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**CLIMATE CHANGE IMPACTS ON RAINFED WHEAT
FARMING AND FARMERS' ADAPTATION RESPONSE:
EVIDENCE FROM PAKISTAN**



18th Seminar (Online through ZOOM) of DAS Event Calendar - 2021

**CLIMATE CHANGE IMPACTS ON RAINFED WHEAT FARMING
AND FARMERS' ADAPTATION RESPONSE: EVIDENCE FROM PAKISTAN**

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Organizer:

Directorate of Advanced Studies
PMAS-AAUR

ACTIVITIES

Outline

1. Introduction
2. Objectives and hypotheses
3. Conceptual framework
4. Recognition of study findings
5. Study area
6. Sampling method and data collection
7. Research findings
8. Conclusions and policy recommendations
9. Major contributions, limitations and future research

2

Introduction

- Climate change is affecting the globe in various ways
- Worst situation in countries with agriculture-based economies in the form of less yields and livelihood losses (Abid et al., 2019)
- Devastating impacts in countries with poor adaptive capacity (Stocker et al., 2013)
- South Asia is among most vulnerable regions to climate change
- Region has to double the food production by 2050 by minimizing climate induced impacts to feed its growing populations (Ladha et al., 2016)

3

Introduction

- Indo-Gangetic Plains (IGPs) may become unsuitable for wheat cultivation because of heat waves, if appropriate measures will not be initiated (Ortiz et al. 2014)
- Similar situation in Pakistan because of agro-based economy, heavy dependency on agriculture sector with 19.2% share in GDP of the country (GOP, 2020-21)
- Climate change is affecting various crops; wheat is among the most vulnerable crop to climate change in country (Ali et al., 2017)
- Changing climatic conditions affect the wheat at various phenological growth stages; ultimately cause a decline in final yield (Arshad et al., 2018)

4

Rainfed wheat farming under climate change

- 80% of global agriculture is under rainfed farming; produces 70% of the glob's staple foods (Sharma et al. 2010).
- In Pakistan, 25% of the total cropped area is under rain-fed agriculture & one-third of the wheat crop is grown in rain-fed areas (Baig et al. 2013)
- Rainfed wheat farming in Pakistan is under heavy threat due to the changing climatic conditions
- Leading food crop of country and has highest area under cultivation in Pakistan and in rainfed zone as well
- Focus of present study is yet an unexplored region i.e. rainfed zone

5

Overall objectives

1. To investigate the impacts of climate change (mainly temperature and rainfall) on mean yield and yield variability of rainfed wheat
2. To quantify the impacts of climate variables on economic efficiency of rainfed wheat farmers and, the role of climate-resilient crop farm trainings for improving economic efficiency
3. To evaluate the impacts of climate change *fatalism* and climate-specific extension trainings and services on rainfed wheat farmers' decision to adapt

Climate Change *Fatalism*: It means that farmers believe that yes, there is climate change but its harmful impacts are pre-determined and we cannot escape from them. So, they don't want to do adaptation measures to minimize these impacts.

