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Climate change and vulnerability: Enhancing the adaptive capacity of the population of Pakistan

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policy brief

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1 INTRODUCTION

Pakistan ranks among the countries most vulnerable to climate change, and also has one of the largest and fastest growing populations in the region. With per capita availability of land and water already very low,[1] the twin challenges of climate change and rapid population growth are compounding difficulties in ensuring adequate agricultural production, food security, and sustainable development. Effective climate change adaptation strategies are required that are informed by both climate change projections and demographic dynamics.

Experts recommend that the adaptation process should enhance the "adaptive capacity" of the population at every stage.[2] In practical terms, this capacity is "the ability to design and implement effective adaptation strategies, or to react to evolving hazards and stresses so as to reduce the likelihood of the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards."[3] A system's inherent adaptive capacity represents the set of resources—natural, financial, institutional, and human—available for adaptation, as well as ability to use those resources effectively. Factors that shape adaptive capacity include, for example, access to material resources, technology, information and skills, institutional arrangements, public health infrastructure, and equity. Some demographic aspects, such as fertility and age structure, migration, urbanization, and labor supply are directly linked to adaptive capacity. Moreover, changes in the size, distribution, and composition of human populations shape future vulnerability and adaptive capacity. Adaptation policies should recognize the interplay of climate-related stresses and population dynamics, and the associated challenges as well as opportunities. In this regard, the current policy brief looks at the situation indicated by some key sources of data[4] concerning the vulnerability and adaptive capacity of Pakistan's population with respect to climate change. It is based on an analysis by the Population Council of climate trends and population dynamics across the country's agro-ecological zones (Figure 1),[5] which is augmented in this brief with findings from additional data[6] and secondary sources.

2 CLIMATE CHANGE IN PAKISTAN

Comparison of high-quality climate data generated at 55 observing stations of the Pakistan Meteorological Department (PMD) for the period 1961–1989 and 1990–2018 shows that:[7]

- The frequency of very warm months (May–August) has increased manifold in the recent decade. Overall, annual hot days have increased by 14 days while annual cold nights have decreased by two days, although local trends vary greatly.

[1] It is estimated that approximately 0.5 hectares of cropland must be available per capita to ensure an adequate diet for a population. Unfortunately, by 2050, the necessities of life will have to be met in Pakistan from a meager 0.10 hectares of cropland, 0.07 hectares of irrigated land, and 0.015 hectares of pastureland per capita. Similarly, per capita water availability in the country has shrunk from 5,260 cubic meters (m^3) in 1951 (population: 34 million) to less than 1000 m^3 in 2018 (population: 207.77 million), and if the situation remains the same, it will dwindle to only 550 m^3 by 2025. Lack of reservoir capacity makes the country even more vulnerable (M. Jamal Khan Khattak, "Exploring the Implications of Climate Change and Population Growth for Agricultural Productivity" in *Climate, Population, and Vulnerability in Pakistan: Exploring Evidence of Linkages for Adaptation*, ed. Zeba A. Sathar and Kiren Khan [Islamabad: Population Council, 2019]).

[2] Ian Burton, Elizabeth Malone, and Saleemul Huq, *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*, ed. Bo Lim and Erika Spanger-Siegfried (New York: Cambridge University Press, 2004).

[3] Nick Brooks and W. Neil Adger, "Assessing and Enhancing Adaptive Capacity" in *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures,* ed. Bo Lim and Erika Spanger-Siegfried (New York: Cambridge University Press, 2004).

[4] The sources include, primarily, the Population and Housing Census, Agriculture Census, Pakistan Demographic and Health Survey (PDHS), and Pakistan Social and Living Standards Measurement Survey (PSLM).

[5] Zeba A. Sathar and Kiren Khan, Climate, Population, and Vulnerability in Pakistan: Exploring Evidence of Linkages for Adaptation (Islamabad: Population Council, 2019).

[6] Additional data sources include Pakistan Bureau of Statistics (PBS), Labour Force Survey 2017-18, Thirty Fourth Issue (Islamabad: Ministry of Planning, Development and Special Initiatives, Government of Pakistan, 2018); National Institute of Population Studies (NIPS) and ICF, *Pakistan Demographic and Health Survey 2017–18* (Islamabad, Pakistan and Rockville, Maryland, USA: NIPS and ICF, 2018); and various issues of the Agriculture Census.

[7] Nadeem Faisal and Mohammad Riaz, "Climate Change in Pakistan" in Climate, Population, and Vulnerability in Pakistan: Exploring Evidence of Linkages for Adaptation, ed. Zeba A. Sathar and Kiren Khan (Islamabad: Population Council, 2019).

