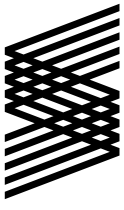
Rural livelihood vulnerability in semi-arid Pakistan: scope of migration as an adaptation strategy

Working paper



PRISE

Pathways to resilience in semi-arid economies

Research for climate–resilient futures

Rural livelihood vulnerability in semi-arid Pakistan: scope of migration as an adaptation strategy

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Acronyms

ADB	Asian Development Bank
AR	Annual Report
CIA	Central Intelligence Agency
CRED	Centre for Research on the Epidemiology of Disasters
D. G. Khan	Dera Ghazi Khan
DfID	Department for International Development
GDP	Gross Domestic Product
GoP	Government of Pakistan
FAO	Food and Agriculture Organization of the United Nations
HKH	Hindu Kush Himalayan Region
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Royal Netherlands Meteorological Institute)
KP	Khyber Pakhtunkhwa
LAPA	Local Adaptation Plans of Action
NAP	National Adaptation Plan
NDMA	National Disaster Management Authority
NNS	National Nutrition Survey
LVI	Livelihood Vulnerability Index
PKR	Pakistani Rupee
PMD	Pakistan Meteorological Department
PPPs	Public Private Partnerships
PRISE	Pathways to Resilience in Semi-arid Economies
PSLM	Pakistan Social and Living Standards Measurement
RCP	Representative Concentration Pathways
TEVTA	Technical Education and Vocational Training Authority
UC	Union Council
USAID	United States Agency for International Development
USD	United States Dollar
WFP	World Food Programme

Executive Summary

Rural livelihoods in semi-arid Pakistan are increasingly exposed to climate impacts such as rising temperatures, erratic rainfalls and more intense and frequent climate-related extreme events. In addition to directly hampering natural resource based livelihoods, these impacts are intensifying other environmental risks such as land degradation, waterlogging, soil erosion, and pest attacks. The agriculture sector in Pakistan, being the lifeblood of the rural economy, is particularly vulnerable given climate change risks like unpredictable water availability, declining agricultural productivity, and frequent crop failures.

Rural areas in Pakistan are more susceptible to such adverse impacts due to their pre-existing marginalisation in terms of lack of development and high prevalence of multidimensional poverty. Lack of diverse livelihood opportunities put a further strain on households which have limited alternative options except agriculture as their main source of income. In response to climate risks and vulnerabilities, farmers in semi-arid regions of Pakistan may require adjustments in their livelihood strategies. One such important adjustment strategy is rural out-migration to cities in search of non-farm economic opportunities.

Building on the findings of Salik et al. (2017) who conclude that planned rural to urban migration can enhance livelihood resilience of households, this study first analyses the climate vulnerability and adaptation potential of agricultural households in three districts of Pakistan:

1) D.G. Khan.
2) Faisalabad.
3) Mardan.

It uses the IPCC Livelihood Vulnerability Index (LVI) approach to analyse the determinants of household livelihood vulnerability defining vulnerability in terms of:

1) Exposure.
2) Sensitivity.
3) Adaptive Capacity.

Furthermore, it also determines various adaptation responses that farmers apply, including migration, and also elucidates the reasons why some farmers choose not to adapt to climate change.

Results of the study show that D. G. Khan is the most vulnerable district to climate change impacts, followed by Mardan, whereas Faisalabad is the least vulnerable of the three districts. It was found that a lack of adaptive capacity, as in the case of Mardan, plays an important role in determining the overall vulnerability of households, given various levels of exposure and sensitivity. Despite having lower exposure and sensitivity to climate change impacts, a lack of adaptive capacity raised Mardan's vulnerability as compared to Faisalabad. In this regard, the adaptive capacity of a household can be enhanced if the head of the household has had higher education, access to information and communication technologies, strong social networks and institutional and government support for risk management. In addition, higher sensitivity to climate change is a result of uncertainty in water availability for irrigation, crop failures as a result of an extreme event, and poor health of agricultural labour.

This study found that the most common methods of adapting agricultural livelihoods in semi-arid Pakistan to climate impacts include intensifying the use of agricultural inputs such as pesticides and fertilisers and use of different crop varieties. In addition, various site-specific measures such as shifting to other livelihoods, migrating for work, and introducing another mode of irrigation are also quite common. Migration is a common adaptation response to climate impacts, yet it varies from one region to another. In contrast, high costs of adaptation and lack of information on how best to adapt to certain climate impacts was noted to be one of the main impediments for those farmers who do not take any adaptive measures for their agricultural livelihoods.

