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VULNERABILITY OF SMALL-SCALE FARMERS IN RELATION TO CLIMATE CHANGE AND THEIR COPING STRATEGIES: CASE STUDY OF SOUTHERN PUNJAB, PAKISTAN

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ABSTRACT

We examined the vulnerability of farmers to climate change in this study. This study was quantitative followed by cross-sectional research design. The study was confined to two districts of the southern Punjab: Muzaffargarh and Khanewal. A total of Two hundred and forty (240) farmers were interviewed face to face. Data were analyzed through Statistical Package for Social Sciences (SPSS). The results were categorized into three section. First section consists of socio-economic profile of respondents. The descriptive analysis was adopted in order to quantify the age, education, land size, income and income sources of the respondents. Second section entailed perception of respondents about the climate change, farmers vulnerability level, factors behind the vulnerability and coping strategies as adopted by the farmers. The mean values and standard deviation were calculated to meet the need of second objective. The third section was the Factor Analysis of the factors through Principal Component Analysis (PCA). The objective was to extract those factors likely to contribute more to vulnerability of farmers to climate change. The values of Kaser-Meyer-Olkin and Barlett's test of sphericity were greater than 0.60, thus running factors analysis was implicit. Four factors (i) low crop yield (ii) small/subsistence farming (iii) large dependent in agriculture and (iv) marketing problem was extracted indicating total variance of 59.67%. The normality test for the newly extracted factors had the probability value of less than 0.005. At the end, the study had brief recommendations for the research, extension and the farmers in order to improve the adaptive capacities of the farmers and persuade climate smart agriculture.

Keywords: *Adaptation, Coping strategies, Climate change, Small farmers,*
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INTRODUCTION

Adaptation and development contexts are two key concepts where vulnerability is repeatedly investigated. Notable institutions, policy makers and public initiatives do intervene and influence the internal dynamics of populations. In case of farming community, measuring the vulnerability at all levels could facilitate their stabilization with reference to the resources (Diyawadana *et al*., 2017). Without any doubt, agriculture and its allied sectors are considered sensitive to climate variations. Processes in the agriculture sector and its production could be liable of severe negative impact due to climatic changes (Sattar *et al*., 2017). Among the farmers, only small farmers in the agriculture sector are considered most vulnerable in comparison to remaining farming community. Xu *et al*. (2020) also pointed out that small farmers particularly in the developing nations face maximum negative series of impacts on agriculture sector due to the climate change. Small farmers consider agriculture as their only source of income and they rely heavily upon this key source of income. High risk to their yield due to climate change in addition to market prices of inputs and unexpected pest breakouts creates financial insecurity alongside increased competition for livelihood assets (Haile *et al*., 2017). Over reliance of small farmers on the subsistence farming along with poverty, high prices of farm commodities, demographic and policy trends pose negative effect to their living standards (Williams *et al*., 2018).

Climate change is recognized as a continuous phenomenon for the present and future as well. This ascertains that it should be given due attentions by the research, academia and the farmers to learn and respond accordingly (Donatti *et al*., 2019). The vulnerabilities associated with climate change could be direct or indirect and the adaptive capacities of farmers could wither worsen or lessen the vulnerability (Jamshidi *et al*., 2019). Improved agricultural practices and technologies are dire need in the changing environment specifically for the marginalized farm families. Keeping in view the urgency posted by climate change vulnerability, each region is responsible in order to initiate alternate measures and offer cost-effective techniques to expedite the adaptive capacities of the farmers (Tessema *et al*., 2019). Disproportionate affects due to climate set the need for

categorizing the local needs of adaptive capacities to cope the vulnerability at local level. As per the demand of the situation, adaptation in case of farmer's behavior toward the climatic condition is mandatory. In the current research study, it was examined: (a) what are the perceptions of farmers regarding climate change? (b) what are the major coping strategies being adopted by respondents to minimize vulnerability towards climate change? and (c) what are the factors that affect vulnerability of small land holders in the scenario of climate change?