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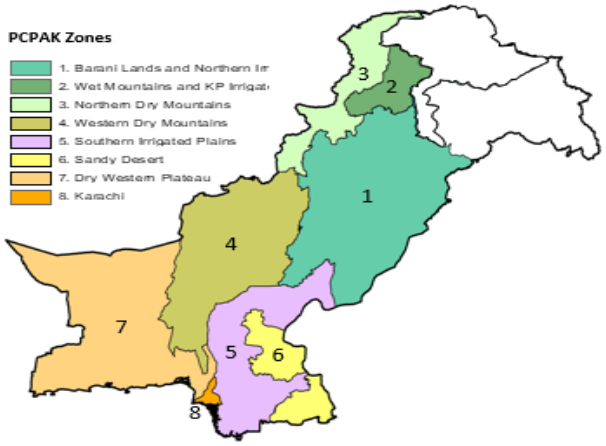
- A decline in annual rainfall is evident in 1990–2018 in the southernmost parts of the country and in the northeastern region of Azad Jammu and Kashmir (AJK) and adjoining areas; there is no change or a slight increase in other parts of the country.
- Overall, between 1961 and 2018, annual winter rainfall in Pakistan has increased by 11% and monsoon rain by 18%. The amount of both winter and monsoon rainfall has increased significantly in Gilgit-Baltistan (GB), Khyber Pakhtunkhwa (KP), and Punjab. However, a major decrease in the amount of winter rainfall is observed in Sindh, while changes in the amount of rainfall in Balochistan and AJK have been insignificant.
- The number of "extreme rain" or "wet" days (defined as a 24-hour period in which rainfall exceeds 30 millimeters) has increased considerably in 1990–2018.
- Analysis of snow depth data, available for the period 2007–18, indicates a significant declining trend.
- The sea level has risen a total of 220.24 centimeters (7.97 inches) in 110 years.

These changes have exacerbated a number of environmental stresses in Pakistan, most prominently heat waves, and faster melting of glaciers, which, combined with heavier rains, is leading to intense floods. In 2010, the country experienced one of the worst cases of flooding in its history because of exceptionally heavy monsoon rains. Pakistan has also experienced three major dry periods (drought) in 1962–66, 1968–72, and 1999–2002. Coastal areas are under stress from a rising sea level and increased frequency of approaching cyclones in recent years. Sindh's coastal zone is considered more vulnerable than Balochistan's because of the former's tidal flat topography and higher population concentration.

Based on the influences of climate change at the subnational level, the agro-ecological zones of Pakistan may be divided into three categories:[8]

1. Less affected zones (experiencing relatively smaller changes in temperature and rainfall), including *barani* lands and northern irrigated plains, wet mountains and KP irrigated plains, and the northern dry mountains (Zones 1, 2, and 3, respectively, in Figure 1).
2. Severely affected zones (experiencing the sharpest temperature increases and rainfall reductions), including western dry mountains, southern irrigated plains, sandy desert, dry western plateau (Zones 4, 5, 6, and 7, respectively, in Figure 1); and
3. Karachi (Zone 8 in Figure 1), which is also a severely affected zone but is characterized by a unique set of vulnerabilities and adaptive potentials as an entirely urbanized region.

Figure 1: Agro-ecological Zones of Pakistan (Adapted)



Source: Zeba A. Sathar and Kiren Khan, Climate, Population, and Vulnerability in Pakistan: Exploring Evidence of Linkages for Adaptation (Islamabad: Population Council, 2019).
Note: The zonation is adapted from the work of the Pakistan Agricultural Research Council (PARC) in 1980.

3 COUNTING THE MOST AFFECTED

About 65 million Pakistanis live in zones severely affected by climate change, including the 16 million residents of Karachi and 49 million people residing in Zones 4–7. Thus, close to a third of the population of Pakistan is exposed to rapid changes in climate, and the associated risks to their livelihoods, well-being, and survival.[9]

65 million Pakistanis reside in the agro-ecological zones severely affected by climate change—and the population growth rate is higher here than in less affected zones

At current rates of growth, it is projected that the severely affected population will increase by 130% by 2050 (reaching a total population of about 85 million), compared to 110% (i.e., total population 159 million) for

[8] Maqsood Sadiq, Zeba A. Sathar, and Muhammad Khalil, "Population Exposure and Vulnerability to Climate Change in Pakistan's Agro-climatic Zones: A Preliminary Data Analysis" in *Climate, Population, and Vulnerability in Pakistan: Exploring Evidence of Linkages for Adaptation*, ed. Zeba A. Sathar and Kiren Khan (Islamabad: Population Council, 2019). Notably, the regions of Azad Jammu and Kashmir and Gilgit-Baltistan were not included in this analysis.

[9] Ibid.

the less affected areas. Population density has also risen disproportionately more rapidly in the severely affected regions, suggesting that demographic and environmental stresses may be combining to compound challenges in adaptation.

4. VULNERABILITY AND ADAPTIVE CAPACITY – A LOOK AT SOME KEY SECTORS

The extent of vulnerability to climate change and adaptive capacity in Pakistan's population is briefly examined below with reference to agriculture and food security; livelihoods; household size, living conditions, and multidimensional poverty; fertility and child survival; migration; and urbanization.

