How to Counter the Impact of Climate Change on Pakistan's Food Security?

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Executive Summary

Agriculture sector in Pakistan is quite sensitive to the ongoing and projected changes in climate parameters. Given the rise of global average surface temperatures by 0.74°C in the last 100 years, efficient management of the agricultural sector by using appropriate adaptation strategies has become a decisive necessity. Focused policy responses that boost the development and dissemination of suitable agricultural practices and technologies will be crucial to find lasting adaptation solutions for the agriculture sector. In this context, this brief recommends:

- Implementation of revised agro-ecological zones in Punjab;
- Diversification of crops and growth of pulses and edible oils;
- Development of weather resistant seeds;
- Adoption of Climate Smart Agriculture (CSA); and
- Improving climate forecasting for farmers.

Detailed recommendations can be found at the end of document.

Issue to be Analyzed

How to counter the impact of climate change on Pakistan's food security?

Analysis and Findings

Climate change-induced rise in mercury and changing rainfall patterns[1] are going to have deleterious effects on agriculture,[2] globally as well as in Pakistan.[3] Climate change distresses agricultural production, rate of crop yield and common farming practices.[4] Consequently, some countries have started suffering from the phenomenon as crops (especially cereal) are no more adaptable to scorching heat and droughts. On one side, some arid lowlands will be affected by rising sea level, floods and salinization of underground water. On the other hand, agricultural lands will be destroyed by water scarcity, mainly because of less rainfall and rapid glacier melting, causing drought-like conditions.[5] Thus, blistering mercury will affect agricultural yields through floods and droughts,[6] making it a significant vulnerable sector to climate change.[7] Table 1 in Annex-A, for instance, shows the difference in temperature and rainfall from 1972-81 to 2010-2019 in Faisalabad. The difference revealed an overall 1.6°C

[1] Intergovernmental Panel on Climate Change, *In Climate Change 2013—the physical science basis.*
[2] Cynthia Rosenzweig, "Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison."
[3] Muhammad Habib ur Rahman et al., "Multi-model projections of future climate and climate change impacts uncertainty assessment for cotton production in Pakistan," *Agricultural and Forest Meteorology* 253-254, no. 1 (2018): 94-113.
[4] Raphael Abrahão et al., "Climate change and the water cycle in newly irrigated areas," *Environmental Monitoring and Assessment* 187, no. 2 (February 2015): 1-5.
[5] Enabling Poor Rural People to Overcome Poverty and United Nations Environment Programme, "Smallholders, food security, and the environment," *IFAD & UNEP*, 2013, https://www.ifad.org/documents/38714170/39135645/smallholders_report.pdf/133e8903-0204-4e7d-a780-bca847933f2e, (accessed on July 22, 2020).
[6] Winston Yu et al., *The Indus Basin of Pakistan: Impacts of Climate Risks on Water and Agriculture* (Washington DC: World Bank, 2013).
[7] Muhammad Tousif Bhatti, "Optimized shifts in sowing times of field crops to the projected climate changes in an agro-climatic zone of Pakistan."

rise in temperature and minus 10.8 mm decrease in rainfall (with delay in monsoon rains as well).[8] Resultantly, impacts of climate change on major crops are as following:[9]

- **Rice**: The amylose contents of rice grains (major determinant of cooking quality) are increased under elevated CO_2; and Concentration of iron and zinc are lowered and protein content of grains decreases under combined increase of temperature & CO_2.
- **Wheat**: The grain yield is decreased by 4 per cent if temperature increase up to 1.8°C.
- **Sugarcane**: Growth and development of sugarcane at high temperatures increases cane weight per acre but lowers sugar contents.
- **Cotton**: High night temperatures cause shedding of small bolls and pollen sterility.

Furthermore, increasing temperature and unusual rainfall leads to following impacts on crops respectively as shown in Table 2 in Annex B.[10]

How to Counter Impacts of Climate Change on Food Security in Pakistan?

Implementation of Revised Agro-ecological Zones (AEZs) in Punjab

Punjab's agro-ecological zoning is a core component of the province's efforts to develop effective farming and food systems. According to revised Agro-Ecological Zones (AEZs) of Punjab,[11] there is huge potential for crop diversification and precision for enhanced crop productivity. AEZs identify most suitable type, land and time for a crop production keeping in view the land characteristics, topography, land use, soil and water analysis, weather and climate, yield and profitability etc. Moreover, crop suitability maps for more than 50 crops have been created in the newly developed AEZs report, and the implementation of these agro-ecological zones will encourage productive agricultural enterprise by enabling farmers to identify most suitable crops for their lands. Most suitable land areas for major crops are shown in Table 3 in Annex-C.