MATERIALS AND METHODS

This study was quantitative in nature and cross-sectional research design was used. Cross-sectional study is more generalizable and can be fit for larger scale of population (Jhonson and Hall, 1988). A field survey was conducted to collect data from the respondents through face-to-face interview technique.

Punjab province is the largest province of Pakistan in terms of its population, agriculture potential and the production. The province is divided into three different zones as southern central and northern. The contribution of Punjab province in cumulative agricultural production of Pakistan is accredited as top with comparison to other provinces. A number of vegetables, crops and fruits are being grown here. Wheat, Rice, Cotton, Sugarcane and Maize are major field crops and Citrus, Guava, Mango, Dates and Melons are the major fruits being cultivated in the Punjab. Present study was conducted in the southern region of the Punjab province. The Southern region of the province is comprised of twelve (12) districts/administrative units. Keeping in view the financial resources and time constraints, the study was limited to two districts. Simple Random Sampling technique was used to select the targeted research aera (districts). Of the total 12 districts of southern region of the Punjab, two districts (Khanewal and Muzaffargarh) were selected through simple random sampling technique. The map of the Punjab province with targeted research areas is presented in Figure 1:

Figure 1. Map showing the study districts

District Muzaffargarh and Khanewal consisted of total four tehsils each. From each district two tehsils were selected at random. Consequently, Tehsil Khanewal and Mian Channu from District Khanewal and Tehsil Kota Adu and tehsil Muzaffargarh were selected from District Muzaffargarh. The list of farmers was obtained from the Offices of Deputy Director of Agriculture (Extension) of both districts. From each tehsil, 60 respondents were selected purposively thereby making a sample size of 240 respondent.

A structured interview schedule bearing closed ended questions was designed/constructed keeping in

mind the objectives of current research. Before actual data collection, validity and reliability of interview schedule was checked. To check the face validity of interview schedule, it was pre-tested on 20 respondents. These respondents were not included in the actual sample size of the study. In addition to face validity, content validity of interview schedule was also checked by consulting faculty members and post graduate students of Department of Agricultural Extension, College of Agriculture, University of Sargodha. Reliability of interview schedule was checked through Cronbach's alpha.

Data was analyzed through Statistical Package for Social Sciences (SPSS). For the socio-economic factors descriptive statistic was used. Cross-tab was used to check the influence of some of the demographic factors. Descriptive Statistics was used to describe their perceptions about climate change, their vulnerability status, vulnerability factors and their coping strategies. Principal Component Factor Analysis was used to extract the factors. There were total 12 factors under consideration and through PCA technique 4 new factors were extracted.

RESULTS AND DISCUSSION

The manuscript is divided into three sections. First section dealt with demographic profile of respondents while the second section deal with perception of respondents about climate change, vulnerability factors, copping strategies adopted by respondents and its effectiveness. The third section is the principal component factor analysis to extract new factors.

Section-1. Demographic profile of respondents

Table 1: Frequency and percentage of respondents regarding their demographic characters *n=240.*

Demographic character	Categories	Frequency	Percentage
Age	21 to 35 years	88	36.7
	36 to 50 years	106	44.2
	Above 50 years	46	19.2
Education	Illiterate	88	36.7
	Primary	42	17.5
	Middle	38	15.8
	Matriculation	40	16.7
	Intermediate and above	32	13.3
Income source	Farming only	118	48.8
	Non-farming	60	25
	Both	62	26.2
Landholding	Up to 2.5 acres	78	32.5
	2.6 to 5 acres	86	35.8
	More than 5 acres	76	31.7
Poverty status	Poor (with monthly income up to 15000 PKR)	70	29.2
	Better-off (Monthly income from 15001 PKR to 30000 PKR)	118	49.2
	Well-off (Monthly income >30000 PKR)	52	21.7
Agriculture	Grow only crops	68	28.3
Diversification	Livestock farming	8	3.3
	Both crops & livestock farming	164	68.3