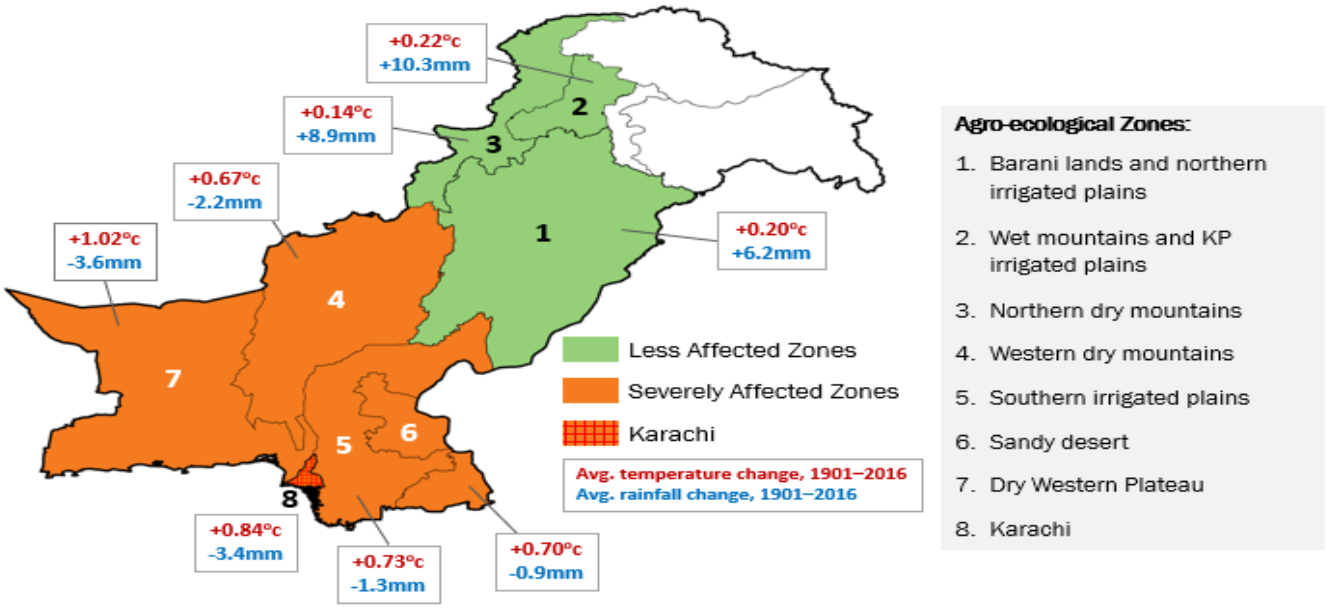
4.1 Agriculture and Food Security

Eighty percent of Pakistan's total land area is comprised of arid or semiarid regions[10] where soils are vulnerable to a wide range of degradation processes. These processes are being exacerbated by rise in temperature, shifting of seasons, and changes in rainfall patterns, including the westward shifting of the monsoon pathway. Climate change has begun to affect the production of different crops and could drastically reduce wheat, rice, sugarcane, and cotton harvests in the next two decades. In southern Pakistan, yields of major cereals are predicted to decline by 15–20% according to regional climate models. Production of fruits and vegetables, which are high-value exports for the country, could also decrease. Prices of major crops are also expected to increase in some regions, further restricting access to food.

Drastic reductions in yields of major cereals, sugarcane, fruits, vegetables, and milk, meat and poultry supplies are expected due to climate change

Livestock production is also being affected in multiple ways. The most important impacts are on animal productivity, animal health and biodiversity, the quality and amount of feed supply, and the carrying capacity of pastures. Increasing variability in rainfall leads to shortages of drinking water, increased incidence of livestock pests and diseases, and changes in their distribution and transmission.[11] It is predicted that the decline in livestock production will be more acute in arid and semiarid regions, and create crises in milk, meat, and poultry supplies, pushing prices beyond the reach of the average Pakistani. Inland fisheries will also be reduced by decreased water availability.

Figure 2: Average changes in temperature and rainfall between 1901 and 2016



Source: World Bank Climate Change Knowledge Portal

[10] Except where specified otherwise, the discussion in this section is based on Khattak, "Exploring the Implications of Climate Change and Population Growth for Agricultural Productivity."

[11] Food and Agriculture Organization of the United Nations (FAO), *The State of Food* and Agriculture: Climate Change, Agriculture and Food Security (Rome: FAO, 2016).

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Risks to agricultural production have adverse implications for food security, both through the direct impact of climate change on crops and livestock, as well as indirectly, through impacts on productive resources, especially soil and water. As agricultural productivity declines, the poorest people, who already use most of their income on food, will have to sacrifice additional income and other assets to meet their nutritional requirements.

Farmers in Pakistan are adapting to climate change through various practices, which several studies have attempted to identify and assess for effectiveness. Broadly, adaptation practices include changes in management of water and soil resources; crop diversification; changes in agricultural inputs; altered crop timing and crop patterns; planting or preservation of shade trees; and improved management of crop pests and diseases.[12] Only a few studies have explored the factors influencing the choice of adaptation practices and associated impacts on household food security and poverty in Pakistan. A 2014 survey of 950 farmers across the four major provinces of Pakistan found that 22% had made sowing time adjustments, 15% had adopted drought-tolerant varieties, and 25% had shifted to new crops.[13] Adoption of an adaptation practice was positively associated with food security, but negatively with poverty levels. Wealth was an important influence on the ability of farm households to invest in coping strategies. Various other studies also show that farmers' adaptation to climate change is constrained by lack of information, lack of money and resource constraints in investing in new agricultural practices, and shortage of irrigation water. In addition, many farmers have no access to agricultural extension or farmer training services to build their capacity.

4.2 Livelihoods

Apart from food security, climate change could also have a huge impact on rural livelihoods in Pakistan, since 67% of the rural population is engaged in agriculture, and the sector accounts for 42% of total employment in the country. Data indicate that in the agro-ecological zones that are exposed to the most severe effects of climate change, the rural population is also more dependent on agriculture and livestock, and therefore more directly vulnerable to adverse economic impacts.[14] According to the Agriculture Census, the proportion of rural households depending on agriculture for livelihoods is higher in the severely affected zones (61%) than in the less affected zones (51%). Within the agriculture households, the proportion of households owning livestock is also considerably higher in the severely affected zones (49.8%) than in the less affected zones (25%). Dependence on livestock is particularly high in the southern irrigated plains, sandy desert, and dry western plateau, implying greater vulnerability with respect to both food security and livelihoods in these severely affected regions.

