UNIVERSITÀ DEGLI STUDI DI MILANO

TO MAGNIFICO RETTORE OF UNIVERSITA' DEGLI STUDI DI MILANO **ID CODE: 6325**

I the undersigned asks to participate in the public selection, for qualifications and examinations, for the awarding of a type B fellowship at **Dipartimento di Department of Economics, Management and Quantitative Methods**

Scientist- in – charge: **Prof. D'Adda**

[Name and surname] Qasir Abbas

CURRICULUM VITAE

PERSONAL INFORMATION

Surname	Abbas
Name	Qasir

PRESENT OCCUPATION

Appointment	Structure
Institute of Agricultural & Resource Economics, University of Agriculture, Faisalabad, Pakistan.	Working as lecturer in Economics subject Since 2012.

EDUCATION AND TRAINING

Degree	Course of studies	University	year of achievement of the degree
Degree (M.Sc Economics)	Economics	The University of Punjab, Lahore, Pakistan.	2009
Specialization (M.Phil Economics)	Development Economics and Public Policy.	Beaconhouse National University, Lahore, Pakistan.	2012
PhD	Agricultural Economics & Management	Nanjing Agricultural University, Nanjing, China.	2021
Master			
Degree of medical specialization			

Degree of European specialization			
Other			

REGISTRATION IN PROFESSIONAL ASSOCIATIONS

Date of registration	Association	City

FOREIGN LANGUAGES

Languages	level of knowledge
English	Proficient

AWARDS, ACKNOWLEDGEMENTS, SCHOLARSHIPS

Year	Description of award
2017	Attained fully funded Scholarship from Govt. of China.

TRAINING OR RESEARCH ACTIVITY

Doing scientific research in the field of economic and its allied sector since 2012.

PROJECT ACTIVITY

Year	Project
2023	Completed funded project on “Efficiency and Productivity Analysis of Rice Farming in Pakistan: An Implication for Concerned Stakeholders” in Deceber 2023

“

PATENTS

Patent

CONGRESSES AND SEMINARS

Date	Title	Place
29th October 2023	international conference on Global Food Security Forum for Young Scientist	Huazhong Agriculture University, Wuhan, China,
19th October 2023	Drivers of Rural Transformation Unveiling Insights and Findings	Center for Advanced Studies (CAS) Auditorium, University of Agriculture, Faisalabad, Pakistan.
14-15 September 2023	Afghanistan Agro-Business Forum	University of Agriculture, Faisalabad, Pakistan.
7th November, 2019	GCHERA World Agriculture Awards Ceremony and the 10th GCHERA World Congress	Nanjing Agricultural University in Nanjing, China
16th May, 2019.	Agricultural education and technology extension training course under the Belt and Road Initiative	Nanjing Agricultural University, Nanjing, China.

PUBLICATIONS

Books
Fiscal Policy in Agriculture (Book Chapter 34), Developing Sustainable Agriculture in Pakistan (with Tahira Sadaf, M. Ashfaq and Rakhshanda Kousar), Taylor and Francis Group, 2018. (pp. 751-784).
Introduction to the Economy of Pakistan (Book Chapter 10), Principles of Agricultural and Resource Economics" (with Sofia Anwar and Muhammad Ashfaq), University of Agriculture Faisalabad Press, 2017. (pp. 211-231).
[title, place, publishing house, year …]

Articles punlished
Estimating Impact of Climate Change Adaptation on Productivity and Earnings of Dairy Farmers; Evidence from Pakistani Punjab" (2023). (with Jiqin Han, Khuda Bakhsh and Rakhshanda Kousar), Environment Development and Sustainability, 2023. (JCR: SCI Q1, IF:4.9).
Do crop diversity and livestock production improve smallholder intra-household dietary diversity, nutrition, and sustainable food production? Empirical evidence from Pakistan" (2023) (with Muhammad Waseem, Xiaoyun Li, Ihsan Jamil, Abu Hayat Md. Saiful Islam, Muhaamd Hasseb Raza, and Moataz Eliw), Frontiers in Sustainable Food Systems, 2023, (JCR: SCI Q1, IF:4.7)
Exploring the Multi-Dimensional Factors Influencing Food Security: A Case Study of District Nowshera, Pakistan" (with Muhammad Hassan Safdar and Najaf Hussain), Journal of Development and Social Sciences, 2023. (HEC W Category)
Income and Yield Effects of Climate-Smart Agriculture (CSA) Adoption in Flood Prone Areas of Bangladesh: Farm Level Evidence (with Asma Akter, Xianhui Geng, Gershom Endelani Mwalupaso, Hua Lu, Fazlul Hoque and Michael Kiraru Ndungu), Climate Risk Management,

2022. (JCR: SCI Q1, IF:5.266).
Adaptation to Climate Change Risks Among Dairy Farmers in Punjab, Pakistan (with Jiqin Han, Khuda Bakhsh, Raza Ullah, Rakhshanda Kousar, Adnan Adeel and Asma Akter), Land Use Policy 119:106184, 2022. (JCR: SCI Q1, IF: 6.189).
Investigating the nexus among sulfur dioxide emission, energy consumption, and economic growth: empirical evidence from Pakistan (with Khuda Bakhsh, Tanzila Akmal and Tauqeer Ahmad), Environmental Science and Pollution Research 29:7214-7224, 2021
Cotton Production for the Sustainable Livelihoods in Punjab Pakistan: A case Study of District Muzaffargarh" (with Tahir Sadaf, Rakhshanda Kousar, Zia Mohy Ul Din, Muhammad Sohail Amjad and Javeria Nasir), International Journal of Ethics and System 38(2): 191-208, 2021. (JCR: SCI Q2, IF: 1.048).
Does Chinese FDI, Climate Change, and CO2 Emissions Stimulate Agricultural Productivity? Empirical Evidence from Pakistan (with Shakeel Ahmad, Muhammad Tariq, Touseef Hussain, Hamidullah Elham, Iqbal Haider and Xiangmei Li), Sustainability 12(18):7485, 2020. (JCR: SSCI Q2, IF: 3.889).
Women Participation: A Productivity Strategy in Rice Production (with Abubakar Rasheed, Gershom Endelani Mwalupaso, Xu Tian and Rafay Waseem), Sustainability 12(7), 2020. (JCR: SSCI Q2, IF: 3.889).
Dairy production under climatic risks: perceptions, perceived impacts and Adaptation in Punjab, Pakistan" (with Jiqin Han, Adnan Adeel and Raza Ullah), International Journal of Environmental Research and Public Health 16(20):4036, 2019. (JCR: SSCI Q1, IF: 4.614).
Secured Land Rights, Household Welfare and Agriculture Productivity: Evidence from Rural Pakistan" (with Rakhshanda Kousar, Makhodum Sohail Amjad Anjum), Pakistan Journal of Agricultural Sciences. 55(1), 2018. (JCR: SCI Q3, IF: 0.748).
Household- decisions of time allocation and wage determination in Pakistan" (with Rakhshanda Kousar, Makhodum Sohail Amjad Anjum and Aqeela Saghir.) Pakistan Journal of Agricultural Sciences 55(3), 2017. (JCR: SCI Q3, IF: 0.748, corresponding author)
Socioeconomic Characteristics and Health Cost of Female Cotton Pickers from Pesticide Exposure in Vehari, Pakistan"(with Khuda Bakhsh, Naeem Ahmad, Sarfraz Hassan, M Asif Kamran, Rashed Saeed and M Sadiq Hashmi), Journal of Bio Med Central (BMC) 16(961), 2016. (IF:4.135)
Agro-Economic Dimensions of Intercropping in Citrus Farms: The Case of District Toba Tek Singh, Pakistan" (with Adeel Ijaz, Sultan Ali Adil, Sarfraz Hassan, Khuda Bakhsh, Muhammad Khalid Bashir), Pakistan Journal of Agricultural Sciences 51(3):765–769, 2014. (JCR: SCI Q3, IF: 0.748).

Congress proceedings
Presented Research Paper " Efficiency and productivity analysis of rice farming in Pakistan: An implication for concerned stakeholders." In International conference on Global Food Security Forum for Young Scientist held on 28-29th October 2023 at HUAZHONG AGRICULTURE UNIVERSITY, WUHAN, CHINA
Presented Research Paper "Impact of research and Development on the Sectoral Performance of Pakistan" in international conference on Food Security and Value chain Improvement under Belt and Road Initiative held on 6-7 December 2022 at Mian Nawaz Sharif University of Agriculture, Multan, Pakistan
Presented Research Paper "Climatic Variation and Cereal Productivity in Punjab, Pakistan" in international conference on Climate Change: Impacts & Solutions, held on 7-9 November 2022 at University of Agriculture, Faisalabad. (ISBN:978-969-8237-94-3).

OTHER INFORMATION

PLOS ONE, Environmental and Resource Economics, Environmental Science and Pollution Research, Land Use Policy, Frontiers in Environmental Science, Sustainability, Pakistan Journal of Agricultural Sciences and Anonymous reviewers for other journals
Computational and Spatial Analysis Packages:R, Eviews, SPSS, Stata, DEAP. Compilation and other packages: LaTeX, Excel, Word, PowerPoint, Internet and email browsers

Declarations given in the present curriculum must be considered released according to art. 46 and 47 of DPR n. 445/2000.

The present curriculum does not contain confidential and legal information according to art. 4, paragraph 1, points d) and e) of D.Lgs. 30.06.2003 n. 196.

Please note that CV WILL BE PUBLISHED on the University website and It is recommended that personal and sensitive data should not be included. This template is realized to satisfy the need of publication without personal and sensitive data.

Please DO NOT SIGN this form.

Place and date: Faisalabad, Pakistan., 06/02/2024

UNIVERSITÀ DEGLI STUDI DI MILANO

TO THE RECTOR
OF THE UNIVERSITY OF MILAN

APPLICATION FORM FOR THE TYPE B COMPETITION NOTICE ID CODE 6325

I, the undersigned Dr.Qasir Abbas

born in Pakistan, on 26/07/1985

ask to be admitted to participate to the public selection procedure, via qualifications and exams, for the assignment of a research fellowship of 12 months' duration.

SCIENTIFIC SUPERVISOR: PROF. D'ADDA

HEREBY DECLARE

under my own responsibility, being aware that making false statements or submitting false documents is a crime punishable by law, pursuant to art. 76 of Presidential Decree no.445/2000 of 28 December 2000 and that this shall result in losing the research fellowship immediately:

BACHELOR'S DEGREE obtained in accordance with the procedures prior to Ministerial Decree no. 509/99 and subsequent amendments and additions in:	B.Sc in Economics (2007) from Bahauddin Zakariya University, Multan, Pakistan
Or **MASTER'S DEGREE (LM)** obtained pursuant to Ministerial Decree no. 270/2004 and subsequent amendments and additions, belonging to class LM_____ in:	M.Sc Economics (2009) from The University of Punjab, Lahore, Pakistan.
Earned in academic year:	M.Phil Economics (2012)
On (date):	03/12/2012
At:	Beaconhouse National University, Lahore, Pakistan

PHD / MEDICAL SPECIALISATION DIPLOMA in:	PhD in Agricultural Economics & Management
Earned in academic year:	2021
On (date):	24/09/2021
At:	Nanjing Agricultural University, Nanjing, China.

- the absence of criminal record and of ongoing criminal proceedings
- of not being employed at Universities or other Bodies stated in art. 22, paragraph 1 of Law no. 240/2010 of 30/12/2010;
- of not exceeding the limits provided by the regulations in force for research fellowships (6 years excluding the period in which it has been enjoyed in coincidence with the PhD without a scholarship, within the maximum limit of the legal duration of the related course)
- of not exceeding the total duration of 12 years, not necessarily continuous, as holder of research fellowships and/or employment contract as fixed-term researcher pursuant to art. 22 paragraphs 3 and 9 of Law no. 240 of 30/12/2010
- of not being within the fourth degree of kinship, up to and including the fourth, with a professor attached to the related department, or with the Rector, the General Director or with a member of the University Board of Directors.