Demographic profile of respondents: exploring the demographic profile of the respondents is perceived helpful in-depth analysis of the situation. Gomez *et al*. (2012) have augmented the key importance of demographic attributes of the respondents while conducting a study to examine the climate change impacts. Therefore, in this study a brief overview of demographic profile of respondents was explored. Table 1 shows, 36.7% of respondents were aged under 35 years. Respondents falling in age racket of 36-50 years were prominent (44.2%) and one fifth (19.2%) of respondents were considerably aged (above 50 years). Of the total respondents, 36.7% were illiterate and 63.3% were literate. Among respondent, 17.2, 15.8, 16.7 and 13.3% had primary, middle, matriculation and intermediate level of education. This implies the level of education of respondents in the area was an average. Being inferior in educational achievement, the farmers in the area would be more sluggish in assessing the climate change and its remedy. For almost half (48.8%) of respondents, farming was the sole income source. One fourth respondents (25%) were getting income from non-farm sources and 26% were reliant over farming and non-farming sources. As indicated earlier the educational level on the area was

just average. Pertinent to low education the individuals were more emphasized on farming rather non-farming sources to generate income. Farmers, in most were small as only 31.7% of respondents had land holding size of more than 5 acres. Among respondents, 29.2% perceived themselves as poor and almost half (49.2%) considered themselves as better-off. More than one fifth (21.7%) respondents were perceived as well-off. Being a key income source, 68.3% of respondents had diversified to cultivating crops and managing livestock in order to get more income. More than one fourth (28.3%) of respondents were cultivating crops only and few of the respondents (3.3%) were managing livestock only.

Section-2. Perception about climate change, vulnerability and coping strategies

Table 2: Perceptions of respondents about climate change.

Factors	Scaling	Frequency	Percentage
Knowledge about climate change	Yes	148	61.7
	No	92	38.3
Recent temperature trends	Moderate	44	18.3
	Hot	90	37.5
	Very hot	106	44.2
Increase in temperature reducing the yield	Yes	158	65.8
	No	82	34.2
Yield affected by rainfall pattern from last 10 Years	Yes	184	76.7
	No	56	23.3

Perception about climate change: Table 2 shows the perceptions of respondents about the occurrence of climate change. Of the total respondents, 61.7% responded had the knowledge about the climate change. This extended awareness was due to accessibility of multiple information sources including traditional, moderns and institutional resource such as public and private sector extension field staff. Conversely, 38.3 refused having understanding about the climate change. Close to one fifth (18.3%) respondents witnessed moderate increase in temperature in recent past. About 44% respondent felt temperature very hot and 37.5 reported temperature being hot with the passage of time. The erratic changes in temperature were anticipated to impact the crops adversely. Majority of respondents (65.8%) reported reduction in the yield due to increase in temperature. During informal discussion respondents augmented that temperature is increasing and they do not have access to the heat resistant varieties and were lacking in much needed information about the climatic events. The exposure of farmers to different determinants of climate change at different stages of the crops made the farmers well verse regarding understanding the impact of temperature in crop yield. Abid *et al*. (2016) has reported that lack of information about climate related events was the main hurdle as respondents perceived impacting their development. About 77% of respondents acclaimed the reduction in their yield due to erratic rainfall pattern in the last decade.

Table 3: Perception of respondent regarding vulnerability and its level.

Factors	Scaling	Frequency	Percentage
Do you think you are vulnerable to climate change?	Yes	192	80.0
	No	48	20.0
Vulnerability level	Low	46	19.2
	Medium	60	25.0
	High	86	35.8
		Mean = 1.77	
		SD = 1.14	

Perception regarding vulnerability: Table 3 shows the description of the results regarding perception of respondents regarding their vulnerability to climate change. Majority (80%) of the respondents agreed that they were vulnerable to the climate change for many reasons. Farmers witnessed gradual increase in temperature and abrupt decline in the crop's growth and production ultimately. Farmers associated the gradual decline in yield with the sudden rise of temperature. Thus, most of the farmers were consistent that they have become vulnerable to the climatic changes. The discussion further unveiled that inadequate access to

information, non-availability of heat resistant varieties, limited resources and small land holdings followed by limited income were the key factors turning them vulnerable to climate changes. Consequently, the farmers were not able to cope with climate change. Findings are supported with those of Abid *et al*. (2016) as they reported due to poor adaptive capacities farmers were vulnerable to climate change. Regarding level of vulnerability, 19.2, 25 and 35.8% of respondents were vulnerable to low, medium and high level respectively.

