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Climate change effect on major crops production in Balochistan, Pakistan

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Abstract

The present study was developed to assess the effect of climate change on production of major crops in Balochistan with special reference to farmers' perceptions. A total of 384 farmers were selected through unknown population formula from the three randomly selected districts of Balochistan province including Musakhail, Loralai and Zhob among which 128 farmers from each district were selected. Data were collected through valid and pre-tested interview schedule. Paired sample t-test and one sample t-test was used for the analysis of data. Significant increase in cultivable waste area and underground water table was observed. Results further reveal that farmers are left to cultivate major crops i.e. wheat 6.18%, Maize, 25.71% and Mash, 59.17% due to less or no water for irrigation and unpredictable rainfall. Significant decreased was observed in the production and area of all major crops in last 10 to 15 years. Majority of farmers are shifting from long term to short term crops. All the farmers were agreed and interested in the adoption of suitable adaptation strategies but the major constraint in the adoption of adaptation strategies is limited awareness, poverty and scarcity of irrigation water. Water management skills of farmers should be developed to avoid water losses. Water reservoirs should be construct to store the rain water for irrigation as well as to recharge the ground water. Agriculture Extension department should create awareness about suitable adaptation strategies to overcome the effect of climate change.

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Introduction

Environmental change is a serious threat for agriculture all around the World. In spite of the fact that agriculture is a complex and very advanced sector but it still depends on environment and growth of crops depend on sunlight, heat and water. Some environmental factors may bring benefits to agriculture e.g. longer season of crop growing and hot temperature. There are also negative effects like decline in water table and other extreme weathers (Singh and Grover, 2013).

Climate can affect agriculture in a variety of ways. Temperature, radiation, rainfall, soil moisture and carbon dioxide (CO_2) concentration are all important variables to determine agricultural productivity, and their relationships are not simply linear. Current research confirms that there are thresholds for these climate variables above which crop yields decline (Challinor *et al.* 2005; Porter and Semenov, 2005). The interaction of temperature increases and changing rainfall patterns determines the impact of climate change on soil moisture. With rising temperatures, both evaporation and precipitation are expected to increase. The resulting net effect on water availability would depend on which force is more dominant. As in Balochistan province the area is mostly arid and rain-fed therefore, it is directly vulnerable to the climatic change effect.

According to German watch report "Global Climate Risk Index for 2019" Pakistan was 8^{th} most effected county by extreme weather events during 1998-2017 with an average death toll 512.40, total losses in million US$ purchasing power parities (PPP) 3826.03 and losses per unit GDP 0.567% annually (Watch, 2018).

Agriculture sector plays a vital role in Pakistan's economy. Its contribution is 19.8% to the GDP and absorbing 42.3% of labor force of the country. The production of agricultural commodities are mostly depending on crop varieties, space and timely precipitation. The basic element of agriculture production is climate; but any negative changes in climate affect the production of agriculture in the form of crop failure, low production, and insect attack etc. which ultimately affect the livelihood of farming community especially of rain fed areas (GoP, 2016). Currently Balochistan is facing serious and emerging threat of drought situation; which is one of the most horrible disaster of country. The most affected areas of the province are upland zone.

The upland areas are always prone to water scarcity, from the last few years, rainfall is decreased to minimal level or no rainfall sometimes. Unexpected decrease of rainfall caused drying up of surface water resources for irrigation and drinking as well as decreased the output of tube wells and springs in the upland of the province. Most of the area's water table has declined to the dead level. Most affected districts of upland zone are Loralai, DeraBugti, Muakhail, Mastung, Zhob, Pishin, QillaSaifullah, Qilla Abdullah and Barkhan (UNDP, 2015).

Objectives of the study

To study the farmers' perception about climate change effects on major crops.

To identify the adaptation strategies of famers to overcome the effect of climate change.

To find out the constraint in the adoption of adaptation strategies in the study area.