Small land holders and landless farmers are likely to be hardest hit by climate change due to lack the resources, information, and irrigation water needed to adapt

Agricultural activities are the most sensitive to climatic conditions and to climatic variability. In particular, with the shifting of the monsoon pathway from east to west, farmers on the eastern and western fringes of the monsoon system will need to alter soil management and cropping practices to avoid soil erosion, waterlogging and salinity, and desertification. As the monsoon path changes, farmers in the new western fringes receiving monsoon rain will need to adopt new practices to cope with excess water and avoid the resulting soil erosion. At the same time, in the eastern areas from which the monsoon system is moving out, soil management practices and cropping patterns will need to be changed to cope with reduced moisture availability, including possible dry spells, and to avoid soil erosion, waterlogging and salinity issues, and desertification.

Within rural areas, smallholding farmers and landless people are likely to be hardest hit by climate change and face a broader range of barriers to sustainable agriculture such as limited access to markets, credit, extension services, weather information, risk management tools, and social protection. Most are resource-poor and operate in a low-input, low-output scenario. It will be especially important to bolster their adaptive capacity in severely affected zones.

[12] Aryal et al., "Climate change and agriculture in South Asia"; Wahid Ullah, Takaaki Nihei, Muhammad Nafees, Rahman Zaman, and Muhammad Ali, "Understanding Climate Change Vulnerability, Adaptation and Risk Perceptions at Household Level in Khyber Pakhtunkhwa, Pakistan," International Journal of Climate Change Strategies and Management (2018); Muhammad Abid, Muhammad, Jürgen Scheffran, Uwe A. Schneider, and M. J. E. S. D. Ashfaq, "Farmers' Perceptions of and Adaptation Strategies to Climate Change and their Determinants: The Case of Punjab Province, Pakistan," Earth System Dynamics 6, no. 1 (2015): 225-243.; Khuda Bakhsh and M. Asif Kamran. "Adaptation to Climate Change in Rain-fed Farming System in Punjab, Pakistan," International Journal of the Commons 13, no. 2 (2019); and Qamar Uz Zaman Chaudhry, Climate Change Profile of Pakistan (Manila: Asian Development Bank, 2017).

[13] Akhtar Ali and Olaf Erenstein, "Assessing Farmers' Use of Climate Change Adaptation Practice and Impact on Food Security and Poverty in Pakistan," *Climate Risk Management* 16 (2017): 183–194, available at www.elsevier.com/locate/crm; Chaudhry, *Climate Change Profile of Pakistan*.

[14] Sadiq, Sathar, and Khalil, "Exposure and Vulnerability to Climate Change in Pakistan's Agro-climatic Zones."

The economic impact of climate change is likely to be felt most acutely by smallholder and landless farmers, who will suffer both lower agricultural output and lower incomes. According to the Agricultural Census 2010, approximately 43% of farmers are small farmers with landholdings of less than one hectare of land. Landless farmers, or tenants/sharecroppers who do not own any land, comprise 64% of farmers.[15]

To assess the adaptive capacity of the population with regard to employment across agro-ecological zones, we analyzed micro-data of the Pakistan Labour Force Survey 2017–18 against four key labor market indicators: labor force participation rate by gender, unemployment rate, sectoral employment, and employment status. There is no major difference across the zones in employment status or in male labor force participation, but female participation is relatively lower in severely affected zones (17%), particularly in the western dry mountains and dry western plateau, than in less affected zones (23%). This indicates relatively less opportunity to be economically active for women in severely affected zones. Interestingly, the open unemployment rate is considerably lower in the severely affected zones (2.6%) than in less affected zones (5.4%); however, this is probably because of more widespread engagement in farming and livestock in the severely affected zones, with more people working on small pieces of land, who are likely to be largely underemployed.

There are more employment opportunities in non-agriculture sectors—most commonly in manufacturing and trade—in the less affected zones than in the severely affected zones, and only 28% of the labor force is engaged in agriculture in the former compared to 44% in the latter. Populations living in the zones most severely affected by climate change are more likely to be living in poverty, mainly because of relatively low employment opportunities in non-agriculture sectors, which also restricts their capacity for livelihood diversification as climate change corrodes agricultural incomes.

4.3 Household Size, Living Conditions and Multidimensional Poverty

Household sizes are strongly associated with standard of living measures and also with health and food security. Average household size in Pakistan has decreased by a substantial 0.4 persons between the 1998 and 2017 censuses from 6.8 to 6.4. This decline is greater in urban than in rural areas, reflecting lower fertility levels in the urban areas but possibly also a lowering of the surge of rural-to-urban migration. Proportionately larger reductions in household size have occurred during this period in the urban parts of the *barani* lands and northern irrigated plains, southern irrigated, sandy desert, western dry mountains, and Karachi. On the other hand, household size has increased in the dry western plateau, one of the most vulnerable regions; a slight increase is also seen in the rural parts of the western dry mountains.