Diversification of Crops and Growth of Pulses and Edible Oils

Crop diversification strategies assist to offset microclimatic changes. Diversified crops offer stronger climate change adaptability potential and food security status. Greater application of varied cultivation systems minimizes climate change sensitivity. While commenting on the need for diversification of crops in Pakistan, Prof. Dr Ashfaq Ahmad asserts that Pakistan has great potential for growing pulses and edible oils.[12] Local production of edible oil is less than 20 per cent of the country's requirement and rest is consistently been fulfilled through import, spending more than US$ 3 billion annually.[13] Directorate of Oilseeds, Ayub Agriculture Research Institute (AARI), Faisalabad has successfully developed high yielding oilseed crop

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[8] Meteorological Observatory, Agronomic Research Institute, Ayub Agriculture Research Institute (AARI), Faisalabad.

[9] Dr Abid Niaz, Convener /Associate Agri. Chemist, Climate Change Research Centre (CCRC), Institute of Soil Chemistry & Environmental Sciences (ISCES), AARI, Faisalabad, In Personal Discussion with the Author.

[10] Dr Abid Niaz, In Personal Discussion with the Author.

[11] Ashfaq Ahmad et al., *Agro-Ecological Zones of Punjab, Pakistan* (Rome: FAO, 2019).

[12] Prof. Dr Ashfaq Ahmad, Centre of Advanced Studies (CAS), University of Agriculture, Faisalabad, In Personal Discussion with the Author.

[13] Hafiz Saad Bin Mustafa et al., "Crop Diversification Through Soybean Cultivation in Punjab," Directorate of Oilseeds, Ayub Agriculture Research Institute (AARI), Faisalabad, 2021, https://www.researchgate.net/publication/348338223_Crop_Diversification_through_Soybean_Cultivation_in_Punjab, (accessed on May 11, 2021).

varieties of Canola, Mustard, Sunflower, Sesame and Soybean which have better adaptability under changing climate scenarios.[14]

These varieties have potential to play key role in enhancing provincial and national production of oilseed crops in coming years. Keeping in view the increasing demand of soybean in edible oil, AARI's Oilseed Directorate has conducted adaptability study of soybean cultivation all over Punjab along with the development of high-temperature tolerant soybean variety – AARI Soybean – considering prevailing climatic conditions of Punjab. Moreover, a big window is still available to work on soybean crop in Pakistan regarding climate-resilient variety development, mechanization, quality seed production, availability and efficient marketing to enhance its cultivation and production in the country.

Development of Weather Resistant Seeds

Abiotic stresses are the major type of stresses that plants suffer. Some bottleneck molecular and physiological challenges present in plants need to be resolved for better plant adaptation under abiotic conditions. For crop resistance against biotic and abiotic stresses, propagating novel cultural methods, implementing various cropping schemes, and different conventional and non-conventional approaches should be adopted to save agriculture in the future.

According to Dr Abid Niaz, breeding approaches will help to develop climate resilient crops with better adaptability under drought and heat.[15] Genome wide association studies (GWAS), genomic selection (GS) with high throughput phenotyping, and genotyping strategies are significant in identifying the different genes for crop improvement under climate change.[16] Genetic engineering approaches have been significantly applied to develop transgenic plants with enhanced resistance against different biotic and abiotic stress responses. In future, one has to make eco-friendly genome edited crops through a CRISPR/Cas9 mediated genome editing to battle against climate change.

Adopting Climate Smart Agriculture (CSA)

CSA approach aims at transforming and re-orienting agricultural development under the new realities of climate change. Recognized CSA approaches include: managing climate risks through changes in agricultural technologies and practices; reducing GHGs emissions; management of resources (farms, crops, livestock etc.) to produce more with less resources; and services for farmers and farm managers to enable them to implement the necessary changes. Benefits of resource conservation technologies[17] are shown in Table 4 in Annex-D.

Climate Forecasting for Farmers

Weather forecasts could also be a key component for climate change adaptation, such as short-adjustments, or autonomous actions that can be implemented without requiring major system changes. Examples of weather-sensitive decision problems of this type include crop selection and sequence, crop calendar adjustments, irrigation and fertilizer application scheduling, pesticide application, and so on. In practice, however, the decision-making process frequently necessitates precise weather forecasts.

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[14] Hafiz Saad Bin Mustafa et al., "Crop Diversification Through Soybean Cultivation in Punjab."
[15] Dr Abid Niaz, In Personal Discussion with the Author.
[16] Ibid.
[17] Ibid.