Based on the findings, a set of recommendations have been devised aimed at not only improving resilience of the agricultural sector in the wake of climate change impacts, but also directed towards facilitating diversification of livelihoods of rural household through rural development as well as planned rural out-migration:

Improve access to irrigation water

Uncertainty in water availability for farm irrigation is a prime factor leading to higher sensitivity to climate change. A weak irrigation infrastructure can lead to such uncertainties in water supply. In response to this, the Irrigation Departments in semi-arid districts can play a more effective role by introducing innovative irrigation and water-harvesting technologies that can help decrease disruption in water flows. Furthermore, Irrigation Departments can develop district level adaptation plans for various scenarios of water availability that will better equip farmers in dealing with increasing water stress.

Raise awareness and enhance participatory capacity building

As climate-related events become more evident and severe, it is essential to rely on rural youth (men and women) for coping with these risks and adapting their livelihoods accordingly. This can be done by improving their capacity to understand vulnerable aspects of rural livelihoods, ability to effectively use new scientific information as well as local knowledge to anticipate and combat climate change risks and stressors such as floods, droughts, and heat waves. Furthermore, district level Technical Education and Vocational Training Authorities (TEVTAs) can play a role in equipping young rural men and women with demand-based skills so they can earn from alternative (non-farm) livelihoods. Doing so will reduce their sensitivity to climate vulnerable livelihoods and allow them to diversify their sources of income. Alternative economic opportunities can also be created by developing agro-based small industries close to the villages through public-private partnership (PPP) schemes.

Encourage and support women's role in non-farm activities

In addition, for encouraging women's participation in non-farm activities, local governments must create opportunities for them to access well-paid work in villages, such as supporting women-owned cottage industries by providing them trainings and access to credit and markets. Women should be formally integrated in the value chains and efforts must be undertaken to reduce the wage gap between men and women. In order to lighten the rural women's workload, especially of those whose husbands have migrated and who have extra responsibilities, they should be provided infrastructure and access to basic amenities such as water, fuel (for cooking) and electricity. This will reduce women's sensitivity (as the activity of collecting water and wood is more climate-sensitive) and lessen their burden of responsibilities as males out-migrate.

Extend, improve and subsidise agricultural extension services to farmers

Climate-resilient seed varieties currently available to small farmers are quite expensive. In this regard, agricultural extension services need to provide subsidised seed varieties to farmers at affordable prices, control the spread of pests and diseases and ensure proper storage of farm outputs.

Develop and integrate policies to facilitate planned migration

Currently, the potential of migration as a resilience enhancing adaptation strategy is not significantly recognised in Pakistan's development plans. Policies facilitating planned migration could support improved climate adaptation for migrant families, and mitigate their risk of displacement. Since migration is an important response/adaptation strategy, the national and sub-national governments should mainstream migration and climate change adaptation into National Adaptation Plans (NAPs) and sub-national integrated development plans (Local Adaptation Plans of Action – LAPAs). Furthermore, facilitating safe and planned migration requires coordination among various national and sub-national departments dealing with (amongst others) health, education, agriculture, industry, and employment.

Improve management of migration flows and data

Tracking migration flows to ensure better management of migrants to avoid unplanned settlements is necessary. The Ministry of Planning, Development and Reforms and the provincial line ministries should develop a registration system across local administrative boundaries to analyse migration flows. This will be useful for providing migrants with affordable accommodation facilities and creating jobs in the market.

Enhance Public Private Partnerships (PPPs)

Through support programmes, PPPs can boost the rural economy by helping rural migrant families channel their remittances into productive uses, such as developing small-to-medium businesses for agriculture value addition, or storage and packaging of agricultural products. For example, banks could partner with the local government to introduce loan schemes for village households.

Implement labour laws and minimum wage rates

In addition, implementation of labour laws in the urban centres for migrants and operationalisation of minimum wage rates could ensure that labour migrants are not being exploited in urban areas and their rights are protected, thus, enabling them to send more remittances back to their households. Higher remittances would translate to more resilience of rural household members.