University of Milan - Salary, Benefits and Independent Contractor Division
Office for Training and Research Contracts
Via Sant'Antonio 12 - 20122 Milano, Italia
assegni.ricerca@unimi.it – DTELA_M_DomandaAssegniRicENG_rev. 01 del 15/01/2024

I also declare to possess the requirements provided for by art. 2 of the competition notice.

MOREOVER, I DECLARE

(self-certification in lieu of affidavit - art. 46 and 47 of Presidential Decree no. 445/2000 of 28/12/2000)

- **that the qualifications attached to the present application form and listed below are equivalent to the original document:**

List of the attached documents:

Personal Information

Application

Declaration form

Curriculum Viate

Other Documents (Cover Letter, CV, Educational Documents, Research Statement, Reference letters)

I confirm that I have read the privacy policy, and I am aware that my personal data will be used by the University of Milan for the purposes related to the management of the selection procedure and the potential establishment of a private law contract, pursuant to Legislative Decree no. 196/2003 and to EU Regulation 679/2016.

Please find attached a photocopy of my identification document.

Read, approved and signed[1].

Date, 06/02/2024 Signature Qasir Abbas

[1] PRIVACY POLICY PURSUANT TO ART. 13 of Legislative Decree no. 196/2003 and to EU REGULATION no. 679/2016

Pursuant to Legislative Decree No.196/2003 (Code regarding the protection of personal data) and subsequent amendments and additions thereto, as well as to EU Regulation No.679/2016 (General Data Protection Regulation, i.e. GDPR) and to article 16 of the University Regulations regarding the protection of personal data, the University undertakes to respect the confidentiality of the information provided by the candidates: all data provided will be processed only for purposes connected to and useful for the management of the selection procedure.

Thorough information is available on the University website at the following page: Privacy.

The present declaration shall be sent together with a scan of a valid identification **document** of the declarant.

UNIVERSITÀ DEGLI STUDI DI MILANO

CANDIDATE'S PERSONAL DATA

COMPLETE ALL FIELDS IN BLOCK CAPITALS

DO NOT SCAN, SAVE AND SEND AS ATTACHMENT TO THE APPLICATION

ID CALL	6325	
SURNAME	ABBAS	
NAME	QASIR	
GENDER	M	(M o F)
FISCAL CODE		
DATE OF BIRTH	26/07/1985	(GG/MM/AAAA)
PLACE OF BIRTH	District Vehari	
PROVINCE OF BIRTH	Punjab	
STATE OF BIRTH	Pakistan	(for example IT)
CITIZENSHIP	Pakistani	

RESIDENCE:

ADDRESS	Institute of Agricultural & Resource Economics	
RESIDENCE TOWN	University of Agriculture, Faisalabad, UAF) Faisalaba	
RESIDENCE PROVINCE	Punjab	
ZIP CODE	38000	
STATE OF RESIDENCE	Pakistan	(for example USA)
CEL	+923327174024	(use: + only numbers without spaces)
EMAIL	qaisarabbas@uaf.edu.pk	

Qasir Abbas
Institute of Agricultural & Resource Economics,
University of Agriculture, Faisalabad, Punjab, Pakistan. 38000.
+923327174024 (Also for WhatsApp)
qaisarabbas@uaf.edu.pk

02/02/2024
Prof. D'Adda
Department of Economics, Management and Quantitative Methods,
Università degli Studi di Milano, Itlay.

Respected professor

I am writing to express my sincere interest in Università degli Studi di Milano's open postdoc position in the field of: The psychological aspects of energy efficiency decisions". I would love to pursue my postdoctoral studies as a member of your team. I am a recent graduate (in Agricultural Economics and Management) of Nanjing Agricultural University, Nanjing, China where I researched on "Climatic Risk and Management and its Impact on Pakistan's Dairy Production" for PhD dissertation. I have published several research articles in good journals but few of them published in well reputed journals from my PhD dissertation and with peers, their titles are given below while the details of these articles you can find in my resume.

1. Estimating Impact of Climate Change Adaptation on Productivity and Earnings of Dairy Farmers; Evidence from Pakistani Punjab 2023.
2. Adaptation to Climate Change Risks Among Dairy Farmers in Punjab, Pakistan 2022.
3. Dairy production under climatic risks: perceptions, perceived impacts and Adaptation in Punjab, Pakistan 2019.
4. Income and Yield Effects of Climate-Smart Agriculture (CSA) Adoption in Flood Prone Areas of Bangladesh: Farm Level Evidence 2022.
5. Investigating the nexus among sulfur dioxide emission, energy consumption, and economic growth: empirical evidence from Pakistan 2021.

Besides this, Recently I have completed a funded project sponsored by HZUA, IFPRI, CIMMYT and IAMO as PI/team leader at national level in December 2023. The title of the project is **Efficiency and Productivity Analysis of Rice Farming in Pakistan: An Implication for Concerned Stakeholders**. In the project we have estimated the green total factor productivity (**CO2 emission from each farming activity**) and efficiency of the rice producers in Pakistan. So, I have experience in surveys and data cleaning and handling. Along with this, I am working as lecturer in the Institute of Agricultural & Resource Economics, University of Agriculture, Faisalabad, Pakistan since November 2012. During this time, I have supervised 20 master's degree students for their thesis research and half of them have done their research by collecting cross-section data and I guided them about questionnaire development and conducting surveys. Some of the students used the panel data as well for their research and I helped them with data analysis through econometric techniques. In the meanwhile, I taught several undergraduate courses like

(Microeconomics, Principles of Agricultural and Resource Economics, Econometrics, Mathematical Economics, Statistical Economics, and Environmental Economics) and postgraduate courses (Applied Economics, Advanced Microeconomic Analysis, Development Economics and Topics in Environmental and Resource Economics etc.). In addition, I have also been involved in administrative activities like I am the focal person for BS Economics admissions and coordinator of the BS Economics evening program etc. Based on all the above qualities, educational background, and good research experience, I think I am the **most suitable candidate for this postdoctoral position**. I look forward to continuing my research and working toward climate change and adaptation at farm level as a member of your research team.

I would appreciate the opportunity to continue my research under your guidance and pursue a long-term future with Università degli Studi di Milano, Itlay. I have supervised two research thesis on energy efficiency to M.Phil students and they collected the field survey and analyzed the results. I have practiced all this tasks in my previous career. Thus, the choice experiment surveys and its handling with econometric modeling is already done by me in my PhD dissertation. I would love to do data analysis, and I have good strength in quantitative methods. Published several papers in international and national journals as first and co-authors with peers. Also reviewed many research articles of different good, reputed journal like Elsevier and Springer and PolsOne. I have also presented research papers at several international conferences and participated in many national and international conferences. Considering all these aspects, I am a good candidate for this post-doc position.

I am a self-motivated, independent researcher with eleven years of experience. As a detail-oriented, qualified, and creative candidate, I feel my research in climate change and sustainability, grant proposal writing and tutoring experience could be a major asset to your research team. I've attached my CV and would be very interested in setting up a time to further discuss my skills and qualifications with you. Please let me know if you have questions and I look forward to hearing from you.

Sincerely,

Dr. Qasir Abbas

Qasir Abbas, PhD

Institute of Agricultural & Resource Economics, University of Agriculture– Faisalabad (Pakistan)
+92 3327174024 • qaisarabbas@uaf.edu.pk

Economist with over years of experience in applied economics and policy research. Expert on climate change, agricultural economics, and development studies with a focus on South-East Asia. Continuously seeking evidenced-based policy answers to address a wide range of challenges in the field of sustainable development.

Work Experience

- **Institute of Agricultural & Resource Economics, University of Agriculture, Faisalabad** — **Faisalabad, Pakistan**
  Lecturer Agri. Economics — *November 2012–Ongoing*
- **Institute of Public Policy, Beaconhouse National University** — **Lahore, Pakistan**
  Research Associate — *July 2012–November 2012*
- **Government college (Boys) Gaddafi Stadium,** — **Lahore, Pakistan**
  College Intern (Lecturer in Economics) — *February 2010–February 2011*

Education

- **Nanjing Agricultural University** — **Nanjing, China**
  PhD in Agri. Economics & Management, — *2017–2021*
  Thesis: Climate Risk and Management and Its Impact on Dairy Production in Pakistan.
- **Beaconhouse National University** — **Lahore, Pakistan**
  Master of Philosophy in Economics, Field: Development Economics and Public Policy *2010–2012*
- **University of the Punjab** — **Lahore, Pakistan**
  Master of Science, Field: Economics — *2007–2009*
- **Bahauddin Zakariya University** — **Multan, Pakistan**
  Bachelor of Science, Field: Economics, Mathematics, Statistics — *2004–2007*

Publications and Working papers

Peer-reviewed Articles

- **Estimating Impact of Climate Change Adaptation on Productivity and Earnings of Dairy Farmers; Evidence from Pakistani Punjab" (2023). (with Jiqin Han, Khuda Bakhsh and Rakhshanda Kousar), Environment Development and Sustainability, 2023. (JCR: SCI Q1, IF:4.9).**
- **Do crop diversity and livestock production improve smallholder intra-household dietary diversity, nutrition, and sustainable food production? Empirical evidence from Pakistan" (2023) (with Muhammad Waseem, Xiaoyun Li, Ihsan Jamil, Abu Hayat Md. Saiful Islam, Muhaamd Hasseb Raza, and Moataz Eliw), Frontiers in Sustainable Food Systems, 2023, (JCR: SCI Q1, IF:4.7).**
- Exploring the Multi-Dimensional Factors Influencing Food Security: A Case Study of District Nowshera, Pakistan" (with Muhammad Hassan Safdar and Najaf Hussain), Journal of Development and Social Sciences, 2023. (HEC W Category).
- **Income and Yield Effects of Climate-Smart Agriculture (CSA) Adoption in Flood Prone Areas**

of Bangladesh: Farm Level Evidence (with Asma Akter, Xianhui Geng, Gershom Endelani Mwalupaso, Hua Lu, Fazlul Hoque and Michael Kiraru Ndungu), Climate Risk Management, 2022. (JCR: SCI Q1, IF:5.266).

- **Adaptation to Climate Change Risks Among Dairy Farmers in Punjab, Pakistan (with Jiqin Han, Khuda Bakhsh, Raza Ullah, Rakhshanda Kousar, Adnan Adeel and Asma Akter), Land Use Policy 119:106184, 2022. (JCR: SCI Q1, IF: 6.189).**
- Investigating the nexus among sulfur dioxide emission, energy consumption, and economic growth: empirical evidence from Pakistan (with Khuda Bakhsh, Tanzila Akmal and Tauqeer Ahmad), Environmental Science and Pollution Research 29:7214-7224, 2021.

  (JCR: SCI Q2, IF: 5.190, corresponding author).
- Cotton Production for the Sustainable Livelihoods in Punjab Pakistan: A case Study of District Muzaffargarh" (with Tahir Sadaf, Rakhshanda Kousar, Zia Mohy Ul Din, Muhammad Sohail Amjad and Javeria Nasir), International Journal of Ethics and System 38(2): 191-208, 2021. (JCR: SCI Q2, IF: 1.048).
- Does Chinese FDI, Climate Change, and CO2 Emissions Stimulate Agricultural Productivity? Empirical Evidence from Pakistan (with Shakeel Ahmad, Muhammad Tariq, Touseef Hussain, Hamidullah Elham, Iqbal Haider and Xiangmei Li), Sustainability 12(18):7485, 2020. (JCR: SSCI Q2, IF: 3.889).
- Women Participation: A Productivity Strategy in Rice Production (with Abubakar Rasheed, Gershom Endelani Mwalupaso, Xu Tian and Rafay Waseem), Sustainability 12(7), 2020. (JCR: SSCI Q2, IF: 3.889).
- **Dairy production under climatic risks: perceptions, perceived impacts and Adaptation in Punjab, Pakistan" (with Jiqin Han, Adnan Adeel and Raza Ullah), International Journal of Environmental Research and Public Health 16(20):4036, 2019. (JCR: SSCI Q1, IF: 4.614).**
- Secured Land Rights, Household Welfare and Agriculture Productivity: Evidence from Rural Pakistan" (with Rakhshanda Kousar, Makhodum Sohail Amjad Anjum), Pakistan Journal of Agricultural Sciences. 55(1), 2018. (JCR: SCI Q3, IF: 0.748).
- Household- decisions of time allocation and wage determination in Pakistan" (with Rakhshanda Kousar, Makhodum Sohail Amjad Anjum and Aqeela Saghir.) Pakistan Journal of Agricultural Sciences 55(3), 2017. (JCR: SCI Q3, IF: 0.748, corresponding author).
- Socioeconomic Characteristics and Health Cost of Female Cotton Pickers from Pesticide Exposure in Vehari, Pakistan"(with Khuda Bakhsh, Naeem Ahmad, Sarfraz Hassan, M Asif Kamran, Rashed Saeed and M Sadiq Hashmi), Journal of Bio Med Central (BMC) 16(961), 2016. (IF:4.135).
- Agro-Economic Dimensions of Intercropping in Citrus Farms: The Case of District Toba Tek Singh, Pakistan" (with Adeel Ijaz, Sultan Ali Adil, Sarfraz Hassan, Khuda Bakhsh, Muhammad Khalid Bashir), Pakistan Journal of Agricultural Sciences 51(3):765–769, 2014. (JCR: SCI Q3, IF: 0.748).