Currently, Karachi has the smallest average household size (less than five persons) while the other severely affected zones have the largest household sizes. The average numbers of people living in one room is also highest in these severely affected zones, at almost four persons per room. In Karachi, this number is significantly lower at 2.5 persons. Similarly, the quality of housing in terms of material used in roof and walls and access to toilet facilities is lower in the severely affected zones. Notably, safe sanitation is not available to 79% of those living in the urban areas of severely affected zones. This has direct implications for health of all members of the household, particularly children.

In the severely affected zones, households are larger, living conditions are more cramped, access to sanitation and permanent housing structures are less prevalent.

Poverty levels measured on a multidimensional scale are expected to demonstrate the overall impact of the major underlying differences in exposure and vulnerability of the zones to climate change. We find substantial variation in levels of multidimensional poverty across the major zones ranging from just 4.4% in Karachi to 72% in the western dry plateau and western dry mountains. Populations living in the most severely affected zones are more likely to live in poverty despite improvements in the last ten years. Poverty has declined most in the urban areas throughout Pakistan.

4.4 Fertility and Child Survival

There is a notable division in fertility in Pakistan, with higher fertility in the severely affected zones and lower fertility in the zones less affected by climate change. Fertility changes affect age structures of households and, through that, dependency ratios, which directly influence household economics. Karachi is an exception, with the number of children under 15 per household substantially lower even compared to the less affected zones.

[15] Pakistan Bureau of Statistics (PBS), Pakistan Social and Living Standards Measurement Survey (PSLM) 2018-19 National/Provincial Report (Islamabad: PBS, Ministry of Planning Development and Special Initiatives, Government of Pakistan).

Importantly, children are much more acutely malnourished in the severely affected zones: 53% are stunted, 13% wasted, and 44% are underweight. These rates are much lower in the less affected zones—in fact, better than Karachi, where the relatively poor indicators of child health raise serious questions about the adequacy of services.

Fertility is higher in the severely affected zones, along with higher child malnutrition, lower immunization levels, and higher under-5 mortality

Immunization levels among young children (ages 12–23 months) are also much lower in the severely affected zones, with only 43 percent provided basic vaccinations compared to 72 percent in the less affected zones and 66 percent in Karachi. While there is no major difference in infant mortality rate between less affected and severely affected zones,

under-5 mortality is relatively higher in the latter (87 deaths/1,000 live births) compared to the former (77 deaths/1,000 live births).[16]

The linkages between climate change and health are complex and interact with many other influences.

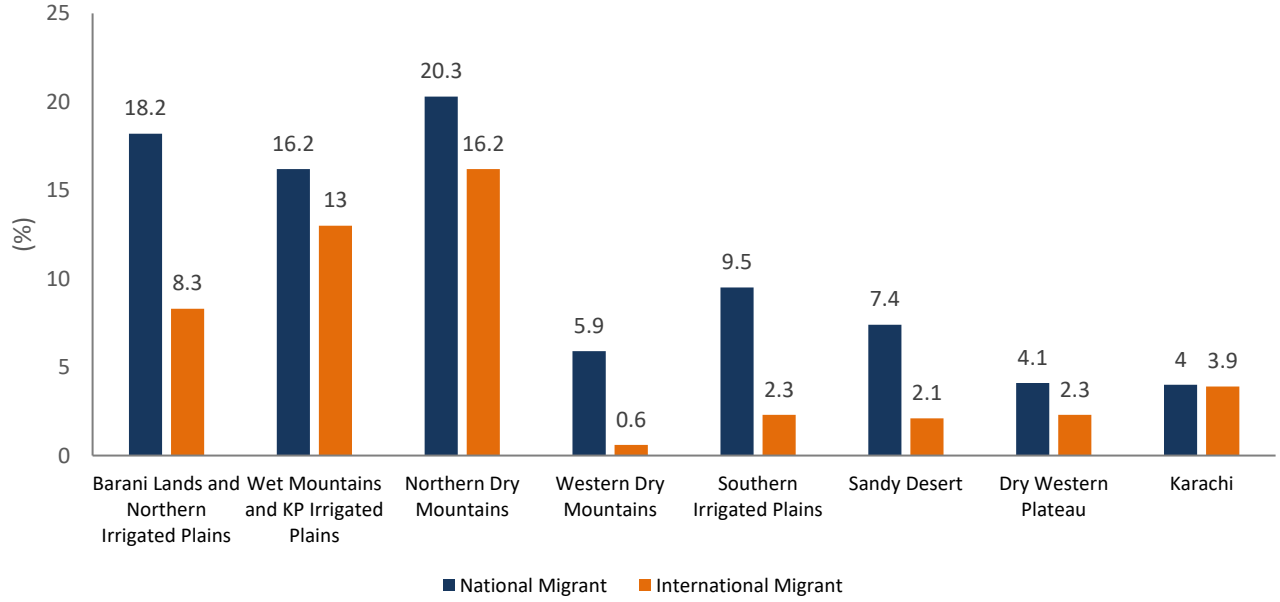
In Pakistan, higher temperature and extended precipitation have increased the risk of water- and vector-borne diseases, such as dengue and malaria, particularly for the poorest communities.

Higher humidity levels and decrease in temperature are also associated with increased asthma cases in children under 5 years of age. Heat waves in the pre-Monsoon months are also posing increasing health risks in affected areas. These issues are compounded by rising food security challenges. In addition, extreme events have been found to be correlated with mental health issues in the affected population, such as depression, distress, and aggression. At the individual and community level, factors such as socioeconomic status, access to health services, and local capacity to cope with weather-related hazards also determine health vulnerability to climate change.[17]

4.5 Migration as Adaptation[18]

Economic migration is defined as the movement of a household member to another location (another district or beyond) for the purpose of employment, business, or study. Such migration may be considered a strategy of the concerned households to diversify their sources of income and therefore as an indicator of adaptive capacity.

