Research Article

Farmers' Knowledge Level Regarding Climate Smart Agricultural Production Technologies in Central Plain Valley of Khyber Pakhtunkhwa

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Abstract | Pakistan agriculture sector is considered as more susceptible to climate change as its variation can directly affect the crop productivity. Therefore, knowledge about climate smart agricultural production technology is the main component and knowledge gap is at the crux of yield gap. The current study was carried out in two districts Charsadda and Nowshera of Khyber Pakhtunkhwa province during 2020 with main objectives to measure farmers' knowledge level in fourteen climate smart recommended agricultural production technologies. The data were collected randomly from 60 sample respondents comprised of 30 respondents each from Charsadda and Nowshera districts through pre-tested interview schedule. The empirical results indicated that majority (68%) farmers of both districts had medium knowledge level (35.19%). The lowest knowledge level of the sample farmers was found in early maturity (short duration) maize (OPVs) varieties (26.67%), IPM techniques (25.84%), wheat on ridges/seedbed (24.17%), heat and drought tolerant maize (OPVs) varieties (20.84%), heat and drought tolerant wheat varieties (20%) and organic farming (16.67%). Knowledge index revealed that both districts' farmers had 35.71% knowledge level in fourteen different indicators in the study area. The farmers of district Charsadda had slightly high knowledge level (38.67%) compared to district Nowshera farmers (32.75%). Results of regression model showed that land holdings, formal education, agricultural extension department contact, and farm services centers membership had positive and substantial effect on knowledge level of farmers. Lack of improved knowledge, lack of financial power, irrigation problems and high cost of inputs were the most important problems faced by the farmers. Agricultural departments need to develop and disseminate climate smart recommended agricultural production technologies. The government and private organizations should arrange trainings and awareness programs regarding climate change to overcome the effect on agriculture.

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Introduction

Climate change is global environmental risk to entire economic segments, primarily farming sector. Amid the most negatively affected countries by climate change, Pakistan is placed at top 10 greatest affected countries because of high exposure to extreme events and low adaptive capacity (Abid *et al*., 2015). Over the period, climate change affects all walks of life (Aggarwal *et al*., 2010). Agriculture sector is considered as more susceptible to climate change and its variation can directly affect the crop productivity (Amiraslany, 2010). Pakistan being an agrarian and largely populated country is visibly vulnerable to the climate change. Climate change disruption has more aggressive impacts on farming, livestock, and farmers' socio-economic in rural areas of Pakistan (Shakoor, 2011). In recent times, disasters in climate change have hit Pakistan significantly such as droughts, cyclones, floods, and storms. These disasters are regular and more damaging (Qasim *et al*., 2015).

Climate change is central challenges which the world is facing in 21st century and is unfavorably distressing sustainable development and communities, health, livelihoods, shelters and even their lives. According to Intergovernmental Panel on Climate Change (IPCC), mean worldwide temperatures is likely to rise by another 0.3 to 4.8 degree centigrade in 2100 (GoKPK, 2016). Therefore, there is a need of the day to adopt and practice climate smart agricultural innovations among farming community in Pakistan. Amin *et al*. (2015) defined climate smart agriculture as sustainable improvement of farming production along with incomes by adjusting and developing resilience to variation in climatic conditions and minimizing emissions of gases from greenhouses. In present climate change knowledge is central in the way that farmers could adjust their farming accordingly. The knowledge gap is the core component of yield (Carlisle and Miles, 2016). Several interactivities in Khyber Pakhtunkhwa were undertaken including tele-farming and model farm services centers to uplift crops production and livelihoods of farmers through dissemination of enhanced knowledge and updated technologies based on their agro-ecological zones.

Although Pakistan is the utmost at risk nation to climate change, but scanty research studies is conducted in realm of climate change impact on farming sector. Thus, this study was designed to assess farmers' knowledge level at farm level about climate smart recommended agricultural production technologies in central valley of Khyber Pakhtunkhwa. In this study, 14 innovative production technologies practiced at farmers' field were assessed with prior consultation to research scientists and agricultural extension experts in central plain valley. These production technologies are termed as climate smart due to prevailing abiotic stress, reducing cost of production and minimizing input losses, and lessening health and environmental risks. It was direly needed to measure the farmers' knowledge level regarding climate smart recommended agricultural production technologies so that appropriate training package should be developed for them regarding climate change mitigation and hence increase agricultural yield. Although several scientists (Abid *et al*., 2015; Ayaz *et al*., 2015; Ali and Erenstein, 2017; Afsar and Idrees, 2019; Siddiqua *et al*., 2019) published research studies on climate change in Pakistan where they inspect impacts of climate change on farming, execution of innovative farming practices and technologies, adapting to change in climate, and outcomes of climate change on farming production. However, this study was unique because farmers' knowledge level was quantified in these 14 climate smart technologies in central plain valley of Khyber Pakhtunkhwa.