Table 4: Factors behind vulnerability of small land holders to climate change.

Factors	Mean	SD
Low crop yield	4.01	1.02
Subsistence farming	3.61	1.49
Large dependency on agriculture	3.10	1.52
Marketing problem	4.16	0.67
Rural poverty	3.18	1.44
Inadequate infrastructure	4.42	0.60
Lack of access to social security networks	3.78	0.77
Limited access to agri. extension services	4.61	0.52
Prevailing food insecurity	3.09	1.27
Limited access to agro meteorological system	4.13	0.70
Limited availability of heat resistant varieties	4.35	0.75
Lack of access to crop insurance facility	3.00	1.54

Scale: S. Disagree=1, Disagree=2, Undecided=3, Agree=4, S. Agree=5

Factors behind vulnerability to climate change: Table 4 shows the different factors behind the vulnerability of small farmers to the climate change. Respondents opined that poor access to agriculture extension services ($\bar{x}$=4.61), limited infrastructure ($\bar{x}$=4.42) and limited availability to the heat resistant varieties ($\bar{x}$=4.35) was the leading influencing factors followed by marketing problem ($\bar{x}$=4.16). This implies that lack of infrastructure hindered the access of the farmers to institutions, resources and technical backstopping and non-availability of heat resistant varieties produced production less than potential. The crashed marketing system earned low prices for the farmers. Farmers had poor access to meteorological system ($\bar{x}$=4.13) and farmers were unable to receive or access early warning system and weather forecasting reports in order to amend their farm strategies. Low crop yield subject to various aspects was another factor pushing farmers to vulnerability ($\bar{x}$=4.01). Farmers had witnessed several more factors with the impact of below medium level, pushing them to vulnerability.

Table 5: Coping strategies as adopted by farmers against climate change.

Coping strategies	Mean	SD
Change in cropping pattern	1.28	0.52
Use of heat/drought resistant varieties	1.92	0.93
Use of varieties with minimum water requirement	1.27	0.58
Inter cropping	2.17	0.70
Tree-planting in the field	1.98	0.82

Scale: Never=1, Occasionally=2, Mostly=3

Coping strategies: Table 5 shows that average level of adoption of coping strategies against the climate change was miserable. The farmers had slight change in cropping patterns, rare adoption of heat and drought resistant varieties, seldom use of varieties requiring minimum water, the average practice of inter cropping and negligible adoption of tree plantation in the field to serve a cover for the crops against heat. This pity status of adoption of coping strategies endorse the high level of vulnerability of farmers to the adverse impacts of climate change.

Section-3. Factor Analysis: We conducted a factor analysis in order to extract those factors which have significant contribution towards vulnerability of farmers to climate change and poverty. Kaser-Meyer-Olkin and Barlett's test of sphericity are often used to examine the factorability of the factors. In this study, the Barlett's test of sphericity was significant (P<0.000). The Kaser-Meyer-Olkin value appeared 0.658. The observed value 0.658 was higher than the standard value 0.60. This implies that it was valid to run a factor analysis. Coakes and Ong (2011) have reported that when the value of

KMO is greater than the 0.60, the factorability becomes legitimate. Pertinent to the found authenticity, factor analysis was proceeded to construct new factor likely to contribute to vulnerability.

Table 6, indicates that total four factors were constructed through principal component factor analysis. The newly constructed four factors included low crop yields, small and subsistence farming, vast dependency on agriculture and marketing problem of agriculture produce. The eigenvalue of newly constructed four factors was higher than 1. Total 59.67% variance would be explained in result of construction of four new factors.

Table 7 is the illustration of the component matrix for the questions the data was recorded for. According to Tabachnik and Fidell (2001), the variables which receive a factor loading equals to 0.45 are assumed of average level. The variables with the factor loadings of 0.32 are considered fewer good. In this study, the variables obtained minimum loading of 0.34 while the maximum as observed was 0.84. This implies that the variables were considerably good in order to help constructing new factor.