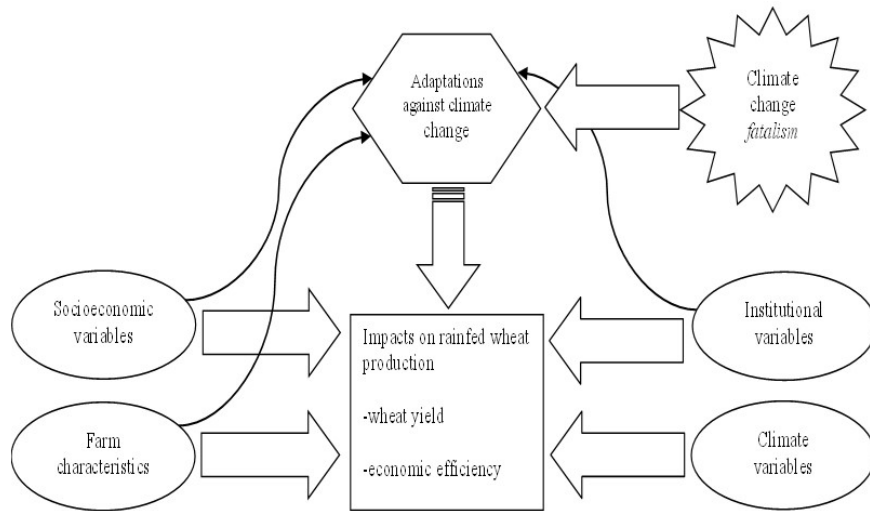
6

Hypotheses

1. Climate change negatively influences the rainfed wheat yield
2. Climate change negatively impacts the economic efficiency of rainfed wheat farmers. Farmers' participation in climate-resilient crop farm trainings enhances their economic efficiency
3. Climate change *fatalism* affects the rainfed wheat farmers' decision to adapt. Provision of climate-specific extension trainings and services significantly influences farmers' decision to adapt various measures

7

Conceptual framework



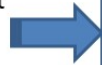
8

Recognition of study findings

Objectives:

1:

Impact of climate change on wheat mean yield and yield variability



Published Articles

Article 1

Science of the Total Environment
(Impact factor = 7.963)

2:

Impact of climate change on economic efficiency of rainfed wheat farmers



Article 2

Environmental Science and Pollution Research
(Impact factor = 4.223)

3:

Effect of climate change *fatalism* and other explanatory variables on the rainfed wheat farmers' decision to adopt and, to choose among different adaptation strategies

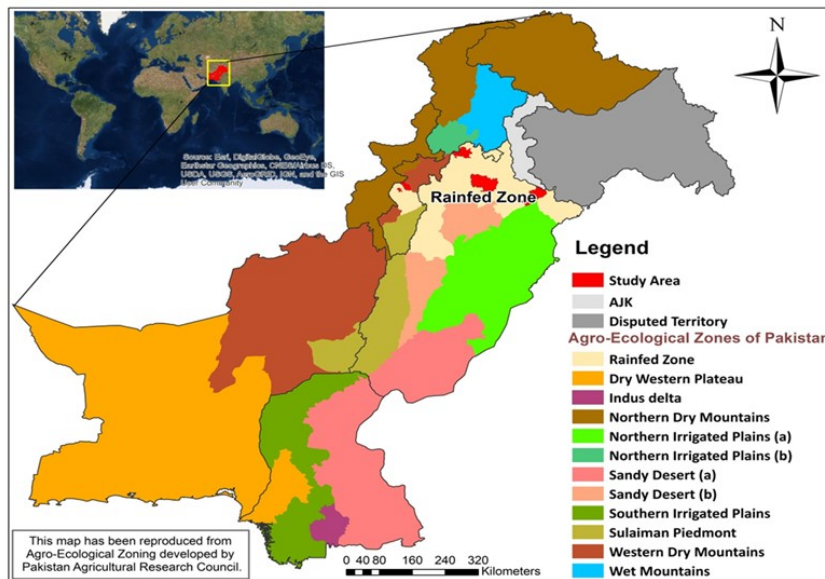


Article 3

Sustainability
(Impact factor = 3.251)

9

Area of research

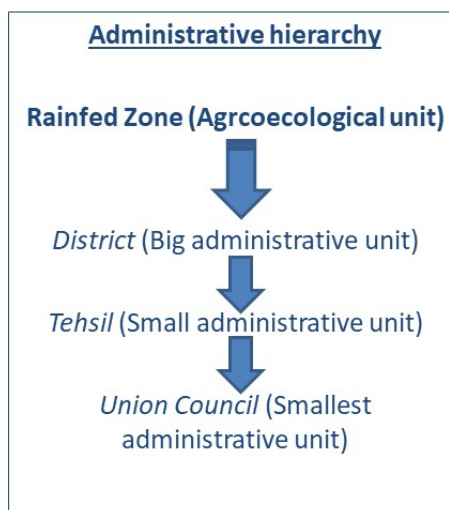


10

Sampling method and data collection

-Multistage simple random sampling technique

- **400 rainfed wheat farmers**
- Four *Districts* from Rainfed Zone
- One *Tehsil* from each district
- One *Union Council* from each tehsil
- 100 farmers from each *Union Council*
- **Secondary data of climate variables (1980-2017)**