Peer-reviewed Chapters and Other Publications

- Fiscal Policy in Agriculture (Book Chapter 34), Developing Sustainable Agriculture in Pakistan (with Tahira Sadaf, M. Ashfaq and Rakhshanda Kousar), Taylor and Francis Group, 2018. (pp. 751-784).
- Introduction to the Economy of Pakistan (Book Chapter 10), Principles of Agricultural and Resource Economics" (with Sofia Anwar and Muhammad Ashfaq), University of Agriculture Faisalabad Press, 2017. (pp. 211-231).

Papers in progress

- An integrated analysis of AI-driven green financing, subsidies, and knowledge to enhance CO_2e reduction efficiency. (with Jafar Hussain and Chein-Chiang Lee), submitted for publication in the Journal of Science of the total environment (STOTEN-D-24-01986) January 2024.
- AI-based green technology innovation simulation for achieving carbon neutrality: Exploring the role of subsidies and knowledge management. (With Jafar Hussain and Zhang Shaohua), submitted for publictaion in *Journal of Computers and Industrial Engineering* (CAIE-D-23-04901) December 2023.

- What determines university student's career choice in developing countries? Empirical evidence from Pakistan. (with Muhammad Waseem, Ihsan Jamil, Abu Hayat Md. Saiful Islam, Ngo Thi Ha) submitted for publication in *Journal of Studies in Higher Education* (SIHE-234701096) December 2023.

Teaching, supervising and other administrative experiences

- **Institute of Agricultural & Resource Economics, University of Agriculture,** **Faisalabad, Pakistan**
  Lecturer, Agri. Economics *November 2012–Ongoing*
- **Supervised More than 20 master's degree students for thesis research** **Faisalabad, Pakistan**
  November 2012–to date
- **Served as Superintendent of Boys hostel for more than 3 years** Faisalabad, Pakistan
  Ayub Hall University of Agriculture, Faisalabad *2012–2015*
- **Coordinator and Admission Focal Person of BS Economics Program** **Faisalabad, Pakistan**
  At Institute of Agricultural & Resource Economics, UAF. *2021–2023*

Grants

- Completed research project as PI (Principal Investigator)/Team leader on "Efficiency and Productivity Analysis of Rice Farming in Pakistan: An Implication for Concerned Stakeholders" funded by Global Food Security Forum for Young Scientist (HZAU China, IFPRI, CIMMYT and IAMO).

Conferences and Workshops:

Participation:

- Participated in the international conference on Global Food Security Forum for Young Scientist held on 29th October 2023 at Huazhong Agriculture University, Wuhan, China, as Discussant in the session "Food and Nutrition Economics".
- Attended the international conference on "Global Food Security Forum for Young Scientist" held on 28-29th October 2023 at HUAZHONG AGRICULTURE UNIVERSITY, WUHAN, CHINA.
- One-Day Symposium "Drivers of Rural Transformation Unveiling Insights and Findings" held on 19th October 2023 at Center for Advanced Studies (CAS) Auditorium, University of Agriculture, Faisalabad, Pakistan.
- Attended International Conference on "Afghanistan Agro-Business Forum" jointly organized by Islamic organization for food security and University of Agriculture, Faisalabad, Pakistan, held on 14-15 September 2023 at University of Agriculture, Faisalabad, Pakistan.
- Completed Training Workshop on "Research Ethics" organized by PERI and UNICEF on 3-5 August 2022, at Lahore, Pakistan.
- Participated in the GCHERA World Agriculture Awards Ceremony and the 10th GCHERA World Congress held at Nanjing Agricultural University in Nanjing, China. November 7, 2019.
- Agricultural education and technology extension training course under the Belt and Road Initiative, Nanjing Agricultural University, Nanjing, China. May 16, 2019.
- Training course on "Young Teachers Capacity Sharing Programme" organized by the Academic Department of Agricultural University, Faisalabad. October 15-20, 2015.
- 20 August 2021, participated in the webinar on issues related to the rural economy "Cooperative approaches in rural development: a case study of women's cooperatives in Bursa, Turkey

Presentations:

- Presented Research Paper " Efficiency and productivity analysis of rice farming in Pakistan: An implication for concerned stakeholders." In International conference on Global Food Security Forum for Young Scientist held on 28-29th October 2023 at HUAZHONG AGRICULTURE UNIVERSITY, WUHAN, CHINA.
- Presented Research Paper "Impact of research and Development on the Sectoral Performance of

Pakistan" in international conference on Food Security and Value chain Improvement under Belt and Road Initiative held on 6-7 December 2022 at Mian Nawaz Sharif University of Agriculture, Multan, Pakistan.

- Presented Research Paper "Climatic Variation and Cereal Productivity in Punjab, Pakistan" in international conference on Climate Change: Impacts & Solutions, held on 7-9 November 2022 at University of Agriculture, Faisalabad. (ISBN:978-969-8237-94-3).

Refereeing activity (in alphabetical order):

- PLOS ONE, Environmental and Resource Economics, Environmental Science and Pollution Research, Land Use Policy, Frontiers in Environmental Science, Sustainability, Pakistan Journal of Agricultural Sciences and Anonymous reviewers for other journals

Computer and Programming Skills:

- Computational and Spatial Analysis Packages:R, Eviews, SPSS, Stata, DEAP.
- Compilation and other packages: LaTeX, Excel, Word, PowerPoint, Internet and email browsers;

Language Skills:

- Urdu (mother tongue); English (fluent); Chinese (basic).

References

- Jiqin Han, Professor at NJAU, Nanjing (China).
  Email: jhan@njau.edu.cn Role: Research supervisor and PhD examiner.
- Khalid Mushtaq, Professor at IARE University of Agriculture, Faisalabad, Pakistan.
  Email: khalidmushtaq@uaf.edu.pk Role: Dean Faculty of Social Sciences (Immediate Boss).
- Khuda Bakhsh, Professor and Head of Department, at Department of Economics
  COMSATS University Islamabad, Vehari Campus, Pakistan. Email: kbakhsh@ciitvehari.edu.pk
  Role: Senior Colleague

Serial No: 002079

Registration No: 2004-GI-80 Roll No: 39033

BAHAUDDIN ZAKARIYA UNIVERSITY MULTAN-PAKISTAN

SESSION 2007

THIS IS TO CERTIFY THAT

QASIR ABBAS

Son of **FIDA HUSSAIN SABIR**

of GOVERNMENT COLLEGE VEHARI (LATE COLLEGE STUDENT)

has passed the 1st *Annual Examination* of the academic session held in May - June ,2007 securing 447 /800 marks and has been placed in SECOND Division.

Having fulfilled the requirements he has been admitted to the degree of

BACHELOR OF SCIENCE

in this University.

The examination was taken by parts

Controller of Examinations

Chancellor

Multan.

رجسٹریشن نمبر
Registration Number

2007-ude-26

University of the Punjab

رول نمبر
Roll Number

M59

جامعہ پنجاب

This university hereby confers upon

Qasir Abbas

son of Fida Hussain Sabir

of the Department of Economics,
University of the Punjab, Lahore

the degree of

Master of Science
Economics

together with all the rights, privileges and honours belonging to this degree.

Session 2007-2009

C.G.P.A. 3.33

یہ جامعہ

قیصر عباس

بن فدا حسین صابر

از شعبہ معاشیات۔
پنجاب یونیورسٹی۔ لاہور

کو

ایم۔ایس سی
معاشیات

کی سند عطا کرتی ہے مع تمام حقوق، امتیازات اور اعزازات جو اس سند کے ساتھ وابستہ ہیں۔

دورانیہ ۲۰۰۷-۲۰۰۹ء

سی۔جی۔پی۔اے۔ ۳۳ء۳

Chancellor چانسلر

Controller of Examinations کنٹرولر امتحانات

Lahore : Pakistan 29 JUN 2011

لاہور: پاکستان

000059

MSS 13695

Serial no.: SLASS/2012/M-0042

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Transcript

School of Liberal Arts & Social Sciences

Department of Economics — **M. Phil in Development Economics and Public Policy**

Student I.D #:	4849	**Registration No:**	F2010-491
Student's Name:	Qasir Abbas	**Date of Issuance:**	December 03, 2012
Parent Name:	Fida Hussain Sabir	**Required Cr.Hrs.:**	36

Semester: I **Exam Session:** F2010 **Academic Year :** 2010-2011

Course Code	Course Title	Credits	Grade
EC-501	Advanced Microeconomics	3	B
EC-502	Advanced Macroeconomics	3	A-
EC-504	Issues in Pakistan Economy	3	B
EC508	New Institutional Economics	3	B

SGPA:	3.17	Credit Hrs. Earned:	12	CGPA:	3.17

Semester: II **Exam Session:** S2011 **Academic Year :** 2010-2011

Course Code	Course Title	Credits	Grade
EC-503	Advanced Econometrics	3	A
EC-507	Public Economics	3	C-
EC-510	Advance Development Economics & Policy	3	B+
EC-512	Trade and Industrial Policy	3	C+

SGPA:	2.83	Credit Hrs. Earned:	24	CGPA:	3.00

Semester: III **Exam Session:** F2011 **Academic Year :** 2011-2012

Course Code	Course Title	Credits	Grade
EC-525	Research Workshop	6	A-

SGPA:	3.67	Credit Hrs. Earned:	30	CGPA:	3.13

Semester: IV **Exam Session:** S2012 **Academic Year :** 2011-2012

Course Code	Course Title	Credits	Grade
EC-528	Thesis	6	A-

SGPA:	3.67	Credit Hrs. Earned:	36	CGPA:	3.22

N. Lodhi
Controller Examinations

Dean

Registrar

Serial No: SLASS/2012/M-0042
Reg. No: F2010-491

BNU

Beaconhouse National University
Lahore

By virtue of the power granted to it by its Charter and upon the recommendations of the Faculty

Qasir Abbas

has been admitted to the degree of

M. Phil in Development Economics and Public Policy

2010-12

with all the honours and privileges pertaining to this degree

Given at Lahore, Pakistan, this Eighth day of December in the year Two Thousand Twelve

Registrar

Beaconhouse National University LAHORE

Vice Chancellor

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南京農業大學
NANJING AGRICULTURAL UNIVERSITY

Nanjing Agricultural University
Transcript of Graduate Student

Degree: Doctor

Name	ABBAS QASIR	Student ID		2017206030
Department (Institute)	College of Economics and Management	Major		Agricultural Economic Management
Total Credits Required	26	Credits Completed		28
Course category	**Course**	**Credits**	**Scores**	**Credit Completed**
Required Course	Microdevelopment Economics	2	75	2017-2018 first semester
Required Course	Price Conduction and Market Integration--Application Analysis of Time Series	2	77	2017-2018 first semester
Elective Course	Agricultural Market Research and Analysis	3	85	2017-2018 first semester
Elective Course	Studies on History of Science and Technology	3	80	2017-2018 first semester
Required Course	Advanced Microeconomics	2	72	2017-2018 first semester
Elective Course	Advances in Processing and Storage Technology of Agricultural Products	2	88	2017-2018 first semester
Required Course	Agricultural Economics Theory and Policy	2	78	2017-2018 first semester
Elective Course	Chinese Language and Culture	2	73	2017-2018 first semester
Required Course	Quantitative Economic Analysis	2	80	2017-2018 second semester
Elective Course	Agrifood Supply Chain and Quality Management	2	86	2017-2018 second semester
Required Course	Applied Economics Research Methodology	2	60	2017-2018 second semester
Required Course	Advanced Econometrics	2	90	2017-2018 second semester
Required Course	Introduction to Chinese Agriculture	2	92	2017-2018 second semester