Table 8 shows that, of the total four newly constructed factors low crop yield obtained highest variance of 21.11%. Small scale farming indicates the variance of 15.27%. This indicated that low crop yield and small/subsistence farming were key factors pushing farmers to poverty. With the decrease in yields and reduction in farming area, the poverty among farmers will increase. Crop yield are associated with the farm areas. Therefore, in order to increase crop yield, to bring an increase in farm area and adoption of best management practices are obligatory, even to cultivate crops on small area. Large dependency on agriculture explained variance of 11.42%. This indicates that agricultural diversification and farmers diversification to other sources as well to generate income could diminish the poverty circle. The established marketing system can earn good prices for the farmers to sustain their livelihoods. The marketing problem explained a variance of 10,78. Karnani (2017) have termed the establishment of effective market system one of the key options to reduce poverty by expending the income generation of farmers.

Normality Test: Table 9 indicates the results of normality test for the newly extracted factors. The normality test was tested using Kolmogorov-Smirvnos method. The normality assumption as laid by the Coakes and Ong (2011) report that, the data is considered normally distributed when the probability values of the tested variables surpasses the 0.05 ($P<0.05$). Taking this assumption in to an account it can be concluded that the normality of the newly extracted factors didn't meet the criteria as the probability values was lesser to 0.05.

Table 6. Total Variance Explained.

Factors	Extraction Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**
Low crop yields	2.663	22.188	22.188
Small scale/subsistence farming	1.833	15.277	37.465
Large dependency on agriculture	1.371	11.425	48.890
Marketing problem of agriculture produce	1.294	10.784	59.674
Extraction Method: Principal Component Analysis			

Table 7: Component Matrix.

Vulnerability Factors	Component Matrix			
	Extracted factors			
	1	2	3	4
Factor 1	.355	.483	.380	.413
Factor 2	.845	.310	.459	.389
Factor 3	.747	.391	.395	.486
Factor 4	.347	.410	.600	.469
Factor 5	.576	.375	.349	.552
Factor 6	.156	.662	.487	.735
Factor 7	.269	.475	.570	.711
Factor 8	.335	.462	.503	.634
Factor 9	.670	.365	.345	.604
Factor 10	.490	.432	.670	.560
Factor 11	.348	.413	.733	.667
Factor 12	.470	.493	.525	.474

Table 8. Percentage of variance.

	Factors	% of Variance
Factor 1	Low crop yields	22.188
Factor 2	Small scale/subsistence farming	15.277
Factor 3	Large dependency on agriculture	11.425
Factor 4	Marketing problem of agriculture produce	10.784
	Extraction Method: Principal Component Analysis	

Table 9. Test of normality for newly extracted factors.

Tests of Normality	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Low crop yields	.297	240	.000
Small scale/subsistence farming	.254	240	.000
Large dependency on agriculture	.265	240	.000
Marketing problem of agriculture produce	.293	240	.000
a. Lilliefors Significance Correction			

Conclusions and Recommendations: We conducted this study to examine the vulnerability of the farmers to climate change and which factors are contributing more towards the vulnerability. We found that, very specifically the farmers had depriving socio-economic profile being low level of education, small landholding, average experience of farming and lack of diversification of agriculture sector. The farmers had over reliance on farming as an income source. Consequently, the vivacious circle of poverty was found trapping the farmers badly. Farmers were not in good position to cope with the climate change and lower the vulnerability.

Farmers were known to indicators of climate change such as increase in heat and erratic rainfalls but they had a limited approach to cope with these challenges. Change in cropping patterns, use of heat resistant varieties, adoption of less water taking varieties and inter cropping were the only strategies that were found narrowly adopted by the farmers. Farmers were lacking in access to appropriate measures in order to cope with climate change for many reasons. Those reasons are explored through the factor analysis. Low crop yields, small/subsistence farming, large dependency in agriculture to generate income and crashed marketing system were they key factors pushing farmers to vulnerability to climate change. Pertinent to these factors, farmers were not generating enough income and resources to revamp their coping strategies to cope climate change.

