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Identification of Local Climate Change Adaptation Strategies for Water Management in Districts Attock and Chakwal, Pakistan

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Abstract: Climate change is predicted to have the main impact on agriculture, economy and livelihood of the populations of under-developed world and mainly in rainfed area of Pakistan, which generally called as Pothwar region. To improve the knowledge in this respect and guide policy making for adequate and relevant adaptation strategies, 60 farmers were interviewed in two districts, namely Attock and Chakwal. Farmers were asked closed and open-ended questions about farm activities, farmer climate knowledge and perceived climate change and adaptation strategies for water management. About 68% of the respondents perceived that Climate Change (CC) resulted in increase in temperature and 55% agreed on low rainfall in the study area. About 81.66% respondents were agreed on water stress in the study area. About 55% perceived that climate change reduced yield of crops and almost 75% respondents were rely on only rain water for crops. Copping strategies for these issues were that respondents favored the planting of drought resistant/tolerant crop varieties, planting of many different types of crops (mixed-cropping) and planting of pest/disease resistant/tolerant crop varieties. The farmers agreed that straw mulching of crops to reduce water loss (33.02%) and increase in use of organic manure (57.13%) are coping strategies to reduce or alleviate the effect of climate change.

Key words: Climate change, water management, Attock, Chakwal, Pakistan

INTRODUCTION

The earth's climate is subject to change by both natural and anthropogenic influences. Climate change will have far-reaching consequences for agriculture that will disproportionately affect the poor, who depend on agriculture for their livelihoods (World Bank, 2007). Such as climate related crop failures, fishery collapses and livestock deaths already cause economic losses and undermine food security and these are likely to become more severe as global warming continues (Nelson *et al*., 2009; RAE, 2010; Agha, 2009). Climate change is expected to impact both on rainfed and irrigated agriculture (UN Water Policy, 2011; ICIMOD., 2007).

Similarly agriculture is the most vulnerable sector to climate change. Agriculture productivity is being affected by a number of factors of climate change including rainfall pattern, temperature hike, changes in sowing and harvesting dates, water availability and land suitability. The largest impact in the agricultural sector is likely to be felt in irrigation, as water supply becomes scarcer in some areas and more subject to extreme variations (Ziska, 2011). Furthermore according to Doll (2002), temperature indirectly affects the water requirement from the crop as a warmer weather means a higher evapotranspiration from the plant (Kundzewicz *et al*., 2007). All these factors which caused less water availability can change yield and agricultural productivity (Kaiser *et al*., 1993).

Pakistan is basically an agricultural country, where out of 22 million hectares (Mha) cultivated land, about 25% area is rainfed and depends on rainfall directly or indirectly for crop production. Water is a scarce source due to various management problems and great difficulties arise in raising crops/plants due to uncertain water supplies. Most of the agriculture in these areas, especially Pothwar Plateau, is practiced through obsolete irrigation and cropping methods. As a result, the crop productivity and water use efficiency are very low. Moreover, poor land and water management is also contributing in the degradation of natural resources where erosion of productive lands is a major threat. Pakistan being an agrarian country heavily depends upon the water sources (Ahmad *et al*., 2003; Razzaq *et al*., 2002). The climate of rainfed area can be classified on the basis of rainfall distribution patterns into three zone, i.e., (1) Low rainfall zone receiving less than 500 mm rainfall, (2) Medium rainfall zone receiving 500-750 mm rainfall and (3) High rainfall areas receiving more than 750 mm rainfall annually (Beg *et al*., 1985; Anonymous, 2009; Abdullah, 1987).

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This may be viewed from the fact that during the recent drought in the country, the Pothwar region was the most affected causing huge loss of crops and livestock. Therefore, there is an emerging need to conduct a comprehensive study on a holistic manner taking the whole Pothwar including high, medium and low rainfall zones. This study aims to assess the local climate change adaptation strategies for water resources and water management issues in Pothwar region. Efforts will be made to link the climate change impacts with the actual field Conditions. The study will be done by social scientist in collaboration with climate change, alternative energy and water resources institute (CAERI, NARC).

This study will investigate the local indigenous adaptation practices for water management with reference to climate change.

Objectives: The specific objectives of the study are:

- To study the existing climate change adaptation strategies for water management in the study area
- To identify positive and negative facts associated with the local climate change adaptation strategies for water management in the study area

MATERIALS AND METHODS

This study covered two major districts of Pothwar region, namely Attock and Chakwal. A total 60 respondents were interviewed. Data was summarized, entered in SPSS software and simple descriptive and Chi-Square analysis applied.

Chi-square test: Chi-square was applied to find out the relationship between certain independent and dependent variables.

The chi-square was calculated with following equation:

$$\chi^2 = \sum \frac{(\text{fo} - \text{fe})^2}{\text{fe}}$$

Where:

O = Observed
E = Expected value
S = Sum of value

In order to judge the significance of results, the calculated values of chi-square were compared with the tabulated value at a given degree of freedom. The result was considered significant of the calculated value of chi-square was greater than the table value otherwise it was regarded non-significant.