南京农业大学研究生院 NanJing Agricultural University 证明专用章

The Degree Awarding Committee, in accordance with "The Regulations Concerning Academic Degrees in the People's Republic of China", has conferred upon

QASIR ABBAS

2017206030

the degree of

DOCTOR OF Philosophy

Agricultural Economics and Management

with all its rights, privileges and honors

given at Nanjing, China,

on the 24 day of September,

in the year of 2021

Chen Fadi

President, Nanjing Agricultural University

Chairman, Degree Awarding Committee

No. 1030722021002798

Publications List

[1] "Estimating Impact of Climate Change Adaptation on Productivity and Earnings of Dairy Farmers; Evidence from Pakistani Punjab" (2023). (with Jiqin Han, Khuda Bakhsh and Rakhshanda Kousar), *Environment Development and Sustainability*, **2023**. **(**JCR: SCI Q1, IF:4.9**).**

[2] Do crop diversity and livestock production improve smallholder intra-household dietary diversity, nutrition, and sustainable food production? Empirical evidence from Pakistan" (2023) (with Muhammad Waseem, Xiaoyun Li, Ihsan Jamil, Abu Hayat Md. Saiful Islam, Muhaamd Hasseb Raza, and Moataz Eliw), *Frontiers in Sustainable Food Systems*, 2023, **(**JCR: SCI Q1, IF:4.7**).**

[3] **"**Exploring the Multi-Dimensional Factors Influencing Food Security: A Case Study of District Nowshera, Pakistan" (with Muhammad Hassan Safdar and Najaf Hussain), *Journal of Development and Social Sciences*, 2023. (HEC W Category).

[4] "Income and Yield Effects of Climate-Smart Agriculture (CSA) Adoption in Flood Prone Areas of Bangladesh: Farm Level Evidence" (with Asma Akter, Xianhui Geng, Gershom Endelani Mwalupaso, Hua Lu, Fazlul Hoque and Michael Kiraru Ndungu), *Climate Risk Management*, 2022. **(**JCR: SCI Q1, IF:5.266**)**

[5] "Adaptation to Climate Change Risks Among Dairy Farmers in Punjab, Pakistan" (with Jiqin Han, Khuda Bakhsh, Raza Ullah, Rakhshanda Kousar, Adnan Adeel and Asma Akter), *Land Use Policy* 119:106184, 2022. (JCR: SCI Q1, IF: 6.189**)**

[6] "Investigating the nexus among sulfur dioxide emission, energy consumption, and economic growth: empirical evidence from Pakistan" (with Khuda Bakhsh, Tanzila Akmal and Tauqeer Ahmad), Environmental Science and Pollution Research 29:7214-7224, 2021.
(JCR: SCI Q2, IF: 5.190, *corresponding author*).

[7] "Cotton Production for the Sustainable Livelihoods in Punjab Pakistan: A case Study of District Muzaffargarh" (with Tahir Sadaf, Rakhshanda Kousar, Zia Mohy Ul Din, Muhammad Sohail Amjad and Javeria Nasir), International Journal of Ethics and System 38(2): 191-208, 2021. (JCR: SCI Q2, IF: 1.048)

[8] "Does Chinese FDI, Climate Change, and CO_2 Emissions Stimulate Agricultural Productivity? Empirical Evidence from Pakistan"(with Shakeel Ahmad, Muhammad Tariq, Touseef Hussain, Hamidullah Elham, Iqbal Haider and Xiangmei Li), Sustainability 12(18):7485, 2020. (JCR: SSCI Q2,

IF: 3.889)

[9] "Women Participation: A Productivity Strategy in Rice Production" (with Abubakar Rasheed, Gershom Endelani Mwalupaso, Xu Tian and Rafay Waseem), Sustainability 12(7), 2020. (JCR: SSCI Q2, IF: 3.889)

[10] "Dairy production under climatic risks: perceptions, perceived impacts and Adaptation in Punjab, Pakistan" (with Jiqin Han, Adnan Adeel and Raza Ullah), International Journal of Environmental Research and Public Health 16(20):4036, 2019. (JCR: SSCI Q1, IF: 4.614)

[11] "Secured Land Rights, Household Welfare and Agriculture Productivity: Evidence from Rural Pakistan" (with Rakhshanda Kousar, Makhodum Sohail Amjad Anjum), *Pakistan Journal of Agricultural Sciences.* 55(1), 2018. (JCR: SCI Q3, IF: 0.748)

[12] "Fiscal Policy in Agriculture (Book Chapter 34), Developing Sustainable Agriculture in Pakistan" (with Tahira Sadaf, M. Ashfaq and Rakhshanda Kousar), Taylor and Francis Group, 2018. (pp. 751-784).

[13] "Household- decisions of time allocation and wage determination in Pakistan" (with Rakhshanda Kousar, Makhodum Sohail Amjad Anjum and Aqeela Saghir.) *Pakistan Journal of Agricultural Sciences* 55(3), 2017. (JCR: SCI Q3, IF: 0.748, *corresponding author*)

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Estimating impact of climate change adaptation on productivity and earnings of dairy farmers: evidence from Pakistani Punjab

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Abstract
Dairy farming is highly vulnerable to climate change in Pakistan; therefore, productivity and earnings of small dairy farmers are at a higher risk. Dairy farmers can reduce the determintal impacts of climate change on productivity and earnings by adaptation to climate change. It is thus critical to understand the adaptation to climate change among dariy farmers and consequent impacts on productivity and earnings. Using cross-sectional data of 450 dairy farmers from three different agroecological zones of Punjab, Pakistan, study has employed the logistic regression to determine determinants of adaptation and to analyze the adaptation impact on farm productivity and on earnings of the farmers. Educated and large farm size farmers are highly probable to adopting more adaptation measures compared to their counterparts. Estimates of PSM reveal that milk productivity and earings of adapters are higher than non-adapters. Regular vaccination found to be the most widely adopted strategy, which provides greater returns in terms of sustained milk prodction and improved dairy income. The research makes significant recommendations for adapting policies to climate change in dairy farming for improving well-being of rural households.

Keywords Climate change · Adaptation · Dairy productivity · Farm household income · Propensity score matching · Rural Pakistan

1 Introduction

Climate change is threatening the world, and it is renowned as a universal phenomenon with possible widespread consequences (IPCC, 2014; Stern et al., 2006) and coupled with more recurrent extreme climatic events (Imran et al., 2020). The climatic changes are

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expected to have the greatest impact on resource poor farmers who live in rural and remote areas of developing countries (Shrestha & Baral, 2018), even though these countries account for only 10% of global CO_2 emissions (Maskrey et al., 2007). The main reason lies in the fact that the huge population remains largely reliant on the rural economy, which is based upon agriculture. This puts serious pressure on society, economy, and ecosystems (Ali & Erenstein, 2017; Mirza, 2011). Due to geographical challenges, lack of resources, and larger dependence on climate-sensitive earning means, the poorest people of the region will be hardly hit by the climate changes particularly in South Asia (WB, 2009). Recent regional catastrophes (for example, severe floods in Pakistan and India) have been directly connected to climate change and have the ability to push the poor into extreme poverty (Rahman et al., 2019).

Numerous climate-sensitive sectors, such as agriculture, and its associated sectors livestock are vulnerable to the impacts of climate change (Abid et al., 2020). The problems pertaining to agricultural productivity and the survival of rural regions are climate change-related extreme events, affecting about 2.5 billion individuals who earn their livelihood from agriculture overall and dairy sector in particular. Reducing the adverse impacts of climate change on dairy productivity can be achieved through the implementation of adaptive measures, which are widely recognized as a crucial component of any comprehensive policy approach to address climate change (Chrobak, 2020; Janetos, 2020). Several studies show that climate change usually affects agriculture and the dairy industry in particular due to lack of adaptation measures. Adaptation strategies can partially offset the negative impacts on dairy productivity (Abbas et al., 2019; Alam et al., 2017; Ali & Erenstein, 2017; Amamou et al., 2018; Bakhsh & Kamran, 2019). The ability of farmers to adapt to climate change will determine how it affects the agriculture and dairy sectors (Abid et al., 2016a).

Within the given context of dairy production, adaptation strategies to climate change encompass several measures, including micro-level choices such as feeding, health care, breeding and shelter management (Amamou et al., 2018; Mahajan et al., 2015; Qureshi, 2012), (b) some long-term adaptations; regular vaccination, selling of weak/diseased animals, changes in cropping pattern for fodder production, diversification of farm through off-farm income activities and migration (Ali, 2018; Oenema et al., 2011; Tiyumtaba, 2016), (c) institutional changes, particularly government reactions such as subsidies/taxes and improving livestock markets (Cimato & Mullan, 2010; Parry, 2016) and (d) technological advancements, such as the creation and dissemination of new techniques for converting traditional farming into advanced and commercialized farming, etc. (Akbar et al., 2020; Paas et al., 2016; Sirohi et al., 2010; Zhu et al., 2011). However, adaptation measures are very specialized and cannot be simply adapted to other localities or farming systems.

1.1 Pakistan dairy sector and climatic challenges

More than 60% population of Pakistan lived in rural areas, and primary source of income is farming and related activities (GOP, 2019). Livestock is one of the leading subsectors of agriculture sector, which contributes about 60.56% in agricultural GDP and 11.69% in national GDP with 2.58% growth rate. More than 8 million families are involved in rearing animals to earn their livelihood in rural areas of Pakistan (GOP, 2017, 2019).

In this perspective, dairy sector is critical for ensuring small and marginal farmers' livelihood, food security, and poverty alleviation. However, increased variability in the weather and changing climates put the sector at danger, and as a result it becomes a major

constraint in achieving Pakistan's potential milk production. The increase in temperature and other extreme events affect performance of dairy sector through the impacts on health of dairy cattle, production of fodder and shortage of water for livestock and crop production. Climate change increases vulnerability of semiarid and dry lands in resources-poor parts of Pakistan such as Sindh, Baluchistan, and rainfed zones of Punjab due to decrease in rainfall amount, increase in evapotranspiration, and drought span.

A number of studies in Pakistan have shown that milking animals and certain agricultural crops exhibit vulnerability to heat stress and rising temperatures. For instance, an increasing temperature would cause milk output to drop by 10–20% (Abbas et al., 2019). Similarly, some other studies show that climatic changing conditions have severely affected the livestock production system, i.e., heat stress and increasing temperature lower milk yield and feed intake, which ultimately reduce the weight of animals and animals become victims of the diseases (Rahman et al., 2019; Younas et al., 2012). Series of floods from 2010 to onward rigorously damaged livestock sector. In the last two decades, extreme weather occurrences have become more common, frequent and intense in Pakistan. About 40% population is greatly prone to multiple frequent extreme events (Hussain et al., 2010; McElhinney, 2011). The livestock sector incurred an approximate loss of US$600 million only due to the 2010 flood (FAO, 2012). Drought is another climatic risk for livestock sector posing much larger effects on dairy farming than other climate extreme events to spatial areas (Durrani et al., 2021; Hewitt, 2014; Obasi, 1994). The severe spell of drought in different parts of Pakistan from 1996 to 2004 affected more than 23 million animals and about 5.12 millions were from Punjab, while Baluchistan province was severely hit (Shafiq & Kakar, 2007). A 20–30% decline in livestock output is anticipated in future as a result of prolonged rising temperatures and other climate dangers, resulting in a crisis in the dairy industry and higher product costs that are out of reach for the common Pakistani (GOP, 2018).

