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FOOD SECURITY AND CLIMATE CHANGE:

A CASE STUDY OF PUNJAB, PAKISTAN

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Civil Society Coalition for Climate Change (CSCCC)

CSCCC provides a networking platform for civil society organizations, climate experts, academia, researchers, media, private sector and concerned citizens to exchange ideas and build synergies while preserving and strengthening the autonomy and independence of its members. The coalition approach was adopted to enhance civil society capacity for effective engagement with policy makers to support mitigation and adaptation actions that build resilience and reduce vulnerability at all levels by integrating adaptation into relevant socio-economic and environmental policies for sustainable development. The concept of the coalition is in line with the Lima-Paris Action Agenda (LPAA) and Paris Agreement on Climate Change which recognizes civil society as a key player in framing climate policies to strengthen climate governance. The strategic focus of the coalition also covers Agenda 2030 for Sustainable Development particularly SDG13 (Climate Action). CSCCC works with "A Whole of Government Approach" and follows the guidelines of "Open Government Partnership (OGP)" to achieve its objectives.

The Civil Society Civil Society Coalition for Climate Change (CSCCC) is a licensed Coalition (registered under Section 42 of the Companies Ordinance, 1984) dedicated to highlighting the subject of climate change in Pakistan and influencing policymaking at the regional, national and subnational levels through research, knowledge-sharing, and advocacy.

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CSCCC PARTNERS

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ABBREVIATIONS

ADB	Asian Development Bank
BISP	Benazir Income Support Program
CLIS	Crop Loan Insurance Scheme
D.G Khan	Dera Ghazi Khan
FAO	Food and Agriculture Organization
GoP	Government of Pakistan
GCM	Global Climate Models
GHG	Green House Gases
IFAD	International Fund for Agriculture Development
IPCC	Intergovernmental Panel on Climate Change
MoCC	Ministry of Climate Change
MPI	Multi-dimensional Poverty Index
NNS	National Nutritional Survey
PRISE	Pathways to Resilience in Semi-arid Economies
PRECIS	Providing Regional Climates for Impact Studies
RCM	Regional Climate Models
SBP	State Bank of Pakistan
WFP	World Food Program

EXECUTIVE SUMMARY

Climate change is a global phenomenon with disproportionate impacts on different geographical areas. Pakistan has been declared one of the top ten countries facing severe climate risks. Further, climate change impacts every component of food security, namely: availability, access, utilization and stability. The food security-climate change nexus is evident through studies depicting previous trends that also forecast its negative influences through spatial and non-spatial analysis. This study conducted a literature review from previous studies for spatial analysis and analyzed micro-evidences derived from two projects: Pathways to Resilience in Semi-arid Economies (PRISE) and R4 Rural Resilience Initiatives in Punjab.
The main objectives of this study are:

> To understand food security components and their relationship with climate change impacts and climate disasters in Punjab, Pakistan.
>
> To identify a set of key policies to deal with food security and the challenges of climate change in the most vulnerable communities of Punjab, Pakistan.

The objectives of this study are based on climate change models and micro-evidences from both projects' survey. The spatial analysis of climate change predictions and their impacts are given through climate change models. Second, micro-evidences focus on land size and their relationship with food security issues and adaptive measures by farmers. It focuses on developing links between land size and food security conditions of farmers in Punjab districts of Muzzaffargarh, Dera Ghazi Khan (D.G Khan) and Faisalabad.

The key findings drawn out of the analysis are as follows:

Food security faces climate-induced risks: The climate models, namely, Global Circulation Model (GCM) and Regional Climate Model (RCM) confirm threats of climate change from irregular precipitation and rising temperature in Pakistan. Particularly, Punjab province, which is a major contributor of agriculture products (major crops, namely, wheat, rice, maize, grains and sugarcane) faces climate change impacts along with rising climate extremes. The rising trends of prolonged droughts, hill torrents and downstream flash floods and severe heat waves are expected to be intensified in future. These climate changes and extreme climatic conditions have significant impact on crop productivity, particularly for wheat, sugarcane, cotton, rice, and minor crops.

Food security is subject to land size: The micro-evidences of farmers in Punjab's districts of Muzzaffargarh, D.G Khan and Faisalabad present a strong relationship between climate change, land size and food security. Farmers reported facing rising challenges of food security due to climatic disasters (floods and droughts) followed by pest attack, rainfall, wind and hailstorms. The common coping strategies used by farmers are diversification of income sources, credit borrowing, modification of food production, reduction in food and non-food items and migration of family member.

Way forward: Government of Pakistan has already taken initiatives such as the Benazir Income Support Program (BISP) and the Crop Loan Insurance Scheme (CLIS) in order to enhance food security. However, there is need for enhancing resilience of farmers by initiating crop insurance and credit borrowing policies that not only provide security in case of financial losses but also support farmers during future cropping activities. Along with that, the government should introduce a national food bank scheme to ensure food supply in hotspot regions meets post-disaster shortages. Furthermore, there is a need for enhancing cash transfers and capacities of farmers in order to strengthen food chains and diversification of income.

1. CLIMATE CHANGE AND ITS IMPLICATIONS FOR DEVELOPMENT

Significant time and attention is being given to the subject of climate change and its impacts on economy, rural livelihoods and development. Scientific evidence shows that rising temperatures, extreme weather events and changes in sea level will adversely affect the global economy, livelihoods and sustainable development (Madzwamuze 2010). Projections and estimations suggest that the poorer countries will be disproportionately impacted, as they do not possess the capacity and resources to deal with the threats resulting from climate change. These countries and peoples need support and assistance to turn their current coping strategies into long term adaptive capacities (OECD 2009). According to Arndt and Tarp (2017), an estimated 900 million people live in absolute poverty in today's world. Further, 36 out of 192 countries continue to be affected by poverty and languish in the low-income category. Under such poverty, the implications of climate change would be severe, especially for agriculture based livelihoods and economies.

The Intergovernmental Panel on Climate Change (IPCC) states in its 5th Assessment Report that more than half of the observed increases in global average surface temperatures from 1951 to 2010 was caused by the increase in atmospheric concentrations of GHGs due to anthropogenic activities. The report further states that a change in extreme weather events has also been observed since 1950 (IPCC 2014). Due to human influences on climate, several climatic changes have been observed, namely: decline in cold temperature extremes, increase in in extreme warm temperatures, rising sea level, increasing number of heavy precipitation events, increase in number of hot nights and decrease in number of cold nights. As a result, heat waves have increased in occurrence in Europe, Asia and Australia. All emission-assessing scenarios find that temperatures will continue to rise in the twenty first century, heat waves will increase in occurrence and so will precipitation extremes (Ibid).

1.1 South Asian Context

The largely poor and rural population of South Asia is at significant risk from the impacts of climate change. The region has already started to witness an increase in extreme weather events such as heat waves and floods (Bhandari 2018). Furthermore, it is stated that a general warming of 2 to 4^{0}C in sea surface temperature is projected to increase tropical cyclone intensities by 10 to 20% in South Asia (Bals et. al., 2008). Rising temperatures along with a decrease in precipitation is likely to exacerbate the issue of water scarcity in South Asia, where water resources are already under stress due to rising demand caused by growing population, and inefficiencies of water use. Projected impacts of climate change in the region suggest increased risk of hunger and decline in yields. Furthermore, it is stated that by 2080, 266 million people in Asia could face hunger. For every 1^{0}C rise in temperature there will be a rise in demand for agricultural water from 6 to 10% (Ibid). If we continue on the current development trajectory, impacts of climate change would reduce GDP growth rates by 2-7 percent. It is estimated that GDP would be 50 percent lower in South Asia as a result of climate change by 2050 (Gogoi et al., 2017)

Impacts of climate change on agriculture would not only result in decreased yields and increased water demand, but also impact production, market dynamics and prices (FAO 2016). The negative impacts of climate change would hurt the national economies significantly where agriculture is the mainstay. Similarly, the countries which are most at risk are the ones that have significant rural and poor populations who do not have the capabilities to tackle the threats of changing climate (Ibid).

The Asia region as a whole has been the worst hit in terms of weather and climate extreme events from year 2000 to 2008. Moreover, the region suffered the economic losses to the tune of 30%, of total global losses due to extreme weather events (CDKN 2014). The negative impacts of climate change on natural resources and ecosystems has a resulting negative impact on agrarian livelihoods.

1.2 Impacts of Climate Change on Agriculture in Pakistan:

Pakistan is amongst the countries most at risk from the adverse impacts of climate change (Kreft et. al., 2017).

In Pakistan, agriculture contributes 19.8% to GDP, while engaging a significant 42.3% of the total national labor force. Similarly, 67% of the rural labor force is directly or indirectly involved in agrarian activities, which makes agriculture a key component of country's economy and people's livelihood options (GoP 2016). This sector is solely responsible for meeting the food requirements of the rising population. The effects of any fluctuations and variations in agriculture impact peoples livelihoods, which in turn affects their food security, especially the rural poor (Arif 2007). Realizing the importance of addressing food insecurity, the Government of Pakistan in its Vision 2025 document aims to reduce the proportion of food insecure populations from approximately 60% at present to 30% by 2025 (Pakistan Vision 2025).

Increasing temperatures will result in enhanced heat and water-stressed conditions, especially in arid and semi-arid regions, leading to reduced agricultural productivity (GoP 2013). The Asian Development Bank (2017) has predicted that the estimated rise in temperature in Pakistan will be higher as compared to the global average. The report suggests the need to assess negative impacts of climate change on agriculture in Pakistan to ensure food security and sustainable agricultural livelihoods. The report further states that precipitation rate does not show any systemic changes, whereas number of hot days and nights are projected to increase considerably and result in significant decline in yields in rice and wheat crops (Ibid).

1.3 Food Security

The Food and Agriculture Organisation (FAO) and the World Food Programme (WFP) define food security in terms of universal access to 'sufficient, safe and nutritious' food that fulfills the adequate dietary requirements and provides satisfaction for a healthy life at all times (FAO and WFP 2009). The definition of food security has undergone several changes over the years since the 1970s, with contributions from the World Food Summit (WFS), FAO, World Bank, and others. What started as a definition based on 'availability' of food by the World Food Conference in 1974 now encompasses aspects of socioeconomic access to food, its nutritional value and dietary preferences (Arif 2007).

FAO (2008) highlights the four pillars of food security, which form the basis of its measurement and determination. These include:

1. Physical availability of food;
2. Economic and physical access to food; and
3. Utilization of food.
4. Stability of food

As the world embarks on eradicating hunger by 2030 under the Sustainable Development Goals, Pakistan still has a long way to go in terms of improving its food security situation. Ranked 106 out of 119 countries in the Global Hunger Index (GHI) (IFPRI 2017), Pakistan is listed in the group of countries with the highest prevalence of hunger. GHI (2017) labels 22% of Pakistan's population as undernourished. As per the last National Nutrition Survey that was conducted in 2011, the state of food security in Pakistan has worsened in recent years, rising from 50% in 2003 to 58.1% in 2011 (NNS 2011). Factors for this rise include poverty, social and political issues and population growth. It is of note that climate change was not addressed in this report. Further, according to World Food Programme (WFP), 60% of Pakistan's population is currently food insecure, with women and the poor among the most marginalized. The gravity of the situation can be assessed by the fact that 43% of Pakistan's children under the age of 5 are suffering from malnutrition, in addition to more than 15% suffering from acute malnutrition (NNS, 2011).

Figure 1: Food Security at a National, Household and Intra-household level

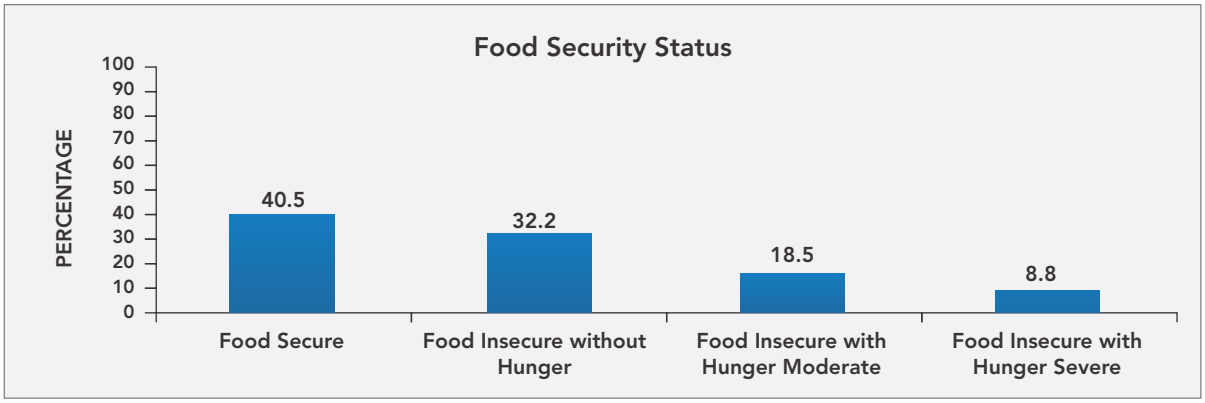
Levels	Food Security		
	Availability	**Accessibility**	**Sustainability**
National Level	• Production • Imports	• Per capita food availability. • Per capita income.	• Incidence of poverty in the country • Level of human resource development of the country • Standard of living of a household.
Household Level	• Production • Storage • Purchase	• Household income. Market Prices. Preferences and tastes.	
Within Household	Division of labour between different household members, i.e., the allocation of resource and responsibilities	• Market prices. • Who has control over cash income. • Who is the major decision-maker.	• Differences in the social and economic status of household members.