1. Introduction

1.1. Background

This study is an output of the project 'Migration futures in Asia and Africa: climate change and climate-resilient economic development' which is part of a multi-country consortium titled 'Pathways to Resilience in Semi-Arid Economies' (PRISE). The project is funded by the Department for International Development (DFID), UK and the International Development Research Centre (IDRC), Canada.

This paper is second in a two-series study that attempts to understand the potential of migration as an adaptation strategy in the wake of climate change and climate-related extreme events. It was preceded by a detailed elucidation of the resilience enhancing potential of migration from rural semi-arid regions of Pakistan (Salik et al. 2017). Through an index-based and case study approach, it was established that in rural areas, households with at least one migrant member have better resilience to any (climate) stressors in terms of improved adaptive, absorptive and anticipatory capacities than non-migrant households in rural Pakistan. The study provided an in-depth analysis of drivers of out-migration, while also highlighting the scope of rural to urban migration in making rural livelihoods resilient to external risks, such as climate impacts. It was observed that migration is associated with lowering poverty scores, reducing food insecurity and enhancing socio-economic status of rural households in Pakistan (Ibid.). Furthermore, it was found that migration as a livelihood strategy is gendered with the trend of out-migration of young men highly dominant in the patriarchal context of Pakistan. Despite this, rural women, especially younger women with some levels of education, aspire to be involved in economic activities and can even opt to migrate for the betterment of their households, provided the cultural norms prevalent in the area allow it.

With out-migration being a predominantly male-centric activity, women are left with shouldering greater workload in their villages, not necessarily leading to an improvement in their economic or social empowerment. The cultural practice of joint family systems plays a dual role – it provides a support system for families whose males migrate so that women do not have to be the sole caretakers of the family left-behind. However, living in a joint family[1] setting often restricts women's empowerment in terms of decision-making regarding economic and social matters. Nevertheless, considered at the household scale, migrant households as a whole prove to be more resilient than non-migrant households.

1.2. Climate extremes and rural livelihoods: a way out through migration

With the positive outcomes of rural to urban migration established, the current paper considers climate vulnerability of rural agricultural livelihoods in semi-arid areas. The study looks at how vulnerable such livelihoods are to climate change and climate impacts; and how migration can be supported as an adaptation strategy if these livelihoods continue to be threatened by climate risks. The premise here is that climate change may make the existing rural economy vulnerable, which may then, increase out-flow of people from villages to cities.

Rural areas are characterised by high dependence on agriculture, low human development levels, low adaptive capacities and receive little attention from policymakers (Skoufias et al. 2011; Dasgupta et al. 2014; Panthi et al. 2015). According to the IPCC Fifth Assessment Report (Dasgupta et al. 2014), climate change introduces grave implications for rural areas through a direct toll on rural livelihoods. Rural economies in semi-arid regions are primarily natural resource based. In this regard, rural livelihoods are shaped by complex political, economic, institutional and biophysical conditions (Abid et al. 2016).This implies that farmers' livelihoods are affected by factors such as government policy on agriculture, the taxing structure, availability of extension programmes, subsidies, market structures, connectivity and infrastructure in addition to the characteristics of natural resources such as soil quality, fertility, and water availability (Belliveau et al. 2006). Climate change and its impacts add another dimension by introducing risks that further complicate livelihood activities (Salik et al. 2015). These impacts may be presented through two pathways:

1) Slow onset of climate /environmental changes affecting rural livelihoods based on agriculture and ecosystems such as (amongst others) the natural trend of environmental degradation, population pressures and land use changes.
2) Extreme events such as (amongst others) droughts, floods, and heat waves (Dasgupta et al. 2014).