Schematic framework for farmers' knowledge cycle

The schematic framework for the farmers' knowledge cycle is shown in Figure 1 which indicates that research system develop climate smart technologies like stress tolerant varieties, use of organic fertilizers, IPM techniques, and ridge plantation. These climate smart technologies then reach to the farmers through several information sources like agricultural extension department, fellow farmers, imput dealers, radio and television and hence their knolwedge is developed. Then there comes the implementation stage of the knowledge, where these climate smart technologies are practiced by the farming community at their fields. However, socio economic characteristics of the farmers like age, education, farming experience *etc*. and several barriers like nonavailability of varieties, lack of imporved knowledge, lack of access to improved technology *etc* significantly effect the implementation of the knowledge. The implementation of the climate smart technologies ultimately increase agricultural production and also agricultural production is signficantly affecting by socio economic characteristics of the farmers and barriers they face during farming activities.

Materials and Methods

Selection of the sites

Khyber Pakhtunkhwa is situated in the mid-latitude region on the planet and most prone to climate change impacts. The central valley plain is one of the zones of Khyber Pakhtunkhwa will be more severely affected in the upcoming years due to rising temperature and

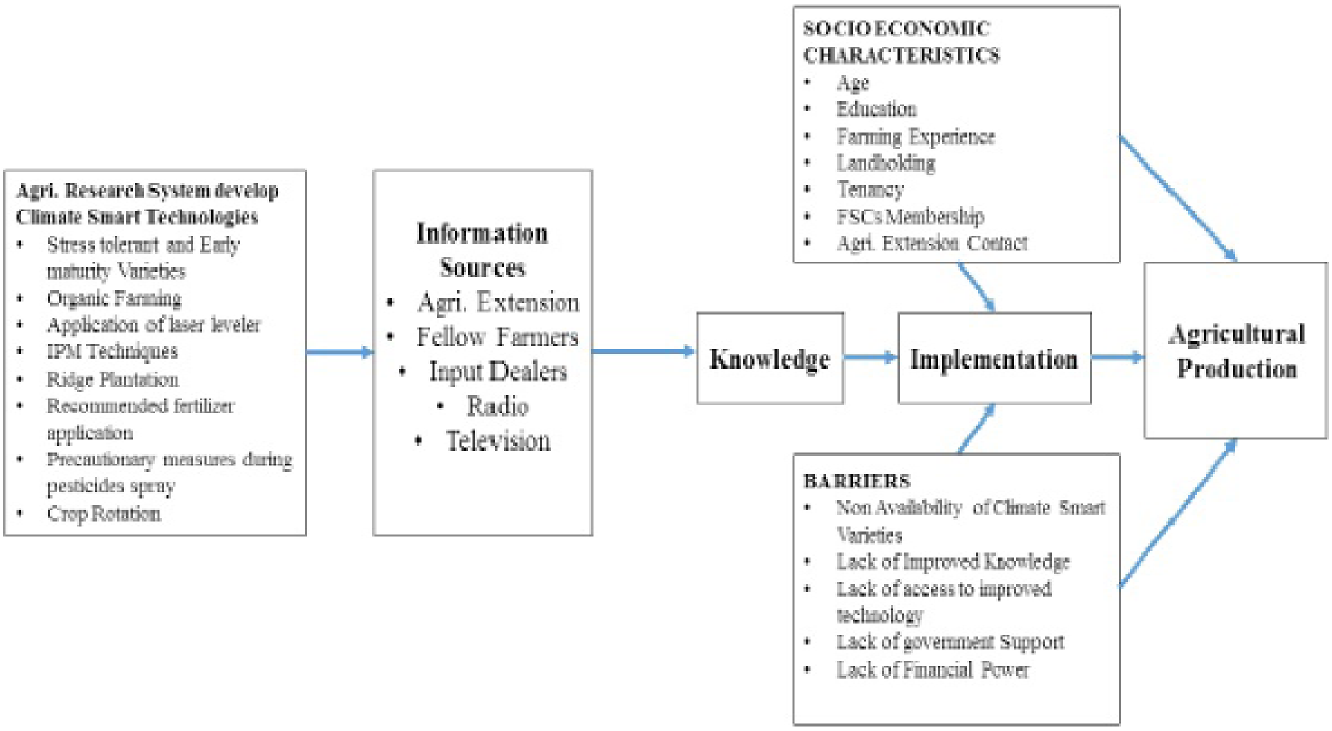

Figure 1: *Schematic framework of farmers knowledge cycle*

decrease of rainfall magnitude. Variations in climate affect soil moisture, growth duration, nutrient levels, and water availability for crops. These variations in climate increase the chance of reduced yields or even crop failure (GoKP, 2016). Keeping in view the above fact about climate changes effects on agriculture especially in central plain valley of Khyber Pakhtunkhwa, this study was conducted in two districts of central plain valley of Khyber Pakhtunkhwa namely Charsadda and Nowshera. These two districts Charsadda and Nowshera were purposively selected from central plain valley zone due to agriculturally rich districts.

Samples, data collection tools and procedures

The present study was carried out in two districts Charsadda and Nowshera during the months of January and February, 2020. Primary data was directly amassed from sample farmers in the research area. The results would have been more accurate, if the whole population of the two districts were interviewed. But keeping in view the budget constraints, the sample size was restricted to 60 farmers due to manpower and financial constraints in the research area. Of the total 60 sample respondents, 30 each were selected from both district of Charsadda and Nowshera. Tabachnick and Fidell (1989) suggested rule of thumb for regression analysis and suggested that minimum number of subjects for each predictor or independent variable in a regression analysis should be 5-to-1. The sample respondents were randomly interviewed at their homes, and fields through well-structured interview schedule whereas, secondary data was collected from articles/studies, broachers and internet sources. To calculate knowledge level of sample farmers regarding climate smart recommended agricultural production technologies. Knowledge test was devised as used by Hakeem and Dipak (2013). Knowledge test was designed based on climate smart suggested agricultural technologies established by Khyber Pakhtunkhwa agricultural research system for assessment of farmers' knowledge level (Table 1).