RESULTS AND DISCUSSION

General farmer's characteristics: On average age of the respondents was 43.00 in district Attock and 47.21 in district Chakwal and overall 41.03. Farming experience on average in Attock, Chakwal and overall were 31.23, 26.19 and 29.21, respectively. Average household was 6.11 in the study area. Education of the respondents in Attock and Chakwal was 5.16 and 7.27, respectively. Lastly total own land average was 4.49 acres in the study area with 4.14 in district Attock and 5.17 in district Chakwal (Table 1).

General climate variability and change: Almost all the farmers were interviewed believe there had been changed in the overall climate pattern. Mostly farmers respond that there was rising temperature and low rainfall in the study area by 68.33 and 55.00%, respectively. Major change in the area was water stress (81.66%) and it was correlated with rising temperature and low rainfall. The droughts, strong winds, cold spells more, warm spells more and erratic rainfall by 31.66, 51.66, 45.00, 56.66 and 58.33%, respectively (Table 2).

Change in rainfall pattern: The summer rainfall was perceived by farmers to be later nowadays than before (Table 3). Almost 65 and 85% farmers from district Attock and Chakwal perceived that summer rainfall was late, respectively. While in case of summer duration in both districts farmers perceived that summer duration increased. The number of rainfall events during winter season was perceived to have decreased (62.50 and 65% in Attock and Chakwal) with the number of dry spells perceived to have increased (Table 3).

Change in temperature: Farmers perceived that generally the number of hot days, summer temperature and winter temperature had increased. The number of chilling days was mentioned to have decreased in the

Table 1: Averages of general farmer's characteristics

Variable	Attock	Chakwal	Overall
Age (years)	43.00	47.21	41.03
Farming experience (years)	31.23	26.19	29.21
Household size (Numbers)	7.04	5.15	6.11
Education (years)	5.16	7.27	7.55
Total Own land (Acres)	4.14	5.17	4.49

Table 2: Aspects of percentage climate change

Variable	Mean	Variable	Mean
Rising temperature	68.33 (41)	Erratic Rainfall	58.33 (35)
Droughts	31.66 (19)	Low Rainfall	55.00 (33)
Strong wind	51.66 (31)	Water stress	81.66 (49)
Cold spells more	45.00 (27)	Warm spells more	56.66 (34)

Table 3: Farmers' perceived change in the rainy season pattern (%)

	Attock (40)	Chakwal (20)
Summer rainfall		
Early	7.50 (3)	00.00 (0)
Late	65.00 (26)	85.00 (17)
No Change	27.50 (11)	15.00 (3)
Winter Rainfall		
Early	15.00 (6)	05.00 (1)
Late	62.50 (25)	65.00 (13)
No Change	22.50 (9)	30.00 (6)
Summer season duration		
Decreased	10.00 (4)	00.00 (0)
Increased	85.00 (34)	85.00 (17)
No Change	05.00 (2)	15.00 (3)
Dry Spell Frequency		
Decreased	02.50 (1)	10.00 (2)
Increased	82.50 (33)	65.00 (13)
No Change	15.00 (6)	25.00 (5)

Table 4: Farmers' perceived change in temperature pattern (%)

	Attock	Chakwal
Summer temperature		
Decreased	17.50 (7)	10.00 (2)
Increased	70.00 (28)	75.00 (15)
No Change	37.50 (15)	15.00 (3)
Winter temperature		
Decreased	10.00 (4)	00.00 (0)
Increased	70.00 (28)	95.00 (19)
No Change	20.00 (8)	5.00 (1)
Hot days		
Decreased	2.50 (1)	00.00 (0)
Increased	80.00 (32)	100.00 (20)
No Change	17.50 (7)	00.00 (0)
Chilling days		
Decreased	77.50 (31)	95.00 (19)
Increased	5.00 (2)	00.00 (0)
No Change	17.50 (7)	5.00 (1)

Table 5: Farmers' crop management adaptations (%)

	Attock	Chakwal
Sowing date		
Early	45.00 (18)	5.00 (1)
Late	47.50 (19)	80.00 (16)
No change	07.50 (3)	15.00 (3)
Crop productivity		
Increased	92.50 (37)	65.00 (13)
Decreased	2.50 (1)	15.00 (3)
No change	5.00 (2)	20.00 (4)
Crop varity		
Changed	85.00 (34)	65.00 (13)
No changed	15.00 (6)	35.00 (7)

study area (Table 4). There was generally an association between the changes in temperature (hot, cool days and months) and country, except the temperature trend itself. Farmers generally perceived no change in the hottest and coolest months of the year.

Farmers' adaptation strategies to climate change: Farmers' adaptation strategies included crop, soil fertility and soil water management practices.

Table 6: Ground water availability and source of irrigation

Specification	Min.	Max.	Mean
Ground water table (feet)	50	550	270.31
Ground water table (feet) (10 years before)	20	300	176.34
Change in depth (Inch/feet)	10	240	76.88

Crop management: As an adaptation to late rain onset the majority of farmer respondents delay sowing dates (Table 5). This change in sowing date was more adopted in the district Chakwal (80%) as compared to the district Attock (47.50%). In case of crop productivity district Attock crop productivity increased more than district Chakwal.

