]. It indicates the general information of the respondents in frequencies and percentage by the different forms of graphs and tables.

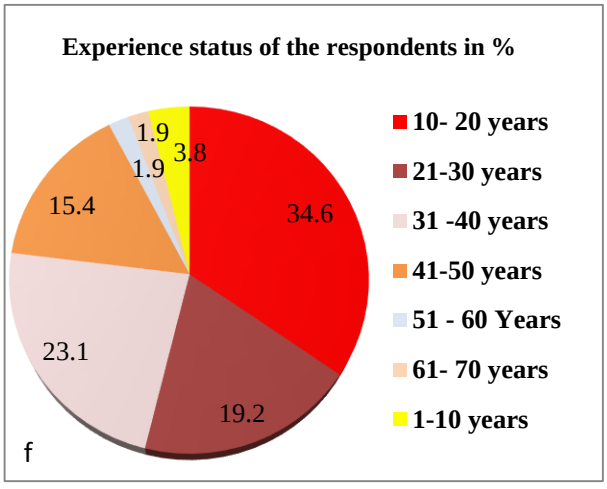












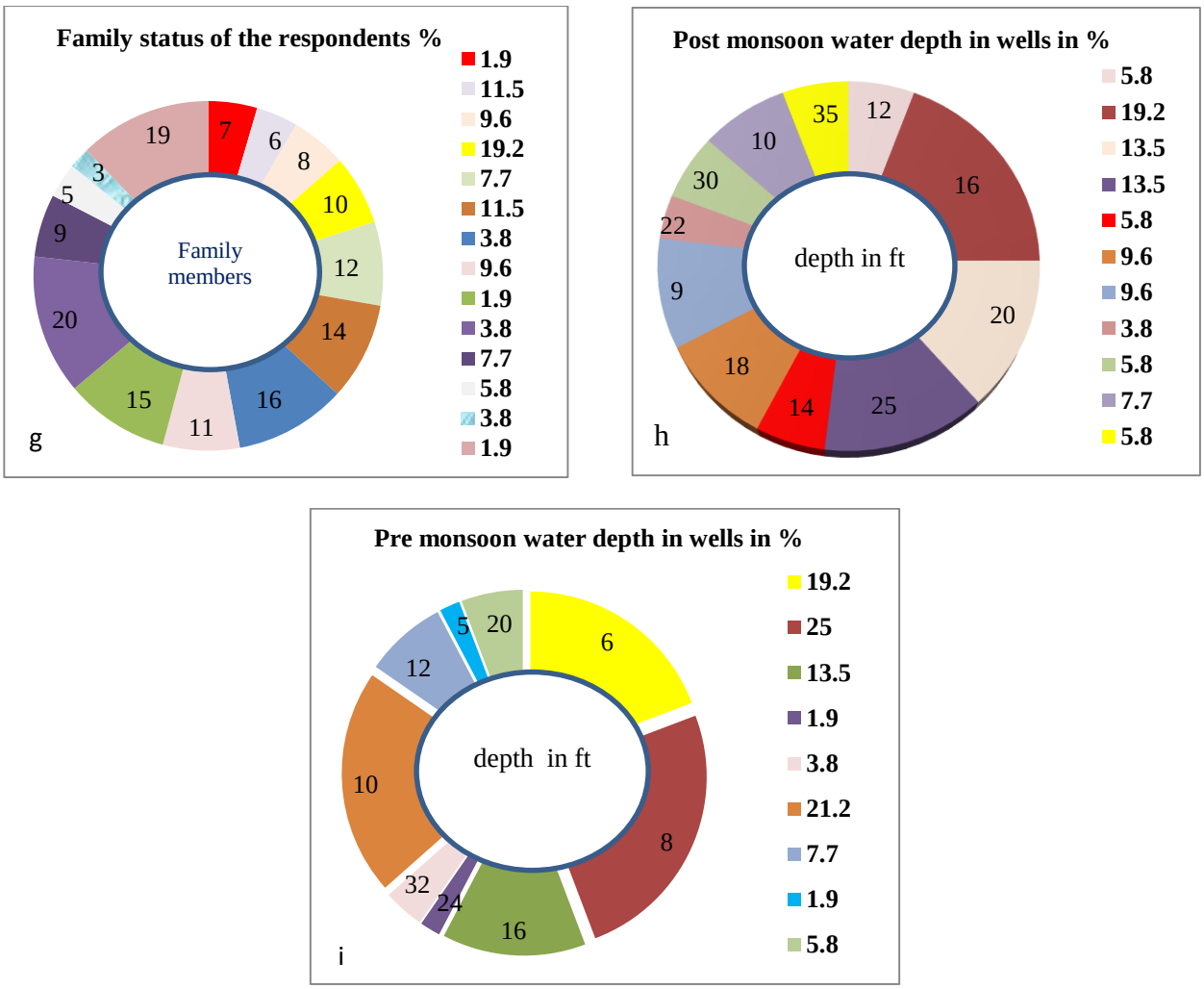


Figure 5. (a - i) General Information of the Respondents about Various Parameters through Descriptive Statistics

Figure 5. consist of 9 sub Figure (a-i); describe the general information about different parameters of the respondents. These Figures show the results in percentage which revealed that mostly respondents were married, widows were very low. Health of the mostly people were good while the education status was poor. Age status of the 42.3 % respondents were between the 50-60 years and remaining mentioned in sub Figure d. Occupation of the 67.3 % respondents were farmer remaining belong to others, brief occupational detail have shown in sub Figure. e. The experience of the 34.6 % were between the 10-20 years, while 23.1% between the 31- 40 years and remaining's were different its detail have mentioned in sub Figure f. The family status of the mostly respondents were too much brief detail mentioned in Figure g. The Figure h and i represent the water depth status in wells during pre and post monsoon, results revealed that water depth was low and decrease in pre monsoon while high and increase in post monsoon, detail of the depth in wells have mentioned in sub Figure h and i. The main parameters which play very important role and are focused for assessing the socio economics impact are analyzed based on the paired samples t-test, its results presented in Tables 5 to 8 and Figure 6. Its further more detail have discussed in results and discussion.

4.1. The Paired Samples T-Test

The t-test (also called the student's t-test), compares two averages (means). There are three types of the t-test. Such as the Independent samples t-test, one sample t-test, and paired samples t-test. These tests are used for determining the differences. The paired samples t-test is also called a correlated pairs t-test, used to determine the difference between paired variables. The difference is assessed and compared significantly between the variables based on the mean, t, and p-values. It states that if the p-value is less than the value of alpha 0.05, means has a significant difference and strong correlations.