Materials and methods

Universe of the study

Universe of the study was Balochistan province of Pakistan. The province lies between 27.7° north latitudes and 65° east longitudes with the total area 347,190 Km^2 and consisted of six divisions i.e. Quetta, Sibi, Makran, Zhob, Nairabad and Kalat (SMEDA, 2017). The most effected division by climate change, Zhob was selected purposely for data collection. Three districts out of six districts were randomly selected from the selected division.

Selection of Respondents

For selection of farmers, the researcher used singlestage sampling techniques (Casley and Kumar, 1988).

$$n = \frac{z^2 v^2}{d^2} \quad \text{.......... (1.1)}$$

Where:

Z^2 = reliability coefficient (Constant) = (1.96)

V^2 = 50% as no similar studies were found in study area and there is 50% chance of respondents being aware of climate change and its adaptation strategies.

n = required sample size

d^2= assumed marginal error (5%)

$$n = \frac{1.96^2 50^2}{5^2} = 384$$

Therefore through convenient sampling, 128 respondents were selected from each selected district.

Data Collection

Interview schedule was developed and designed in the light and on the basis of objectives of the study in order to collect appropriate, relevant and complete data/information.

Three point likert scale was used to measure the effect of climate change, adaptation strategies and constraints in adaptation strategies and weights were assigned such as 1=Uncertain, 2= Disagree and 3= Agree. The Interview schedule was pre-tested in pilot phase on 25 farmers which were not included in the sample size for the purpose of corrections and suggestions by the farmers.

Data analysis

The collected data was analyzed through Statistical Package for social Science (SPSS) Version 20 and the following statistical test was applied.

Paired Sample t-Test

To check the difference between variables, a paired t-test was applied to check the significant difference at 5% level of probability. The Paired t-test for convenience is given as;

$$t = \frac{\bar{d}}{Sd\sqrt{n}} \quad \text{.......... (1.2)}$$

Where:

D= difference between two sample observations (before and after effect)

N= number of pairs

Sd= standard deviation

Sd = $\sqrt{\frac{\sum (d_i - \bar{d})^2}{n-1}}$ and $\bar{d} = \frac{\sum d_i}{n}$, the mean of d-values.

One sample t-test

To express perception regarding different attributes. One sample t-test was used. One sample t-test is expressed in equation (1.3) bellow for convenience;

$$t = \frac{\bar{X} - \mu}{s/\sqrt{n}} \quad \text{.......... (1.3)}$$

Which under the null hypothesis follow a t-distribution with $(n-1)$ degrees of freedom. In equation (1.3),

Where,

$\bar{X}$ And μ = the sample and population means

s = is the sample standard deviation

N =is the sample size.

Results and discussion

Comparison cultivable waste area and water table before 10-15 years and present

Data in Table 1 show the paired sampled t-test results of cultivable waste area and underground water table in the study area at present and 10-15 years ago. Results of cultivable waste area revealed that before 10-15 years was 25.87 acres which increased 27.42 acres with mean difference of 1.55 acres and t-value of 8.91. There was highly significant increase in cultivable waste area over the last 10-15 years. The results further shows that underground water table before 10-15 years was 45.27 feet which increased to 141.14 feet with mean difference of 95.86 feet and t-values of 29.60. The decline in underground water table over the last 10-15 years was statistically highly significant at 1% level of probability. The results were also supported by Ahmad (2006) who reported that in upland Balochistan the overall water table decline from 15-30 meters to 60-200 meters in a period of around 30 years is a clear example of water mining. The inefficient irrigation methods, drought, uncontrolled installation of tube wells in large numbers, indiscriminate pumping of water and highly subsidized electricity are the main reasons for this. Declining of groundwater was accelerated by the drought during 1998-2004, which caused a large number of groundwater sources like karezes, springs and tube wells to become dry.

Table 1. Comparison of cultivable waste area and water table before 10-15 years and present.