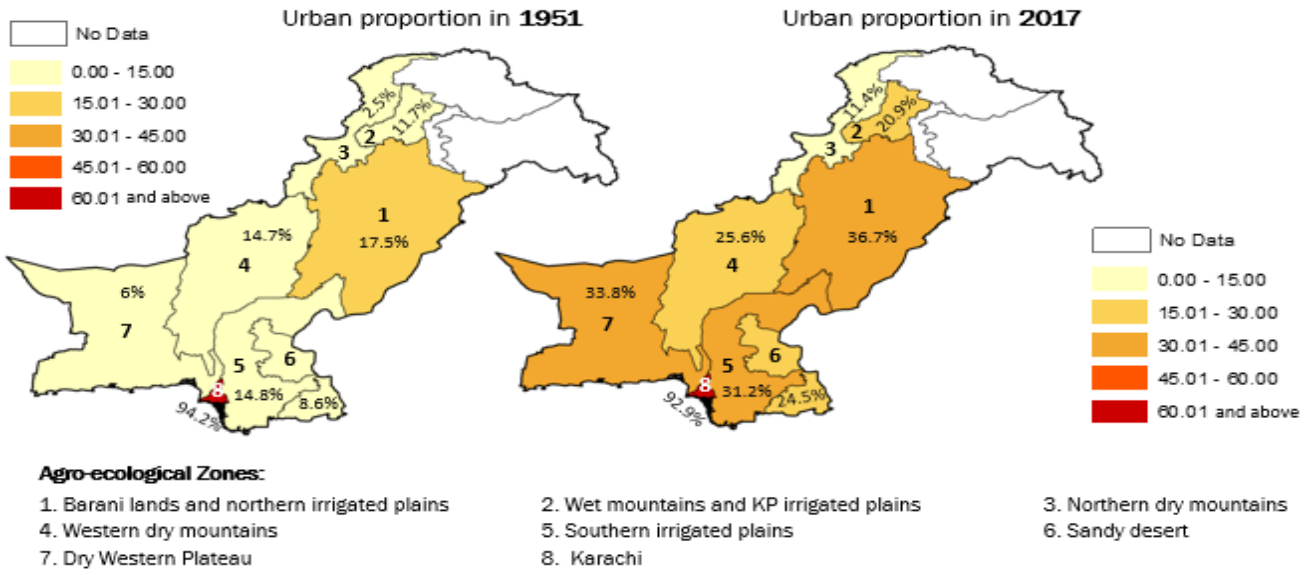
Figure 3: Percentage of households reporting an international or internal migrant within Pakistan during last 10 years



Source: PDHS 2017-18

[16] Ibid.
[17] LEAD Pakistan, *Climate Change and Health: Exploring Issues*, Action Research 27 (Islamabad: Asia-Pacific Network for Global Change Research, 2011).
[18] G. M. Arif and Maqsood Sadiq, "Climate Change and Migration-as-Adaptation in Pakistan: Preliminary Findings" in *Climate, Population, and Vulnerability in Pakistan: Exploring Evidence of Linkages for Adaptation*, ed. Zeba A. Sathar and Kiren Khan (Islamabad: Population Council, 2019).

Figure 4: Urbanization in agro-ecological zones in 1951 and 2017



Source: Based on data from Population and Housing Censuses of 1951 and 2017

In the Pakistan Demographic and Health Survey (PDHS) 2017-18, 9% of the sampled households reported economic migration of a member. A considerable proportion of households, particularly in rural areas, attach great importance to migration to diversify their sources of income to reduce vulnerabilities. The incidence of economic migration from rural areas is double (11.1%) the magnitude of migration from urban areas (5.7%). In addition, 7% of the households reported emigration of a household member during the last 10 years.

There is great variation in migration across the agro-ecological zones: compared to only 4% of households in the dry western plateau zone (a severely affected zone), almost a fifth of households in the wet mountain and northern dry mountain zones (within the less affected zones) reported the movement of a household member within the country. In fact, migration, internal as well as international, is more pronounced from all agro-ecological zones of Punjab and Khyber Pakhtunkhwa compared to Sindh and Balochistan. It appears that a mix of environmental and non-environmental factors generate migratory streams of working-age populations to reduce households' vulnerabilities and improve well-being.

Migration is more pronounced from the northern provinces than from Balochistan and Sindh, which house the severely affected zones

Migration has the potential to improve the adaptive capacity of households in the face of environmental and non-environmental stresses, but populations living in severely affected zones have a lower propensity to exploit this on a large scale.

4.6 Urbanization

Stressors on the rapidly expanding urban areas of Pakistan are an important subject for the climate change discourse, requiring further disaggregation and deeper study. The rate of urbanization in Pakistan is estimated at 0.62% for the period 2015–2020 and it is predicted that by 2025, nearly 39% of the country's population will live in urban areas. More than 20% of Pakistanis now live in just 10 major cities, whose population has virtually doubled during the last two decades.