Source: Nazli and Hamid (1999)

2. FOOD SECURITY OF PUNJAB

Provincially, Punjab has fared better in terms of food security as compared to the other provinces of Pakistan[1]. According to the National Nutrition Survey (2011), out of a total sample size of 30,000 households, less than half (40.5%) of the respondents from Punjab considered themselves food secure. Among the 59.5% that considered themselves food insecure, 32.2% were food insecure without facing hunger. These include households facing food insecurity in the form of adequate but poor quality of food supply. Approximately 18.5% reported food insecurity with hunger and 8.8% reported food insecurity with severe hunger (Figure 1). In this context, Punjab appeared to be performing better in terms of an overall proportion of food secure population compared to the Federally Administered Tribal Areas (FATA), Sindh and Balochistan. Geographically, the central part of the province is found to be more food insecure than northern and southern parts of Punjab. Food security has positive relations with income, education, livestock assets and number of earners in household but negative linkages with family size (Bashir et al., 2012). The northern areas of Punjab, like Potohar region face severe challenges in terms of food security because of lower agriculture production, inefficient utilization of land, insufficient off-farm opportunities and volatile income in rural and urban areas (Abbasi et al., 2014).

Figure 2: Food Security Perceptions in Punjab



Source: (NNS 2011)

2.1 Food Availability and Linkages to Agriculture

Food availability refers to the supply dimension of food security and is defined in terms of food production, stocks and storage of food, transfers and aid of food products and net trade in food items (FAO 2008). In other words, it is determined by a combination of food production as well as market availability of food in the country. Food availability in Pakistan is intrinsically linked to its agriculture sector through crop based and livestock based food production. Pakistan is generally self-sufficient in terms of food production, although distribution of food production greatly varies across different regions of the country (Ramay 2013).

Wheat, a staple food crop in Pakistan is grown over 40% of the country's cultivated land during the 'rabi' or winter crop season (USDA Foreign Agricultural Service 2018). In 2017, it constituted 10% of the value added to the agriculture sector and 2% to the total Gross Domestic Product (GDP) (GoP 2017). The country's major crops, wheat, rice, sugarcane, maize and cotton are contributing 23.85% to agriculture and 4.66% to the GDP (GoP 2017). Since 1990s, crop yield is fluctuating because of its higher dependence on weather conditions (Hussain and Akram 2008). In 2016, the overall growth rate of crops was 3.46% against the target of 3.5%. Wheat, sugarcane, maize and rice all experienced an improvement in yield; however, wheat witnessed a decline in growth at 0.46% compared to 2.18% in the

[1]The National Nutrition Survey (2011)

previous year. Livestock, accounting for 58.33% in the agriculture sector grew by 3.43% as compared to 3.36% in 2016 and the fishing sector experienced a growth of 1.23%, lower than its performance in 2016 during which it grew by 3.25% (GoP 2017).

Table 1: Crop Yields of Major Crops (Kg/hectare)

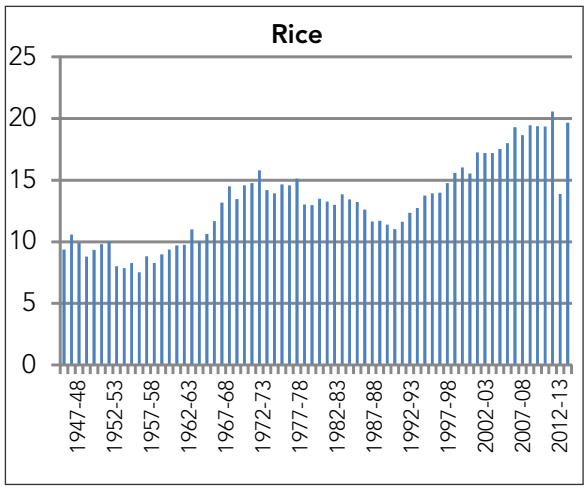
Years	Sugarcane	Rice	Wheat	Maize
2012-2013	56,466	2,398	2,796	3,981
2013-2014	57,511	2,437	2,824	4,233
2014-2015	55,062	2,422	2,726	4,323
2015-2016	57,897	2,483	2,779	4,426
2016-2017 (P)	60,428	2,514	2,845	4,595

Source: GOP, 2017

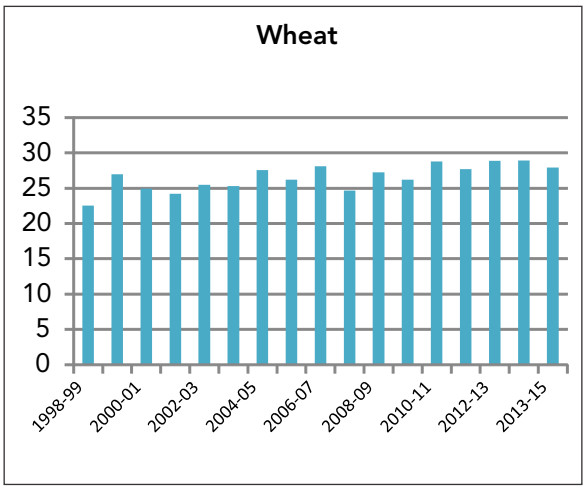
Punjab is considered the breadbasket of Pakistan owing to its land fertility and a strong network of irrigation canals. The province has the largest share in agricultural food production, e.g. 75.5% of wheat, 70.2% of rice, 79.8% of maize, 86.5% of gram and 67.8% of sugarcane (Samee et al., 2015) (Figure 2). It also has the most contributions to fruit production, providing 76.8% of national production of guava, 79.6% of mangoes, 96.5% of citrus fruits and similar high proportions in a variety of vegetables including pumpkin, cucumber, eggplant, beans, spinach, radish, cabbage etc. (Ibid.). Punjab performs better than the rest of the provinces in terms of production of staple crops and also provides the largest share for the rest of country; however, even within Punjab, there are wide disparities in terms of crop production (Ramay 2013).

Figure 3 shows yields of major crops in Punjab (kg/hectare). The graphs indicate that the yields have steadily increased over the years.

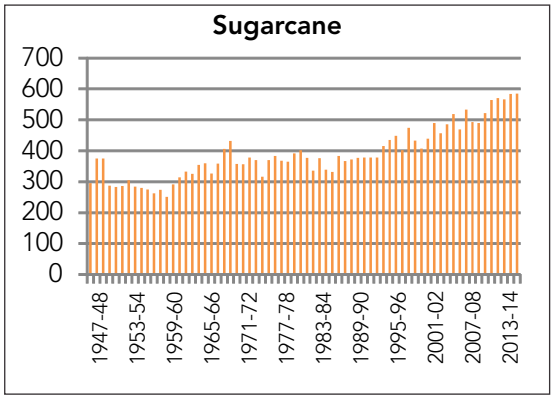
Figure 3: Crop Yields of Major Crops in Punjab (kg/hectare)



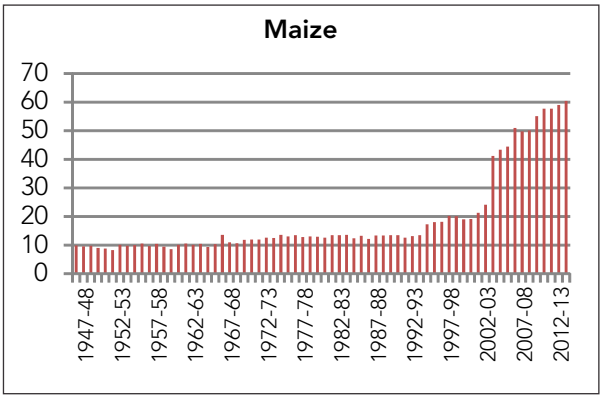
Source: Agri Marketing Information Service (AMIS)



Source: (Ibid)



Source: (Ibid)



Source: (Ibid)

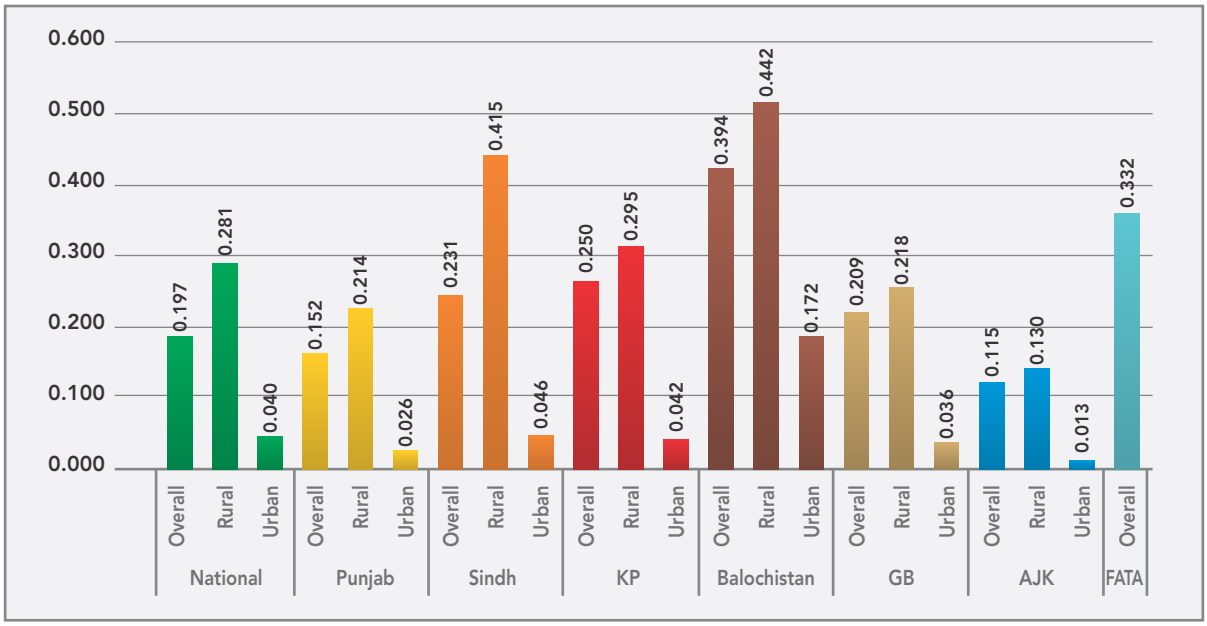
In addition to these food crops, livestock production also determines food availability. As per the 2006 Livestock Census, Punjab hosts 14 million cattle, 17 million buffaloes, 6.3 million sheep, 19 million goats, and 25 million poultry (GoP 2006). The by-products of these animals are an important source of meat and dairy food requirements for the whole country. In fact, 40 billion litres of milk is produced annually in Pakistan, most of which comes from Punjab (Samee et al. 2015). In light of these statistics, the status of food availability is quite satisfactory in the Punjab province.

2.2 Food Access

Food security can only be ensured if the available, required and desired food is also accessible and within reach of the population at all times. It refers to economic and social means to benefit from the available food (Arif 2007). While availability of food is rather satisfactory in Pakistan in general and Punjab in particular, food insecurity is largely shaped by the unequal access to different types of food. Thus, food access is a major hurdle in ensuring food security in Pakistan.

The Economic Survey 2018 reveals that percentage of people living below the poverty line is at 24.3 percent (Farooq 2018). Multidimensional poverty estimates are even more discouraging, with approximations of as much as 39% of the population labeled poor[2] (UNDP 2016). Even though Punjab appears to have lower scores of multidimensional poverty, yet within the province, there are quite significant disparities, especially within the rural-urban dichotomy (Figure 4).