Variables	Present		Before 10-15 Year		Mean Difference		t-value	P-value
	Mean	S.E	Mean	S.E	Mean	S.E		
Cultivable waste area (in acres)	27.42	1.56	25.87	1.48	1.55	.17	8.91	.000
Water table (in feet)	141.14	1.44	45.27	4.57	95.86	3.23	29.60	.000

Reasons of cultivable waste area

The overall picture regarding reasons of cultivable waste in the study area is presented in Fig. 1, which shows that the overwhelming majority (331) of the respondents mentioned shortage of irrigation water as the major reason behind cultivable waste area, followed by high land preparation cost reported by 288 respondents. The results further revealed that 281 respondents reported unavailability of modern technologies as the major reasons of cultivable waste area, whereas, 228 of the respondents reported high input costs as the main reasons of cultivable waste lands. The results are confirmed by Rehman (2009) who also reported that shortage of water is the major reason of cultivable waste area.

Table 2. Total reported area and production of major crops before 10-15 years and present of the respondents in the study area.

Major crops	Before		Present		% Area Change	% Respondent Difference	Overall production (tons)		
	Area (ha)	Frequency	Area (ha)	Frequency			Before	Present	Percent change
Wheat	1007.28	384	944.93	384	<6.18%	<0%	1305.32	1119.29	<14%
Maize	694.33	310	515.78	269	<25.71%	< 13.22%	496.97	315.53	<36%
Mash	108.09	85	44.13	43	<59.17%	< 49.41%	17.00	5.33	<69%

Source: Author Survey results, 2018.

Effect of climate change on the area and yield of major crops

It was found that before 10-15 years wheat was cultivated by the respondents over the area of 1007.28 ha in the study area which was decreased to the area of 944.93 ha at present. Similarly, maize was grown over an area of 694.33 ha whereas at present the area under maize was squeezed to the 515.78 ha. Moreover, the area of mash has been minimized to 44.13 ha, from the 108.09 ha. Furthermore, the overall production (1305.32 tons) of wheat, maize (496.97 tons) and mash (17.00 tons) has been decreased to 119.29 tons, 315.53 tons and 5.33 tons respectively (Table 2). To find out mean significant difference of area and yield under major crops before 10-15 years and present, Paired sample t-test was used and the computations were given in the Table 3. The results showed that there was highly significant ($P \le 0.01$) difference before 10-15 years and present regarding area of wheat and maize with the mean difference of -0.40 and -0.56 acre. While there is statistically no significant difference in area of mash before 10-15 years and present. Similarly, there was highly significant ($P \le 0.01$) difference of yield regarding maize and mash i.e. -58.24 and -54.16 kg/acre whereas significant ($P \le 0.05$) for wheat with the mean difference of -45.08 kg/acre. The subsistence farmers of Balochistan focus on growing just enough to feed their families. It is concluded from the results that there is decrease in area and yield of major crops in the study area. The declining agricultural production may be caused by low precipitation, reliance on rain fed agriculture and unfavorable weather conditions which were the principal causes of poverty in rural areas. UNDP (2015) reported that almost 50-80% yield losses were recorded in the year 2011-14 of different crops in uplands of Balochistan.

Table 3. Comparison of area and yield under major crops before 10-15 years and present of the respondents in the study area.

Major crops	Present		Before		Mean difference		t-value	P-Value
	Mean	S.E	Mean	S.E	Mean	S.E		
Wheat Area in Acre (n=384)	6.08	0.14	6.47	0.17	-0.40	0.08	-4.68	.000
Wheat Yield (Kg per Acre)	479.56	24.58	524.65	10.41	-45.08	21.52	-2.09	.037
Maize Area in Acre (n=269)	4.74	0.13	5.30	0.15	-0.56	0.091	-6.22	.000
Maize Yield (Kg per Acre)	257.02	4.65	315.26	4.73	-58.24	2.42	-23.99	.000
Mash Area in Acre (n=30)	2.20	0.18	2.26	0.18	-0.06	0.046	-1.43	.161
Mash Yield(Kg per Acre)	148.33	9.26	202.50	5.39	-54.16	9.01	-6.00	.000

Source: Author Survey results, 2018.