Statistical analysis

Knowledge level: Knowledge level denotes, knowledge possessed by farmers in climate smart recommended agricultural production technologies. To measure the knowledge level of farmers in fourteen different knowledge indicators such as drought and heat tolerant wheat varieties, heat and drought tolerant maize (OPV) varieties, early maturity (short duration) maize (OPV) varieties, early/mid maturity (short duration) sugarcane varieties, laser leveler (saving of water), wheat on ridges/seedbed, maize (OPV) varieties on ridges/seedbed, organic farming, wheat crop recommended fertilizer application, maize (OPVs) crop recommended fertilizer application, sugarcane crop recommended fertilizer application, IPM techniques, pesticides application precautionary measures and crop rotation were pinpointed with consultation of agricultural research and extension experts. For calculating knowledge level, score allotted for each of climate smart recommended agricultural practices in knowledge test was 0 = no knowledge, 1 = partial knowledge, and 2 = complete knowledge. Total score of 14 questions were 28 and each question carried two scores. Total score achieved in all knowledge items in knowledge test was considered as the knowledge score of the farmers. The knowledge score of the individual respondent was transformed into the knowledge index. The knowledge level was calculated by applying knowledge index. Hakeem and Dipak (2013) and Farooq *et al*. (2019) also used alike Knowledge Index (KI) techniques. Knowledge index (KI) was used to determine knowledge level of sampled respondents as shown below:

$$KI = (X/Y) \times 100 \ldots\ldots\ldots (1.1)$$

Where;
KI: Knowledge Index; X: Knowledge score achieved by respondents; Y: Maximum achievable score.

Multiple Regression Model: Multiple regression analysis was utilized to inspect the effect of education, age, farming experience, farm size, acquaintance with department of agriculture extension, farm services centers membership, districts and tenancy status on knowledge level. This model is useful over the other statistical tests because it helps to understand how much the dependent variable will be change by changing independent variables. Similar model was also used earlier by Farooq *et al*. (2020) and Hakeem and Depak (2013).

$$Y=\beta o+ \beta 1X1+ \beta 2X2+ \beta 3X3+ \beta 4D1+ \beta 5D2+ \beta 6D3+ \beta 7D4+ \beta 8D5+ \varepsilon \ldots\ldots\ldots\ldots (1.2)$$

Whereas:
Bo, β1, β2, β3, β4, β5, β6, β7, β8 are parameters
Y (KI) = knowledge level of sampled respondent; X1: Age = age of sampled respondent; X2: Land holdings = farm size; X3: Farming experience = farming experience; D1: Formal education = 1 when respondents having formal education, otherwise 0; D2: Contact extension department = 1 when respondent has acquaintance with agriculture extension department, otherwise 0; D3: Farm services centers membership = 1 if the respondent having farm services centers membership, 0 otherwise; D4: Districts =1 if the district is in the district Charsadda, 0 otherwise; D5: Tenancy Status = 1 when respondent is owner cultivator, 0 otherwise = random error or residual term.

