Environmental Science and Pollution Research (2020) 27:1334–1338
https://doi.org/10.1007/s11356-019-06878-1

REVIEW ARTICLE

Climate change, vulnerability, and its impacts in rural Pakistan: a review

Shah Fahad[1] · Jianling Wang[1]

Received: 26 March 2019 / Accepted: 24 October 2019 / Published online: 5 December 2019

Abstract

Pakistan is one of the most vulnerable countries especially in Southeast Asia experiencing floods and droughts as a result of climate change. Variation in climate adversely affects agriculture sector, ground water, nutrition, soil quality and soil organic matter, health conditions, and poverty. The main purpose of this study is to review the impact of climate change and adaptation strategies used at farm level in response to variation in temperature and precipitation. As per literature, Pakistani farmers adopt several adaptation strategies in response to climate change, like change in fertilizer, change in crop variety, pesticide, seed quality, water storage, farm diversification, plant shade trees, irrigation practices, off-farm activities, permanent and temporary migration, and selling of assets. Literature also showed that farmers living wetland area perceived less variation in climate than farm households living in dry area.

Keywords Climate change · Variability · Vulnerability · Adaptation · Pakistan

Introduction

Worldwide, all regions are influenced by variation in climatic events, which results in extensive agitations that can be projected to natural ecosystems, which ultimately effects the economic systems of highlands (Kohler and Maseli 2009). Climatic conditions are essential element of agricultural production where precipitation and temperature possess key drivers of farm productivity (Wheeler and Von Braun 2013). The risk and uncertainties in relation to agricultural sector make it a composite practice. Growers are susceptible to uncertainties of profit from agricultural investments and the likelihoods of loss in agricultural production due to climate change. Small subsistence farmers and rural populations of the developing world are the most disadvantaged group that affected most by the variation in climatic events, because of the insufficient right to use of alternative means of productivity and poor adaptive capacity (IPCC 2007; Skoufias et al. 2011). There is a substantial geographic gap within and across areas, particularly in non-industrialized and humid countries and therefore, a large spatial variability in climate change impacts (Wheeler and Von Braun 2013). Several researchers such as those of Field (2012), Greenough et al. (2001), and Mirza (2003) have estimated that disparities in climatic circumstances are likely to bring an increase in the frequency of few uncertain climatic actions and calamities which include droughts, floods, cyclones, and storms. This could be due to terrestrial sites and positions of the susceptible regions in the globe, inadequate resources, high exposure to climatic variation, and speedy population growth (Hay and Mamura 2010).

Pakistan is amongst the most pretentious areas related to the variation in climatic events. Climatic events might be in the form of fluctuations in temperature, variation in rainfall, and frequent incidence of risky events (IPCC 2014; Fahad and Wang 2018). Floods and droughts are foremost cause of economic and social risks for the individuals among diverse natural threats to which people are exposed and contribute escalation to mortalities. Particularly, in developing countries, rural inhabitants are often susceptible to floods owing to the little adaptive capability and assets (Fahad and Jing 2018; Huong et al. 2018b). The strength and harshness of flood events in developing countries are mostly linked with the ecological

Responsible editor: Philippe Garrigues

✉ Shah Fahad
shah.fahad@mail.xjtu.edu.cn

Jianling Wang
wangjl@mail.xjtu.edu.cn

[1] School of Management, Xi'an Jiaotong University, Xi'an 710049, Shaanxi, China

and climatic fluctuations. If the efficient identification of the effects of variations in climatic conditions on farming systems is not carried out professionally, it might exceptionally and adversely impact the food productivity and its safety and also it might be a hurdle in the exertions for declining of poverty and sustainable development.

Pakistan is an agrarian country, where overall involvement of agricultural sector in GDP is 21.9% and directly or indirectly employs 45% of the country's total labor force, consisting of about 60% of the rural inhabitants; thus, any adverse outcome of climatic actions could influence their livelihoods (Fahad et al. 2018b; GOP 2010).