11

Processing of secondary data for climate variables

➤ Temperature anomaly (°C)

= Mean temperature of 2017 – Historical mean temperature (1980-2016)

➤ Heat stress (n)

= Number of days with temperature > 30°C

➤ Rainfall anomaly (mm)

= Total rainfall during whole wheat cropping period (2017) – average of “total rainfall during whole wheat cropping period” from 1980-2016

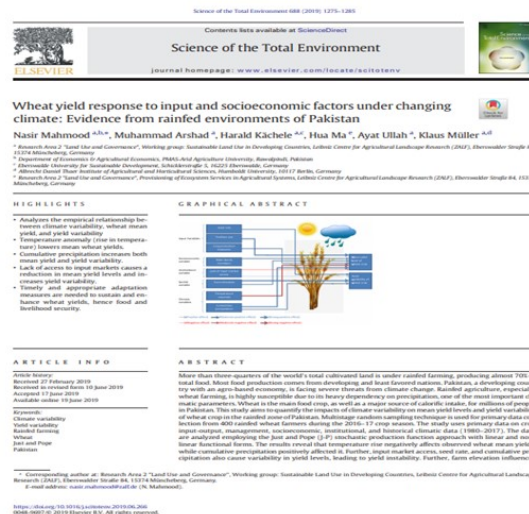
➤ Total rainfall (mm)

= Total rainfall during whole wheat cropping period for the study year i.e. 2017

12

Research Objective 1

To investigate the impact of climate change on rainfed wheat mean yield and yield variability



14

Methods

- Just and Pope production function (Just and Pope, 1978)

Wheat mean yield and yield variability =
 f (socioeconomic, input, institutional, farm and climate variables)

15

Results

Results of Just-Pope production function

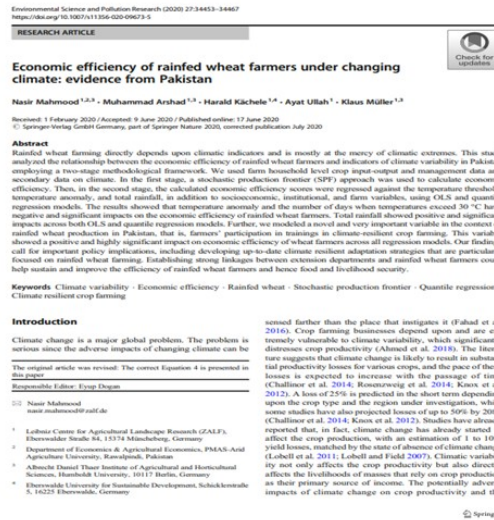
Explanatory variables	J-P mean yield	J-P yield variability
Farm altitude (base is high altitude)	-	-
'1' for low altitude (meters)	604.4669***	4.459133**
'2' for moderate altitude (meters)	638.5399***	4.488956*
Male family members (n)	10.61321**	0.0094568
Age of farmer (years)	-0.68698	0.0019191
Education of farmer (schooling years)	-1.243576	-0.0089194
Distance from input market (km)	-2.783193**	0.048057*
Availability of input market within the village of residence (n)	8.174241	0.1294747
Area cultivated (hectare)	-2.047346	0.0018834
Ploughings (passes season ⁻¹)	0.2394806	0.018657
Seed rate (kg ha ⁻¹)	-0.000559	0.0000662**
Farmyard manure (kg ha ⁻¹)	0.14700000	-0.00000079
Nitrogen-phosphorus (kg ha ⁻¹)	0.0020601**	-0.000012
Chemical crop protection measures (liters ha ⁻¹)	1.428496**	-0.0014309
Total rainfall during wheat season (mm)	0.0082786***	0.00051**
Deviation of the wheat season's mean temperature from historical mean (°C)	-27.57974***	-0.1530659