Weather forecasting system for farmers in Pakistan is on weekly or monthly basis. However, Prof. Dr Ashfaq Ahmad opines that long-term weather forecasting (3-4 months at least), including information germane to temperature, rainfall and humidity, can provide farmers the required information as to which crop should be sown for maximum possible production. Similarly, Dr. Abid Niaz opined that separate weather forecasting for different agriculture areas in a city such as Faisalabad should also be materialized.[18] He also recommended that there should be effective dissemination and integration of related weather forecasting information to local farmers.[19]

Adoption of Improved Information and Communication Technologies (ICTs)

Traditional farming which has eventually led to major improvements in agricultural productivity and sustainability, has been reformed by the introduction of Information and Communication Technologies (ICTs). Enhanced effectiveness and viability of small farms is crucial to empower farmers. ICTs are the technologies which provide access by telecommunications means.[20] ICTs also help improve productivity in agriculture through better techniques and cost-efficiently.

Agricultural extension employees in Pakistan are using various ICTs channels for disseminating information and expertise in the farming culture. These include new knowledge and collaboration technologies that play a significant role in enhancing crop and consumer information availability. According to Prof. Dr. Ashfaq Ahmad, usage of ICTs for information dissemination, remote sensing for crop modelling and MODIS Vegetation Index Products (NDVI and EVI)[21] for precision agriculture[22] in Pakistan is need of the hour.[23]

Recommendations

1. Revised agro-ecological zones of Punjab should be implemented for crop diversification and enhanced crop productivity. Implementation of AEZs will encourage productive agricultural enterprise by enabling farmers to identify most suitable crops for their lands.
2. Crop diversification strategies should be adopted to offset climate change and food security nexus. Moreover, high yielding and temperature tolerant oilseed crop varieties such as AARI Soybean can play key role in enhancing provincial and national production of oilseed crops in coming years.

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[18] Dr Abid Niaz, In Personal Discussion with the Author.

[19] Ibid.

[20] Telecommunications means include radio, television, cellular telephone, computers, and satellite technology. The Internet includes e-mails, instant messages, video and social websites.

[21] MODIS vegetation indices, produced on 16-day intervals and at multiple spatial resolutions, provide consistent spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure. Two vegetation indices are derived from atmospherically-corrected reflectance in the red, near-infrared, and blue wavebands; the normalized difference vegetation index (NDVI), which provides continuity with NOAA's AVHRR NDVI time series record for historical and climate applications, and the enhanced vegetation index (EVI), which minimizes canopy-soil variations and improves sensitivity over dense vegetation conditions. The two products more effectively characterize the global range of vegetation states and processes. For further detail see: "MODIS Vegetation Index Products (NDVI and EVI)," NASA-MODIS, https://modis.gsfc.nasa.gov/data/dataprod/mod13.php, (accessed on May 2, 2021).

[22] Precision agriculture (PA) is an approach to farm management that uses information technology (IT) to ensure that crops and soil receive exactly what they need for optimum health and productivity. The goal of PA is to ensure profitability, sustainability and protection of the environment.

[23] Prof. Dr Ashfaq Ahmad, In Personal Discussion with the Author.

3. Novel cultural methods and implementation of various cropping schemes should be utilized for crop resistance against biotic and abiotic stresses.
4. Weather forecasts could also be a key component for climate change adaptation, such as short-adjustments, or autonomous actions that can be implemented without requiring major system changes. Moreover, there should be effective dissemination and integration of related weather forecasting information to local farmers.

Annex-A

Table 1

Comparison of Temperature in Faisalabad							
Season	**Month**	**Avg. Max Temp (°C)**			**Avg. Min Temp (°C)**		
		1972-81	**2010-19**	**Diff**	**1972-81**	**2010-19**	**Diff**
Summer	*May*	38.6	40.0	1.4	23.3	24.3	1.0
	June	40.0	40.0	0.3	26.5	26.9	0.4
	July	35.7	37.2	1.5	26.0	27.2	1.2
	August	34.7	36.5	1.8	26.1	26.7	0.6
	September	34.7	36.1	1.4	23.6	24.6	0.9
	October	32.5	33.9	1.4	17.0	19.3	2.3
Winter	*November*	26.3	28.1	1.8	9.6	12.2	2.6
	December	20.2	23.1	2.9	4.7	6.6	1.9
	January	17.7	18.8	1.1	3.4	5.2	1.8
	February	19.9	22.7	2.8	5.7	8.3	2.6
	March	25.1	28.3	3.2	10.9	13.7	2.8
	April	33.4	35.3	1.9	18.0	19.0	1.0
	Avg.	29.9	31.7	**1.8°C Increase**	16.2	17.8	**1.6°C Increase**