In spite of the substantial stake in total economy, the farming region has faced severe encounters from terrible flood impacts (Nomman and Schmitz 2011). Therefore, adaption of the farming sector to flood impacts is an effective and essential measure to guard the livelihoods of farming community. Pakistan was placed 12th position in 2012 and 8th position in 2015 and positioned 7th amongst the topmost constituencies worldwide that were visible to the notions of climatic variation (Kreft and Eckstein 2013). Recently, Pakistan has been smashed badly by floods and other climatic calamities, for instance, droughts, storms, and cyclones (Mueller et al. 2014; Tingju et al. 2014). These climatic catastrophes converted to more persistent as well as caused more losses (Qasim et al. 2015). The natural calamities in Pakistan, for instance 2010 (Fig. 1) to 2014 floods, had badly confounded lots of rural inhabitants (Fahad and Wang 2018).

Numerous research studies have described that farming communities of Pakistan are highly susceptible to the variations in climatic conditions (Deressa et al. 2009;Füssel and Klein 2006) and are severely affected by the variations in climate acknowledged by several researchers across the country (Qasim et al. 2015; Tingju et al. 2014). The constant issue faced by the establishment of Pakistan is the climatic hazards that arise repeatedly; nonetheless, the sufficient use of current advances in guidelines, policies, and cost-effective tools and viable interferences is, however, still lacking in the country (Qasim et al. 2015). Hence, this paper reviews the response of farm household to the variations in climatic conditions, adaptation, and variability in Pakistan.

Climate change impact on agriculture

Agriculture is the major sector of any economy that is always adversely affected by climate variations. The impacts of climate variability have become progressively deceptive over the past eras (Patt et al. 2009). Climate variability predictions propose a variable climate with high level of vulnerabilities in lower-income regions (Easterling et al. 2000; McCarthy 2001). The effect of climatic events sturdily depends on the dimensions to adapt to those hazards (O'Brien et al. 2006). Impacts of non-climatic inducements on adaptation choices are among the main problems in the farm level adaptation process. The farm households, who are the decision-makers in their farming sector, face a very complex situation characterized by economic, political, biophysical, and institutional conditions (Belliveau et al. 2006). Pakistan is one of the highly vulnerable among other developing countries to climatic changes (Schilling et al. 2013). The country has already faced an increase in the frequency and severity of climatic events such as floods, droughts, high temperatures, water shortage, and increased incidents of pests and diseases in certain regions (Smit and Skinner 2002). As per Global Climate Change Vulnerability Index (CCVI) report, Pakistan ranked the 29th among the most vulnerable regions over 2009–2010 and ranked 16th most vulnerable during 2010–2011 (Khan and Fee 2014). The floods since 2010, 2011, 2012, and 2014 and the severe drought lasting since 1999 to 2003 are some instances of more frequent climatic events in Pakistan. Pakistan is among the regions with a least-adaptive capacity due to the presence of poverty at high level and lack of financial and physical resources (Abid et al. 2015; Adger et al. 2005; Wandel and Smit 2000). These numerous experiences directly or indirectly affect the farmers' management and their adaptation decisions to climate variation and its related risks (Abid et al. 2015; Adger et al. 2005; Wandel and Smit 2000).

Fig. 1 2010 flood in rural Pakistan

Besides these, there are also several other factors such as farming practices, personal characteristics, and individual circumstances that further describe farmers' response and their capacity to adapt (Bryan et al. 2013). Extreme climatic variability also affects the economic, social, and natural ecosystems and also the upcoming variations linked with current supplementary challenges (Karl et al. 2008). Variability in climatic events causes the severity and frequency of natural events; some indirect effects of climatic variability include land and water condition, changes in frequency of pest infestation, changes in soil moisture, and the distribution of diseases. The rise in temperature, variability in precipitation, and reduction in crop productivity directly affect the food security in less developed and agro-based economies. Consequently, the influence of climate variability is unfavorable to the regions where their livelihood depended mainly on agriculture (Edwards-Jones et al. 2009).