Figure 4: Prevalence of Multidimensional Poverty in Pakistan



Source: UNDP (2016)

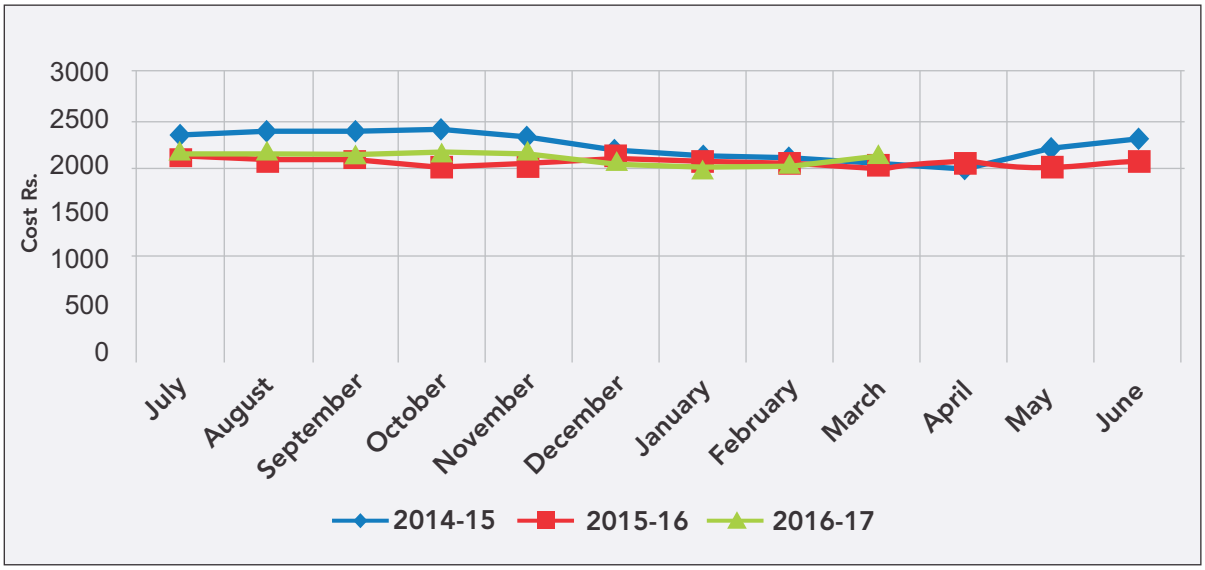
The agriculture sector not only contributes to food production, but also employs 42.3% of the national labor force (GoP 2017). However, most of the agriculture producers are small landholders and most of the agricultural labor includes wage laborers, earning low incomes (SDPI 2009). Rural women are extensively engaged in the agriculture sector as landless laborers and small farmers; they are generally engaged in agriculture production, vegetable hoeing and livestock rearing (Samee et al. 2015). It must be highlighted that women working on the farms and their time spent on livestock rearing is rarely counted as economic activity (Ibid.). This limits their access to economic resources, and thus may restrict their access to food.

The challenges to food access are also linked to the high unemployment rate (5.9% in 2016 as per estimates of Pakistan Bureau of Statistics (2016) as

[2]The term *'poor'* is based on intensity and incidence of deprivation in multidimensional poverty index.

well as the high inflation rate[3]. The core inflation rate in Pakistan averaged 7.52% per annum during the time period from 2010 to 2017 (State Bank of Pakistan 2017). It also peaked at an all-time high of 11.40% in June 2012 (Ibid.). Between January and June 2017, prices of wheat and wheat flour decreased and prices of non-cereal food crops also decreased. However, the price decline was offset by a rise in prices of chicken, cooking oil and vegetable ghee (WFP 2017). In addition, fluctuations in fuel prices also impact the accessibility to food. High poverty rates, coupled with high unemployment rates and inflation rates all act in unison to determine the discouraging state of food security in Pakistan through their impact on food access (Figure 5).

Figure 5: Cost of Food Basket (PKR) per Capita/month



Source: GoP (2017)

2.3 Utilisation of Food

Food security not only includes availability and access to food, it also entails food consumption. Food consumption is closely linked to nutrition and meeting the energy requirements of the population (Arif 2007). Besides relating to solid food intake, proper food utilisation embodies clean drinking water and sanitation facilities as they determine the extent of nutritional value. In urban areas, food accounts for 46% of the total household expenditure, while in rural areas it is 58% of the total expenditure (Malik et al. 2014). During the period of 1949-50 to 2012-13, calorie intake on average increased from 2,078 kcal per capita to 2,450 kcal per capita (Ibid). Wheat, cereals and dairy products largely constitute the dietary intake for average Pakistani households (Malik et al., 2014). However, the dietary diversity in terms of food intake is quite limited for the average Pakistani. Cultural food preferences and static patterns of food consumption reflect that 35% Pakistanis do not consume a balanced ratio of all seven food groups (Usmani, 2016).

In Pakistan, 68% of households are unable to afford a nutritious diet. The cost of nutritious diet also varies provincially. In Punjab, cost of nutritious diet per person per month was PKR 2,061 as compared to PKR 2,415 in Balochistan (WFP 2017). This reflects linkages between food access and food utilization. The provincial differences in micronutrients exist due to regional dietary inclinations and nutritious foods (GoP 2017).

Health of children is a key supporter of economic development and quality of life. Better child health influences adult health, educational attainment, income and productivity of varied occupations (Afzal 2012 and Khan et al. 2015). Malnutrition is a common health issue in children under the age of 5 years. It has led to increase in stunting and wasting in children. Almost 44% children have stunted growth, more than 15% are wasted and 31.5% are underweight. All three issues of stunting, wasting and underweight are comparatively higher in rural than urban areas throughout Pakistan (Ibid). There are higher

[3]Core inflation rate is an inflation rate that excludes transitory volatility in prices.

chances of stunting and wasting in children of households living as independent, nuclear units. Education of mothers and health knowledge plays a vital role in reducing chances of stunting (Afzal 2012 and Khan et al. 2015). In addition to malnutrition, deficiencies in essential nutrients are also a grave concern, especially in children. NNS (2011) depicts that 61.9% children face iron deficiency, 54% experience vitamin A deficiency, 40% have vitamin D deficiency and 39.2% have zinc deficiency in Pakistan.

1.4 Stability of Food

The final component of food security is food stability. It refers to individuals or households having access to food supply without having any risk about losing food access. The risks to food supply occur because of sudden shocks (economic or climatic) or cyclical events, irregularity of incomes and the volatility of food prices. Food stability can be achieved by enhancing markets access and changing contributions from trade (FAO 2016).

In case of Pakistan, climatic risk has been increasing. The Ministry of Climate Change (MoCC) (2013) report forecasts reduction of rainfall in central Punjab. Similarly, Salik et al., (2016) also forecasts reduction in rainfall in northern region of Punjab, thus predicting a significant rise in temperatures with the passage of time in Pakistan (ADB 2017 and Haensler 2013). These climatic risks are accompanied with increased salinity, water scarcity and decreasing ground water levels, which ultimately disrupts farmers' income and reduces their capacity to pay back loans. Government of Pakistan launched a scheme of Crop Loan Insurance Scheme (CLIS) in 2008 with the aim of providing subsidized insurance to subsistence farmers (up to 12.5 acres). This policy is subject to loan borrowers only for coping with natural disasters in case of calamity. While this policy has benefitted farmers, inefficiencies such as the late declaration of calamity by the government, delayed assessment of field loss, slow disbursement of insurance claims, meager amount of insurance claims and political influence in selection of calamity declaration of villages (Siyal, 2018) have impacted its effectiveness. Farmers are willing to participate in crop insurance schemes for which there is need for an independent crop insurance policy that can ensure food stability in regions facing natural disasters (Ali, 2013, Umar 2017). Similarly another study, Ghazanfar et al., 2015a, concluded that farmers from Punjab (D. G Khan, Rajanpur and Bahawalpur) were willing to participate in crop insurance. However negative perceptions of higher premium led to avoidance of crop insurance (Ibid). Along with the premium, dissatisfaction with crop loan insurance schemes, harboring beliefs about its non-Islamic views, lack of knowledge about crop insurance and slower processing were other factors determined to be barriers for avoidance of crop insurance (Ghazanfar et al., 2015, b). In order to enhance the trend of crop insurance in Punjab, education and previous experience of credit borrowers is essential (Ibid). It must be incorporated into any new such schemes.

3. CLIMATE CHANGE VULNERABILITY IN PUNJAB

IPCC AR5 (2014) defines climate change as 'a state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer.' The definition further recognizes the role of natural variability as well as human activity in bringing about a long term change in climate. In terms of climate vulnerability, there exists a huge reserve of literature that highlights climate impacts on physical and human resources, both directly (losses through extreme events like floods, loss of lives etc.) and indirectly (financial losses incurred as a result of decline in productivity etc.) (Ibid).

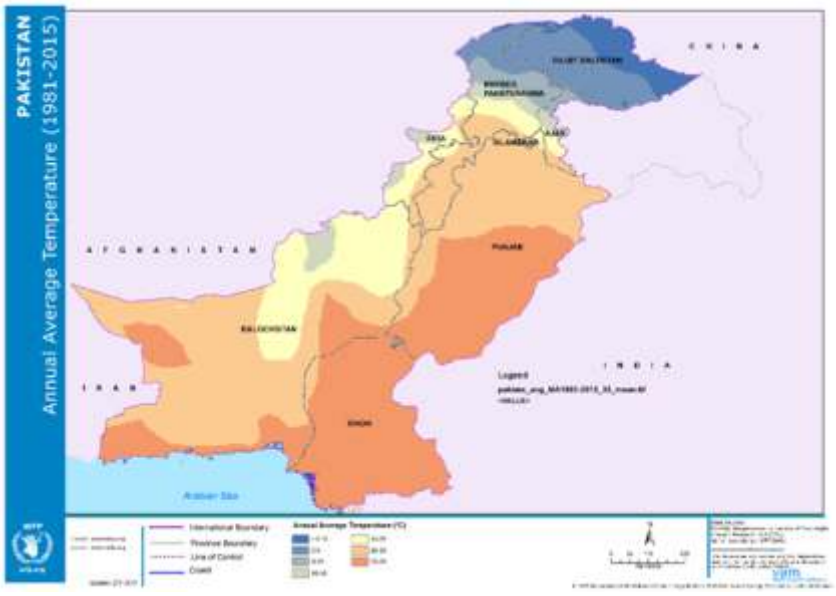
Various parts of the country are recurrently affected by climate catastrophes including floods and droughts, which not only impact social structure of the country but also have huge economic implications (ADB 2017). Apart from climate extremes, Pakistan is also incurring huge economic losses due to gradual changes in temperature and rainfall variability (Ibid).

Punjab is the second most urbanized and the most populous province of the country. It has a mix of irrigated, semi-arid and arid regions, with a variable climate ranging from extremely hot temperature in summers to mildly cold temperature in winters. Monsoon rains serve as a major source of water to the province, along with five rivers, including Indus, Jhelum, Chenab, Ravi and Sutlej. Punjab, being an agro-based region, is highly vulnerable to climate change, which has huge implications for agricultural production (Siddique et. al 2009 and Hanif et. al 2010). This region has seen changing patterns of monsoon rains, episodes of flooding and droughts, and temperature increase during the last few decades. Major observed trends and future projections related to temperature, precipitation, floods, and droughts are discussed in the sections below.

3.1. Temperature and Rainfall Trends in Punjab

In line with IPCC (2014) temperature projections for global and South Asian region, Pakistan specific studies highlight an increase in temperature for Pakistan over the next few decades. An increase of 0.6°C in average annual temperature has been observed for Pakistan during the last 100 years (Sheikh et. al, 2009). Concurring to this, ADB (2017) also reported an increase of 0.57° in the average annual temperature for Pakistan during the last century. In case of Punjab, we can see that most of the districts already fall under areas with high change in mean annual temperature (Figure 8).

Figure 6: Mean Annual Temperature (1981-2015) for Pakistan



Source: WFP 2017

3.1.1. Past temperature trends

Most of the studies reviewed hinted towards an increasing trend in temperature for Punjab. Chaudhry et. al (2009) found an increase of 0.97°C in winter mean temperature during 1960 to 2007 for the Punjab region. Abbas (2013) carried out a historical analysis (1981–2010) of the daily minimum and maximum temperatures for five semi-arid cities in Punjab. The analysis highlights a significant increasing trend of extreme hot nights and days; number of summer days; and number of tropical nights, whereas the frequency of extremely cold days and nights was found to be decreasing over the period under consideration.

Past trends in maximum and minimum temperatures for nine districts of Punjab were assessed by Khattak and Ali (2015). Using the temperature data from 1961 to 2014, they found an increasing trend in maximum temperature for two districts of Punjab (Rawalpindi and Faisalabad), whereas an increasing trend in minimum temperature on annual basis was found for the rest of the districts. Cheema et. al (2015) also found a significant increase in temperature on annual basis for the Punjab region.

A detailed assessment of past trends of different climate indicators in Punjab region was carried out by Ahmad and Mahmood (2017). The authors find that there is an overall decreasing trend of cold spell duration and number of frost days in Punjab. Moreover, using the data of last 54 years, they found an increasing trend in number of warm nights and monthly minimum value of daily minimum temperature. On the contrary, Jahangir et. al (2016) found that there was no significant trend in annual minimum temperature for five tehsils of Punjab under study.

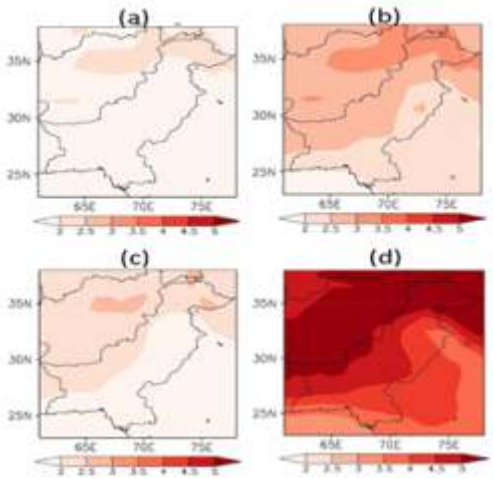
A comparison of these studies shows that there are variations in temperature change between different districts in Punjab. All researchers studied different indicators of temperature, resulting in some of the indicators not matching the overall trend of the changing temperature.