Farmers use a variety of adaptation strategies in dairy farming. Adaptation strategies like regular vaccination, selling of animals, changes in cropping pattern for fodder production (e.g., more stress/drought resilient varieties, or growing short duration variety of fodder) could significantly decrease the climate change vulnerability (Ali, 2018; Shahbaz et al., 2020; Sirohi et al., 2010). Insurance, diversification of farm through off-farm income activities and migration are other adaptation measures (in drought and flood conditions) (Alam et al., 2017; de Vries, 2019; Esiobu & Onubuogu, 2014). Along this, farmers also tend to adapt some short-term measures such as feeding and breeding practices and healthcare coping measures for animals so that the undesirable effects of climatic risks can be mitigated to sustain farm production and livelihood (Parameswaranaik et al., 2017; Uma et al., 2017). The majority of the research on adaptation to climate change in the dairy farming has been done in either developed or emergent African countries. However, there is a scarcity of adaptation literature from South Asian countries, particularly Pakistan, where a few studies exist (Abbas et al., 2019, 2022; Shahbaz et al., 2020). Most adaptation studies have concentrated on farmers' experience by changing climatic conditions, adaptation methods, and their determinants, as well as, defining specific constraints for various regions and socioeconomic settings. Only one study (Ali, 2018) has looked at this issue at the farm level in dairy farming, so, there are few empirical evaluations of the effectiveness of adaptation efforts. More research aimed at economic evaluation of current adaptation processes will then demonstrate the magnitude of the gains and recommend policies for measures to expedite local adaptations (Shahbaz et al., 2020). This research aims to fill the gap by investigating dairy farmers' adaptability to climate risks and their effects on dairy farm productivity and

income. This article specifically addresses a number of research questions. First and the foremost, how do dairy farmers deal with climate change? Second, how does adaptation practices differ among the small, medium and large farmers? And the last but not the least, how does adaptation to climatic risks impact farm productivity and income of dairy farmers?

The paper is structured into distinct sections, namely the conceptual framework, study region, sampling procedure, data collection, and analytical strategies employing an empirical model, all of which are encompassed within Sect. 2. Section 3 of the paper presents the data analysis, results, and discussion, while Sect. 4 is dedicated to the final remarks.

2 Material and methods

2.1 Study area and data collection

Pakistan is a low-carbon producing (0.2 million metric tons) country, but it is considered as the most devastated country that severely hit by climate change and its reaction to the problem is still insignificant (Chaudhry, 2017; Smadja et al., 2015). Due to adverse climatic conditions, Pakistan is forced to pay significant economic consequences, such as the loss of property and infrastructure, a decline in agricultural output, and the high costs of reconstruction and rehabilitation in disaster-affected areas (Dorosh et al., 2010; Rahman et al., 2017).

The research was carried out in the Punjab province due to its significance. It is the largest province according to human population, i.e., more than 110 millions-53% of total country's population and having the largest number of dairy animals (cattle and buffalos-13.2 million cattles) and 16 million buffalaos (40% of Pakistan). It contributes about 67% of total milk production in the country (PDS, 2019). Punjab comprises of four agroecological zones; Irrigated fields, Barani area, Thal region and Marginal lands. Due to a budget constraint, we studied only three zones except the Thal region. Each selected agroecological zone exhibits distinct climatic, environmental, and geographical characteristics, with varying environmental and socioeconomic limitations. Figure 1 illustrates a map of the research area located within the Punjab province.

From three distinct agroecological regions within Punjab, 450 dairy producers were interviewed by using multistage-sampling technique in December 2019. The Punjab province was selected as the primary research location for the initial stage. Three agroecological zones were selected during the second stage. These zones inluded irrigated, marginal land and the arid-zone or the Barani areas. In next step, three sample districts from three agroecological zones were chosen at random; Jhang (the irrigeated plains), Muzaffar Garh (marginal land) and Jhelum (the Barani or rainfed zone). During the fourth stage, two tehsils from each district were randomly selected. In the fifth phase of the study, three rural union councils (UCs) were chosen from each tehsil using stratified random sampling. In the sixth step, two villages from each UC were chosen through simple random sampling. In total, we surveyed 36 villages across the study region. In the final stage, we selected 12–13 farmers from each village based on the list provided by the revenue department, which contained information about dairy farmers. Farmers information regarding socioeconomic factors, adapting strategies, and access to several institutional supports were all gathered through in-person interviews with the farmers.

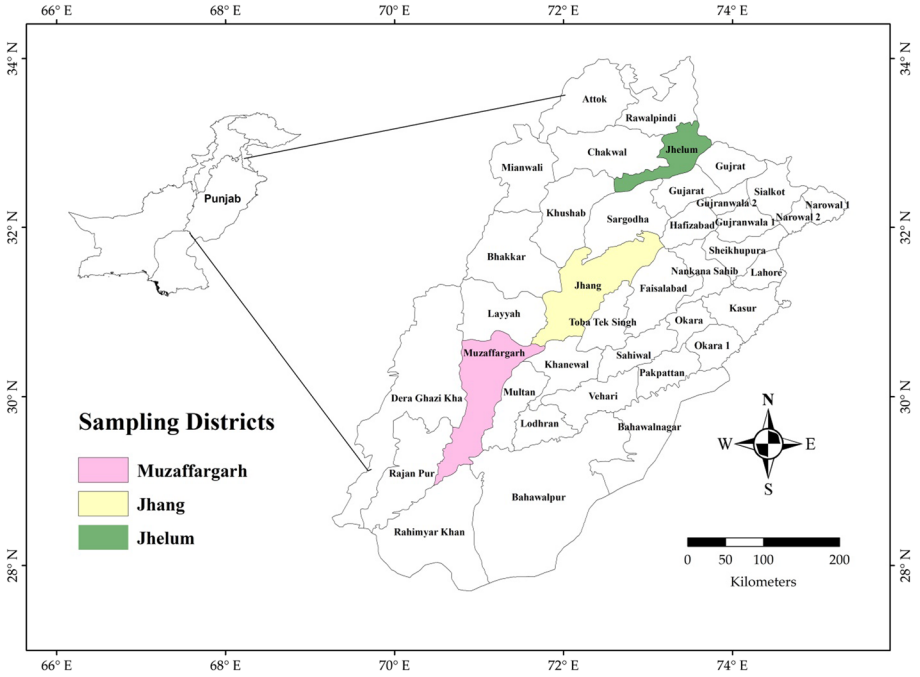


Fig. 1 Study area of sampled districts

2.2 Conceptual framework

The conceptual framework for this study based on the vulnerability of farms to climate change, with potential implications for farm productivity and the income of farm households (see Fig. 2). In the past 10 to 20 years or more, climate change has been considered as the perceived or observed changes in local environments in terms of extreme climate

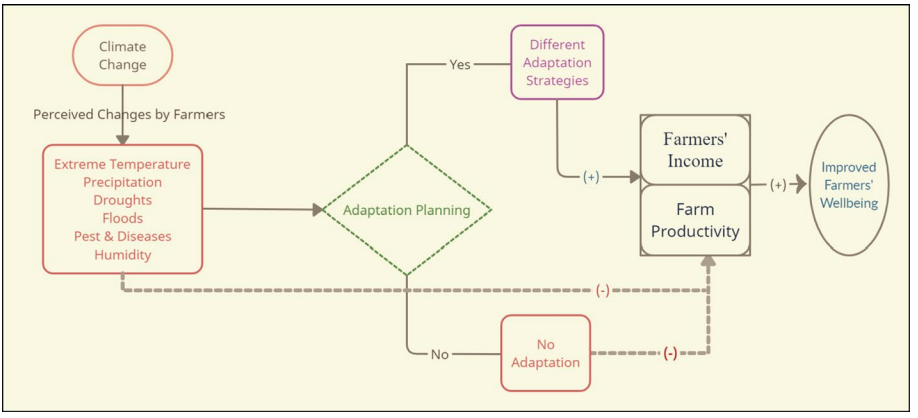


Fig. 2 Conceptual framework showing interactions among climate change, adaptation and farmers' well-being

events, like extreme temperatures, uncertain precipitation, floods and droughts (Call et al., 2019). Climate change has the potential to adversely affect the livelihoods of farmers, either directly or indirectly, by reducing milk yields and thus reducing production and income at farm level (Abbas et al., 2019; Ali, 2018). Here, farm production mainly refers to milk yield as milk has become the number one farm commodity in terms of contributing to national GDP of Pakistan. Climate change's negative impact on milk productivity may have direct consequences for rural livelihood by limiting milk productivity. However, by timely managing their dairy farms, producers can lessen the effects of climate change. Certain farm-level adaptations may help farmers not only reduce potential climate change losses, but also boost milk productivity and net income. In the end, improved milk yield and income can enhance farm production and thus improve farmers' well-being. On the other hand, non-adaptation could potentially have a negative effect on farm (milk) productivity and the welfare of farmers.

2.3 Analytical framework

2.3.1 Adaptation decision

The research at hand addresses climate change adaptation as an instrument for minimizing losses. caused by changes in several climatic parameters like temperature, precipitation, flood, drought, pests and diseases and humidity. If a farmer implements certain adaptation measures, he/she will be classified as an adapter; if he does not, he will be considered as a non-adapter. We followed Kato et al., (2011), who employed decision modeling for dairy farmers' adaptative behavior by using random utility framework. It is assumed in the model that farmer will only adapt the meausers/strategies to climatic risks if he/she expects the positive outcomes from adaptation (Abid et al., 2015). Reduced farm productivity losses or increased farmer well-being are the possible adaptation benefits. A latent variable (U_i*) could be used to represent the difference in net benefits:

$$U_i^* = X_{\mathrm{ik}}\beta + \mu_i \tag{1}$$

In this context, "X_{ik}" represents the set of explanatory variables, whereas "β" represents the set of coefficients used in logistic regression while μ_i indicate error term. U_i* is latent variable that is unobservable, and thus we have:

$$U_i = \begin{cases} 1 \; if \; U_i^* > 0 \\ 0 \; if \; U_i^* \leq 0 \end{cases} \tag{2}$$

"For the i-th farmer, U_i indicates their willingness to adapt to climate change ($U_i = 1$) contingent upon the anticipation of favorable net benefits resulting from adaptation ($U_i > 0$)." In contrary to this, the farmer may not adapt ($U_i = 0$) if net benefits would not be positive ($U_i \leq 0$).

Effective adaptation to climate change can improve farmers' well-being by increasing dairy farm productivity and household earnings. Distinguishing between the well-being of those who adapt and those who do not could be difficult. When randomization is used to collect experimental data and the control group is described in detail, it is easier to distinguish between adapters and non-adapters (Abid et al., 2016b). In situations where counterfactual data are not available, the direct impacts of adaptation can be assessed by comparing the results of individuals who adapt and those who do not, using cross-sectional

data, as conducted in this research. However, such results could be inacurate and biased. When evaluating the impact of adaptation on farm productivity and revenue, it is essential to address the issue of self-selection bias. The relationship between outcome and adaption factors can be described by the ordinary least square (OLS) equation to illustrate the effect of self-selection bias: Y_{ij}

$$Y_{ij} = \gamma X_{ik} + \delta U_i + \varepsilon_i \tag{3}$$

where Y_{ij} is representing the outcome variables that are farm productivity (milk) and farmer income whereas ε_i is indicating error term. Just as in Eq. 1, where X_{ik} represents all explanatory variables, γ and δ are both coefficients in the regression model. The decision to adapt (U_i), assumed to be independent in the previous Eq. (3), may potentially be influenced by unobservable factors such as the farmer's knowledge, perception, education, and farm size. These attributes have already been considered in the error component (ε) of Eq. (3). In other words, Eq. (3) 's error term (ε_i) can be correlated to Eq. (1)'s error term (μ_i) and this selection distortion can produce biased estimates (Thoemmes, 2012). The literature demonstrates a variety of strategies for overcoming this selection bias. The Heckman two-step technique has been utilized in several research studies which presumes that unobservable variables are normally distributed. The other method is instrumental variable (IV). Generally, this method uses at least one variable as an instrument variable from treatment equation to define the outcome equation. Thus, it is difficult to figure out which instruments are valid for various empirical studies (Heckman et al., 1998). In addition, the control variable's coefficients are the same in the treatment and control groups since the OLS and IV approaches force the model into a linear functional form.