According to the FAO (2011), climate variability strongly affects the farming sector by altering or demeaning productive dimensions and by increasing the direct and indirect risks linked with production. Climate variability causes extensive possessions in the environment and on socio-economic and its related sectors, such as agriculture and food security, water resources, terrestrial ecosystems, human health, and biodiversity. Variation in precipitation pattern is also probable to lead to the severity in water shortages and flooding. Increased temperatures also cause the changes in crop growing periods that impact the food security and variation in the spreading of disease that puts people at risks of such diseases like malaria. Rise in temperature severely increases rates of destruction for many environments and species (UNFCCC 2008).

Impact of climate change on health conditions and poverty

Variations in temperature might affect health conditions. Climate variability was assessed to be accounted for nearly 2.4% of worldwide diarrhea and 6% of malaria in several low-income regions in the year 2000 (WHO 2002). In developing countries, especially in Southeast Asia, Pakistan is extremely susceptible to climatic hazards such as floods and droughts. Floods since 2010 to 2014 have led to a massive loss of life and property as well as migration of people from their homes. Other climatic events in Pakistan are pest attacks, seasonal and flash floods, and droughts. The farming sector in Pakistan has faced three continuous massive floods that confounded the overall economic and farming sector. Agriculture sector is the only largest sector that contributes 21% of the total national income of the country; its share has deteriorated with period and engrosses 45% of the labor force. Almost of 70% of the population are living in rural areas and most of them are directly dependent on farming sector (Fahad and Wang 2018; Fahad and Jing 2018). The share of agriculture sector in Pakistan's GDP is 21.4%, 24.5% in the 1990s, 32% in 1977–1978, 53% in 1959–1960, and 64% in 1947–1948 (Fahad et al., 201z8b).

Climate change adaptation strategies in Pakistan

The agriculture sector has the capacity to adapt the technologies, resources, and management changes that have been relatively quickly undertaken (Mendelsohn and Dinar 2009). A study was conducted researchers (Fahad and Wang 2018) in rural area of Khyber Pakhtunkhwa province of Pakistan by employing household survey method; the study findings revealed that changes in fertilizer, changes in type and variety of crop, pesticide, quality of seed, plant shade trees, farm diversification, and storage of water were the main adaptation strategies in the study area. Adaptation to climate variability effects in general and to the farming sector in particular is a prevailing phenomenon. According to Mendelsohn et al. (2001), climate variability adaptation will require modifications and variations at every level from the community level to the national and international. To build the resilience in the public groups is very essential that includes adaptation of appropriate technologies to make them aware of traditional knowledge and to diversify their livelihoods to cope with the present and future climatic stress. Mendelsohn et al. (2001) also stated the importance of optimum crop substituting that must be considered when computing the effect of climate variability on agriculture. According to the IPCC third assessment report, adaptation has the potential to diminish adverse influences of climate variability and to improve beneficial effects, but will sustain the costs and will not avert all damages. Furthermore, it is contended that human and natural systems will, to some extent, adapt separately and that strategic adaptation can supplement autonomous adaptation. However, options and incentives are greater for the adaptation of human systems than for adaptation to defend natural systems (IPCC 2007). Local coping approaches and traditional knowledge need to be employed unified with governmental and local interventions. To enable the effective adaptation measures, governmental agencies as well as nongovernment organizations (NGOs) must consider integrating climate variability into their strategies while budgeting all levels of decision-making. Farmers adapt to climate variability in order to maximize their profits by changing planting and harvesting patterns and a host of agronomic exercises (Deressa et al. 2011). By using household survey methods, Bryan et al. (2009) revealed that the use of different crop varieties, soil conservation, changing planting dates, irrigation, and planting trees are the main adaptation strategies in the study area. However, despite having perceived variation in temperature and precipitation, a huge percentage of farm households did