1 Extended family living arrangement generally including two or more generations of kindred.

The adverse impacts of climate change on rural livelihoods are manifested through shifts in cropping seasons and a loss in agricultural productivity (IPCC, 2014). This not only translates into loss of income, it also exacerbates food insecurity among the rural population, especially those vulnerable households who are engaged in subsistence farming. Furthermore, climate extremes resulting in widespread destruction have livelihood consequences that may resonate long after the event has passed. Through loss of lives, property and livelihoods, people lose both gradually as well as rapidly their human, physical, natural and financial capital that has long lasting repercussions on income and income generating means (Gray and Mueller, 2012; Ngwa et al. 2015). It is estimated that between 2000 and 2005 alone, natural disasters led to a loss of about 250 million livelihoods per year globally (Feron, 2012, cited in Ngwa et al. 2015). Climate extremes add new costs to the rural economy that include loss and damage associated with future adaptation costs, as well as psychological impacts which cannot always be estimated in monetary terms (Handmer et al. 2012). This may lock the already marginalised rural population in poverty traps as their livelihoods are exposed to additional risks, thereby perpetuating poverty, deprivation and livelihood insecurity (IPCC, 2014; Ngwa et al. 2015).

As scientists and researchers across the globe invest their efforts in understanding climate change implications and vulnerabilities in rural areas and how the human population can adapt to the consequences, focus on migration as an adaptation strategy is increasingly gaining momentum (McLeman and Smit, 2006; Scheffran et al. 2011; Etzold and Mallick, 2016). In this regard, IPCC (2014) also highlights the potential of migration as an effective adaptation strategy in response to climate extremes and flags the need of more empirical research in this regard. The academic narrative is now shifting away from the negative innuendo attached to climate-related migration seen in terms of displacement and 'running away' to a more positive understanding, contextualising migration as a gateway to diverse livelihood opportunities (Etzold and Mallick, 2016).

Against this background, this study approaches the concept of migration by understanding the risks introduced by climate change and extreme weather events to the rural population's existing livelihoods and speculate how that may influence the decision to migrate out of semi-arid villages. By using a Livelihood Vulnerability Assessment Approach (LVAA), the study explores how farming households adapt to different climate impacts and stressors (Adger et al. 2003; Connelly-Boutin and Smit, 2015) and whether migration is viewed as a feasible adaptation option. Based on the findings, key policy recommendations are proposed that would help in devising a nuanced approach to help better understand and manage internal migration in Pakistan.

The paper is structured as follows: Section 2 provides a contextual background of Pakistan's rural livelihood profile and gives an overview of the impacts of climate extremes in semi-arid regions. Section 3 focuses on the methodology, comprising of the analytical framework, study sites, data collection and an explanation of the construction of the Livelihood Vulnerability Index. Section 4 states the results and Section 5 is an analysis of the study findings. Section 6 summarises the findings, concludes the discussion and provides policy recommendations.

2. Pakistan's rural livelihood profile and impact of climate extremes in semi-arid regions

2.1. Rural livelihoods in Pakistan – strengths and weaknesses

Being primarily an agrarian country, 61% of the population of Pakistan lives in the rural areas and over 45% derives its income from agriculture (The World Bank, 2015). However, Pakistan's economy is transforming from agrarian and rural to a more industrial and service-based economy, leading to a declining share of agriculture in the Gross Domestic Product (GDP) (GoP, 2016).

As pointed out in Salik et al. (2017), the semi-arid study areas (D.G. Khan, Faisalabad, and Mardan) have limited alternative sources of livelihoods besides agriculture. Semi-arid regions are not only marred by a lack of institutional focus, complex governance issues and shortcomings in farm input facilities, they also suffer from environmental and climatic threats (Abid et al. 2016). Despite the declining share of agriculture in the GDP, it cannot be denied that rural agriculture still continues to be the backbone of Pakistan's economy. Besides providing livelihoods to more than 45% of the population, it provides food to more than 200 million people (Shah et al. 2005; The World Bank, 2015). As agriculture is largely concentrated in the arid and semi-arid regions of Pakistan, these areas are the breadbasket of the country.

The socio-economic conditions of semi-arid rural communities define the strength or weakness of their livelihoods. In Pakistan, poverty is a largely rural phenomenon (The World Bank, 2007) and it is more pronounced in arid and semi-arid regions of the country (Saeed et al. 2015). The rural livelihood profile of Pakistan shows that households' livelihood activities are somewhat diverse, but the prime source of income is mostly from agriculture (Irfan, 2007; Hamid and Afzal, 2013). It is not easy to differentiate between farm and non-farm activities as there are strong linkages between factor and product markets (Shah et al. 2005). In addition to farming, livestock rearing is an important contributor to rural livelihoods (Ibid.).