Explanation of the modal variables

Independent aariable	Explanation
Age	Shiferaw and Holden (1998) highlighted that farmers' age moves exposure to several farming practices, experiences and seasons. Therefore, "age" is likely to have significant impact on knowledge of farmers about climate smart technologies. Mean age of sampled respondents were 44.2 years with SD = 12.3.
Landholdings	Greater landholding provides the opportunity to farmers to investigate and tests numerous farming technologies on their field based on their observation/awareness about change in climate. Farmers having greater landholding is likely to positively affect their knowledge about climate smart technologies. In the study area, mean landholdings was 7.6 acres with SD = 7.8.
Farming experience	Greater experience in farming helps farmers to understand and see things from a wide perspective and thus likely have positive effect on knowledge about climate smart technologies. In the study area, mean farming experience was 19.5 years with SD = 12.3.
Education	Education of the farmers enhances their knowledge about climate smart technologies and therefore likely to have positive effect. Bielders *et al*. (2003) found direct correlation among education of the farmers with their awareness regarding climate change impacts. The mean education of sampled respondents was 4.7 (in years) with SD = 4.93.
Agricultural extension contact	Contact with agriculture extension department helps the farmers to acquire improved knowledge about climate smart technologies and hence likely have positive effect. About, 75% of sampled respondents have contact with agriculture extension department.
Farm services center membership	Farmer's services center provides agricultural inputs and technical guidance to their registered member farmers. Hence, membership with these centers likely have positive effect on knowledge about climate smart technologies. In this study, only two respondents while eight respondents in district Nowshera have membership with farm services centers.
District	The district/locality of the farmers likely have significant effect on knowledge of the climate smart technologies due to better opportunities, access to market, and good extension staff. In this study, 30 farmers from both the districts i.e. 30 were interviewed selected as sample size.
Tenancy status	Tenancy status also likely have significant impact on knowledge about climate smart technologies due to opportunity of practicing improved technology at their farms. Among the respondents of the study, 15% were owner, 6.7% were owner cum tenants, 31.7% were tenants, 25% were lessee, 18.3% were owner cum lessee and 3.3% were tenants and lessee.

Results and Discussion

Categorization of knowledge level

The respondents' knowledge level is categorized in to three classes based on mean like low (up to 3.55), medium (3.56-16.44), and above 16.45 as high knowledge which is shown in Table 2. Less than half (38%) have medium knowledge (37.11%) followed by 7% respondents who have high knowledge level (72.32%), while 5% farmers have low knowledge level (5.95%) in district Charsadda. Majority (30%) farmers had medium knowledge level (32.74%) followed by 12% respondents had low knowledge level (6.12%) while in Nowshera, about 8% farmer had high knowledge level (70%). The whole results revealed that maximum farmers (68%) have medium knowledge level (35.19%) followed by 17% farmers had low knowledge level (6.07%) whereas 15% farmers had high knowledge level (71.03%) in the study area.