Newly Adopted vegetables

Farmers of the study area are shifting from long to short duration crops due to water shortage. Farmers of the study area have started cultivation of some vegetables in recent past from 1-2 years. Banerjee (2015) reported that most of the farmers have diversified to short term crops. Table 4 shows that mostly in Zhob District Chili was cultivated on 13.33 hectares with the average yield of 0.97 tons per hectare similarly, in District Musakhail and Loralai Chili was cultivated on 2.63 and 11.34 hectares with the average yield per hectare of 1.21 and 1.17 tons respectively.

Table 4. Total reported area, yield and production of newly Adopted vegetables in last few years by the respondents in the study area.

Vegetables	Districts	Area in hectare	Total production (tons)	Average yield (t/ha)	Total area (ha)	Overall production (tons)	Average yield (t/ha)
Chili	Musakhail	2.63	3.18	1.21	27.30	29.40	1.08
	Loralai	11.34	13.24	1.17			
	Zhob	13.33	12.98	0.97			
Garlic	Musakhail	2.23	13.60	6.11	21.10	129.85	6.15
	Loralai	10.12	71.44	7.06			
	Zhob	8.75	44.81	5.12			
Cucumber	Musakhail	0.81	2.60	3.21	23.91	91.32	3.82
	Loralai	22.27	86.52	3.89			
	Zhob	0.83	2.20	2.64			

Source: Author Survey results, 2018.

On total area of 27.30 hectares, Chili were cultivated in the study area with overall 29.40 tons production and the average yield per hectare in the study area were 1.08 tons. Garlic is mostly cultivated in district Loralai on 10.12 hectares with average yield 7.06kg per hectare, while in district Musakhail and Zhob the area under garlic cultivation is 2.23 and 8.75 hectares with average yield of 6.11 and 5.12 tons per hectare.

Overall Garlic was cultivated on 21.10 hectares in the study area with total production of 129.85 tons and average yield of garlic in the study area was 6.15 tons per hectare. Cucumber is mostly cultivated in district Loralai followed by Zhob and Musakhail on 22.27, 0.83 and 0.81 hectares with average yield of 3.89, 2.64 and 3.21 tons per hectare. Overall cucumber was cultivated on 23.91 hectares with total production of 91.32 tons and average yield of 3.82 tons per hectare in the study area.

Table 5. Constraints in climate change adaptation strategies in the study areas.

S. No	Constraints in climate change adaptation	Disagree	Undecided	Agree	Mean average	Rank	t-value	P-value
1	Limited awareness or information about Climate Change	0 (0)	8 (2)	376 (98)	2.98	1	134.16	.000
2	Poverty	8 (2.1)	8 (2.1)	368 (95.8)	2.93	3	57.94	.000
3	Low level of technology	34 (8.9)	54 (14.1)	296 (77.1)	2.68	6	21.27	.000
4	Shortages of labor inputs	213 (55.5)	59 (15.4)	112 (29.2)	1.73	7	-5.83	.000
5	Poor soils	273 (71.1)	45 (11.7)	66 (17.2)	1.46	8	-13.71	.000
6	Lack of water	19 (4.9)	1 (0.3)	364 (94.8)	2.89	4	40.31	.000
7	Shortages of land for cultivation	322 (83.9)	33 (8.6)	29 (7.6)	1.23	9	-25.92	.000
9	Belief System of the local people	48 (12.5)	9 (2.3)	327 (85.2)	2.72	5	21.22	.000

Source: Author Survey results, 2018.

Constraint in adaptation strategies

To find out the constraints which hinder the adaptation strategies for adoption of various techniques the respondents were investigated and their responses are presented in Table 5.