Livelihood security in the rural areas of Pakistan is extremely volatile and subject to limited livelihood alternatives, low wage rates, rising costs of inputs and other socio-economic and biophysical factors (Arif, 2007). Much of the rural labour force is involved in the informal sector, working in poor conditions. Food insecurity is also higher in rural areas than in urban areas (NNS, 2012). High dependence on natural capital makes rural livelihoods susceptible to environmental and climatic factors (Abid et al. 2016). Besides inequality in access to land and water, based on socio-economic differences and gender, disparities in household incomes and access to public facilities are also quite evident (The World Bank, 2007). Statistics show that rural areas of Pakistan have low human capital with poor indicators for education and health, much more disproportionate for women than for men. Table 1 gives a snapshot of the socio-economic conditions of rural communities in Pakistan:

Table 1: Snapshot of socio-economic conditions of rural Pakistan

No.	Indicators	Value %	Reference
1.	Percentage of rural population (of total population)	60.1	(GoP, 2017) in Pakistan Economic Survey 2016-17
2.	Male to female ratio	105.07`	Pakistan Bureau of Statistics (PBS), 2017
3.	Improved drinking water facility	89.9	CIA World Fact book 2016
4.	Improved sanitation facility access	51.1	CIA World Fact book 2016
5.	Adult literacy rate (male)	63	PBS (2014) in PSLM, 2013-14
6.	Adult literacy rate (female)	36	PBS (2014) in PSLM, 2013-2014
7.	Net primary enrolment ratio (male)	57	PBS (2015)a in PSLM, 2014-15
8.	Net primary enrolment ratio (female)	48	PBS (2015a) in PSLM, 2014-15

No.	Indicators	Value %	Reference
9.	Percentage of out of school children (total)	21	GoP (2017) in Pakistan Economic Survey 2016-17
10.	Percentage of out of school children (male)	8	GoP (2017) in Pakistan Economic Survey 2016-17
11.	Percentage of out of school children (female)	13	GoP (2017) in Pakistan Economic Survey 2016-17
12.	Percentage of food insecure population	60.6	National Nutrition Survey, 2011
13.	Labour force participation rate (male)	47.4	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
14.	Labour force participation rate (female)	20.2	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
15.	Employment share in agriculture	42	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
16.	Employment in formal sector (male)	24	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
17.	Employment in formal sector (female)	22	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
18.	Employment in informal sector (male)	75.7	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
19.	Employment in informal sector (female)	78	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
20.	Unemployment rate	5	PBS (2015b) in Pakistan Labour Force Survey (2014-15)
21.	Multidimensional poverty rate	54.6	GoP, 2016
22.	Percentage of households satisfied with agricultural extension programs	69	PBS (2015a) in PSLM, 2014-15
23.	Percentage of households satisfied with basic health units	56	PBS (2015a) in PSLM, 2014-15

Source: Collated by authors.

2.2. The role of women

The role of women in the rural economy is crucial, yet it goes largely unnoticed because of strong patriarchal norms. Rural women of all ages actively participate in agricultural production, livestock rearing and cottage industries. However, much of the work they perform is unpaid or underpaid and mostly ignored in public policy and development planning. Women are involved in farming during various stages such as seed bed preparation, weeding, and crop harvesting (Ishaq and Memon, 2016), yet despite all their efforts, they are merely considered 'helpers' to their male family members and get little to no remuneration.

According to a FAO study, there are about 7 million rural households that rely on livestock for a living, with women playing a dominant role in this field. Despite their involvement in this sector, the benefits they accrue are narrow owing to limited mobility and access to markets (Samee et al. 2015). The role of women is important to mention here with regards to climate change adaptation as they play a crucial role in household welfare in rural Pakistan, especially when males out-migrate to urban areas.