Table 1: *Climate smart recommended agricultural production technologies.*

S.No.	Name of technology	Recommended Practices
1	Heat and drought tolerant wheat varieties	PS-2015, PS-2005, Pakistan-2013, KT-2017, Pasena 2017, and Shahkar2013
2	Maize OPVs (open pollinated varieties) heat stress varieties	Iqbal, Jalal, Azam
3	Early maturing maize OPVs varieties	-Iqbal duration 75-80 days -Azam 85-100 days --Jalal 100 and above days
4	Early/mid maturing sugarcane varieties	**Early maturing varieties** Mardan-93, Jn-88/1, Abid-86, S.N.98 etc. **Medium maturing varieties** CP-77/400, Mardan-2005, SPSG-394,
5	Laser leveler	Irrigation water saves due to uniform distribution of water Increase farm productivity, field area, reduce farm operating time, increase in nitrogenous efficiency, precise level, smoother soil and better soil management, reduced weed in field etc.
6	Wheat sowing on ridges	Saving water, lodging resistance, less weed competition, easiness in farm management practices, uniform and judicious utilization of key inputs, increased yield etc.
7	Maize (OPVs) sowing on ridges	Saving water, lodging resistance, less weed competition, easiness in farm management practices, uniform and judicious utilization of key inputs, increased yield etc.
8	Organic farming	Avoid using artificial fertilizers, pesticides and genetically modified organisms, minimizes pollution of air, soil and water, recycle all organic waste, pest control by biological agents.
9	Recommended application of chemical fertilizers in wheat crop	Depends on fertility of land Urea= 2 bags/acre, DAP= 1-2 bags/acre, Potash= 1 bag/acre Urea 50%, DAP and Potash full dose application at time of land preparation and the remaining 50% urea use at different split doses at various stages
10	Recommended application of chemical fertilizers in Maize (OPVs) crop	Depends on fertility of land Urea= 2 bags/acre, DAP= 2 bags/acre, Potash= 1 bag/acre Urea 50%, DAP and Potash full dose application at time of land preparation and the remaining urea use at first or second irrigation
11	Recommended application of chemical fertilizers in sugarcane crop	Depending on land fertility: - 1 to 2.5 bags per acre of Phosphorus fertilizer (DAP) application in addition to 1.25 to 2 bags per acre of Potash fertilizer (SOP/MOP) in furrows before sowing along with 1.5 to 3 bags of Urea per acre for three times in growing season. **Autumn Cultivation** Apply 1/3 urea in start of November, second dose in March and third in the end of April during earthing up **Spring Cultivation** Apply first dose of Urea in April, second in May and third in June during earthing up

12	IPM techniques	Cultural Control of Pest -Disease free and resistant varieties -Crop rotation - Treatment and use of hygienic seeds - -Disease effected plants, removal, up rooted/cut and burial them in soil -Harvest sugarcane at 1-1.5 inch above soil. - Frequently doing Earhting up in sugarcane -Remove of weeds - Covering ratoon with soil layer during May to June in cane crop. - One Feet Trench digging around the field for collection of larvae -Manual collection and burning of larvae (army worm) **Mechanical Control of Insects** -Practice light traps at night during March to October for insects control in sugarcane and also use tillage for control of insects in other crops - Deep ploughing before sowing -use nets for catching pyrilla adults or flying insects for sugarcane
		-burn the dry leaves of sugarcane and leave some dry leaves which beneficial insects not effected. **Biological Control** Biological control in cane crop for insects pests is application of 15-20 Trichogramma cards in one hectare at 15 days interval during the month of April to September. **Chemical Spray** -Spray of pressurized water with power sprayer Spray of pressurized water with power sprayer for aphid - Spray of soap mixed water to minimize attack for aphid -use recommended pesticides
13	Pesticides application precautionary measures	-Read carefully the instructions given on label and apply accordingly -Keep the water quantity 120 to 150 liter per acre for spray -use special nozzles flat-fan or T-jet for spray - Do not eat or smoke during spray - Do not spray in rain/wind and fog condition - Disposal the empty bottles/packets bury them in soil -Do not use spray weeds as animal fodder -Wearing personal protection equipments when handling pesticides/concentrations - use recommended pesticides and did not used additional pesticides for an increased effect
14	Crop rotation	Soil fertility maintain, improve soil structure, water conservation, soil erosion control, weed control, insects/pest control, climate change mitigation, higher crop yields

Source: *Agricultural Research System, Khyber Pakhtunkhwa.*

Knowledge level of respondents regarding climate smart recommended agricultural production technologies

The knowledge level regarding climate smart recommended agricultural production technologies is presented in Table 3. Knowledge index indicated that farmers of Charsadda district have highest knowledge level in crop rotation (73.34%), maize (OPVs) varieties on ridges/seedbed (66.67%), early/mid maturity (short duration) sugarcane varieties (60%). While medium knowledge level was found in pesticides application precautionary measures (50%), wheat crop recommended fertilizer application per acre (48.34%) followed by maize crop recommended fertilizer application per acre (46.67%), sugarcane crop recommended fertilizer application per acre (43.34%). Whereas, least knowledge level was observed in wheat cultivation on ridges/seedbed (26.67%), IPM techniques (26.67%), early maturity (short duration) maize (OPVs) varieties (25%), heat and drought tolerant maize (OPVs) varieties (23.34%), heat and drought tolerant wheat varieties (18.34%), laser leveler (16.67%) and organic farming (16.67%). The data indicated that sample respondents obtained 10.83 score out of 28 attainable score and had 17.17 mean gap score and thus the knowledge index showed 38.67% knowledge level in district Charsadda.