The collected data were analyzed based on descriptive statistics and t - Paired Samples test, using SPSS Software, and its key results are mentioned in Tables and Figures, also discuss as follows:

General information of the respondents was taken from different respondents about different parameters and its analyzed results have shown in Figure 5, which consists of 9 sub Figures. Each figure has given information of the respondent separately about each parameter. The Figure 5(a) has showed the marital status of the respondents, 98.1% of

the respondents were married while 1.9% was widowed. The Figure 5(b) has showed the health status of the respondents. The health of the 23.1% of respondents was found normal, while 75% were good and 1.9% was average. The Figure 5(c) showed the education status of the respondents, the education status of the 26.9 % respondents was primary while 3.8% were middle and 9.6% were high. Furthermore, added that 17.3% was graduates and the remaining 42.3% were illiterate. Same way all Figures have given different information about respondents, the information detail of the remaining sub Figures (5d, 5e, 5f, 5g, 5h, and 5i) have mentioned in Figure 5.

Table 5 to 8. These tables describe the status of the analyzed results of the different parameters based on the paired samples test. These tables are contained on std. deviation, std. error, t- value and p-value (sig. 2-tailed). These statistical parameters are used to determine the difference between the paired variables. The difference is assessed and compared significantly between the variables based on the mean, t and p – values (sig. 2-tailed). The statistical results of the parameters obtained through test are mentioned in Tables (5-8), which clearly indicate that variations have occurred among the parameters in positive way and have strong correlation except one after the execution of dams.