2.3. Rural livelihoods and climate change

Pakistan, owing to its geographical location in arid and semi-arid zones,[2] is expected to witness high temperatures as impacts of climate change make themselves more evident (Hussain, 2010). Climate change impacts are expected to worsen in the future, the consequences of which would be evident through losses

2 About 70% of Pakistan's geographic area can be characterised as semi-arid, receiving annual rainfall of about 250mm (Alam, 2000; Qaisrani, 2015).

in agriculture, disruption in associated ecosystems and population displacement (Pachauri and Reisinger, 2007). In fact, Afzaal and Haroon (2009) postulate in their study that the rate of temperature rise in Pakistan is speeding up, with the rate of change being 0.2°C between 1907 and 1945, which by 2007 had gone up to 0.53°C per decade. In a comprehensive assessment, Salik et al. (2015) explain future climate trends in Pakistan based on country-specific climate scenarios. It was projected that during 2030-59, temperature is expected to rise by 2°C or slightly less in semi-arid regions, especially in the irrigated plains. Precipitation has the probability of declining in the monsoon belt, comprising the arid and semi-arid regions. Figures 1a and 1b provide an overview of the annual mean temperature and precipitation in Pakistan:

Figure 1a: Annual mean temperature (°C)

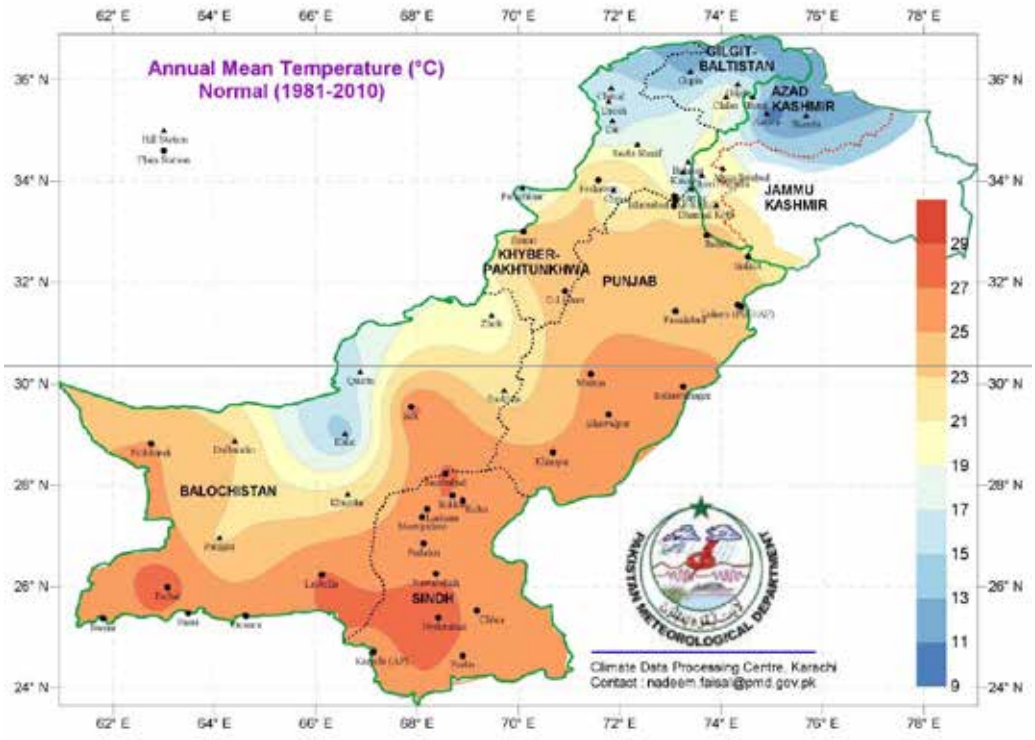
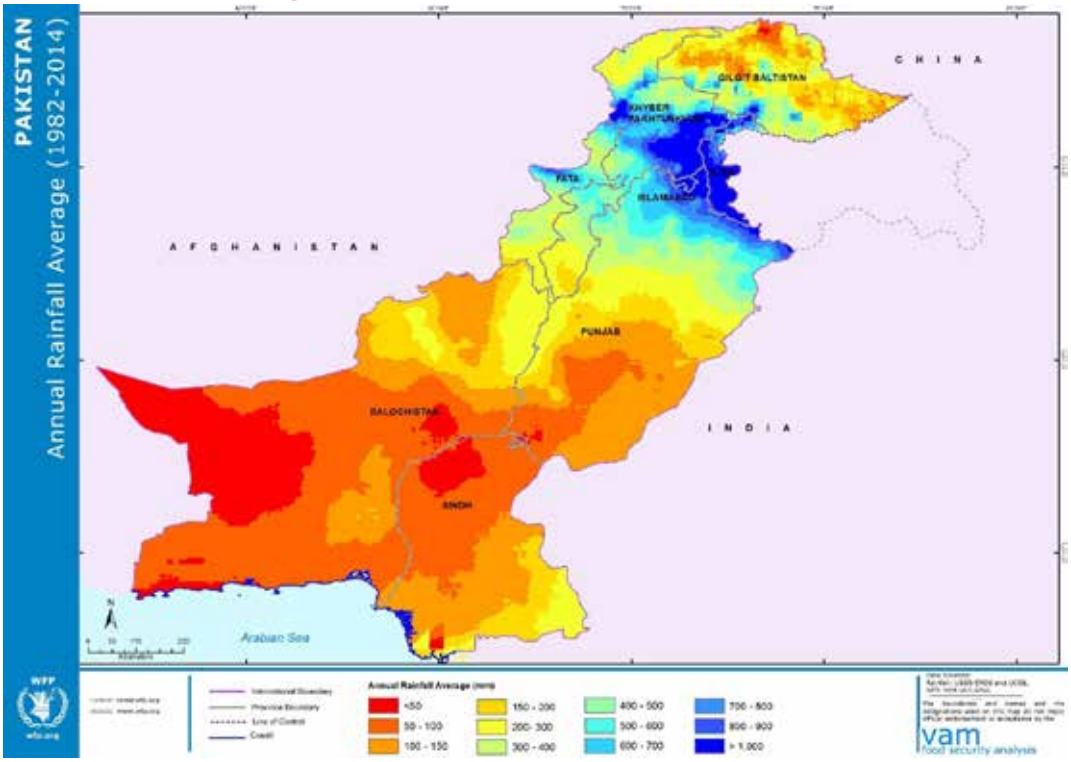