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Low altitude=225-350m, moderate altitude=351-475m & high altitude= >475 m

16

Research Objective 2

To evaluate the impact of climate change on economic efficiency of rainfed wheat farmers



17

Methods

- Stochastic Production Frontier (SPF) model is used to calculate economic efficiency
- Ordinary Least Square (OLS) and quantile regression analyses

Economic efficiency of rainfed wheat farmers = f (socioeconomic, institutional, farm and climate variables)

18

Results

Results of ordinary least square (OLS) and quantile regression analyses

Explanatory variables	OLS Estimates	Quantile regression estimates				
		-	0.25	0.50	0.75	0.95
Number of family members (n)	-0.0032		0.0325	-0.0037	-0.0039	-0.0063**
Age of the farmer (dummy) ^a	0.0318		0.0229	0.0306	0.1440	0.0151
Distance from input market (km)	-0.0034**		-0.0041**	-0.0019	-0.0099	-0.0004
Soil type (dummy) ^b	0.0456**		0.0449	0.0820*	0.0360	-0.0026
Climate-resilient crop farm trainings (dummy) ^c	0.0724***		0.1103***	0.0852***	0.0429**	0.0227*
Deviation in the observed wheat growing season's mean temperature from historical mean (°C)	-0.0045		-0.0148	-0.0123**	-0.0017	-0.0109
Days with temperature > 30°C during wheat growing season (n)	-0.0028***		-0.0033	-0.0034**	-0.0022*	-0.0021***
Total rainfall during the wheat cropping season (mm)	0.0003**		0.0006**	0.0029*	0.000017	0.0001

Note: ^a represents '1' for young farmers, otherwise '0'; ^b indicates '1' for clay soil, otherwise '0'; and ^c denotes '1' for participation in trainings in climate-resilient wheat farming including the use of heat tolerant varieties, otherwise '0'. 0.25=lower; 0.50=middle; 0.75=higher & 0.95=highest quantile, **p* < 0.1, ***p* < 0.05, ****p* < 0.01

19

Research Objective 3

To find out the effect of climate change *fatalism* and other explanatory variables on the rainfed wheat farmers' decision to adopt and, to choose among different adaptation strategies




Fatalism, Climate Resiliency Training and Farmers' Adaptation Responses: Implications for Sustainable Rainfed-Wheat Production in Pakistan

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Abstract: Climate change is a severe threat to the agricultural sector in general and to rainfed farming in particular. The aim of this study was to investigate the factors that can potentially affect the adaptation process against climate change. This study focused on wheat farmers and farming systems in the rainfed agroecological zone of Pakistan. Farmers' data related to climate change *fatalism*, the availability of climate-specific extension services, socioeconomic and institutional variables, and farm characteristics were collected. A logit model to assess farmers' decisions to adopt an adaptation measure and a multinomial logit model to assess their choice of various adaptation measures were used. The results showed that fatalistic farmers were unlikely to implement climate change adaptation measures. The variables related to the climate-specific extension services, including farmers' participation in training on climate-resilient crop farming and the availability of mobile communication-based advisory services, had highly significant and positive impacts on farmers' decisions and their choice of adaptation measures. Input market access and tractor ownership also had positive and significant impacts on farmers' decisions to adopt and their choice of adaptation measures. This study highlights the need to improve rainfed wheat farmers' education levels to change their fatalistic attitudes towards climate change. Furthermore, government action is needed to provide climate-specific extension services to ensure sustainable production levels that will ultimately lead to food and livelihood security under a changing climate.