3.1.2. Future projections

In terms of future projections of temperature, Chaudhry et. al (2009) projected the temperature for the period 2011 to 2015 and found a positive trend in temperature for Pakistan, with maximum rise expected in central and southern Punjab. Similar results for southern Punjab were found by projections carried out by the Ministry of Climate Change (2013). In addition to this, the study finds a maximum increase of 4.5°C in summer temperature and 2°C rise in winter temperature for the Punjab region by the end of this century.

ADB (2017) also highlights the modeling results of a study by Global Change Impact Study Center (GCISC), which used the General Circulation Model for future climate change projections. The model predicts that the temperature in Pakistan will increase up to 4.38°C by 2080. Haensler (2013) also projects rise in temperature of up to 3.8°C in Pakistan by the end of this century. Moreover, a study conducted by Salik et. al (2015) projects rise in surface temperature for most areas in Punjab region using RCP 4.5 and RCP 8.5 scenarios (Figure 7). These projections correspond to the period 2030-2059 (a & c) and 2070- 2099 (b & d).

Figure 7: Temperature Projections for Pakistan based on CMIP5 Model

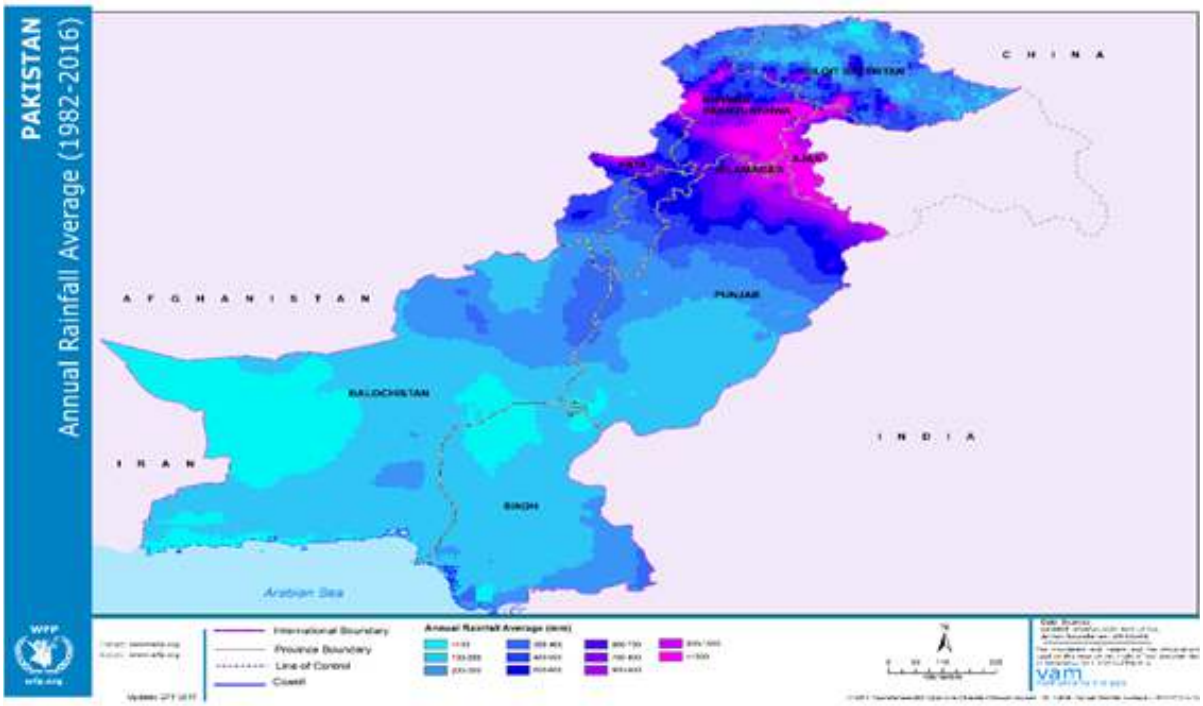


Source: Salik et.al (2015) *The upper panels exhibit results of RCP4.5 scenarios whereas the lower panels show results of RCP 8.5 scenario.

3.2. Precipitation Trends in Punjab

Precipitation is one of the major indicators of climate change which has huge implications for agricultural production, especially for a country like Pakistan where most of the agriculture production is dependent on rain water. Figure 8 below shows varying rainfall pattern for different regions in Punjab.

Figure 8: Average Annual Rainfall (1982-2016)



Source: WFP 2017

3.2.1. Past trends

Multiple reports have used varying indicators for their respective studies hence the outcomes are different. A report by GCISC (2005) shows an increasing trend in annual mean precipitation for all regions of Pakistan, except for coastal areas. On the contrary, analysis by Chaudhry et al., (2009) shows that there is a decreasing trend of rainfall from 1901 to 1953, whereas the period from 1955 to 2007 exhibits an increasing trend in the annual average rainfall. In terms of seasonal rainfall, the same study highlights inter-decadal variations in rainfall. The period after 1970 shows a sharp decline in monsoon over Punjab region.

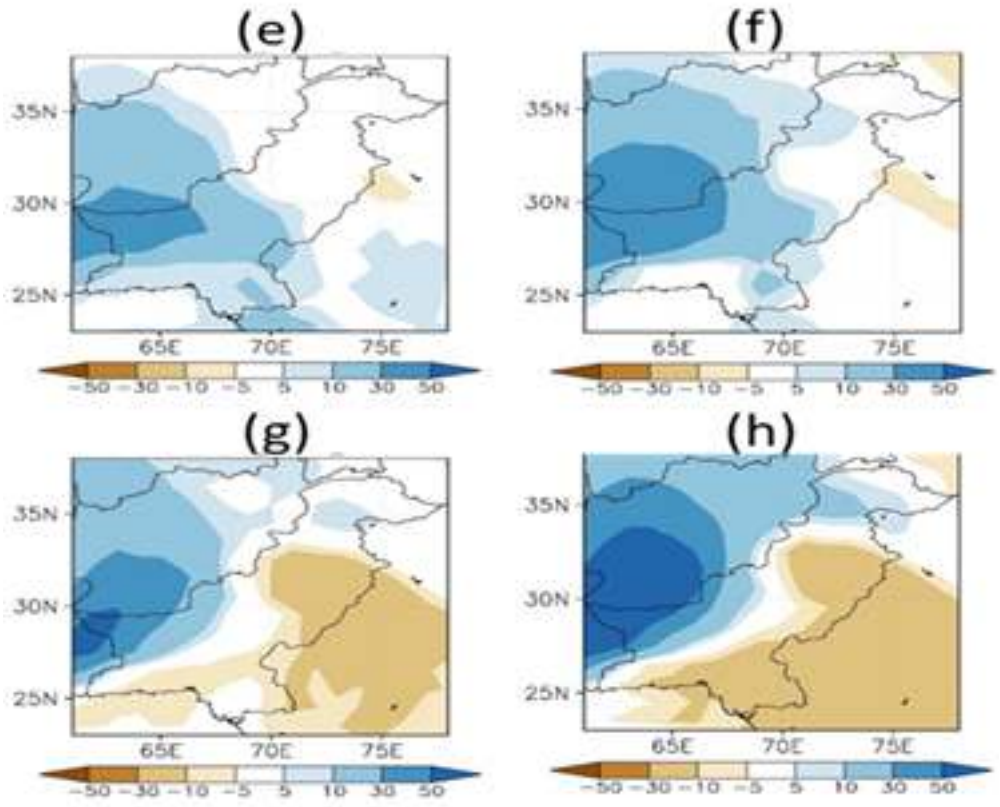
Zahid and Rasul (2011) used precipitation data from 1965 to 2009 to assess the changes in precipitation at the country level. They found an increasing trend of extreme precipitation events in southern Punjab at ≥ 100mm. On similar lines, Khattak and Ali (2015) found that summer, autumn and annual rainfall has increased in the Punjab region during 1961-2014 period. A significantly increasing trend in number of days with heavy precipitation was found by Ahmad and Mahmood (2017).

3.2.2. Future projections

A decrease in precipitation by 5-30% in central Punjab region was found using the ECHAM5[4] model by MoCC (2013). Results using the FVGCM[5] model also show a decrease of 5-20% in precipitation for southern Punjab. Salik et. al (2015), however, find that northern Punjab may face significant shortage of rainfall during the next few decades (Figure 11).

[4]European Centre Hamburg Model- atmospheric general circulation model developed at the Max Planck Institute for Meteorology).
[5]Finite Volume General Circulation Model. 3

Figure 9: Precipitation Projections for Pakistan based on CMIP5 Model



Source: Salik et.al (2015)

**The upper panels exhibit results of RCP4.5 scenarios whereas the lower panels show results of RCP 8.5 scenario.*

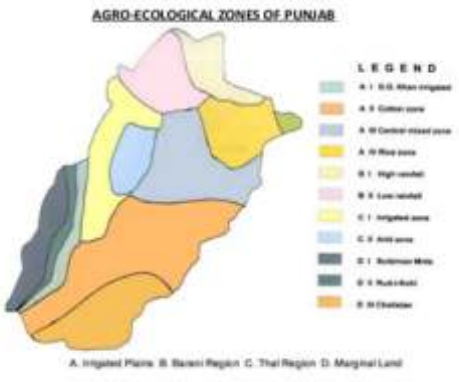
These studies show that there high variations in precipitation patterns are observed for overall Pakistan and the Punjab region. The change in precipitation pattern depends on the indicator under study. For example, monthly precipitation may show a slight increasing pattern but annual average precipitation for a particular region may show no major changes.

3.3. Agro Ecological Zones and Vulnerabilities

Most of the area in Punjab is plain and has arid and semi-arid characteristics. The southern part of the province predominantly receives less rain fall and is classified as an arid region. The rest of the plain areas are considered semi-arid and irrigated through the five-river system (Abbas et al., 2014). This water network is the major reason for Punjab's significant contribution to agriculture production in the country (Qureshi and Haq 2006). Pakistan Agriculture Research Council (PARC) has divided Punjab into four regions based on the water availability for agriculture. Climate change impacts these regions differently based on their characteristics. Riverine areas (most of the semi-arid) are vulnerable to floods, whereas arid region is vulnerable to drought (Abbas et al. 2014).

According Punjab Climate Change Policy (PCCP 2017), lower part of Zone A and marginal lands near Indian border of Zone D are most vulnerable to droughts (Figure 10). Whereas, some parts of Zone A and western part of Zone C and D are most vulnerable to hill torrents and downstream flash floods. The eastern part of Zone A is more likely to face urban flooding.

Figure 10: Agro-Ecological Zones of Punjab



Source: Pakistan Agriculture Research Council (agriculture maps of Pakistan)

3.4. Extreme Events

High temperatures and low rainfall (drought like situation) affect the productivity of various crops. Further, intensive rainfall increases the probability of floods, which can completely damage crops and lead to food security issues for farmers and for the country (Salma et al., 2012). Due to climate change, extreme and frequent weather events have been occurring on yearly basis in many parts of Punjab.

3.4.1 . Floods

Floods have been considered as an environmental hazard throughout history. Despite advancement in technology and vast experience, human beings are still vulnerable to damages from floods. Pakistan is among the most sensitive countries to climate change threats, and has become more vulnerable to climate extreme events (floods and droughts), due to global warming (Chaudhry 2017). In Pakistan, floods mostly occur due to intense rainfall coupled with increasing snowmelt as a result of climate change. The country has recently experienced six major floods from 2010 to 2015 (Table 2), which resulted in severe damage to lives (both humans and animals), livelihoods, assets and infrastructure. Inadequate capacities of institutions to deal with flood management exacerbate these damages (Ibid). According to the Federal Flood Commission report 2016, a total loss of USD 38.171 billion has occurred due to past 24 flood events. Along with this financial damage, around 12,330 people have lost their lives and 197,275 villages were damaged due to mega floods (Ibid). Floods occur during July – October and directly affect the standing kharif crops (sugarcane, rice, cotton, maize etc.) cultivated along the river banks. Rabi crops are also affected by floods in inundated lands because of their slow dry up requirement. The flood of 2010 is considered one of the mega disasters in the history of Pakistan; it affected over 20 million people in the country (GoP 2016). Only in Punjab, more than 5 million people were affected and more than 1.9 million acres of crops were damaged due to the 2010 flood.