Similarly, the sample farmers of district Nowshera had highest knowledge level in crop rotation (56.67%) whereas medium knowledge level was found in pesticides application precautionary measures (50%), maize (OPVs) varieties on ridges/seedbed (48.34%), laser leveler (45%), wheat crop recommended fertilizer application per acre (43.34%), maize crop recommended fertilizer application per acre (43.34%). The lowest knowledge level was observed in early maturity (short duration) maize (OPVs) varieties (28.34%), sugarcane crop recommended fertilizer application per acre (25%), IPM techniques (25%), heat and drought tolerant wheat varieties (21.67%), wheat on ridges/seedbed (21.67%), heat and drought tolerant maize (OPVs) varieties (18.34%), organic farming (16.67%) and early/mid maturity (short duration) sugarcane varieties (15%). The data revealed that sample farmers obtained 9.17 score out of 28 attainable score and had 18.83 mean gap score and thus the knowledge index showed 32.75% knowledge level of district Nowshera farmers.

The overall knowledge level of both districts showed that the sample respondents had highest knowledge level in crop rotation (65%) and maize (OPVs) varieties on ridges/seedbed (57.50%) while the farmers had medium knowledge level in pesticides application precautionary measures (50%), wheat crop recommended fertilizer application per acre (45.84), Maize crop recommended fertilizer application per acre (45%), early/mid maturity (short duration) sugarcane varieties (37.5%), sugarcane crop recommended fertilizer application per acre (34.17%), laser leveler (30.84%). The sample farmers had lowest knowledge level in early maturity (short duration) maize (OPVs) varieties (26.67%), IPM techniques (25.84%), wheat on

Table 2: *Categorization of knowledge level of sample farmers by district.*

Knowledge Gap	Districts	Freq	Knowledge level (%)
Low (upto 3.55 Score)	Charsadda	3(5)	5.95
	Nowshera	7(12)	6.12
Medium (3.56-16.44 Score)	Charsadda	23(38)	37.11
	Nowshera	18(30)	32.74
High (Above 16.45 Score)	Charsadda	4(7)	72.32
	Nowshera	5(8)	70
All	Charsadda	30(50)	38.67
	Nowshera	30(50)	32.75
Overall			
Low (upto 3.55 Score)		10(17)	6.07
Medium (3.56-16.44 Score)		41(68)	35.19
High (Above 16.45 Score)		9(15)	71.03
Overall		60(100)	35.71

Figures in Parenthesis are percentages; **Source:** *Field Data;* **Obtainable Score:** *28;* **Mean:** *10 SD: 6.45.*

Table 3: *Knowledge level of sample respondents in climate smart recommended agricultural production technologies.*

Technologies	Obtainable Score	Districts		Overall	Districts		Over all
		Charsadda	Nowshera		Charsadda	Nowshera	
		Obtained Score	Obtained Score	Obtained Score	Knowledge Level Index (%)		
Heat and drought tolerant Wheat varieties	2	0.37	0.43	0.40	18.34	21.67	20
Heat and drought tolerant Maize (OPV) varieties	2	0.47	0.37	0.42	23.34	18.34	20.84
Early maturity (short duration) Maize (OPV) varieties	2	0.5	0.57	0.53	25	28.34	26.67
Early/mid maturity (short duration) sugarcane varieties	2	1.2	0.3	0.75	60	15	37.5
laser leveler (saving of water)	2	0.33	0.90	0.62	16.67	45	30.84
wheat on ridges/seedbed	2	0.53	0.43	0.48	26.67	21.67	24.17
Maize (OPV) varieties on ridges/seedbed	2	1.33	0.97	1.15	66.67	48.34	57.50
Organic farming	2	0.33	0.33	0.33	16.67	16.67	16.67
Wheat crop recommended fertilizer application	2	0.97	0.87	0.92	48.34	43.34	45.84
Maize crop recommended fertilizer application	2	0.93	0.87	0.90	46.67	43.34	45
Sugarcane crop recommended fertilizer application	2	0.87	0.50	0.68	43.34	25	34.17
IPM techniques	2	0.53	0.50	0.52	26.67	25	25.84
Pesticides application precautionary measures	2	1	1	1	50	50	50
Crop rotation	2	1.47	1.13	1.30	73.34	56.67	65
Overall	28	10.83	9.17	10.00	38.67	32.75	35.71