An overall variation occurred in the analyzed results of each parameter have presented in above mentioned Table 5-8, and Figure 8. in percentage. Before and after dam construction, two images of the years 2008 and 2016 were classified based on the three classes. Classification results summary of the images before and after dams construction have presented in Figures 7 and 8. Which indicated that the water availability, vegetation cover and soil cover rate was changed. Water availability and vegetation cover were low while soil cover high during pre-dam's construction. Former two classes were improved and soil cover rate decreased after the execution of dams.

- **Analysis of the Parameters Using T - Paired Samples Test**

Table 5. Houses and Water Status

Parameters	Std. Deviation	Std. Error mean	t value	Sig.2-tailed (p value)
Houses status	.53638	0.052	-23.26	0.000
Water depths	3.87824	0.380	- 6.05	0.000
Water distance	2.80560	0.274	0.631	0.0495
Water fetching time	6.22443	0.6104	0.283	0.0495

Table 6. Land Cultivation and Crops Yield Status

Parameters	Std. Deviation	Std. Error mean	t value	Sig.2-tailed (p value)
Land cultivation	4.82249	0.473	-.405	0.0493
Area cult: Rabi mix crops	3.77736	0.369	-5.60	0.000
Area cult: Kharif mix crop	5.03187	0.493	-5.84	0.000
Yield of Rabi mix crop	2.88512	0.282	-6.73	0.000
Yield of Kharif crop	3.42403	0.335	-9.04	0.000
Rabi Single crops area cultivated	3.73050	0.366	0.683	0.0492
Area cultivated with single crop in Kharif	3.78708	0.370	-0.467	0.0495

Table 7. Livestock Status

Parameters	Std. Deviation	Std. Error mean	t value	Sig.2-tailed (p value)
Buffaloes	0.602	0.059	-6.83	0.000
Cows	1.586	0.155	-6.64	0.000
Goats	4.735	0.464	-0.702	0.0490
Sheeps	1.483	0.145	-9.51	0.000
Oxen	1.421	0.139	-2.20	0.0491
Horses	0.4196	0.0411	-0.463	0.059
Camels	0.7399	0.072	-14.30	0.000
Donkeys	0.833	0.081	-10.19	0.000

Table 8. Income, Expenditure, Saving and Migration Rate Status

Parameters	Std. Deviation	Std. Error mean	t value	Sig.2-tailed (p value)
Income	6.224	0.6104	6.49	0.000
Expenditure	8.758	0.858	-2.57	0.000
Saving	6.983	0.968	3.951	0.000
Migration rate	2.645	0.366	1.415	0.04901

- **Overall improved results summary of the parameters based on t - paired samples test after dams construction**