Table 2: Loss and Damage due to Floods

Year	Crops affected (acres)	Persons Died	Persons affected
2010	1,914,104	258	5,038,992
2011	125,513	4	26,393
2012	473,998	60	887,345
2013	745,655	109	184,147

Source: PDMA Punjab flood reports

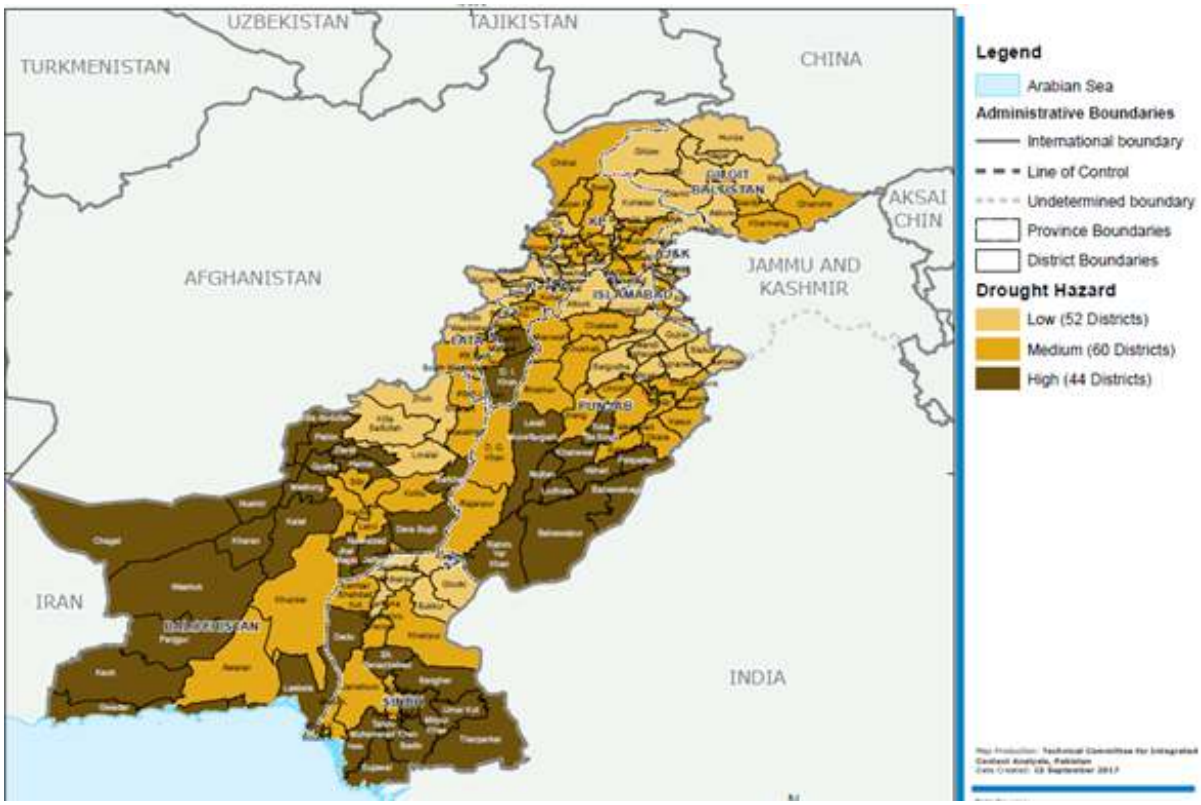
3.4.2. Droughts

When a region receives below average rainfall for a long period of time it becomes more likely to face a drought. Droughts can damage agriculture and ecosystems within the affected region and ultimately result in economic losses. Pakistan has recently faced a series of droughts in the last decade. One of the worst drought spells occurred from 1998 to 2002, followed by a moderate spell of drought from 2004 to 2005 and then a weak drought spell from 2009 to 2010. These droughts affected the population of Balochistan, Sindh and some parts of southern Punjab (PMD 2016). The farming communities in these areas were severely affected as their crops were damaged and livestock perished due to extreme heat and degradation of pasture (Ibid.).

During summers, Punjab faces high temperature and low rainfall that can lead to a drought like situation in the region. Southern Punjab shows a higher vulnerability to prevailing drought conditions. Droughts can have serious impacts on livelihoods of these areas as majority of the population is dependent on agriculture (Salma et al,. 2012). Furthermore, the situation could be worsening as the incidents of drought in Asian region are expected to increase (IPCC 2014).

According to IPCC (AR5) 2014 report, the frequency and magnitude of the heat waves is expected to increase in Asia. Pakistan has already begun to see an increasing trend in terms of heat wave events over the past decade. Over 1,000 people died due to heat stress in June 2015 in Sindh. The Integrated Context Analysis report (2017) has classified three levels of drought hazards and district vulnerabilities based on the data from 1951 and 2010 (GoP 2017), as shown in Figure 11.

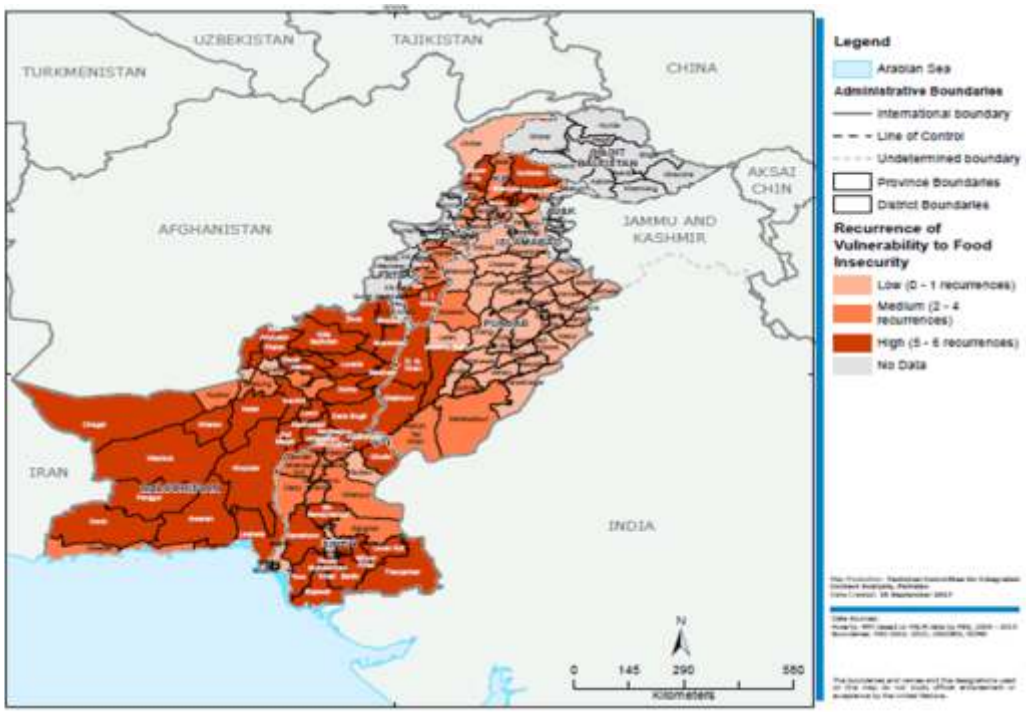
Figure 11: Drought Prone Districts of Pakistan



Source: (GoP 2017)

With the frequent occurrence of high or medium level natural hazards, 44 districts are highly at risk to food insecurity in Pakistan in terms recurrence vulnerability. At provincial level, Punjab is least vulnerable as compared to other provinces. Of the district most impacted, 19 are in Balochistan, 13 in Sindh, 7 in Khyber Pakhtunkhwa (KP) and 3 in Punjab (GoP, 2017). This is depicted in Figure 12.

Figure 12: Pakistan Recurrence of Vulnerability to Food Insecurity Map



Source: (GoP 2017)

4. CLIMATE CHANGE AND FOOD SECURITY INTER-LINKAGES

4.1 Impacts of Climate Change on Food Security

The climatic changes and frequent disasters have cumulative impact on food security situation in Pakistan. The climatic changes influence food security aspects, namely, availability, access, utilization and stability. Similarly, intensity of climatic shocks defines the level of impact on food security conditions (IPCC, 2012).

The rising threats ranging from droughts to floods have raised an alarming call for water conservations and risk management strategies to save agriculture and protect public health (Ahmed et al. 2016). Numerous studies have confirmed rising trends of temperature and their negative impacts registered from extreme hot nights and days, number of summer days, number of tropical nights and rising minimum temperature in Punjab province (Abbas, 2013, Khattak and Ali, 2015, Cheema et al., 2015, Ahmad and Mahmood, 2017). Along with temperature, variation in precipitation due to climate change is also having its impacts. In some regions, there is increasing trend of precipitation in Punjab (Khattak and Ali, 2015, Ahmad and Mahmood, 2017) but in central and northern parts of Punjab studies found decreasing trends of precipitation (MoCC 2013, Salik et al., 2015).

Recently, Climate Change Policy of Punjab (2017) elaborates climatic changes by specifying regional changes. The lower part of Zones A (Rajanpur, Rahimyar Khan, Bawalnagar, Lahore, Sheikhupura, Gujranwala and Kasur) is facing droughts, while, eastern part of the same zone faces urban flooding. The western part of Zone C and D (Layyah, Bakkhar, Mianwali, Khushab, Dera Ghazi Khan, Bahawalpur, and Rahimyar Khan) suffers from hill torrents and downstream flash floods. Finally, Zone B (Rawalpindi, Attock and Chakwal) relies on heavy monsoon from Bay of Bengal which gets deflected from Himalayan Range (PCCP, 2017).

Climate change will impact all facets of food security in the Punjab, including availability, access, utilization and stability. These are discussed below.

(1) Availability

The links of frequent disasters and climatic changes are connected with aspects of food security. The agriculture productivity has been affected by climate induced changes that have led to decreased yields, rising water demand and market access and prices throughout the world (FAO 2016). In case of Pakistan, food availability conditions are affected by rising trends of heat and water-stressed conditions in semi-arid and arid regions (GoP 2013). Along with that, climatic changes, like temperature rise, increasing number of hot days and nights and low rainfall negatively influence crop productivity. Similarly, intense rainfall increases chances of floods that damage crops, leading to food security issues for farmers. These changes have aggravated production of major kharif and rabi crops, namely, rice and wheat (Salma et al., 2012), (ADB, 2017), (GoP, 2016).

Droughts pose another threat to food security. More recent droughts include a major episode from 1998 to 2002, followed by 2004 to 2005 and 2009 to 2010. The southern part of Punjab was particularly impacted by these droughts, which were responsible for crop losses, deaths of livestock due to excessive heat and degradation of pastures (PMD, 2016). Numerous spatial studies confirm trends of climatic changes and predict severe conditions in future due to irregular increase of precipitation and temperature followed by heat waves. These changes will affect productivity of agriculture and reduce crop cycle (Nasim et al., 2016, Amin et al. 2018 and Saeed and Suleri, 2015). These studies used climatic models, namely, SimClim[6], 40 General Circulation Models (GCMs)[7] and Regional Climate Projections (RCPs). Apart from spatial climatic models, Raza and Ahmad (2015) and Siddiqui et al (2012) also validate influence of climatic changes on crops namely, wheat, rice, sugarcane and cotton. These studies used Fixed Effect Models (FEM) and Random Effect Models (REM) for

[6]SimCLIM software can be used to study the impacts and adaptation strategies to climate change and climatic extremities,
[7]Global circulation model (GCM) predict about frequency and severity of these changes in future. Regional Climate Projections (RCP) analyze the future climate change scenario with the associated uncertainty range.

analyzing climatic changes and suggested for improving awareness of climatic changes and appropriate use of inputs.

One of the interventions from Government of Punjab under Southern Punjab Poverty Alleviation Project – Additional Financing (SPPAP-AF, 2016-2021), in coordination with IFAD, was to support vulnerable rural families. This programme targets ten districts – Bahawalpur, Bahawalnagar, Rahimyar Khan, Muzzaffargarh, Rajanpur, Dera Ghazi Khan, Layyah, Bhakkar, Khushab and Mianwali. This program aims to provide small housing units to landless/homeless women, livestock packages, food banks, community revolving funds, initiating vocational and entrepreneurial trainings to enhance income generation, educational awareness of food and nutritional security and enhancing community development through strengthening of community organizations, including village organizations (VOs), and local support organization (LSOs) (IFAD 2017). This program has supported farmers in rural areas of Southern Punjab to cope with food insecurity from climatic disasters.

(2) Access

The component of food access depends on economic affordability of food. It gets weakened by lower employment opportunities, higher inflation and existing multidimensional poverty (Pakistan Bureau of Statistics, 2016, MPI report, 2016, IRIN, 2012[8]). These facets further impact the demands of rising population which has reached 207.7 million (Rana, 2017). Along with population, oil and food price shocks shrink consumption power and increase poverty level (GoP, 2017, Chaudhry and Chaudhry, 2008). In particular, increasing food prices impact rural population more severely than urban residents. The increase of food prices by 20% can increase poverty head count level by 8% in rural areas (Chaudhry and Chaudhry, 2008). The food items comprise approximately 46% of urban household expenditure and 58% of expenditure of rural household expenditure (Malik et al., 2014). There is lack of dietary diversity as few food items, namely, wheat, cereals and dairy products are major part of household food consumption (Usmani, 2016). The calorie intake of households has increased by meager amounts since past many decades (Malik et al., 2014).The economic affordability of people can be enhanced by social protection programs, like Benazir Income Support Program (BISP). Such social protection programs can not only improve economic and social value but also increase political stability and restrain crime. The BISP program, launched in 2008, provides cash transfers that reduce short term stress and insecurities which inhibit poverty alleviation in the long run. The cash transfers in the said program have helped its beneficiaries (Nayyab and Farooq, 2014). Under this program, more than 5 million beneficiaries in Punjab receive unconditional cash transfers (UCT) to cope with rising food, fuel and financial crises. These cash transfers were increased from Rs. 1000 to Rs.1566 per month in July 2015. The annual budget for BISP program was raised from Rs. 16 billion to 96.56 billion in 2015/16 (GoP, 2017). According to Cluster report of BISP, it has covered more than 4.9 million households in Central Punjab and 4.5 million households in Southern Punjab. Out of 4.5 million of Southern Punjab, this program has covered 396,635 households in D.G Khan and 784,855 households in Muzzafargarh (GoP, 2017).