not make any adjustments to their farming practices. The adaptation strategy, crop diversification, means to evade the hazards of total crop failure rather than to maximize yields of one certain crop (Huong et al. 2017; Huong et al. 2018a). Crop diversification is very common adaptation strategy used to overcome climatic events in Pakistan (Fahad and Wang 2018). According to previous literature (Kristiansen 2011), the use of diverse crop varieties in the same term could be related to lesser costs and ease of access by farm households. Farmer's vulnerability to climate changes can be mitigated only if the farmers have an off-farm income (Cooper et al. 2008). Off-farm activities might be labor and side businesses like shops in Pakistan. Farmers in Pakistan have often used different kinds of soil and water conservation strategies; soil and water conservation strategies are mainly used because of soil degradation and soil erosion and because farmers, due to this, want to rehabilitate their fields (Fahad and Wang 2018; Fahad et al. 2018a). Sales of assets are identified by the Pakistani farmers as a coping tool to climatic hazards. The use of irrigation is also practiced in Pakistan as an adaptation strategy among the major adaptation strategies. In Pakistan, most of the farmers are less educated with lesser land holding size and are living in remote areas. In order to measure the climate change perception of farm households, the most appropriate method is by conducting household survey. The studies of Abid et al. (2015) and Fahad and Wang (2018) showed that the age of the households' head and farming experience have a significant relationship with climate change perception; for instance, educated and experienced farmers are more likely to perceive climate change than farmers with less education level and inexperienced farmers. The education level of the households' head is likewise assumed to be positively associated with awareness of climate variation. Information access of farmers to climatic issues and access to extension services of farmers also create awareness and favorable condition for the adoption of farming practices.

Conclusion

A developing country like Pakistan is one of the most prone regions to severe climatic events around the globe, such as droughts and floods, fluctuation in temperature, and variation in precipitation which are the main causes of climatic variability. In developing world and in Southeast Asia, Pakistan is one of the most vulnerable regions exposed to variations in climate, and farming sector is one of the mostly affected sectors of the country. Lower subsistence farm households are the most deprived party in farming sector, which faces several climatic calamities in their fields. Pakistani farmers are mostly less educated with lesser landholding size, particularly living in rural vulnerable areas which require a strenuous attention on adaptation to build resilience and lessen poverty. Frequent floods, droughts, rise in temperature, and changes in rainfall are the main threats linked with climate variability that have negative impact on the agricultural sector in the country in recent era. Farmers' living in diverse agro-ecological areas used different adaptation strategies in response to climatic changes. It has been showed that growers living in less precipitation zones with high temperature are more likely to adopt different adaptation measures than farmers living in high precipitation areas with low temperature. After the occurrence of 2010–2014 floods in Pakistan, diseases such as dengue fever, cholera, malaria, and other respiratory diseases were some of the adverse effects of climate change. Because of heavy rainfall and floods, land degradation, damage to roads, communication, and other infrastructures were also reported in the region.

Acknowledgements The authors extend their sincere thanks to the editor of this journal and the anonymous reviewers for their invaluable comments and suggestions that have significantly improved the manuscript. This study is supported by China Postdoctoral Project Grant No. 2019M660262

References

Abid M, Scheffran J, Schneider UA, Ashfaq M (2015) Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. Earth Syst Dyn 6: 225–243

Adger WN, Arnell NW, Tompkins EL (2005) Successful adaptation to climate change across scales. Glob Environ Chang 15:77–86

Belliveau S, Smit B, Bradshaw B (2006) Multiple exposures and dynamic vulnerability: evidence from the grape industry in the Okanagan Valley, Canada. Glob Environ Chang 16:364–378

Bryan E, Deressa TT, Gbetibouo GA, Ringler C (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ Sci Pol 12:413–426

Bryan E, Ringler C, Okoba B (2013) Adapting agriculture to climate change in Kenya: Household strategies and determinants. J Environ Manag 114:26–35