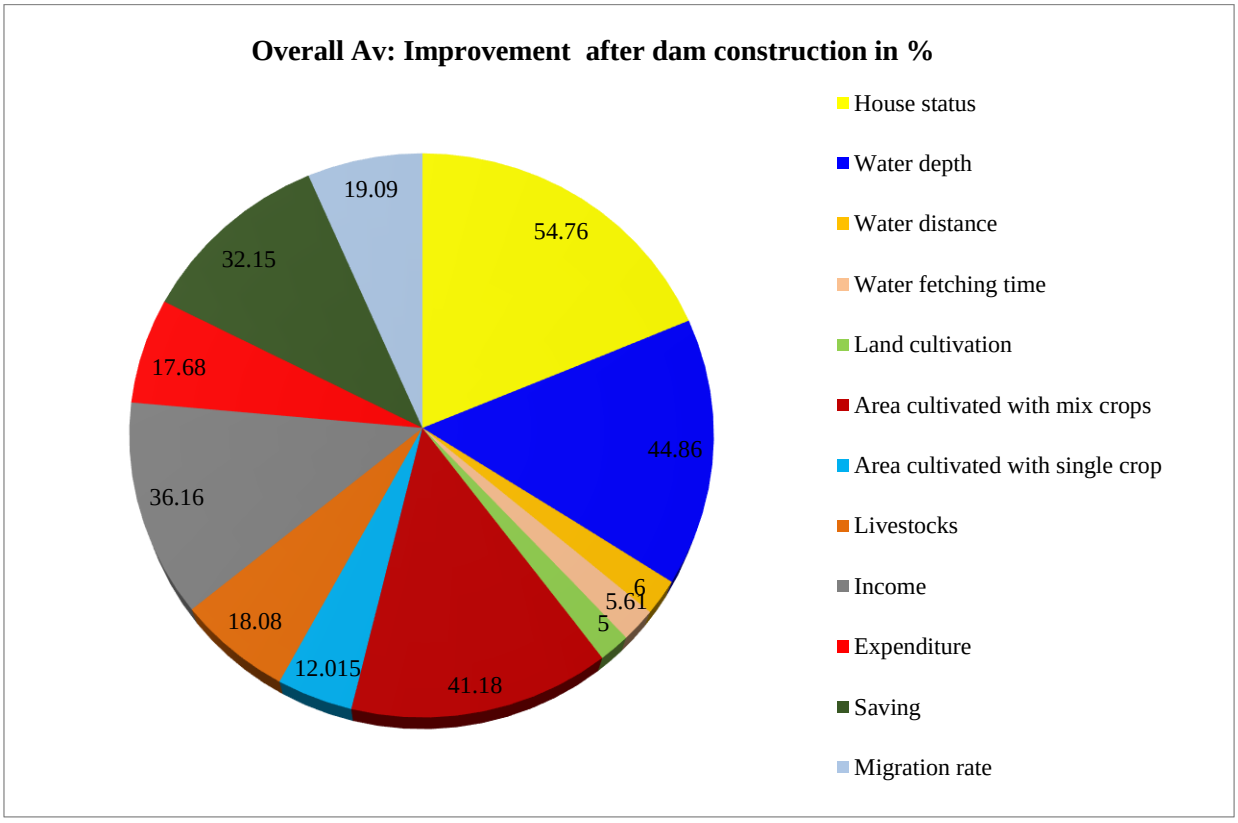


Figure 6. Overall Improved Results Summary of the Parameters after Dams Construction

- **Vegetation cover change classification results summary of the satellite images**

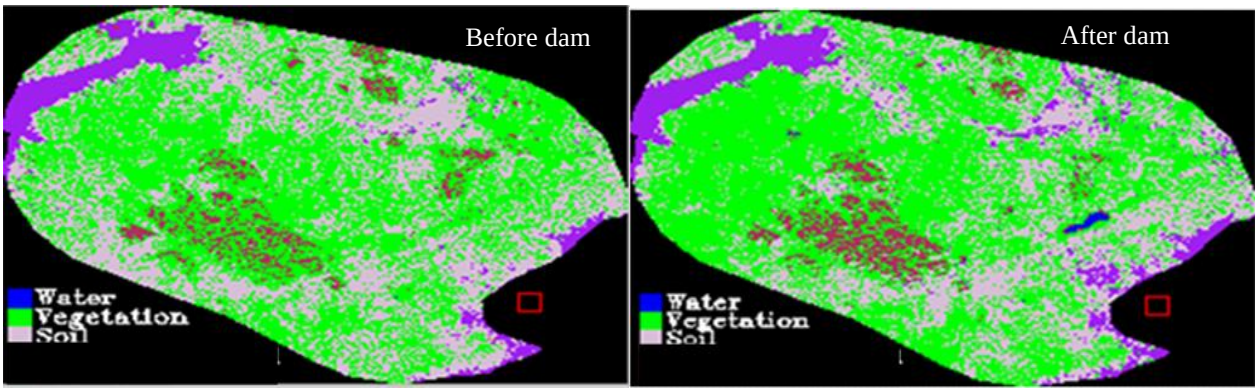


Figure 7. Vegetation cover change results summary of the satellite images before & after Dam