The majority of farmers changed crop variety in Attock (85%) and Chakwal (65%) and they adopted high yielding varieties on their fields and in a result they gain more productivity than ever before (Table 5).

Water management: Farmers perceived that change in ground water-table mean was 76.88 feet. Currently ground water-table mean value was 270 feet with minimum of 50 feet and maximum of 550 feet. While ten years back on average ground water-table was 176 feet with minimum of 20 feet and maximum of 300 feet (Table 6).

Water management practices: Farmers perceived that on average, 43% farmers were aware about water harvesting technique and on average 31.07 farmers were practicing this technology. The practice of development and maintenance of watersheds were known by 21% farmers and practiced by 11.13 farmers in the study area. The extraction of ground water technology was known by 83% respondents and used by 69.25 respondents. Drainage management was known by 61% farmers and used by 43.27 farmers. Use of sprinkler and drip irrigation was known by 83% and 74% farmers but used by only 6.00 and 13.11 farmers due to high cost (Table 7).

Mostly famers were managed external water for their crop by depending upon rain water (75%) and farm ponds (27%). Farmers were improving water holding capacity, using manure applications, tied ridges, straw mulching and earthen contour bunds by 57, 41, 33 and 11%, respectively. While they were increasing plant water uptake capacity, using dry planting (41%), optimum crop rotation (40%), pest control (26%), improved crop varieties (73%) and intercropping techniques (14%) on their fields (Table 8).

Chi-square and correlation analysis: The Chi-square analysis confirms that significant differences exist in the study area between climate change variables and crop

Table 7: Water management practices

Practices	Whether aware (Y/N) percent	Are you practicing percent
Water harvesting	43.00	31.07
Development and maintenance of watersheds	21.00	11.13
Extraction of ground water	83.00	69.25
Drainage management	61.00	43.27
Use of sprinklers	83.00	6.00
Use of drip irrigation	74.00	13.11

Table 8: Factors influencing the harvesting system, water holding and water uptake capacity

How you manage external water for harvesting systems please specify management practices (%)?			
Farm ponds	27.50 (11)	Subsurface tanks	02.50 (1)
Subsurface mini dam	07.50 (3)	Depend upon rain	75.00 (45)
How you improve soil water holding capacity please specify management practices (Mean)?			
Tied ridges	41.11	Earthen contour bunds	11.07
Straw mulching	33.02	Manure applications	57.13
How you increase plant water uptake capacity systems please specify management practices (%)?			
Dry planting (early)	41.23	Improved crop varieties	72.83
Optimum crop rotation	39.76	Intercropping	13.79
Pest control	26.57		

Table 9: Relationship between perception of climate change with crop productivity and socio economic variables (a chi-square analysis)

Management practices	Chi-square	Significance level
Rising temperature vs crop productivity	70.24	0.019
Low Rainfall vs crop productivity	39.23	0.011
Change in cropping pattern due to climate change	103.22	0.000
Water management and crop yield	11.79	0.049
Climate change and crop rotation	14.37	0.017
Water management and experience	3.09	0.079
Climate change and improved crop varieties	27.78	0.001
Droughts and crop productivity	84.13	0.003
Awareness and crop productivity	2.13	0.148
High rainfall and crop productivity	14.89	0.061

productivity and socio economic variables. For example, except Water management and experience and Awareness and crop productivity, all the other variables mentioned in Table 9, are highly significant and have strong variation between climatic factors and crop productivity and socio economic variables (Table 9). Correlation analysis showed negative association between increase in temperature and decrease in rainfall affect the crop productivity significantly in the study area.

About 68% of the respondents perceived that climate change resulted in increase in temperature on similar lines, study declared that the surface temperature of Pakistan is rising rapidly over the years with higher ratio. About 55% farmers agreed on low rainfall in the study area on similar lines, Latif and Tariq (2006) stated the average rainfall decrease in Pakistan and they also concluded that the rain is erratic and insufficient for crop growth in Pakistan. About 81.66% respondents were agreed on water stress in the study area. About 55% perceived that climate change reduces yield of crops and almost 75% respondents were rely on only rain water for crops, similarly, Heisey and Edmeades (1999) described that water stress due to climate change damaged the crops yield when it rose at reproductive stage of crop's life cycle.

The farmers agreed that straw mulching of crops to reduce water loss (33.02%) and increase in use of organic manure (57.13%) are coping strategies to reduce or alleviate the effect of climate change. Many studies show that crop yields were increased through straw mulching and with the use of organic manure (Stroosnijder, 2003).

CONCLUSION

The subject study found that crop managements strategies (change in sowing date and crop cultivar) were more adopted than soil fertility and soil water management's practices due to socio-economic constraints associated with the latter ones. Moreover study found that many farmers were still hesitating to adopt the adaptation strategies which highlight the need to evaluate them so as to facilitate decision making. Efforts should be geared towards developing and making available crop varieties and livestock breeds that are tolerant to adverse conditions associated to climate change such as diseases, flood, drought and temperature. A multi-media enlightenment campaign of the effects and possible coping strategies should be adopted by all tiers of government to reach the farmers using the available extension structures.

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