Figure 1b: Annual rainfall average



Source: Pakistan Meteorological Department (2010), cited in WFP (forthcoming 2018).

Semi-arid lands in Pakistan predominantly feature irrigated agriculture. However, in southern semi-arid districts of Pakistan such as D.I. Khan, agricultural farms are also irrigated through hill torrents (Dawn, 2007). In case of irrigated lands, water for agriculture is supplied through an extensive network of canals that largely depend on glacier-fed river flows originating from Northern mountainous parts of the country (Iqbal et al. 2015; Hasson et al. 2017). It has been predicted that climate change would render river flows highly unpredictable due to increasingly early and rapid melting of glaciers. In some years, the increase in early melting of Hindu Kush Himalaya (HKH) glaciers will be coupled with monsoon period in the country, often leading to increased flooding in the rivers (Hasson et al. 2017). Whereas, in other years, projections also show that delayed and decreased glacier melting may reduce river flows, thereby unfavourably affecting crop production (Ibid.).

On the other hand, rain-fed or barani areas are wholly dependent on rainfall (Alam, 2000). As agricultural production is at the disposal of rains that are often irregular and unreliable, not only is it threatened by droughts, it is also exposed to the peril of floods due to torrential rains on parched soil (Manig and Kuhnin, 1984). This hinders the economic and social uplift of those whose livelihoods are dependent upon it. These areas are also neglected in development planning owing to the high costs associated to sustain productivity (Alam, 2000).

One fourth of the cultivable area of Pakistan suffers from wind and water erosion, salinity, inundation and water logging (Irfan, 2007). Agricultural productivity, particularly for winter crops such as wheat, often suffers due to heat waves (Qin et al. 2014; Saeed et al. 2015). A study by the Asian Development Bank (2012) observes that subsequent impacts of climate change may adversely affect the production of cereal crops in Pakistan. It is also projected that arable lands would shift upwards to the north as a result of environmental degradation and climate change consequences such as reduction in livestock, fisheries, water resources and food supply (Qin et al. 2014). With the River Indus being the lifeblood of semi-arid regions, alternate periods of droughts (1999-2012) and floods (2010 onwards) have immensely increased the vulnerability of livelihoods based on river flows (Ibid.). A CRED (2007) study analysed that such disasters have greatly increased since the 1990s. The changing patterns of monsoon rains increase the risk of flash-flooding in the hill-torrent zones of the country (Hussain, 2010). As a result, extreme events have become more frequent and less predictable in the recent years (GoP, 2013). Zaman et al. (2009), in a study commissioned by the Pakistan Meteorological Department (PMD), forecasted that the incidence of heat waves will be on the rise in Pakistan. This indicates that in the years to come, the number of warm days will increase as compared to previous years.