This study concludes very briefly in line to the findings that there is an urgent need to improve the adaptive capacity of the farmers to take up advance technique and site-specific technologies under perplexed impacts of the climate change. First, there is need to initiate educational activities for the farmers to improve their educational abilities and understanding about the environment. The adult education programs under the agricultural extension department could be the convenient in this regard. Second, the farmers should be resourceful. For this purpose, the institutions should emphasize on establishing effective marketing mechanism for the farmers. It has been reported in many studies that marketing system in Pakistan is broken and middleman gets more income as compared to producer. Farmers cannot get good return unless the marketing system is not favorable for them. The government should set up model markets for the farmers. Thirdly, the farmers need access to the basic inputs. Right now, the country is lacking in those varieties which are heat resistant and less water requiring. The research institutions in the country should take the matter seriously and should develop heat resistant varieties of the major crops. Fourth, this study urges a proactive role from the department of extension in order to motivate farmers to adopt climate smart techniques in order to conserve resources and environment. Agricultural diversification, zoning of areas and changes in cropping patterns could harness the best outcomes.

REFERENCES

Abid, M., U. A. Schneider and J. Scheffran (2016). Adaptation to climate change and its impacts on food productivity and crop income: Perspectives of farmers in rural Pakistan. J. Rur. Stud. 47, 254-266.

Coakes, J.C. and C. Ong. (2011). SPSS Version 18.0 for Windows Analysis Without Anguish. 1st Edition. Dougall Street, Milton: John Wiley & Sons Australia, Ltd, 2011.

Diyawadana, D.M.N., S. Pathmarajah and E. R. N. Gunawardena (2017). Vulnerability of

smallholder farmers to climate change: a case study from Hakwatuna-oya irrigation scheme in Sri Lanka. Trop. Agri. Res. 28 (3): 223 – 237.

Donatti, C. I., C.A. Harvey, M.R. Martinez-Rodriguez, R. Vignola and C.M. Rodriguez (2019). Vulnerability of smallholder farmers to climate change in Central America and Mexico: current knowledge and research gaps. Clim. and Devel. 11(3): 264-286.

Haile, M.G., T. Wossen, K. Tesfaye and J. von Braun (2017). Impact of climate change, weather extremes, and price risk on global food supply. Econ. Dis. and Cli. Chan. 1(1): 55-75.

Jamshidi, O., A. Asadi, K. Kalantari, H. Azadi and J. Scheffran (2019). Vulnerability to climate change of smallholder farmers in the Hamadan province, Iran. Clim. Ris. Manag. 23: 146-159.

Johnson, J. V. and E. M. Hall (1988). Job strain, work place social support, and cardiovascular disease: a cross-sectional study of a random sample of the Swedish working population. Amer. J. Pub. Heal. 78(10): 1336-1342.

Karnani, A. (2017) "Marketing and Poverty Alleviation: The Perspective of the Poor. Mar. Glob. & Dev. Rev. 2(1). DOI: 10.23860/MGDR-2017-02-01-05

Sattar, R.S., S. Wang, M. Tahir and C. Caldwell (2017). Assessment of Smallholder Farmers Vulnerability Due to Climate Change in Arid Areas of Pakistan. Appl. Ecol. Environ. Res, 15: 291-312.

Tabachnik, B.G., and L. S. Fidell (2001). Using Multivariate Statistics (4th ed.). Pearson: Needham Heights, MA.

Tessema, I. and B. Simane (2019). Vulnerability analysis of smallholder farmers to climate variability and change: an agro-ecological system-based approach in the Fincha'a sub-basin of the upper Blue Nile Basin of Ethiopia. Ecol. Proc. 8(1): 5.

Williams, P. A., O. Crespo, M. Abu and N.P. Simpson (2018). A systematic review of how vulnerability of smallholder agricultural systems to changing climate is assessed in Africa. Envir. Res. Lett. 13(10): 103004.

Xu, X., L. Wang, M. Sun, C. Fu, Y. Bai, C. Li and L. Zhang (2020). Climate change vulnerability assessment for smallholder farmers in China: An extended framework. J. Envir. Manag. 276: 111315.