On the positive side, urban growth presents alternative employment opportunities to agriculture, which will become increasingly important as agricultural livelihoods face greater risks from climate change. Urbanization is more advanced and had already increased dramatically by 1972 in the zones less affected by climate change, probably reflecting an earlier diversification of incomes and employment away from agriculture to non-agricultural alternatives. The more severely affected regions did not urbanize until later.

On the other hand, the pattern of urbanization seen in Pakistan has also put a great strain on urban

infrastructure and led to a proliferation of slums as well as conversion of agricultural land. Rapid population growth and urbanization increase the demand for housing, sanitation, health, and education facilities, and of course food. It is important to explore the carrying capacity of Karachi and other big cities and whether we have reached the limits, especially in providing services. In particular, planning for the expansion of cities and towns based on evidence from municipal authorities, Census data, and surveys is largely missing leading to haphazard town planning and heightened risks.

Urbanization is growing but the carrying capacity of existing cities, may soon be exhausted

Moreover, disaster risks attain unique additional dimensions in urban contexts where, in addition to residential and commercial concentration, key elements of transportation and energy infrastructure are often also situated. Past experiences show that infrastructure located in areas exposed to extreme weather events or near climate-sensitive features such as rivers, coastal areas, storm tracks, and arid areas is at risk from climate change; transportation systems can be particularly affected, for example, through increased frequency of landslides in mountainous areas.[19] The energy sector is also at risk from extreme weather events such as flooding, storm surges, and drought, which will affect energy sources as well as the supply and distribution infrastructure, as was witnessed in the devastating 2010 floods in Pakistan, which caused a shortfall of more than 3,500 megawatts of electricity for several days.

5 Policy Implications

The National Climate Change Policy (NCCP) 2012 provides a framework for minimizing the risks associated with climate change, primarily by facilitating sustained economic growth; pro-poor, gender-sensitive adaptation; food security; energy security; and minimizing of disaster risks. As the foregoing discussion shows, exposure, vulnerability, and capacity to adapt to climate change risks vary greatly across the different agro-ecological zones, implying a need for careful targeting and prioritization of the suggested sector-specific adaptation measures delineated in the NCCP.[20]

The analysis presented in this brief underscores the importance of incorporating the implications of population dynamics in adaptation plans, from the perspective of both vulnerability and adaptive potential. The focus of adaptation efforts must be on building the population's adaptive capacities, which will not be a simple process but entail similar complexities as the promotion of sustainable development. In this regard, the above analysis implies the following considerations:

1. Take a regional approach in facing Pakistan's climate change challenges. Pakistan is extremely vulnerable to a diverse range of climate change impacts. However, changes in temperature and rainfall and associated climatic stresses vary greatly across the agro-ecological zones, with areas in Sindh and Balochistan more severely affected.

Not only exposure to climate risks, but capacity to adapt to those risks also varies across the population. Our data analysis presents a quite consistent pattern of higher vulnerability in the population of the zones most severely affected by climate change, i.e., the sandy desert and southern irrigated plains in Sindh, and the dry western mountains and western dry plateau in Balochistan. This is seen in the form of greater dependence on agricultural livelihoods; lower propensity to migrate for income diversification; lower extent of urbanization and industrial employment opportunities; higher fertility and dependency ratios; poorer child health indicators; more inferior living conditions at the household level; and much higher multidimensional poverty than in the zones less affected by climate change.

Therefore, each region needs to be approached keeping in view not only administrative domains or the specific extent and nature of the climate change risks to which it is exposed, but also the ways in which its population is vulnerable, especially in terms of livelihoods, infrastructure, and above all, propensity for adaptation. Regional inequalities in employment opportunities, poverty, and health services should particularly be addressed and reduced through adaptation plans that are both climate- and people-centered.

2. Address loss of rural livelihoods. Changes in temperature and rainfall patterns have confronted farmers with a host of challenges ranging from soil degradation and desertification to waterlogging and salinity, new pests and diseases, and risks of disasters such as floods. Such stresses are corroding both the output and incomes of farmers. The uptake and success of adaptation measures is at present heterogeneous across the farming community, and is often shaped significantly by farmers' individual landholding and socioeconomic status.

Government and other relevant stakeholders should provide easy access to extension and training services

[19] Chaudhry, *Climate Change Profile of Pakistan*.

[20] Ibid.

so that farmers can learn advanced farming techniques and how to effectively adapt. This is particularly important for small and poor farmers who have more limited adaptive capacity. Policies should promote climate change adaptation strategies among farmers, but should be framed with an awareness and knowledge about local contexts of climate change, adaptation strategies, and their benefits. Achieving adaptation in agriculture and food security will require both technological and non-technological solutions to produce more food where needed and to reduce risks.

It is critical to provide agriculture insurance in Pakistan, especially for small and landless farmers who have little to no resilience capacity. In addition, research is urgently needed to identify optimal crop sowing times, sowing methods, and seed treatment techniques under changing climate conditions. Soil moisture conservation, rainwater harvesting, and water-use efficiency must be ensured for wider adaptability. New varieties of crops, fruits, and vegetables should be developed that can tolerate extremes of climate. A huge challenge for farmers, land managers, policymakers, researchers, and the general public is how to fulfil basic necessities of life, such as food and water, from dwindling shares of land and other natural resources. The availability of extension and training services for farmers will have to be improved to enable them to benefit from research and equip them with the new knowledge and skills they need to adapt. These measures need to be taken within a broader policy framework that aims to promote climate-smart agriculture (CSA) for economic growth and development of the agriculture sector in Pakistan.[21]

In particular we need to focus on the very set of agriculturalists that are unable to access inputs and are unaware of emerging technologies because they live in remote or vulnerable regions.