Cooper PJM, Dimes J, Rao KPC, Shapiro B, Shiferaw B, Twomlow S (2008) Coping better with current climatic variability in the rain-fed farming systems of sub Saharan Africa: an essential first step in adapting to future climate change? Agric Ecosyst Environ 126:24–35

Deressa TT, Hassan RM, Ringler C (2009) Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Glob Environ Chang 19:248–255

Deressa TT, Hassan RM, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. J Agric Sci 149:23–31

Easterling DR, Evans J, Groisman PY, Karl T, Kunkel KE, Ambenje P (2000) Observed variability and trends in extreme climate events: a brief review*. Bull Am Meteorol Soc 81:417–425

Edwards-Jones G, Plassmann K, Harris IM (2009) Carbon foot printing of lamb and beef production systems: insights from an empirical analysis of farms in Wales, UK. J Agric Sci 147:707–719

Fahad S, Jing W (2018) Evaluation of Pakistani farmers' willingness to pay for crop insurance using contingent valuation method: the case of Khyber Pakhtunkhwa province. Land Use Policy 72:570–577. https://doi.org/10.1016/j.landusepol.2017.12.024

Fahad S, Wang J (2018) Farmers' risk perception, vulnerability, and adaptation to climate change in rural Pakistance. Land Use Policy 79: 301–309

Fahad S, Wang J, Hu GY, Wang H, Yang XY, Shah AA, Huong NTL, Bilal A (2018a) Empirical analysis of factors influencing farmers crop insurance decisions in Pakistan: evidence from Khyber Pakhtunkhwa province. Land Use Policy 75:459–467

Fahad S, Jing W, Khan AA, Ullah A, Ali U, Hossain MS, Khan SU, Huong NTL, Yang XY, Hu GY, Bilal A (2018b) Evaluation of farmers' attitude and perception toward production risk: lessons from Khyber Pakhtunkhwa Province, Pakistan. Hum Ecol Risk Assess Int J 24(6):1710–1722

FAO (2011) Framework programme on climate change adaptation. Food and Agriculture Organization of the United Nation, Rome

Field CB (2012) Managing the risks of extreme events and disasters to advance climate change adaptation: special report of the intergovernmental panel on climate change: Cambridge University Press

Füssel H-M, Klein RJT (2006) Climate change vulnerability assessments: an evolution of conceptual thinking. Clim Chang 75:301–329

Govt of Pakistan (2010) Pakistan economic survey. Finance Division, Govt of Pakistan

Greenough G, McGeehin M, Bernard SM, Trtanj J, Riad J and Engelberg D (2001) The potential impacts of climate variability and change on health impacts of extreme weather events in the United States. Environ Health Perspect 109(S2):191

Hay J, Mamura N (2010) The changing nature of extreme weather and climate events: risks to sustainable development. Geomatics, Nat Hazards Risk 1(1):3–18

Huong NTL, Yao SB, Fahad S (2017) Farmers' perception, awareness and adaptation to climate change: evidence from Northwest Vietnam. Int J Clim Chang Strateg Manag 9:555–576. https://doi.org/10.1108/IJCCSM-02-2017-0032

Huong NTL, Bo YS, Fahad S (2018a) Economic impact of climate change on agriculture using Ricardian approach: a case of northwest Vietnam. J Saudi Soc Agric Sci. https://doi.org/10.1016/j.jssas.2018.02.006

Huong NTL, Yao SB, and Fahad S (2018b) Assessing household livelihood vulnerability to climate change: the case of Northwest Vietnam. Hum Ecol Risk Assess Int J. https://doi.org/10.1080/10807039.2018.1460801

IPCC (2007) Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland

IPCC (2014) Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change

Karl TR, Meehl GA, Miller CD, Hassol SJ, Walpe AM, Murray WL (2008) Weather and climate extremes in a changing climate. Synthesis and Assessment Product 3.3. Report by the US Climate Change Science Programme (CCSP) and the subcommittee on global change research, Department of Commerce, NOAA National Climate Data Center, Washington, DC