Source: *Field data.*

ridges/seedbed (24.17%), heat and drought tolerant maize (OPVs) varieties (20.84%), heat and drought tolerant wheat varieties (20%) and organic farming (16.67%). The overall data showed that sample farmers obtained 10 score out of 28 attainable score and had 18 mean gap score and thus the knowledge index showed that both districts farmers had 35.71% knowledge level in fourteen different indicators in the study area. The main reasons of low knowledge level regarding climate smart recommended agricultural production technologies in both districts was possibly associated with awareness scarcity along with communication gap between farmers and agricultural departments in the study area. Chahali *et al*. (2015) found that maximum respondents have medium knowledge about innovative farm technologies. Also, Naik *et al*. (2009) found that low knowledge of farmers in organic farming was associated with no government support and complex technologies. Moreover, Hakeem and Dipak (2013) reported that low farmers' knowledge in adoption of improved farming technologies was associated with higher costs of inputs like fertilizers and pesticides.

Regression analysis

The value of F-test indicates overall significance of the test and R-squared value shows about 64% variations in knowledge level that has been explained by age, land holdings, experience in farming, formal education, acquaintance with change agents, Farm services centers membership, districts Charsadda and Nowshera and Tenancy status (Table 4 and Table 5). The empirical results of the model show that formal education (D1), agri. extension contact (D_2) and D_3 (FSCs membership) and land holdings (X_2) were significant at 5% level with the knowledge level of the farmers, while age (X_1), farming experience (X_3), district (D_4) and tenancy status (D_5) not contributing in farmers' knowledge level.

Table 4: *Model summary.*

R	R Square	Adjusted R Square	Std. Error of the Estimate
.799[a]	.638	.582	14.90413

Table 5: *ANOVA test.*

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	19997.740	8	2499.718	11.253	.000[a]
Residual	11328.791	51	222.133		
Total	31326.531	59			

The result of the regression model discloses that land holdings have positively contributed in knowledge level about climate smart agricultural technologies because farmers who possessed more land holdings, their contacts will be more with agriculture departments regarding obtaining climate smart agricultural production technologies. The findings further explain that education is positive and highly significantly connected to farmers' knowledge regarding recommended climate smart agricultural production practices as educated respondents had higher ability of understanding, being innovator, higher access to resources on climate smart agricultural technologies by using print and electronic media and seeks rapid respond to changes and adoption of new technologies. The results of farm services centers membership show that farmers had memberships were more knowledgeable. The reason might be that the member farmers had more contact with agricultural extension department and have more awareness, training and exposure resulting more knowledge.

The results in Table 6 shows that farmers who contacted with agricultural extension department had higher knowledge level as compared to those who had no contact with agricultural extension department because interacting with change agents helps to become conscious of climate smart technologies and their adoption at the fields. Similarly, the dummy variable of tenancy status shows that owner farmers had low knowledge level regarding climate smart agricultural technologies and the reason is that maximum activities of the fields are performed by hired expert labors and landowner is not fully involved in farming activities.

Innovation, education and mass media contributes significantly in increasing knowledge level of the farmers while age had no significant contribution as previously concluded by Naik *et al*. (2009). Similarly, Hakeem and Dipak (2013) identified that extension methods usage, use of information sources and education of the respondents had significant effect and age being non-significant on knowledge of farmers in improved agricultural technology. Also, contact with change agents and education of respondents had positive and significant effect on improved farmers' knowledge as previously reported by Pillegowda *et al*. (2010).

Table 6: *Value of regression analysis of predicted variable with predictor variables.*

Variables	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	9.236	9.45		0.977	0.333
X1 (Age)	0.171	0.237	0.091	0.722	0.474
X2 (Land holdings)	0.692	0.29	0.236	2.388	0.021
X3 (Farming Experience)	-0.309	0.239	-0.166	-1.293	0.202
D1 (Formal Education)	21.994	4.483	0.481	4.906	0.000
D2 (Agri. Extension Contact)	16.755	4.764	0.324	3.517	0.001
D3 (FSCs membership)	14.649	5.87	0.239	2.495	0.016
D4 (District)	7.224	4.241	0.158	1.703	0.095
D5 (Tenancy)	-5.512	4.199	-0.118	-1.313	0.195

Source: *Calculated by Author*

Table 7: *Main barriers for adopting strategies about mitigating climate change effect on crops.*