Policymakers need to find ways to create employment in non-agriculture sectors and to facilitate economic migration within Pakistan and overseas. Similarly, low participation of females in economic activities, particularly in severely affected areas, is also a challenge for policymakers and concerned households. Special policy interventions are needed to counter the impact of climate change on employment, such as providing employment opportunities to females in severely affected areas, and giving the rural population access to employment opportunities in the urban non-agriculture sector. Migration of the working-age population, within Pakistan as well as abroad, needs to be encouraged considering the large labor supply available for the next three decades; it is beneficial for households, communities, and the country since it is generally associated with inflows of remittances and conducive for reducing all types of risks. Migration may be considered a major source for the diversification of household income, particularly in severely affected areas.

3. Address food shortages. Pakistan has a food security policy and it is at the top of the policy agenda. The production component of food security is most vulnerable to climate change impacts. Potential increase in food prices also poses a critical risk for food security. An integrated approach should be adopted that considers production as well as accessibility and affordability of food.

Climate change is adversely affecting both food crop harvests and the productivity of livestock, with significant declines predicted in production of staple cereals, meat, milk, poultry and eggs in the not too distant future. Meanwhile, per capita shares of cropland, irrigated land and pastureland are decreasing sharply due to continued high population growth, especially in zones severely affected by climate change. These challenges imply imminent risks for food security through both reduced production and increased prices. Drastic reductions are also expected in rice, cotton, and sugarcane in the next two decades. Fisheries and horticultural production will also decline. With decline in production, prices of major crops are expected to increase, affecting adversely the accessibility and affordability of food.

The most serious concern is that food scarcity arising from threats to agriculture associated with climate change is exacerbated by the growing demand for food due to rising population sizes, especially in vulnerable areas. Climate change poses a challenge to food security through its expected adverse effects, both direct and indirect, on food production. In particular, wheat production, which is the staple crop, depends significantly on changing climate variables, is a challenge for the nation. The current per capita caloric availability in Pakistan is 2,432 kilocalories per day; this is likely to fall unless food production keeps pace with population growth.

4. Enhance health care services in the context of climate change impacts. The federal and provincial governments are managing a number of programs and projects to improve the health status of the people and to reduce the burden of communicable and non-communicable diseases. However, health programs

[21] Ibid.

remain limited in scope and the health care system still suffers from inefficiencies due to weaknesses such as poor governance, lack of access and unequal resources, poor quality of the Health Information Management System, corruption, lack of monitoring in health policy and planning, and lack of trained staff.[22] Improvement in health indicators has been very slow over the last five decades, and the COVID-19 pandemic has further strained the system. Despite these constraints, the health system must observe how health risks are being exacerbated by climate change, such as rising incidence of heat stroke, asthma in children, and dengue fever. Research should also be conducted to identify the compounding effects of rising population density in cities, for example through cramped living conditions and pollution. In rural areas as well, farmers' health and physical wellbeing should be monitored in areas where environmental stresses have worsened or where use of chemical inputs such as new pesticides has increased. Mental health care must also be improved, especially for populations confronted with disaster risks.

5. Address rapid population growth. Last but not least, to rein in population growth, strong policies must be effectively framed and implemented to provide universal access to family planning services and also promote small family norms through women's education and empowerment.

Family planning must be prioritized to check further decline in per capita availability of essential natural resources

Pakistan's population has more than doubled in the past two decades, growing at a rate of approximately 2% per year and is expected to further increase to 244 million by 2030 and 300 million by 2050. At the same time, life expectancy in the country is projected to increase from 66 to 71 years by 2050. Such exponential growth will put significant strains on the already extended and vulnerable agriculture system by boosting demand for food. It is critical to address the country's high population growth (fertility), particularly in regions severely affected by climate change. If the population continues to grow at its current rate, already limited land, soil, and water resources will soon be exhausted. Pakistan is beginning to experience serious issues in food production and the quality and quantity of food available to most poor Pakistan is insufficient for meeting their basic nutritional needs. There is a famine-like situation in the region of Thar almost every year, and many children die of different diseases caused by malnutrition. Already, malnutrition is a national challenge and child malnutrition is relatively high in the severely affected regions of the country. Notably, population density is higher in regions with the highest prevalence of undernourishment and high vulnerability to the impacts of climate change. The issues of poverty, hunger, agricultural production technologies, desertification, and climate changes are all interlinked and must be addressed collectively.

Related to rapid growth and pressures on employment is the speed of migration to urban areas, and the urbanization of rural areas. The rising trend in urbanization in most regions of the country is an opportunity for socioeconomic development but also a challenge in terms of loss of surrounding agricultural land, and the risk of poorer living conditions for poor residents and migrants, especially in terms of access to water and sanitation, particularly in urban slums. Urban development plans must ensure that urban spaces are sustainable and climate-safe. At a broader level, economic and urban development plans should attempt to create new urban centers to reduce the pressure on existing cities and expand access to non-agricultural employment opportunities.

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[22] Z. Kurji, Z. S. Premani, and Y. Mithani, "Analysis of the Health Care System of Pakistan: Lessons Learnt and Way Forward," *J Ayub Med Coll Abbottabad* 28, no. 3 (2016): 601–604.