It was found that among all the major constraints limited awareness or information about the various techniques and adaptation strategies was reported by majority of the respondents i.e. 98% and was ranked at 1st order.

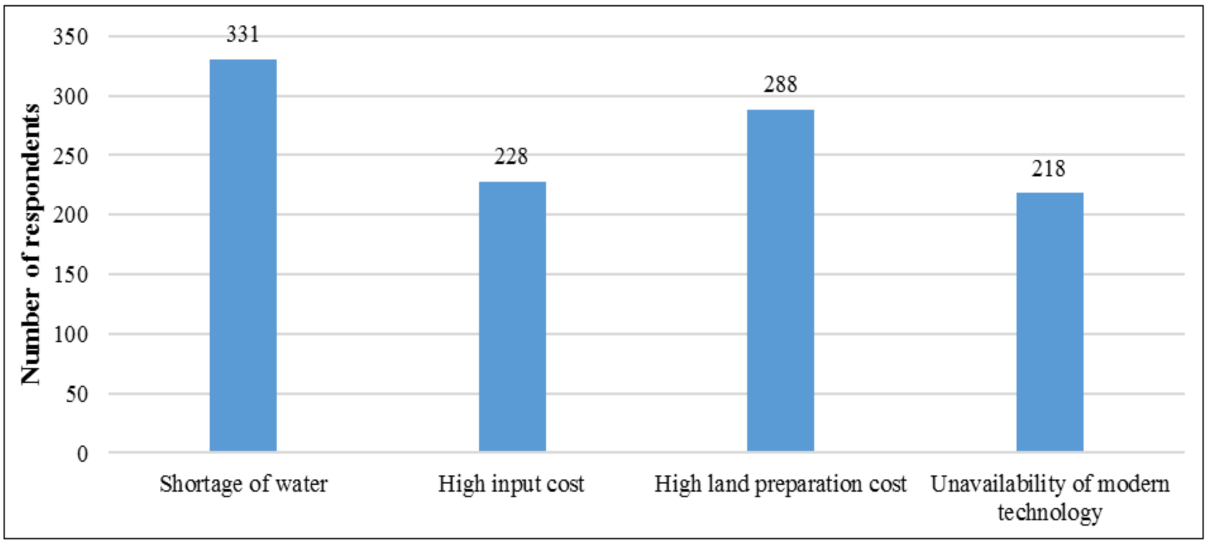

Fig. 1. Reasons of cultivable waste in the study area.

Poverty was reported by 95.8% of the total respondents as constraint and stood at 2nd rank followed by lack of water (94.8%), belief system of the local people (85.2%) and low level of technology was reported by 77.1% of the total respondents. Moreover, shortage of labor inputs was reported by only 29.2% as a constraint whereas poor soil was reported by 17.2%, and shortage of land was reported by only 7.6% of the total respondents. These results are also in agreement with (Thomas *et al.,* 2007; Mertz *et al.,* 2009) who reported that limited awareness about climate change adaptation, low access to credit and to agricultural extension services have influences in the decision of farmers about climate change adaptation.

Conclusion

It can be concluded that climate change has highly affected the farming community and agriculture sector. The climatic change has brought drastic change in the cropping pattern, the cultivated area and the yield of the crops grown in study districts. Which revealed that the farming community of Balochistan is under sever climatic change threat. Cultivable waste area significantly increased due to the non-availability of irrigation water which is the result of drastic increase in depth of water table.

The highest ranked constraints faced by farming community in adaptation strategies include limited awareness, poverty and lack of irrigation water. Therefore it is suggested that farmers should be aware of water management skills to overcome water issues. One the other hand government should also put serious concern over constructions of reservoirs and utilizes water shed management in real zeal. Similarly, the Agriculture Extension Department should also come forward to create awareness regarding this real threat and create awareness regarding plantations, afforestation, and climate change adaptation strategies.

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