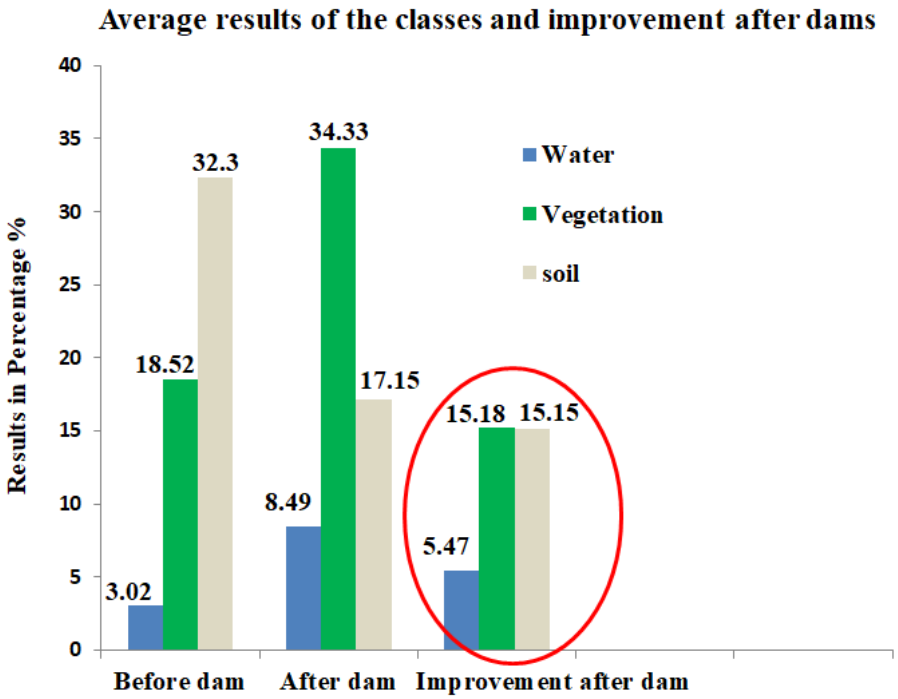


Figure 8. Vegetation cover change results summary of the satellite images before & after Dam and Improvement Occurred after Dams Construction

5. Conclusion

Overall analyzed results summary of the parameters obtained based on the t- paired samples test has revealed that significant variation occurred in the study area after construction of the dam. The numbers of the packa houses and water depths have increased 54.76% and 44.86% respectively. The distance and water fetching time decreased 6% and 5.61 % respectively. The overall land cultivation has increased 5% of each farmer, while the area cultivated with mix and single have increased 41.18% and 12.015 % respectively. Overall average area cultivated with crops has increased by 26.55%. The average yield of the almost every crop in both rabi in Kharif seasons have increased 55%. The overall livestock has increased by 18.08% while the number of horses decreased by 1.5% after the construction of the dam. The income, expenditure, and saving have increased significantly to 36.16%, 17.68%, and 32.15% respectively, while the migration rate has decreased19.09% since the construction of the dam. The cropping pattern has also changed from inferior crops to superior and market-oriented crops. The water table and quality have improved, and wells have recharged. The classified results summary of the satellite images has shown variation among the results. The detail of variation revealed that water availability and vegetation cover rate were increased by 5.47% and 15.18% respectively while soil cover rate decreased by 15.15 % after the construction of dams. The decreased soil cover brought the change in the shape of improved vegetation cover. It was very clear from the results summary of the t- paired samples test and satellite imaged that the small dams have a positive impact on land cover change, agriculture, houses, water level, time, distance, livestock, income, expenditure, saving and migration rate in direct and indirect way and also play very important role on the socio-economics conditions of the settled communities of the arid area.

6. Funding and Acknowledgments

Authors express sincere appreciation and gratitude to all who supported during this research work. Authors are much thankful to University of Utah and Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan for research funding, availability of office, time and support. Finally we acknowledge the anonymous reviewers for their critique to improve the quality of the paper.

7. Conflicts of Interest

The authors declare no conflict of interest.

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