Comparison of Rainfall (mm) in Faisalabad				
Season	**Month**	**1972-81**	**2010-19**	**Difference**
Summer	*May*	12.4	19.5	+7.1
	June	27.7	40.9	+13.2
	July	182.8	132.0	-50.8
	August	116.2	84.1	-32.1
	September	32.6	82.3	+49.7
	October	4.4	8.6	+4.2
Winter	*November*	2.0	2.7	+0.7
	December	6.6	2.3	-4.3
	January	10.8	6.2	-4.6
	February	18.7	20.2	+1.5
	March	27.6	25.2	-2.4
	April	11.9	19.0	+7.1
	Total Rainfall	453.7	442.9	**-10.8 Decrease**

Annex-B

Table 2

Effects of High Temperature on Major Crops	
Crop	**Effects**
Wheat	Delayed germination, leaf injuries at seedling stages, interveinal chlorosis, bronzing of leaves, yellowing appearance of crop
Cotton	Leaf's yellowing, bronzing, interveinal chlorosis, Higher fruit shedding, pollen abortion, less fertilization, reduced boll size, high pest attack (whitefly), less pesticide efficacy
Rice	Reduced growth, less pollination & sterility in late sown rice, low grain formation, smaller grains
Sugarcane	Reduced growth and cane weight, yellow and brown strips, shoot tip burning
Maize	Leaf burning, tassel blast and sterility, reduced cob size & less grain filling, reduced pollen shedding duration
Chickpea & lentil	Reduce pollen viability, Low seed setting, forced maturity, germination affected, problems in nodules formation.
Vegetable	Rains delayed sowing of winter vegetable, delayed maturity particularly in seed crop, heat waves (tomato nursery damages)

Impacts of Heavy Unusual Rainfall		
Effects	**Crops**	**Possible Impacts**
Positive	***Sugarcane, rice***	Except heavy rains in sugarcane cause lodging, red rot and pyrilla & white fly attack
Negative	***Cotton***	- Depletion of the nutrients - Less ability of roots to absorb nutrients due to submergence - Reduced pollination & shedding of squares/flowers - Excessive vegetative growth - High pest pressure particularly whitefly and Cotton leaf curl virus - Proliferation of weeds
	Pulses	Less germination, reduce pollination, excessive vegetative growth, promote insect/pest and disease complex
Minimum effects	***Wheat, maize***	Rainfall at the time of maturity and harvesting

Annex-C

Table 3

Crop	Most Suitable Land
Rice	Upper Punjab: Gujranwala, Sialkot, Gujrat, Sheikhupura, Sargodha and Nankana Sahib
Wheat	Hafizabad, Sheikhupura, Nankana Sahib, Okara, Toba Tek Singh, Sahiwal, Pakpattan, Khanewal, Vehari, Lodhran, Bahawalpur, Rahim Yar Khan
Sugarcane	Bhakkar, Layyah, Jhang, Toba Tek Singh, Muzaffargarh, Khanewal, Vehari, Lodhran and some areas of Bahawalpur, Rajanpur and Rahim Yar Khan
Maize	Chiniot, Nankana Sahib, Faisalabad, Toba Tek Singh, Kasur, Okara, Sahiwal, Khanewal, Pakpattan, Vehari, Lodhran, Bahawalnagar and some areas of Bahawalpur
Mash	Bhakkar, Jhang, Khanewal, Kasur, Okara and Pakpattan
Moong Bean	Mandi Bahauddin, Bhakkar, Sheikhupura, Faisalabad, Okara, Pakpattan, Vehari, Khanewal, Bhakkar, Layyah and some areas of Rajanpur
Cotton	Lower Punjab: Khanewal, Vehari, Multan, Muzaffargarh, Bahawalpur and Bahawalnagar
Citrus Fruits	Whole Punjab but the most suitable are the lands of Jhelum, Sargodha, Gujranwala, Layyah and Rajanpur
Mango	Central and Lower Punjab: Rajanpur and Rahim Yar Khan etc.
Guava	Central and Upper Punjab: Gujrat, Jhelum and Sialkot etc.
Vegetables can be grown in almost all of Punjab.	
Cabbage	Gujrat and Narowal
Turnip	Desert areas of Punjab: Bhakkar, Layyah, and Mianwali

Annex-D

Table 4

Technology	Fuel saving (L)	*CO_2 /methane reduction (kg)	Yield increase (mounds)	Water saving (%)
Relay sowing (wheat)	18	48.6	5-15 (Wheat) 2-5 (Cotton)	-
Zero Till (wheat)	18	48.6	-	10
Bed Planting (Wheat)	-	-	2-3	30-50
Ridge planting (Wheat)			4-5	30
Ridge planting (Sesame)	-	-	2-4	-
Ridge planting (maize fodder)	-	-	150-200	-
Ridge planting (Chickpea)	-	-	8-10	-
Direct Seeded Rice	15	40.5	-	10-20