Propensity score matching (PSM) is a commonly employed method for mitigating the problem of selection bias. The PSM approach assesses the similarities in observable characteristics between the treatment group (adapters) and the control group (non-adapters) (Dehejia & Wahba, 2002). In comparison to OLS and instrumental variable IV methods, the PSM methodology provides a greater degree of flexibility by reducing constraints related to functional form, the assumption of normal distribution for unobserved covariates, and the identification of instrumental factors in determining the outcome equation. The ability to match and detect treatment-related effects on an outcome variable involves a set of observable variables (Heckman & Vytlacil, 2007). On the other hand, PSM assumes that the selection process is influenced by observable variables, and it does not take into consideration unobservable elements directly. When instruments are weak or unavailable, PSM may be a better option (Ali & Abdulai, 2010). So the present study employs PSM method.

According to Rosenbaum and Rubin (1983), given the characteristics of pre-adaptation, PSM represents the conditional probability that a farmer will adapt to climate change. PSM pairs individuals who have adapted with those who have not adapted based on the estimated probabilities of climate change adaptation (p-score), relying on the conditional independence assumption, as if it were a randomized trial (Kassie et al., 2011; Thoemmes, 2012). Climate change adaptation becomes random and unrelated to outcome variables once that assumption has been established or X has been controlled for all unobserved variables.

$$p\left(X_{ik}\right) = \Pr\left[Ui = 1 \middle| X_{ik}\right] \tag{4}$$

"Here, 'p' represents the propensity scores derived from pre-adaptation factors (Xik), 'Pr' stands for probability, and 'U_i' represents climate change adaptation. The conditional distribution is identical to Xik for both adapters and non-adapters (Thoemmes, 2012).

PSM can be summarized as a five-step process. Based on theoretical assumptions, the first stage is to identify a group of pre-test covariates. In second step, propensity values (p-values) are estimated by logistic regression such that outcome variable is regressed against the selected variables (Ali, 2018). In the third step, the nearest neighbor method (NNM) is used to perform a matching procedure (Abid et al., 2016a, 2016b). The fourth step involves calculating adaptation's causal effects on outcome variables. During the fifth and final phase, matched data are subjected to a sensitivity analysis to ensure that the results are satisfactory.

Both the average treatment effect and the average treatment effect on the treated and treatment, both showing the influence of adaptation to climate change on the outcome variable, can be used to describe the role that adaptation performs with regard to the outcome. However, the term ATT refers to only those who have been treated, for all parcipants which are matched adapters and non-adapters ATE is supposed to be the influence of climate change adaptation on outcome variables, i.e., productivity and income. Following Abid et al. (2016a, 2016b), adaption's impact on outcome variables can be represented as follows:

$$\tau U_{i=1} = E(\tau \left| U_i = 1 \right.) = E(Y_1 \left| U_i = 1 \right.) - (Y_0 \left| U_i = 0 \right.) \tag{5}$$

here τ is representing the average treatment effect (ATE) for all farmers and Y_1 and Y_0 showing the adapters and non-adapters outcome variable values, respectively. As we mentioned earlier that $E(\tau|_i = 1)$ cannot be estimated directly but we have to estimate the difference $[\tau^e = E(Y_1|_i = 1) - (Y_0|_i = 0)]$, and it is a bias estimator. Study employed the propensity score model to treat this biased selection (Dehejia & Wahba, 2002).

Our focus here lies on the average treatment effect on the treated (ATT), which can be computed after estimating the propensity scores:

$$T = E\{Y_1 - Y_0 | U_i = 1\} = E[E\{Y_1 - Y_0 | U_i = 1, P(X)\}] = E[E\{Y_1 | U_i = 1, P(X)\} - E\{Y_0 | U_i = 0, P(X)\} | U_i = o] \tag{6}$$

Here ATT is represented by T while the propensity scores are indicated by P(X) as already explained in Eq. (4). The research utilized the nearest neighborhood method (NNM), which is considered the most effective approach for selecting individual cases from the groups of adapters and non-adapters based on their proximity to one another as suitable matching partners. Propensity scores are used to determine the degree of closeness. The NNM approach balances adapters and non-adapters, excluding cases that are not matched from both categories (Smith & Todd, 2005).

3 Results and discussion

3.1 Descriptive statistics of farmers and farm characteristics

Table 1 summarizes the variables employed in the analysis. The distinction between adapters and non-adapters highlights the significance of these aspects in understanding climate change adaptation.

Adapters had significantly higher milk yields and dairy income (generated by milk production in a year) than non-adapters. Similarly, adapters are better than non-adapters in terms of education, dairy animals (including adult cows and buffalos at farm) and in expereinced farming also. Similar findings have been seen in other investigations by (Abid

Table 1 Descriptive statistics of dairy farm adapters and non-adapters

Variables	Adapters	Non-adapters	Difference*
Milk yield (liters/day)	13.08	11.00	2.08***
Dairy income (PKR)	82,229.20	77,371.00	4858.10**
Education of farmer (years)	7.53	6.35	1.18*
Farming experience (years)	24.30	19.50	4.80**
Family size (Number of heads)	8.80	8.40	0.40
Farm Size (ha)	4.04	2.41	1.63*
Number of dairy animals at farm	11.30	7.90	3.40*
Access to extension/veterinary services (1 if farmer had access, 0 otherwise)	0.60	0.50	0.10
Access to climatic information (1 if farmer had access, 0 otherwise)	0.73	0.35	0.38**
Access to credit facilities (1 if farmer had access, 0 otherwise)	0.38	0.40	−0.02

Averages of adapters and non-adapters are subtracted to determine the difference

*$P<0.10$, **$P<0.05$, ***$P<0.01$

et al., 2016a, 2016b; Ali, 2018; Yesuf et al., 2008), When compared to farmers with less education and experience, it is evident that more educated and experienced farmers exhibit a greater degree of adaptability. The famers with higher education and greater experience may be more aware and knowledgeable of ongoing environmental changes than the less educated and experienced farmers and thus adapt to climate change more. In comparison with non-adapters, it is apparent that adapters possess better farms and enjoy improved access to institutional services, such as extension services and climate information. These findings support the idea that access to institutional services can play a crucial role in helping farmers to make wiser adaptation choice. These results align with the findings of Bakhsh and Kamran (2019) as well as Arunrat et al. (2017).

3.2 Farmers' perception and adaptation to climatic risks

To ascertain farmers' perceptions of climate change and the procedures they employ at the farm level for adaptation, we conducted a combined evaluation of farmer perceptions, as well as planned and actual climate adaptation actions, across three study districts (Fig. 3).

Farmers' responses diminish considerably as they transfer their attention from perception to planning and actual adaption. In the past decade, a majority of farmers, specifically 85%, have observed changes in the climate. Furthermore, although 73% of farmers have planned adaptation strategies in response to recognized climatic changes, only 46% have actually implemented such steps in dairy production. All three districts are experiencing the same pattern. Internal or external restrictions limiting the climate change adaptation in the studied areas may contribute to differences in perspectives, plans, and actual adaption.

Farmers adopted several measures in the presence of adverse effects of climatic risks in the above mentioned three districts (Fig. 4). Generally, the most adopted strategies are regular vaccination, selling of weak/diseased animals, changing cropping pattern for fodder production, diversifying farm through off-farm income activities and migration. As was said earlier, most adapters sell weak/diseased animals particularly in flood and drought conditions and try to reduce their herd size so that they can easily manage their farms and

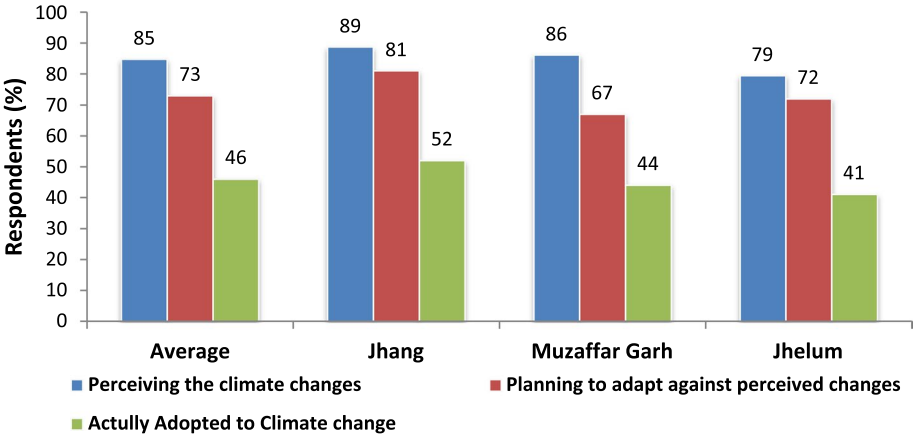


Fig. 3 Perceptions, planning and actual adaptation among dairy farmers

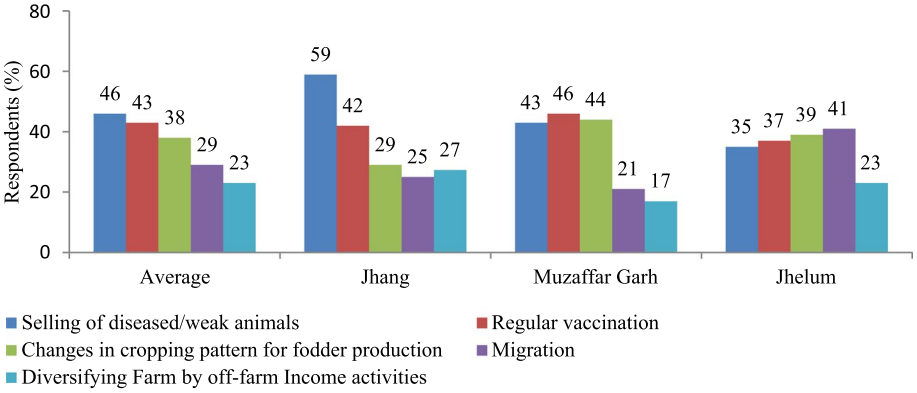


Fig. 4 Adaptation measures adopted by dairy farmers. Note: sum exceeds 100 as a result of simultaneous adoption of several adaptive measures

properly feed the milking animals to ensure livelihood. For example, farmers from the Barani region employ this technique more frequently because of their higher dependency on rainfall and are severely affected by these extreme events.

Further, regular vaccination is the most widely used measure to protect dairy animals from heat stress, viral diseases and some infectious diseases during floods and droughts. Farmers implement adaptation strategies differently in response to locally specific requirements and climatic concerns. For instance, in Muzaffargarh, dairy farmers primarily rely on regular vaccination as their primary adaptation measure as it is the most flood prone area and farmers make efforts to save their animals from extreme climatic events while primary adaptation measure taken by farmers in Jhang district is the selling of diseased/weak animals. These findings are consistent with the outcomes of other research studies like (Bakhsh & Kamran, 2019; Shahbaz et al., 2020; Ul-Haq et al., 2016). The Barani region of Pakistan is grappling with increasing water scarcity, especially in rainfed areas like Jhelum and semiarid regions like Jhang, due to ongoing climate change. Similarly, (Ali, 2018) also observed a shift in cropping pattern in irrigated

regions because of climate change. Overall, migration and diversification of farms are the less adopted measures by the dairy farmers. However, about 41% dairy farmers are found to migrate to other areas in search of water and pasture land during the drought situations in Jhelum district. Several other studies (Ado et al., 2019; Khan et al., 2020; Salman et al., 2018) have identified various resource and financial constraints that hinder farmers' capacity to effectively address climate change.

We also analyzed adaptation measures at farm level across various farmer categories, i.e., size of the farm and level of education (see Fig. 5a, b).

Small farmers with up to five animals, medium-scale farmers with six to ten animals, and large-scale farmers with more than ten animals made up the three groups of farmers based on the size of their farms. Farmers were separated into two groups based on their level of education: those who were illiterate or undereducated and had completed fewer than seven years of school (the average number of years in a sample), and those who had completed seven or more.