(3) Utilization

The food utilization component of food security plays a vital role as it is linked with nutritional well-being. It deals with nutritious diet, clean water, sanitation and health care (FAO 2016 and Arif 2007). However, in Pakistan, affording nutritious diet is a major problem as 68% of households cannot afford a nutritional diet and almost 18 to 22 percent of children go to sleep hungry every night (WFP 2017, GoP 2017). Women along with children are facing higher vulnerability in terms of food utilization as compared to men. The issues of stunting, wasting and underweight are common in children while, issues of obesity are common in women. Similarly, micro-nutrition deficiencies are also faced by children; almost 62% of children are facing iron deficiencies, 54% face vitamin A deficiency, 40% have vitamin D deficiency and 39.25% have zinc deficiency (NNS, 2011)., These micronutrient issues in children are higher in rural areas as compared to urban areas. Overall, 44% of children are facing stunting, wasting and underweight issues (GoP 2017). In Punjab, cost of nutritious diet is lower than other provinces. It can be one reason behind micronutrient deficiencies being lower in Punjab than other provinces (GoP, 2017).

[8]http://www.irinnews.org/report/96849/pakistan-inflation-hits-food-security

The BISP program provides cash transfers, which are found to increase food consumption, especially the amount of proteins. The proteins ultimately enhance quality of food intake (GoP, 2017). Similarly, International Fund for Agriculture Development (IFAD) reports establishing food banks that can help in reduction of seasonal food shortages and cash borrowing (IFAD, 2016). There is a need for increased coordination and integration of Benazir Income Support Programme (BISP) initiative with other IFAD programmes that can help identify and enhance resilience of marginalized and ultra-poor people[9] in Pakistan. Along with that, in order to build resilience for sustainable nutrition and food security under zero-hunger programme, GoP,[10] FAO and WFP must continue to plan and implement numerous interventions (Ibid).

(4) Stability

The final component of food security is food stability. It is more linked with unpredictable climatic conditions which can cause changes in seasonality, productivity fluctuations and higher chances of risks to supply (FAO 2016). The existing threats from frequent climatic disasters, slow onset climatic changes, insufficient storage facilities for water have increased vulnerability of people in hot spot areas (Usmani 2016). In Pakistan, almost 42 districts are highly vulnerable to recurrent floods and nine of those are located in Punjab (GoP, 2017). Historically, Pakistan has faced more than a hundred natural disasters, which have cost the economy billions of dollars (FFC, 2016). Similarly, droughts have significantly influenced cropping productivity and livelihood opportunities in many regions (Salma et al., 2012). The southern part of Punjab is more vulnerable to drought than other areas of Punjab. According to ICA report (2017), ten districts of Punjab are ranked as highly vulnerable to droughts, majority of remaining were facing medium vulnerability and few of them had low vulnerability against droughts. In addition, environmental degradation poses serious threats to food security conditions. The rising dependence on irrigation water and supply of saline ground water further aggravates quality of land which reduces agriculture productivity. These issues undermine sustainability of agriculture productivity throughout the country, and especially in Punjab (Muhammad, 2010). These climatic conditions have affected food security conditions, particularly food stability in Punjab, the highest contributor to agriculture output in Pakistan. The future projections of climate models note above average rising temperature in Pakistan and predict severe conditions for agriculture, which needs timely policies to address food security and to reduce risks to agriculture livelihoods.

Crop insurance is one of the solutions for minimizing food insecurity risk. The major determinants for willingness of farmers to buy into index-based insurance are farmer's economic status, household assets and membership of community organizations. A subsidized insurance policy can reduce risks and ensure food security (Ali, 2013).

Globally, another strategy used for enhancing food security is implementation of climate smart villages (CSVs). Such villages engage researchers, local partners and farmers for formulating climate smart agriculture interventions. These interventions can not only increase farmers' income but also enhance resilience against climatic risks. It will ensure agriculture productivity that will influence food security. The CSVs comprise of climate smart technologies, climate information services, local knowledge and institutions and village development plans (CGIAR, 2013). Similarly, government of Punjab plans to distribute smart phones among small farmers (land size less than 12.5 acres) under *Kissan* package. This intervention will update farmers about weather updates, agriculture department's plans and policies (Pakistan Today, 2016). These updates will be based on an app developed in collaboration with Telenor and Punjab Information Technology Board (PITB). Additionally, farmers can use this app for application of loans that will reduce *patwari*[11] and bank agent culture (The Nation, 2018). However, majority of farmers' in Punjab are not using climate smart agriculture interventions. For example, less than 30 percent of farmers are using drought tolerant varieties, organic fertilizers, heat

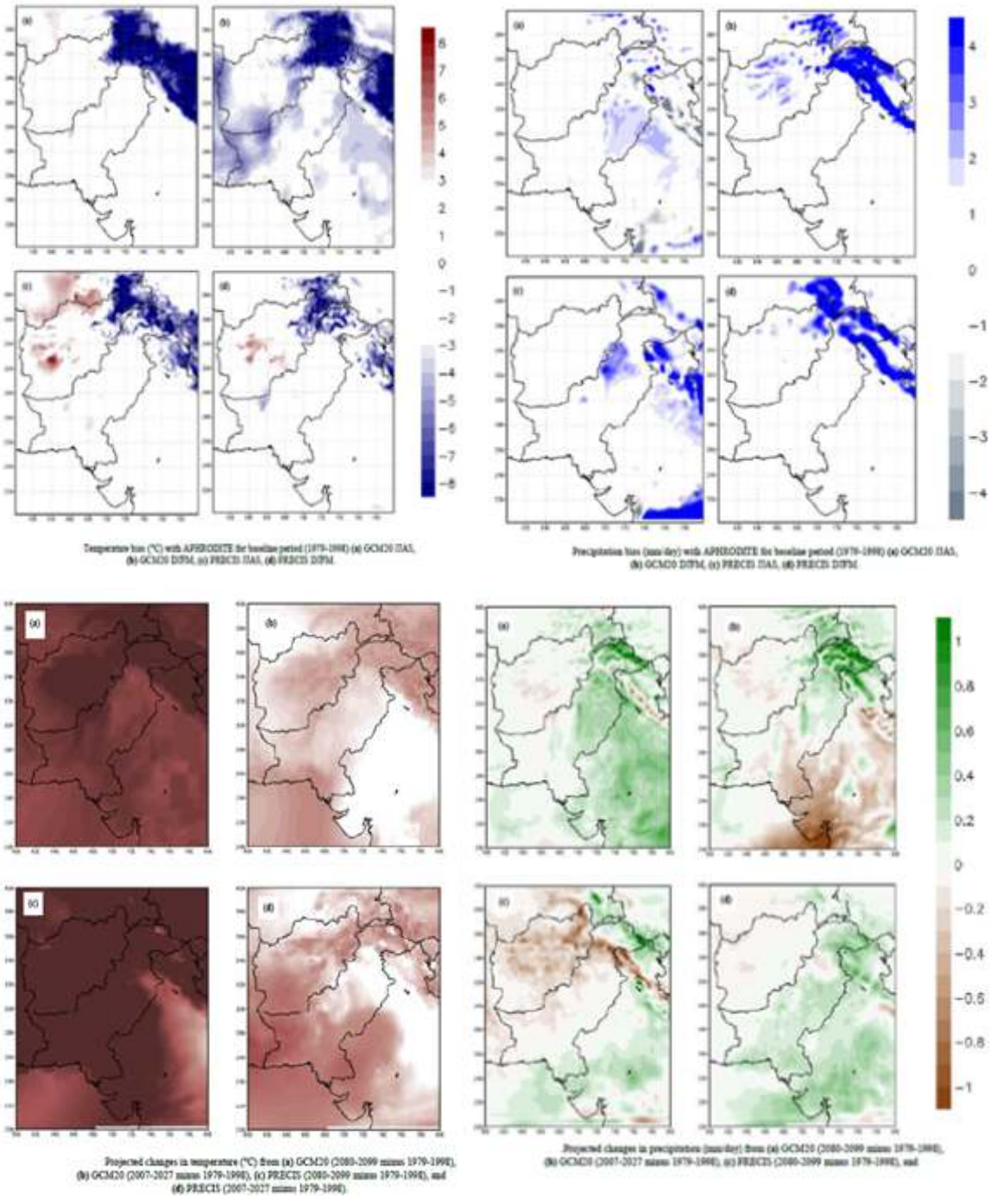
[9]Ultra poor are defined as households lying in range of 0 to 16 in poverty score card, poor (12 to 18) and transitory poor (19 to 23) (IFAD, 2016).
[10]Zero Hunger Program comprises of key interventions that will include: women's management of community food banks linked to provincial disaster management agencies (1,500 poor/vulnerable communities); promotion of climate-smart agriculture and production systems (with FAO and the Consultative Group on International Agricultural Research [CGIAR]); and investments in and promotion of innovative irrigation and water-harvesting systems in collaboration with other donors, research institutes and universities.
[11]Patwari' means a local administrator of land administration system (Ali and Nasir, 2010)

tolerant varieties, early maturing varieties, crop rotation and integrated pest management (World Bank, 2017). Therefore, there is need for mainstreaming CSVs to support stable food production in Punjab.

4.2 Climate Change Models Predictions

The spatial climatic models help in analyzing weather pattern changes over a period of time. The Global Circulation Model (GCM20) and Regional Climate Model (RCM) analyze regions of Hindukush, Himalaya and Karakoram (Ahmad et al., 2014). The regions with higher terrain are expected to have increase of temperature from 1oC to 1.5oC as per GCM20 and 1.5oC to 2oC as per Providing Regional Climates for Impact Studies (PRECIS) model. Similarly, precipitation in northern regions will also be increased from 0.5mm/day to 1mm/day as per climate models GCM20 and PRECIS.

Figure 13: Forecasting about Changes in Precipitation and Temperature

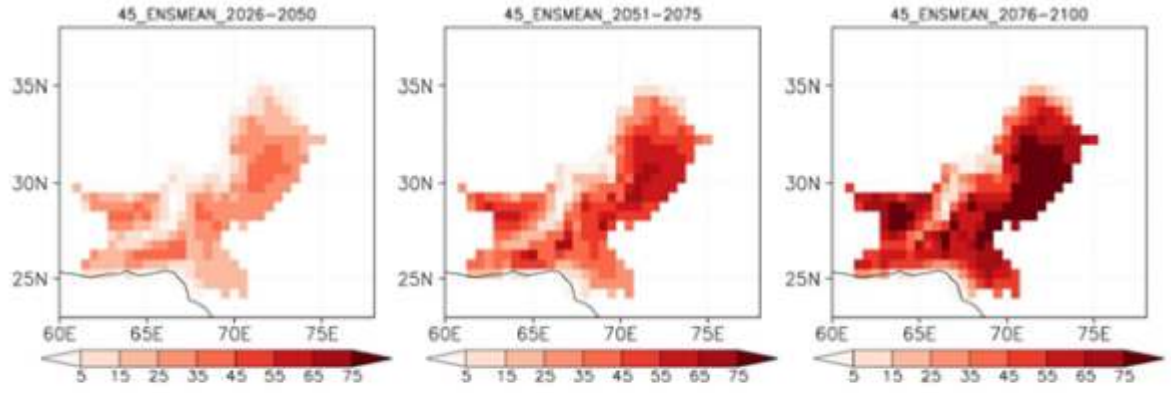


Source: Ahmad et al., 2014

The weather data analysis of time period from 1980 to 2011 shows higher risk of climatic uncertainties with respect to agriculture of southern region of Punjab. This study used another climate model, namely, SimCLIM[12] which was used for model projection with 40GCM for climate projections. In future, irregular increase of precipitation and temperature will enhance risk with respect to managing climate change and appropriate projections will enhance the risk management decisions (Amin et al., 2018).

Another study, Saeed and Suleri (2015), analyzed conditions of heat waves by three Regional Climate Models (RCMs) in Pakistan. The heat wave projections of 2026-2050 show significant increase in number of heat waves in hyper-arid and arid regions of Pakistan.

Figure 14: Heat Waves Forecasts



Difference in number of heatwave events between control and three sub-periods 2026-2050 (left), 2051-2075 (middle), 2076-2100 (right). The data presented in these plots is the ensemble average of all the three RCMs.