Barriers	Charsadda		Nowshera		Overall	
	1	2	1	2	1	2
Irrigation problem	1(2)	2(5)	5(8)	1(3)	6(10)	3(8)
Non availability of climate smart varieties	5(8)		-		5(8)	
high cost of inputs	5(8)	12(32)	1(2)	2(5)	6(10)	14(38)
Lack of improved knowledge	14(23)		17(28)		31(52)	
Poverty (Lack of financial power)	5(8)	-	7(12)	7(19)	12(20)	7(19)
Tenancy land		1(3)				1(3)
Lack of govt. support		1(3)		1(3)		2(5)
lack of access to improved technology	-	2(5)		8(22)		10(27)
Total	30 (50)	18(49)	30 (50)	19(51)	60 (100)	37(100)

Source: *Field Data;* **1:** *Most important;* **2:** *Important (Figures in parenthesis are percentages)*

Ranking of barriers faced by farmers

The farmers had a number of obstacles influencing adopting strategies regarding mitigating climate change effect on crops in the study area. These barriers are ranked as most important and important barriers and are highlighted in Table 7.

Most important barriers in Charsadda district were lack of improved knowledge (23%) and 8% each farmer reported non-availability of climate smart varieties, high cost of inputs and lack of financial power followed by irrigation problem (2%). The important problems perceived by the respondents as high cost of inputs (32%), 5% each farmer reported irrigation problem and lack of access to improved technologies, while 3% each farmer mentioned tenancy land and lack of government support.

Alike in district Nowshera, the most important problems as lack of improved knowledge (28%), lack of financial power (12%), irrigation problem (8%) and high cost of inputs (2%) were stated by the farmers. The important problems as lack of access to improved technologies (22%), lack of financial power (19%), high cost of inputs (5%) and 3% each farmer reported irrigation problem and lack of government support were second most problem reported by respondents.

Overall data indicated that utmost barriers faced by respondents were lack of improved knowledge (52%), lack of financial power (20%), 10% each farmer reported irrigation problem and high cost of inputs and 10% farmers stated irrigation problem. while important obstacles as high cost of inputs (38%), lack of access to improved technologies (27%), lack of financial power (19%), irrigation problem (8%), lack of government support (5%) and tenancy land (3%) were narrated by the farmers in the study area.

Conclusions and Recommendations

The results of this study inferred that maximum farmer had medium level of knowledge in fourteen indicators of climate smart agricultural production technologies. District Charsadda farmers had slightly more knowledge level as compared to district Nowshera farmers. The overall knowledge level of both districts showed that the sampled farmers had highest knowledge level in crop rotation and maize (OPVs) varieties on ridges/seed bed while the farmers had medium knowledge level in pesticides application precautionary measures, wheat crop recommended fertilizer application per acre, maize crop recommended fertilizer application per acre, early/mid maturity (short duration) sugarcane varieties, sugarcane crop recommended fertilizer application per acre, and laser leveler. The sampled farmers had lowest knowledge level in early maturity (short duration) maize (OPVs) varieties, IPM techniques, wheat on ridges/ seed bed, heat and drought tolerant maize (OPVs) varieties, heat and drought tolerant wheat varieties, and organic farming. The results of the regression model showed that education, land holdings, contact with agricultural extension department, farm services centers membership and locality had extensive effect on knowledge level of respondents. The problems that were faced by farmers in the study area included lack of improved knowledge, lack of financial power, irrigation problems and high cost of inputs. Thus, it is recommended that:

1. Agricultural research institutions should initiate and develop climate smart agricultural production technologies based on agro-ecological zones of Khyber Pakhtunkhwa.
2. Agriculture extension department/Agricultural research institutions and private organizations needs to disseminate technical-know-how through awareness training programs and field days to educate the farmers about climate smart agricultural production technologies for increasing their yield and income.
3. Agriculture extension workers should visit and provide proper recommendations regarding effect of climate change on farming at farmers' fields.
4. The government may ensure the availability of farm inputs like chemical fertilizers, pesticides and seeds, and climate smart technologies at affordable prices for increasing the adoption level of these technologies that ultimately will improve farm yields and also improve the living standard of farmers.

Novelty Statement

This research is novel in the sense that it attempts to discover farmers' knowledge level regarding climate Smart Agricultural production technologies in Khyber Pakhtunkhwa.

Author's Contribution

Arshad Farooq: Conceived the idea, designed interview schedule and prepared first draft of the manuscript.
Abdul Hassan: Reviewed relevant literature and pretested interview schedule and modified accordingly.
Muhammad Ishaq: Helped in data analysis and write-up of results and discussion.
Asif Nawaz: Helped in data collection and reviewed the first draft.
Iltaf Ullah: Prepared list of references and formatted the manuscript according to journal guidelines.
Hidayatullah: Helped in final proofreading.

Conflict of Interest
The authors declare that there is no conflict of interests regarding publication of this article.

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