Figure 5a indicates that adaptation decisions are positively linked to education level. Farmers with less education, about 30% of them, have adapted to climate change, compared to nearly 70% of farmers with a higher degree. On the other hand, about 60% farmers with less educational level have not adapted agaisnt climate change. The studies such as Bryan et al. (2013) and Abid et al., (2016a, 2016b) report positive associations between adaptive behavior and education. Figure 5b illustrates that large-scale farmers are more inclined to adapt compared to small-scale farmers. The proportion of large-scale farmers among adapters is 40%, while among non-adapters, it is only 16%. Medium-scale farmers have approximately similar proportions in adapters (33%) and non-adapters (36%) groups. On the other hand, small farmers account for 28% of the adapters and 48% of the non-adapters. These results are in line with the findings of Shahbaz et al. (2020), which also observed a positive correlation between climate change adaptation and the number of animals. Similarly (Ali, 2018; Bosire et al., 2019) determined the significant relationship between education and climate change adaptation.

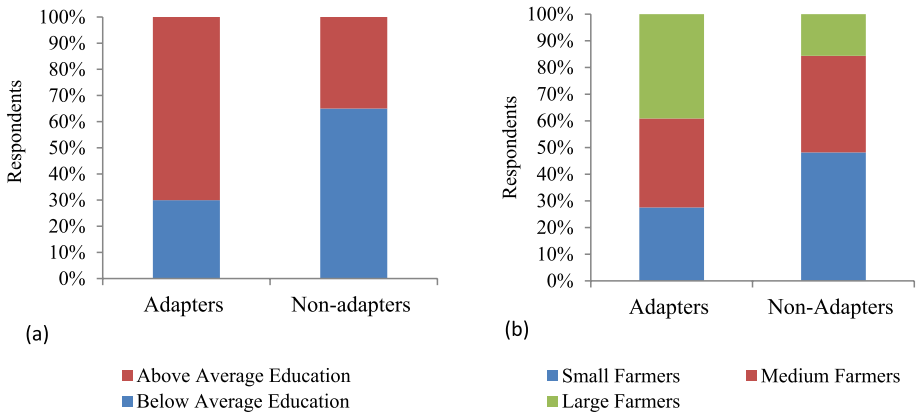


Fig. 5 **a** and **b**: Division of adapters and non-adapters by educational attainment and farm size (% of group samples)

3.3 Empirical results

3.3.1 Results of propensity score matching

Table 2 provides a summary of the PSM estimation results. The findings indicate that household and farm-related variables have a significant impact on the likelihood of climate change adaptation.

Specifically, the positive coefficients for levels of education, years of farming experience, farm size, number of dairy animals, access to extension services, and climatic knowledge indicate that these factors contribute to facilitating climate change adaptation. These results are in line with prior research studies (Abid et al., 2016a, 2016b; Ali, 2018; Iqbal et al., 2015) and lend support to our preliminary hypotheses. Dairy farmers' adaptation decisions are negatively impacted by their access to credit, but the coefficient is insignificant. Moreover, family size has positive but nonsignificant coefficient.

We employed a propensity score matching approach to assess the impact of various strategies for addressing climate change risks on farm output (specifically, milk production) and household incomes, as indicated in Table 3. This approach used the NNM approach for estimation, since nearest neighbors matching their similar ones in opposite groups. In matching procedure, the unmatched non-adapters are excluded, which reduces the sample size of each strategy. The PSM analysis presents results comparing farmers who have implemented climate change adaptation strategies to those who have not. This comparison is summarized in the average treatment effect for the treated (ATT).

The implementation of regular vaccination as a risk coping measure has a substantial and statistically significant impact on both milk production and household income. According to the ATT findings, farmers who used regular vaccination as a risk coping strategy have higher milk yield of 1.76 L per day than those who did not. This finding of the study supported by the (Marsh et al., 2016; Schmitt–van de Leemput et al., 2020) who found that vaccination to dairy animals increased milk yield.

The findings of the study signify that there is a modest increase of roughly 3225 Pakistani rupees in household income as a result of ATT, with a level of significance at 5%.

Table 2 Results of logistic regression

Variables	Coefficients	Standartd error	*Z*-value
Education of farmer (years)	0.15	0.05	4.19***
Farming experience (years)	0.05	0.02	3.02***
Family size (Number of heads)	0.03	0.02	1.34
Farm size (ha)	0.03	0.01	1.85*
Number of dairy animals at farm	0.09	0.03	2.27**
Access to extension/veterinary services	0.11	0.06	3.08***
Access to climatic information	0.28	0.12	3.85***
Access to credit facilities	−0.12	0.26	−0.22
Intercept	−2.25	0.48	−4.03***
Number of observations	450		
Pseudo R-square	0.32		
LR-χ^2	59.05		

***, **, * represent level of significance at 1%, 5% and 10%, respectively

Table 3 Impact of adaptation strategies on dairy production and income

Outcome	ATT	*t*-values	Critical level of hidden bias	Number of treated	Number of controls
Regular vaccination					
Milk (liters/day)	1.76***	2.75	1.10–1.20	129	314
Dairy income (Rupees)	3225.00**	2.34	1.30–1.40	129	314
Selling of weak/diseased animals					
Milk (liters/day)	− 1.04**	− 2.28	1.20–1.30	105	288
Dairy income (Rupees)	2150.00***	− 3.05	1.20–1.30	105	288
Changes in cropping pattern in fodder production					
Milk (liters/day)	1.25***	2.98	1.50–1.60	93	303
Dairy income (Rupees)	2845.00**	2.17	1.30–1.40	93	303
Diversifying by off-farm activities					
Milk (liters/day)	0.86***	2.62	1.10–1.20	118	267
Dairy income (Rupees)	2483.00***	2.85	1.20–1.30	118	267
Migration					
Milk (liters/day)	− 0.93**	− 2.16	1.20–1.30	49	238
Dairy income (Rupees)	− 1337.00*	− 1.74	1.40–1.50	49	238

PSM was employed by using the Nearest Neighbor Matching (NNM) method

***, **, * are the level of significance at 1%, 5% and 10%, respectively, and US$1 = PkRs155

With regular vaccination, dairy farmers protect their animals from diseases and cured the affected animals. In this way, milk yield of milking animals increased and ultimately it improved the households' income and their well-being.

The variable of the effects of selling weak/diseased animals is statistically significant and negative for milk production, but positive for household income. In the short term, when the dairy households sell the weak/diseased animals, it increases cash income, while in the long run it declines revenue generation. This is evident from the decline in milk production when they sell weak/diseased animals in order to cope with climate risks. Due to selling the weak/diseased animals, number of dairy animals at farms decreased and total milk production declined and small farmers have not much resources to purchase more adult animals with mere money that they received by selling diseased animals. Similar results were found by (Ali, 2018; de Vries, 2019; Koç & Uzmay, 2021) who assessed that by reducing the herd (especially the weak/diseased animals) in severe climatic condition reduced their milk yield and income.

For milk productivity and household income, the PSM results for changing cropping patterns for fodder production were positive and significant. The ATT results for milk indicate that farmers who tried to increase fodder production were able to increase milk productivity because there is an abundance of variety of feed and sufficient nutrients. These outcomes align with the results of previous studies, as demonstrated in (Idrissou et al., 2020; Shahbaz and Boz, 2020). According to the ATT findings, this technique increases household income by up to 2845 Pakistani rupees.

Diversifying farm through off-farm income activities is one of the important strategies used by the small farmers who have large family size. They send young male family members to urban areas to earn some livelihood by labor work and protect the farm and families in the times of famine. With extra income, they can add some good breed animals at the

farms which ultimately increase milk productivity as well as income. Results in Table 3 indicate that milk productivity and income of households increase significantly by practicing this strategy against the climatic risks. Some other studies like (Ata et al., 2021; Garcia-Cornejo et al., 2020; Ullah, 2016) also estimated the similar results for diversifying farms which can enhance productivity and income.

In certain places, households, especially those with fewer water resources, migrate to safer areas. The results of the ATT milk yield are unfavorable and statistically significant, indicating that migrant farmers produce up to 0.93 L/day less milk. Income of households also dereases. As a result, migration should be the least favored approach for climate risk mitigation. These results are also verified by findings of (Ali, 2018) in the context of dairy farming.

Limited research has been conducted to quantify the impact of climate change adaptation on the productivity and income of farm households. In this regard, some studies like (Ali, 2017; Gul et al., 2019; Odari, 2018; Suresh et al., 2021) revealed the considerable influence ofadaptation to climate change on dairy and agriculture productivity. Similarly, several other studies such as (Mikémina et al., 2018; Odhiambo et al., 2019; Sujakhu et al., 2020) discovered that adaptation had a large and favorable effect on farmers' income. The study in hand and empirical findings of the literature confirmed that Farmers' productivity and income may both enhanced adaptation agaisnt climate change.

Table 4 summarizes the findings of number of treated and control groups along with critical level of hidden bias. The degree to which dairy farmers who practice risk management differ from those that do not due to unobservable factors is referred to as the critical level of hidden bias. Since sensitivity analysis for negligible effects is meaningless, we only computed Rosenbaum bounds for effects that were statistically different from zero in the treatment group. A critical value of 1.20 is the minimum, and a value of 2.10 is the maximum. These findings remain robust to potential hidden bias, and even significant levels of unobserved heterogeneity do not alter the conclusions drawn from the estimated effects.

Table 4 also presents the R^2 value derived from the propensity score estimation and the subsequent re-estimation of the propensity score using the matched sample. Both the pre-match and post-match likelihood-ratio tests, assessing the collective significance of all regressors in the logit model used for propensity score estimation, are presented, along with their corresponding p-values. The p-values obtained from the likelihood-ratio test indicate that the collective relevance of the regressors on treatment status can consistently be rejected following the matching process. However, prior to matching, it had never been rejected. The rather low R^2 value and the p-values from the likelihood-ratio test of the combined significance of the regressors suggest that there is no clear pattern or systematic difference in the distribution of covariates between those who participated and those who did not after the matching process.

In spite of this, as was already said, The fundamental objective of propensity score estimate is not to generate a precise prediction of entry into treatment but rather to equalize the distributions of important variables between the two groups. By comparing the median absolute standardized bias reduction between the matched and unmatched models, the balancing abilities of the estimations are determined. Table 4 presents the median absolute standardized bias before and after matching, as well as the overall reduction in

Table 4 Covariates balancing indicators (before and after estimates)

Outcome	Bias before matching	Bias after matching	%age bias reduction	Value of R^2 before matching	Value of R^2 after matching	LR-χ^2 before matching	LR-χ^2 after matching
Regular vaccination							
Milk(liter/day)	16.90	6.10	63.90	0.04	0.01	0.01	0.89
Dairy Income (Rupees)	16.90	5.50	67.50	0.04	0.01	0.01	0.95
Selling of weak/diseased animals							
Milk(liter/day)	29.30	8.60	70.60	0.12	0.01	0.00	0.16
Dairy Income (Rupees)	24.90	9.70	61.10	0.12	0.02	0.00	0.07
Changes in cropping pattern in fodder production							
Milk(liter/day)	45.30	12.20	73.10	0.26	0.03	0.00	0.28
Dairy Income (Rupees)	39.40	10.70	72.80	0.25	0.04	0.00	0.37
Diversifying by off-farm activities							
Milk(liter/day)	17.30	5.80	66.50	0.05	0.01	0.00	0.92
Dairy Income (Rupees)	17.20	6.20	64.30	0.05	0.01	0.00	0.86
Migration							
Milk(liter/day)	9.90	3.50	64.60	0.02	0.00	0.00	0.265
Dairy Income (Rupees)	10.90	4.90	67.50	0.02	0.01	0.00	0.351

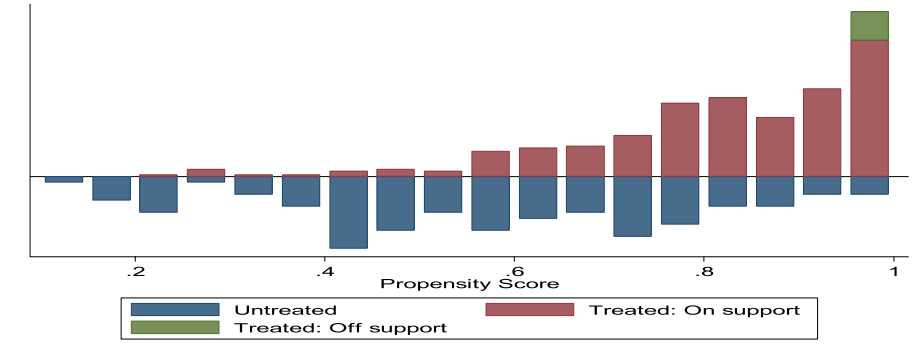
bias achieved through the matching technique. The results indicate substantial reductions in bias. Rosenbaum and Rubin (1985) proposed that a remaining 20% standardized bias is acceptable.