Source: Saeed and Suleri (2015)

Apart from temporal scale based studies, district level disaggregated data was used to analyze impact of climate change on cotton production provincially. The model follows panel data methodology of Fixed Effect Model (FEM) and Random Effects Model (REM) for provinces of Sindh and Punjab. Punjab province is comparatively less prone to climate change and rising temperature, as compared to cotton growers of Sindh. The adverse impact of climate change can be minimized by enhancing awareness of climate change and appropriate fertilizer usage (Raza and Ahmad, 2015). Another study observed impacts of climate change on four major crops, namely, wheat, rice, sugarcane and cotton. This study considered district wise crop productivity and climate change variables and conducted analysis of Fixed Effect Model (FEM) with multiple stages of temperature and precipitation indicators. Rise of temperature can aggravate conditions for wheat in short run. On the contrary, rice crop can benefit from slight increase of temperature, but above an optimal threshold, it becomes harmful. Similarly, sugarcane can be negatively influenced by rising temperature in long run. For cotton crop, changes in temperature or precipitation can be harmful for its productivity. Precipitation changes can also harm wheat and cotton but does not harm rice productivity (Siddiqui et al., 2012).

Climate models, such as GCM, RCM, SimCLIM confirmed evidences of climate change in different regions of Pakistan. Some studies have connected climate change impacts to crop productivity in Punjab. In general, the studies highlighted the negative influence of climate change on major crops and grains, with rising temperature and precipitation variation largely responsible.

4.3.1 Section on Micro-evidence of Climate Change and Food Security

Study Sites and Methods

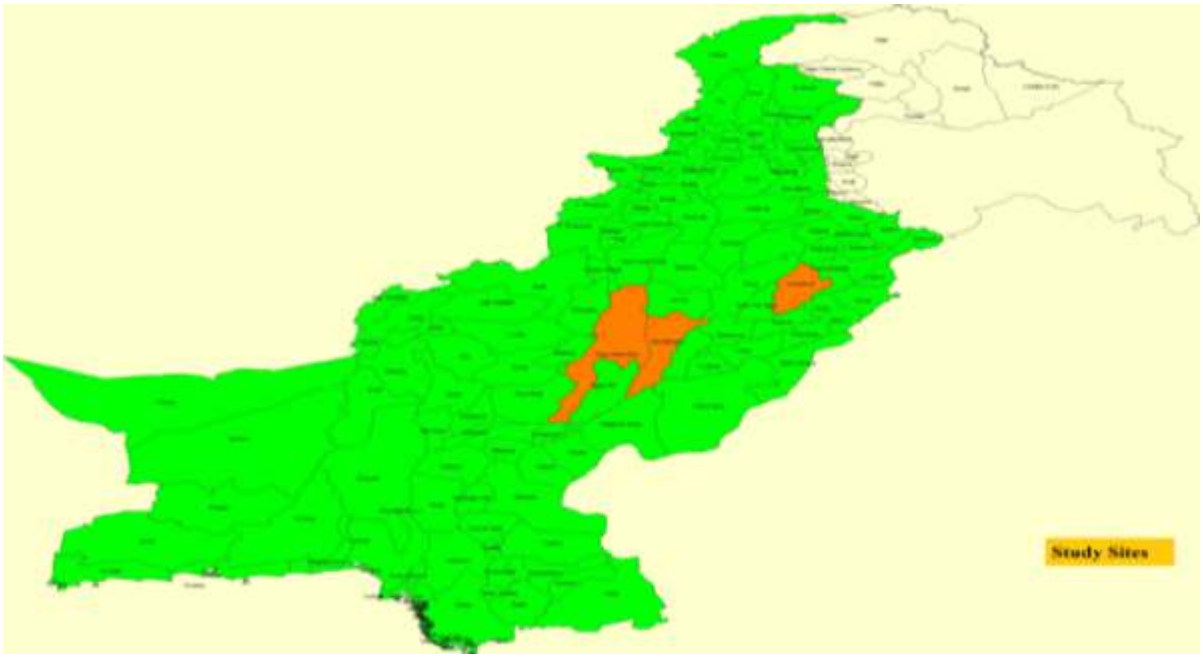
In this study, food security conditions and challenges from climate change are observed for the Punjab province. Along with desk review, this

[12]SimCLIM can be used to study the impacts and adaptation strategies to climate change and climatic extremities (Warrick et al. 2012)

study analyses relationship of food security and climate change with land ownership (size of land). The aspect of land size segregates analysis to a deeper level. There are four categories of farmers: marginal farmers (less than 5 acre), small farmers (5 – 12.5 acre), medium farmers (12.5 acres to 25 acres) and large farmers (above 25 Acres) (Rashid and Sheikh 2015).

This study comprises of micro-evidences from two research projects conducted by SDPI that collected data from three districts of Punjab: Faisalabad, Dera Ghazi Khan and Muzzafargarh. Both research projects were based on an extensive, structured questionnaire survey of selected districts. The data of Faisalabad and Dera Ghazi Khan is based on Pathways to Resilience in Semi-arid Regions of Pakistan (PRISE), a project funded by Department for International Development (DfiD) and International Development Research Centre (IDRC). In this survey, the sample size of selected farmers was 200 from each district, conducted using multi-stage stratified random sampling. Particularly for this study, relationship between land size and food security situation is analysed along with coping strategies. Data for Muzzaffargarh was obtained from project survey of Rural Resilience Initiative, which looked at reducing and transferring agricultural risks to insurance schemes in case of disasters. In this survey, total sample size of households was 167 farmers from five villages within three union councils of Muzzaffargarh. The data collected was analysed using Exploratory Data Analysis (EDA), to identify and assess the socioeconomic determinants of risk perceptions and risk management strategies and their access. The selected districts of this study are given in Figure 15.

Figure 15: Study Sites



Source: Author's estimation

4.3.2 Results

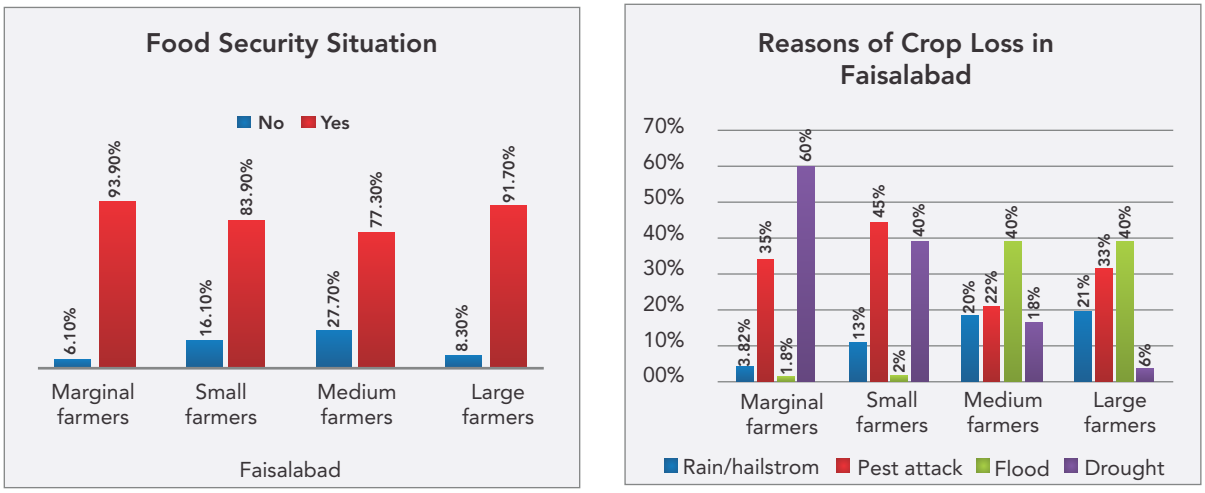
Faisalabad

In Faisalabad, during past 60 years, climatic changes are evident through changes in temperature and rainfall. The rise in temperature during winter season and increasing temperature during summer season are signs of such changes (Cheema et al., 2006). The factors of water availability at suitable intervals of time, air and soil temperature, and rainfall helped higher productivity of crops. However, climatic changes resulting in heavy precipitation during flowering time of *kharif* season can lead to lower productivity (Imran and Ayaz, 2015).

The results of this study show that higher proportions of medium and large farmers considered in the study saw significant crop loss. Particularly, medium and large farmers faced floods, leading to crop destruction. Such farmers considered drought conditions, pest attacks (35%)

and rain/hail storm (3.82%) as the major causes of crop loss. Similarly, small farmers (45%) considered pest attacks as major reason for their crop loss.

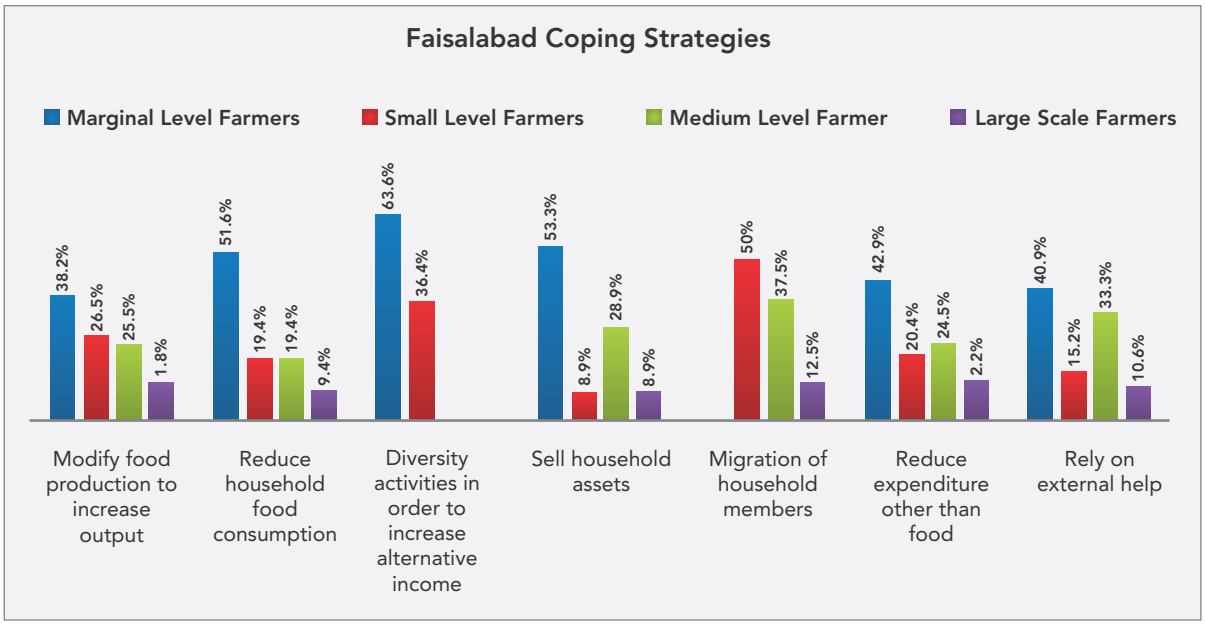
Figure 16: Food Security Situation and Reasons of Crop Loss in Faisalabad



Source: Author's calculation

Due to such climatic shocks and resulting crop loss, the majority of every category of farmer agreed that food shortages and lack of funds to purchase food items lead to their food insecurity. As such, marginal farmers have considered diversification of income as their major coping strategy against food insecurity and small farmers considered migration of family members as their main coping strategy. A small proportion of medium (28.8%) and large farmers (9.3%) adopted migration of their household member (Figure 17).

Figure 17: Faisalabad Coping Strategies



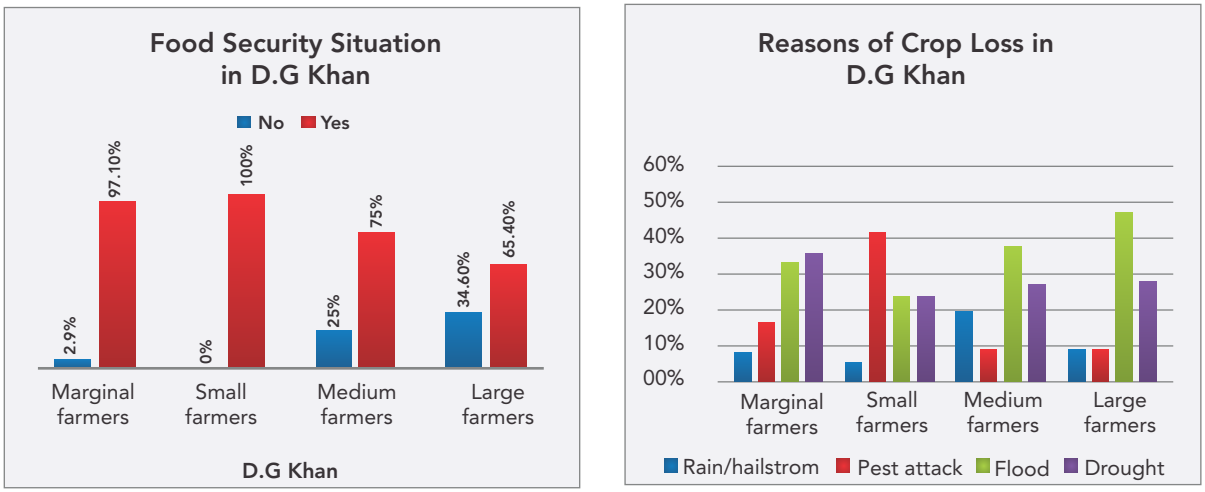
Source: Author's findings

D.G Khan

In D.G Khan, impacts of climate change and disasters negatively affected crop productivity (Rasheed and Khan 2015; Amer et al., 2009). These climatic changes include floods, extended monsoon, pest attacks, shifts of summer and winter seasons, and inadequate drainage system leading to higher level of water logging and salinity. The results of this study found that in D.G Khan, higher proportion of large, medium and marginal farmers considered drought and flood as a major reason for their crop losses, while, small

farmers considered pest attack and rain/hailstorm as major reason for their crop losses followed by other reasons. Due to these climatic changes and disasters, majority of farmers faced food shortage or lack money to purchase food. The major coping strategy used by marginal farmers was external help and small farmers used reduction of household consumption, followed by other strategies. However, such food insecurity issues did not prevail for majority of medium and large farmers. The lesser proportion of those faced food insecurity and considered modifying food production to increase output.