Keywords: fatalism; climate-specific extension services; climate-resilient farming; rainfed farming; adaptation

1. Introduction

Agriculture is the only business entity that is under the direct influence of climate change, and the success of this business, especially crop farming, is directly related to changing climatic conditions. The problem of climate change is global in nature, but the situation in the developing world is worst

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20

Methods

- Logit model to determine the factors affecting the decision to do an adaptation

Logit (adopter/non-adopter) = f (Fatalism, climate-specific extension services, information on climate change, socioeconomic variables, institutional factors, tractor holding, farm characteristics)

- Multinomial logit model to determine the factors affecting the various adaptations:

Multinomial logit (Four adaptation measures) = f (Fatalism, climate-specific extension services, information on climate change, socioeconomic variables, institutional factors, tractor holding, farm characteristics)

21

Results

Estimated results of the logit and multinomial logit models

Explanatory variables	Logit Model	Multinomial Logit (MNL) Model			
		Using Heat- and Drought-Resistant Wheat-Crop Varieties	Changing Sowing Dates	Planting Shade Trees	Changing the Composition of Fertilizer
Climate change/fatalism	-1.013***	-1.1182***	-1.2229***	-0.9186***	-0.8968***
Farmers' participation in trainings on climate-resilient wheat-crop farming	2.3118***	2.3641***	3.3450***	1.8749***	2.2955***
Availability of mobile communication technology (MCT)-based advisory services	0.7286*	1.3089***	-0.0301	0.5887	0.1990
Availability of information on climate change	1.1127***	1.4879***	0.3282	0.7352*	1.2920***
Age of the farmer (years)	0.0022	0.0066	0.0040	-0.0088	0.0170
Number of male family members (numbers)	0.3171**	0.4418**	0.3021*	0.3390**	0.0185
Input market access	0.8007**	0.9071**	0.9319**	0.7352*	0.6072
Tractor ownership	0.8383**	0.8287*	0.2597	0.9122**	1.1051**
Crop farming as main source of income	0.9146***	1.0891***	1.0387**	0.5865	1.1426***
Monocropping	1.6990***	1.4394***	2.1167***	1.5191***	2.4151***

Note: *, ** and *** show the level of significance at * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$, respectively

22

Conclusions

- Rising temperature negatively influenced the wheat yield and, economic efficiency of rainfed wheat farmers
- Distance from input market negatively influenced the mean yield, and economic efficiency of farmers
- Total rainfall during the whole crop growth period showed a positive impact on rainfed wheat yield and, on economic efficiency of rainfed wheat farmers as well
- Farmers' participation in trainings showed positive impact on the economic efficiency of rainfed wheat farmers and, on their decision to adapt against climate change

23

Conclusions.....

- Easy access to input market showed a highly significant and positive impact on farmers' decision to adopt various adaptations
- Rainfed wheat farmers having fatalistic views about climate change did not show any interest in adopting against climate change

24

Policy recommendations

- Need of research emphasis on the development of heat- and drought-resistant wheat varieties
- Investments are required to enhance the institutional capacity regarding the provision of easy access to input markets, climate-specific trainings etc
- Identification of, and then scaling-up the most effective adaptation strategies is needed for rainfed areas
- Special education and counselling of rainfed wheat farmers could be helpful to change their fatalistic views towards climate change

25

Major contributions

- First zone-specific study in Pakistan
- Pioneering study that assesses the impact of climate change on rainfed area's main food crop i.e. wheat
- Modelled climate-resilient crop farming trainings instead of general extension trainings
- First study that has investigated the role of "climate change Fatalism" in process of adaptation decision-making in Pakistan

26

Limitations of study

- Research findings cannot be generalized to other zones
- Detailed picture could be captured by conducting field surveys at various growth stages of wheat crop
- Unavailability of panel data set for rainfed zone is a big constraint and reason of relying on cross-sectional data
- Dynamic nature of climate, econometric methods, role of various variables

27

Future research directives

- Zone-specific climate-based research is needed for identification of respective adaptations
- Identification and scaling-up of composite measures of adaptations could be next step
- Conducting feasibility studies for constructing dams to harvest rainwater and installation of solar-powered tube-wells could be the focus of future research (*already initiated by Punjab government*)
- Lastly, panel data analysis could provide clearer picture of climate change impacts and farmers' adaptation response

28

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