Furthermore, Fig. 6 illustrates the application of common support conditions and the process of covariate balancing.

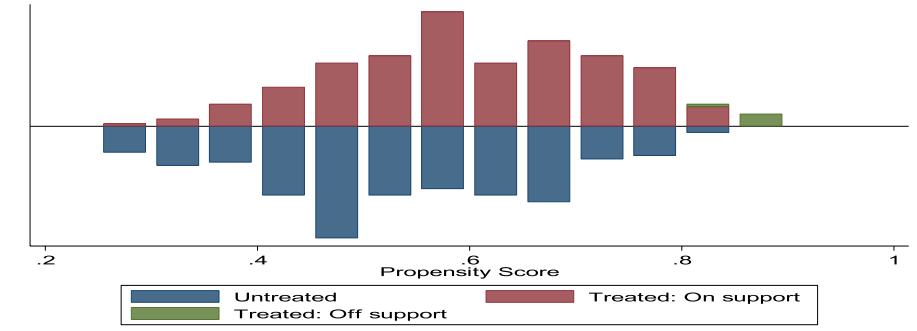
Farmers who were treated on support were more likely to find a compatible match in the other group, while farmers who were treated off support were less likely to do so. Farmers who could not find a suitable match in the other group were not included in the treatment group.

3.3.2 Combined impact of adaptations on milk productivity and dairy income

On the basis of adaptation measures, we have compared milk and dairy revenue in different categories of farmers (Fig. 7). Findings indicate that as the extent of adaptation increases, milk production and dairy income increase as well. This result implies that the farmers



(a)



(b)

Fig. 6 Indicators of covariates balancing **a** Impact on milk production **b** impact on farm household income

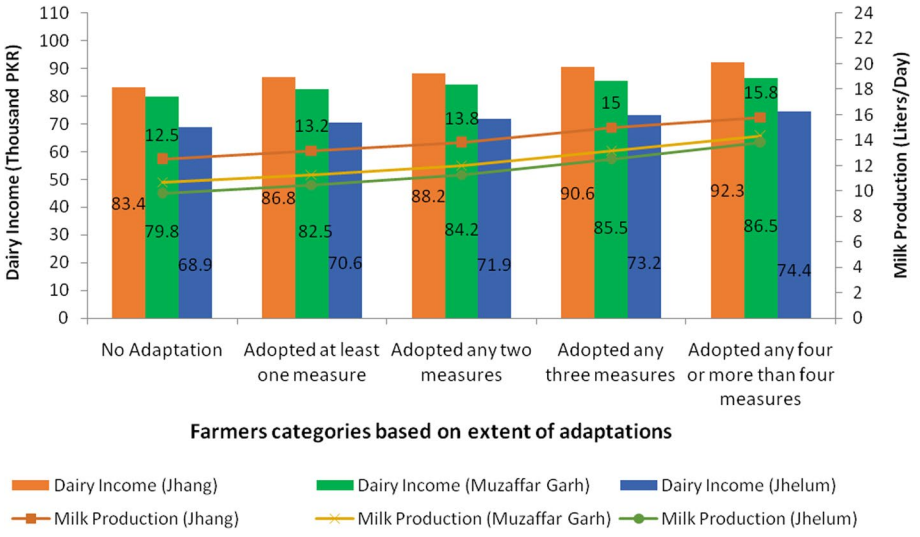


Fig. 7 Milk production and dairy income among different adaptation categories of farmers

who adopt more adaptation strategies achieve high milk yields and dairy incomes than those farmers who adopt fewer/no adaptations. These results are consistent with the outcomes of previous studies, including as (Abid et al., 2016a, 2016b; Gorst et al., 2018; Iqbal et al., 2015) while Ali (2018) determined the effect of risk management strategies on farmers' welfare.

4 Conclusion

The study provides insights into how farmers perceive and respond to the adverse effects of climate change on their farm production and income. Although the majority of farmers recognize climate change as a significant and ongoing phenomenon, our observations reveal a notable decrease in farm-level responses when transitioning from awareness to planning and adaptation. This decline can be attributed to a lack of information, resources, and financial constraints. Farmers adapted to climate change in a variety of ways, ranging from short-term to long-term plans. The main adaptation strategies adopted by farmers included regular vaccination, selling of weak/diseased animals, changes in cropping pattern for fodder production, diversifying farm through off-farm income activities and migration. The factors that significantly influence farmers' adaptation decisions include their level of education, prior experience in farming, the size of their farm, the number of dairy animals they possess, their access to extension and veterinary services, as well as their ability to obtain precise weather forecasts. Additionally, the study demonstrates that large-scale farmers tend to respond more promptly than small-scale farmers, underscoring the vital role of resource accessibility in adapting to climate change.

The study also finds that regular vaccination is the most adoptd strategies in the study area and it also provides greater return in terms of sustaining milk production and improving dairy income of the farmers. Estimates of econometric method show that climatic risk adaptation strategies have a significant effect on welfare of farm households, with adopters having higher milk yields and dairy income than non-adapters. Policies should concentrate on adopting and enforcing measures to mitigate the impact of climate change on dairy farming. This will improve the well-being of rural families, particularly regular vaccination which can be improved by easy access to extension/veterinary officers, changing the cropping pattern to allocate more land for fodder production and diversifying the farms to reduce the extreme effects of climatic risks. A policy that includes climate risk education and training, as well as enhanced extension services and asset endowments, would aid in mitigating climate change risk on dairy farms.

Appendix

See Figs. 8, 9 and 10

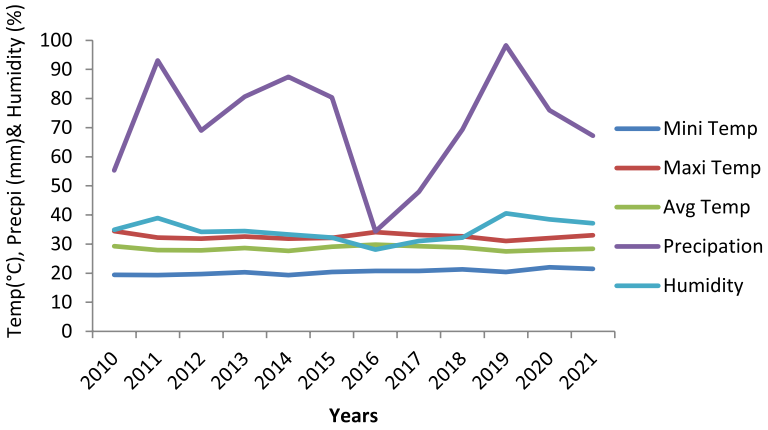


Fig. 8 Climatic condition for district Jhelum

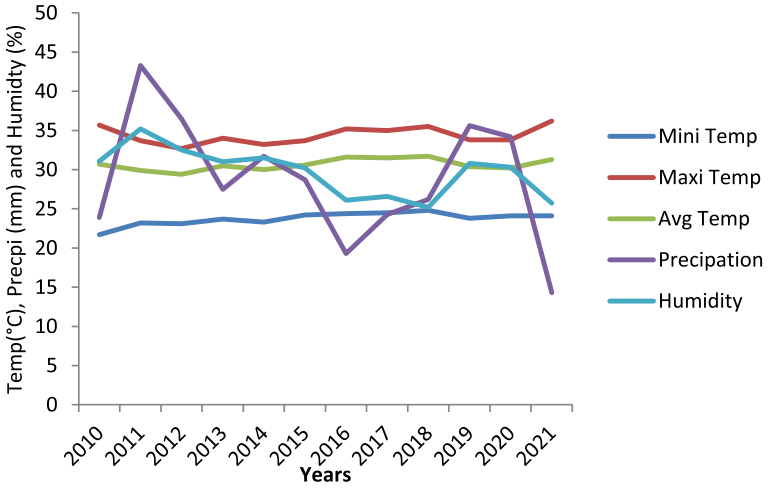


Fig. 9 Climatic condition for district Jhang

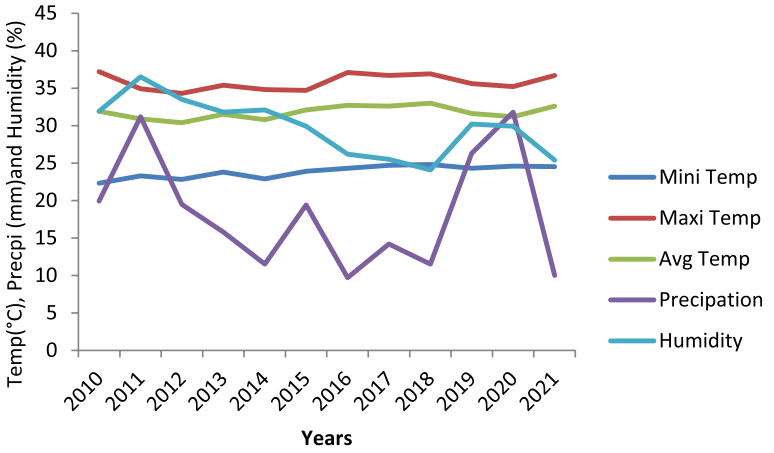


Fig. 10 Climatic condition for dsitrict Muzaffargarh

Author contributions All authors contributed to the study conception and design. Material preparation, data collection, and analysis were perfomed by QA, KB, and RK. The first draft of the manuscript was written by QA and JH and all authors commented on previous draft of the manuscript. All authors read and approved the final manuscript.

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Data availability The data will be made available on the reasonable request to the authors.

Declarations

Conflict of interest The authors have no relevant financial and nonfinancial competing interests to disclose.

Ethical approval Ethical Committee of COMSATS University Islamabad, Vehari Campus reviewed questionnaire used for data collection from dairy farmers and found that verbal consent of the farmers was obtained and ethical standards were followed (CUI-VHR-18-12/ECSR).

Consent to participation The interviewers informed the respodents about the purpose of the study and ensured confidentiality of the information. A verbal consent was obtained from all the selected respondents.

Consent to publication Authors have not submitted or published this manuscript, and it is not under consideration for publication elsewhere.

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Research Statement: Work till date and Future plans

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Research areas: Agricultural Economics, Environmental Economics, Productivity & Efficiency Analysis, Public Policy

I am an applied economist with strong interest in sustainable development policy issues.

My research interest can be broadly classified into three categories. The first revolves around the economics of agricultural systems. The second concerns the effectiveness of policies and programs geared towards improving the lives of the poor in developing countries. The third involves understanding environmental problems and ways to manage them.

My doctoral dissertation studies all three dimensions of the climate change-agriculture linkage (impact, adaptation, and sustainability) with special focus on dairy farming. Along with this risk perception, farmers risk behavior and adaptation barriers and impact of climate change adaptation on farmers income and productivity were also the focus of the doctoral study. As for as the productivity and efficiency analysis is concerned, currently I am working on the funded project with title "Efficiency and Productivity Analysis of Rice Farming in Pakistan: An Implication for Concerned Stakeholders". During my academic and research career, I have worked with my supervision students on environmental efficiency, impact of climate change on cereal production, climate change and rural household vulnerability, renewable energy as an adaptation option for climate change.

At present, I am interested in rapid climate-driven changes in the world are giving rise to multi-scale water-related issues ranging from sustainable living in world communities (e.g., drinking water, food security, infrastructure) to regional-scale shifts in water storage and fluxes. Novel approaches and applications that can help quantify and predict hydrologic response to climate change in different regions are to be sought while keeping the mechanism of policy making, rural development and environmental issues in mind.

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