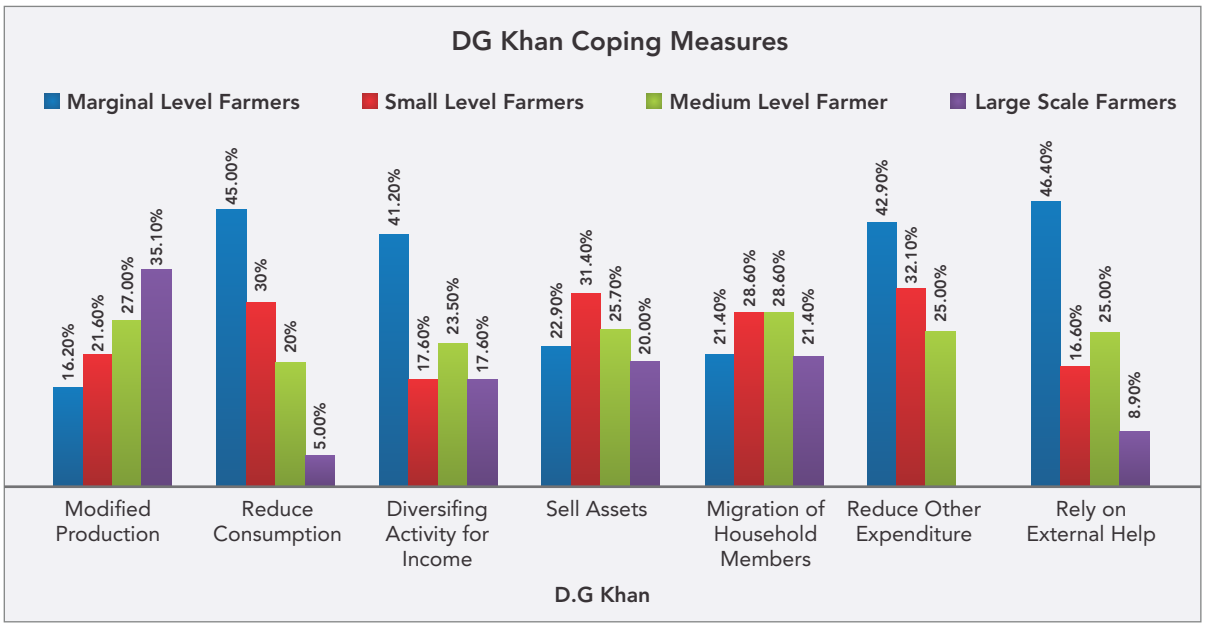
Figure 18: Food Security Situation and Reasons of Crop Loss in D.G Khan



Source: Author's Findings

In order to deal with food security issues (Figure 19), marginal farmers majorly considered relying on external help (borrowing credit) followed by reducing consumption, reducing other expenditures and diversifying activities in order to increase alternative incomes. The higher proportion of small farmers considered reduction of other expenditures, the sale of assets and reducing consumption as major coping measures. Similarly, medium farmers considered migration of household members, followed by modification of production and selling assets majorly. Lastly, large farmers modification of production as their major coping measure followed by migration of household members.

Figure 19: D.G Khan Coping Measures



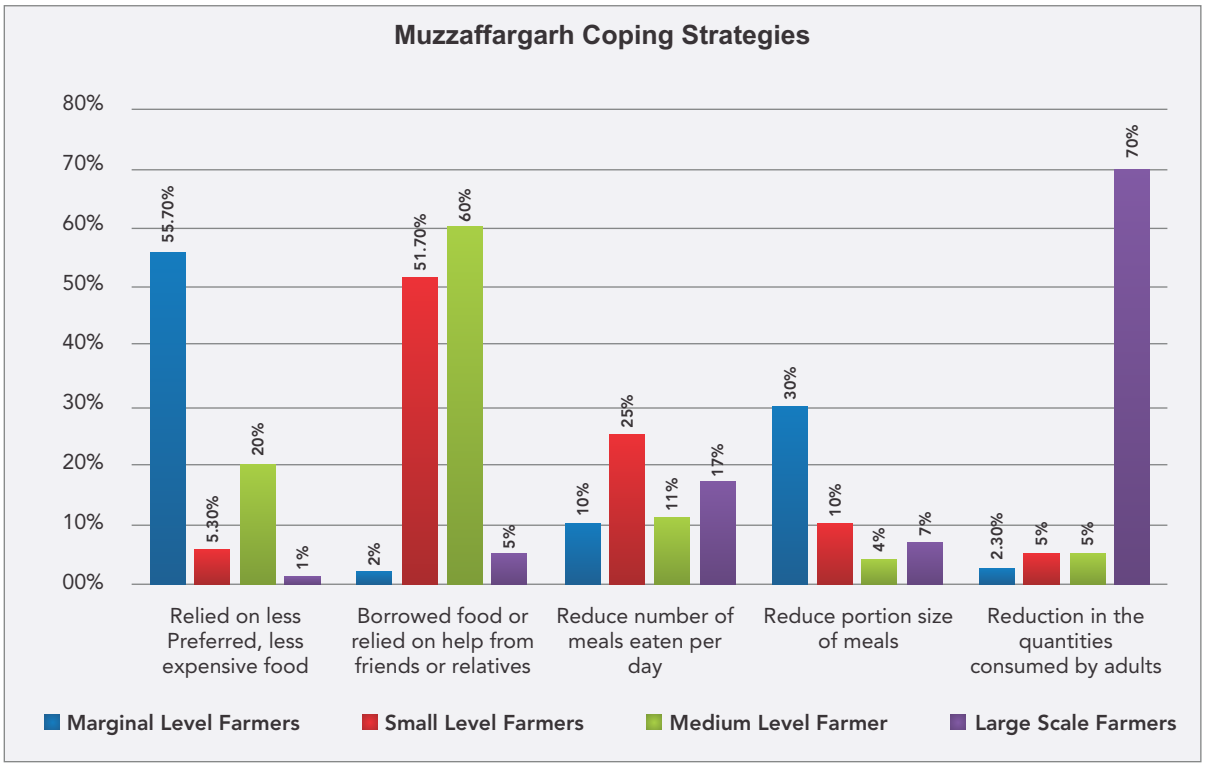
Source: Author's findings

Muzzaffargarh

The climatic risks were faced by all farm holders (marginal, small, medium and large) in Muzzaffargarh. The marginal and small farmers majorly reported drought followed by floods, shortage of canal water, windstorms and untimely rain as the main climate risks for crop loss. Medium and large farm holders considered major risks from windstorms followed by flood, untimely rain events and shortage of canal water.

Only small and marginal farmers were facing food deficient conditions due to financial constraints. Higher proportions of medium and large farmers had food sufficient for few months. In order to deal with food security conditions, Figure 20 shows that the major proportion of marginal farmers (55.7%) relied on less preferred and less expensive food and reduced portion of size of meals, followed by reduction in number of meals eaten per day and quantity of food by adults monthly. The small farmers (51.7%) borrowed food or relied on help from friends or relatives as well as reducing the number of meals eaten per day, followed by other coping strategies. The majority of medium farm holders (60%) also borrowed food or relied on help from friends or relatives. Finally, large farmers majorly reduced consumption as their coping strategy.

Figure 20: Muzzaffargarh Coping Strategies



The impact of climatic change on crop production of Punjab is undeniable (Siddiqui et al., 2012). Along with the results of this study, increasing climatic risks and climate-induced disasters were the major reason for crop loss for every farmer irrespective of their land size or district. The crop losses are the result of increasing and volatile floods and droughts, followed by pest attack, hail and windstorms. The farming community especially the marginal and small farmers, face severe food insecurity due to either lack of food availability or lack of funds. In order to cope with food security issues, farmers relied on diversification of income, migration of a household member, modification of food production to increase output, sale of household assets, reliance on external help and purchased less preferred or cheaper food items or reduced consumption of non-food and food items.

5. CONCLUSION AND RECOMMENDATIONS

The phenomenon of climate change has increased risks for human and animals relying on natural resources, mountains, lands, plateaus, forests, coastal zones, seas and oceans. The impacts of climate change are felt through rising temperatures, lower rainfalls which are triggering desertification and heat stress conditions in semi-arid regions and escalating drought years in arid regions. The outcomes of such changes are linked with reduction of crop output and quality, increased number of deaths of livestock and people. Pakistan is ranked among top ten countries that face climatic risks and appears at quite low position in hunger and food security indices. It shows poor condition of Pakistan in every component of food security, namely, availability, access, utilization and stability.

Provincially, Punjab being the highest contributor of agricultural products, staple and cash crop, faces severe climatic conditions as per past trends of climatic variables. The Global and Regional Climatic Models' future forecast of climatic change shows a rise in temperature and reduction in precipitation in the region of Punjab which will disrupt agriculture productivity in the region. It will lead to an adverse effect on each food security component of availability, access, utilisation and stabilization. In order to mitigate the impact of climatic changes on food security, this study investigated farming communities with respect to land size. The results of micro-evidences analysed food security situation for marginal (less than 5 Acres), small farmers (between 5 to 12.5 acres), medium farmers (greater than 12.5 acres but less than 25 Acres) and large farmers (greater than 25 acres) in the districts of D.G Khan, Faisalabad and Muzzaffargarh. The insights from these micro-evidences are given below,

- Farmers in all three districts, (Muzzaffargarh, D.G Khan and Faisalabad) faced climatic shocks (primarily; floods and droughts) which severely affected their crops followed by pest attack and rain/hailstorm.
- Food security depends on land size of farming community. The food security was a major problem report by all farmers in Faisalabad, Muzzaffargarh and D.G. Khan. In Faisalabad, marginal and small farmers considered diversification of their income sources, while, small proportion of food insecure medium and large farmers considered migration of one of their family members as their coping strategy. In D.G Khan, the major coping strategy used by marginal farmers was external help (credit borrowing) and small farmers used reduction of household consumption followed by other strategies. While, migration of household members and modification of production were common major coping measures for medium and large farmers. The district of Muzzaffargarh faced similar situations as in D.G Khan. The marginal farmers relied on less expensive food and reduction of food consumption as their adaptation strategy. The small, medium and large farmers had a similar coping strategy which relied on help from friends or reduced number of meals and quantity of food consumption.

In light of the above discussion, we would like to make the following recommendations:

Recommendations

- Introduce crop insurance schemes based on weather based index that protect farmers' income in hotspot regions. *Responsible Authorities:* Joint efforts of Pak Met-Department and ZTBL can modify the process to weather based index in hotspot regions.
- Introduce credit-borrowing schemes for farmers in disaster prone areas on easy terms and conditions to enhance their resilience. *Responsible Authorities:* SBP-department of Agriculture credit can help in introducing new schemes through taskforce by involving stakeholders.
- Increase conditional cash transfers to farmers in climatic hotspot regions, especially to marginal and small level farmers. *Responsible Authorities:* Ministry of Planning and Development can facilitate in introducing new scheme of cash transfers for hotspot regions.

- Enhance the capacity of agricultural extension programmes to develop training initiatives for farming communities that cater to the adaptation needs in face of a changing climate. *Responsible Authorities:* Joint efforts of PARC and NARC will help in enhancing capacity of agriculture extension programmes.
- Initiate a national scheme of food bank[13] to secure food supply of vulnerable communities. *Responsible Authorities:* Ministry of National Food Security and Research need to play active role for initiating such schemes along with Ministry of Climate Change.
- Introduce reforms in vocational trainings centres to introduce trainings courses that can help in capacity building to strengthen food chains and diversify income of households, especially for women. *Responsible Authorities:* Pakistan Vocational Training Centers in collaboration with Ministry of National Food Security and Research and Ministry of Climate Change can help in introducing new training courses.

[13]Food Bank: A place where stocks of food, typically basic provisions and non-perishable items, are supplied free of charge to people in need, mostly by government.

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