Khan JA, Fee L (2014) Cities and climate change initiative-abridged report: Islamabad Pakistan, climate change vulnerability assessment. United Nations Human Settlements Programme (UN-Habitat) (Available at: http://www.fukuoka.unhabitat.org/programmes/ccci/pdf/Islamabad(Pakistan)_23_February_2015_FINAL(5th_revision).pdf. (Last access: 07.10.2015)

Kohler T, Maseli D (2009) Mountains and Climate change -from understanding to action, Bern, Switzerland: Published by Geographica Bernensia with support of the Swiss Agency for Development and Cooperation (SDC) and an international team of contributors

Kreft S, Eckstein D (2013) Global Climate Risk Index 2014: who suffers most from extreme weather events? Weather-Related Loss Events in 2012 and 1993 to 2012. Germanwatch eV, Bonn

Kristiansen S (2011) Climate change impacts and adaptations among Ethiopian farmers

McCarthy JJ (2001) Climate change 2001 In: Impacts, adaptation, and vulnerability: contribution of working group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge university press, Cambridge

Mendelsohn R, Dinar A (2009) Climate change and agriculture: an economic analysis of global impacts, adaptation and distributional effects. Edward Elgar Publishing, Cheltenham

Mendelsohn R, Dinar A, Sanghi A (2001) The effect of development on the climate sensitivity of agriculture. Environ Dev Econ 6:85–101

Mirza MMQ (2003) Climate change and extreme weather events: can developing countries adapt? Clim Pol 3:233–248

Mueller V, Gray C, Kosec K (2014) Heat stress increases long-term human migration in rural Pakistan. Nat Clim Chang 4(3):182–185

Nomman MA, Schmitz M (2011) Economic assessment of the impact of climate change on the agriculture of Pakistan. Business Econ Horiz (4):1–12

O'Brien G, O'Keefe P, Rose J, Wisner B (2006) Climate change and disaster management. Disasters 30:64–80

Patt A, Peterson N, Carter M, Velez M, Hess U, Suarez P (2009) Making index insurance attractive to farmers. Mitig Adapt Strateg Glob Chang 8:737–753

Qasim S, Khan AN, Shrestha RP, Qasim M (2015) Risk perception of the people in the flood prone Khyber Pakhtunkhwa province of Pakistan. Int J Disaster Risk Reduction 14:373–378

Schilling J, Vivekananda J, Khan MA, Pandey N (2013) Vulnerability to environmental risks and effects on community resilience in midwest Nepal and south-east Pakistan. Environ Nat Resour Res 3: 27–45

Skoufias E, Rabassa M, Olivieri S (2011) The poverty impacts of climate change. Economic Premise, vol 5622. Worldbank

Smit B, Skinner MW (2002) Adaptation options in agriculture to climate change: a typology. Mitig Adapt Strateg Glob Chang 7:85–114

Tingju Z, Xie H, Waqas A, Ringler C, Iqbal MM, Goheer MA, Sulser T (2014) Climate change and extreme events, impacts on Pakistan's agriculture. International Food Policy Research Institute (IFPRI) (PSSP Policy Note 002)

UNFCCC, COP 13 (2008) "Report of the Conference of the Parties on its thirteenth session, held in Bali from 3to 15 December 2007, Addendum part two: Action taken by the Conference of the Parties at its thirteenth session

Wandel J, Smit B (2000) Agricultural risk management in light of climate variability and change. Agricultural and environmental sustainability in the New countryside. Hignell Printing Limited, Winnipeg, pp 30–39

Wheeler T, Von Braun J (2013) Climate change impacts on global food security. Sci. 341:508–513

WHO (2002) The World Health Report 2002, Reducing risks, promoting healthy life. World Health Organization, Geneva http://www.who.int/whr/previous/en/index.html, (accessed on 14.04.2007)