Rural areas of semi-arid Pakistan are likely to feel the impacts of climate change more adversely owing to their existing marginalisation and higher incidence of multidimensional poverty (Hussain, 2010; Naveed and Ali, 2012). Majority of rural households are involved in subsistence farming, with limited capacities to deal with any unforeseen shocks, climatic or non-climatic (Hussain, 2010). Most of the agricultural lands country lies in arid and semi-arid regions which are characterised by high temperature and low rainfall intensity. Therefore, susceptibility of agriculture-based households may rise further as they are pushed to less productive lands that become more vulnerable to climatic extremes (Ibid.).

Through a detailed study of semi-arid regions of Pakistan, Khan et al. (2011) drew on farmers' experiences and perceptions regarding the impact of climate change on their farm activities. They highlighted that as farming livelihoods are threatened by change in rainfall patterns and rising temperatures, a major increase in out-migration of people has been witnessed in search for alternative livelihood options. It is expected that with higher temperatures in Pakistan and varying rainfall trends, the risk of hydro-meteorological disasters would rise that is likely to be disastrous for crops, land, property, livestock and even humans (Hussain, 2010; Shakoor et al. 2015) (see Box 1):

Box 1: Losses incurred in 2010 floods of Pakistan

1. 1/5th of Pakistan inundated
2. 20 million people affected
3. 6 million people rendered homeless
4. Economic losses amounting to USD 43 billion
5. 1985 people lost their lives; 2946 were injured
6. 1,895,259 homes destroyed

Source: NDMA (2011).

The floods of 2010 affected over 20% of the land area. The associated losses were wide-ranging - from damage to the infrastructure - to loss of human assets and disruption of complete livelihoods (Ashraf et al. 2013). In 2015 alone, floods caused a total loss of 238 lives, rendered 232 injured and destroyed 10,716 houses, affecting about 1,572,1191 people countrywide (NDMA, 2015). Unfortunately, sex and age segregated data is not available in terms of lives lost and people affected, which would have been critical in assessing the gendered impacts of these disasters. Disruptions caused by such catastrophes echo long after the event, as men and women struggle to get back to their previous standards of living. As explained by Kirsch et al. (2012), even 6 months after the incidence of 2010 floods in Pakistan, rural families were far from attaining their previous standard of life and access to services.

Not only are rural areas in semi-arid regions threatened by floods and droughts, other catastrophes, often related to climate change and climate-extremes are becoming more visible. Although they do not send 'shockwaves of terror' they cause monetary and livelihood losses to those who depend on natural resources. These include land degradation, waterlogging, soil erosion, and pest attacks related to temperature hikes (Memon 2011). As the rural economy in semi-arid regions is embedded in agriculture, any catastrophe that hits this sector is likely to force the economy and livelihoods to the brink of peril. This may leave many people unemployed and force many households into a vicious cycle of poverty (Ibid.). A direct hit on agriculture translates into a risk of food insecurity and a further push towards poverty for the already marginalised due to loss in income, as discussed by Ashraf et al. (2013). Drought-like conditions directly affect crop productivity and also impact health and livestock leading to a reduction in the purchasing power of agriculture-based rural communities through decreased earnings.

2.4. Institutional and policy support to rural areas

In the past, the Government of Pakistan (GoP)'s response to climate extremes was primarily reactive, providing only relief and rehabilitation to the victims. However, considering the continuous occurrence of such disasters, efforts are now being directed towards building the adaptation capacity of communities as well as providing institutional and policy support. The following policy initiatives undertaken by the GoP are a testament to these efforts:

1) Climate Change Act passed by the National Assembly in 2016.
2) Nationally Determined Contributions for the Paris Agreement (2016).
3) Adoption of the Sustainable Development Goals as the National Development Goals in 2015.
4) Implementation Framework for the National Climate Change Policy (2014).
5) Vision 2025 formulated in 2014.

The new policy approach draws on building synergies between climate change, disaster risk reduction and sustainable development by being cognizant of communities' and peoples' resilience.

While government initiatives wait to be unfolded through actual implementation, rural households themselves, in response to the changing climate and increasing intensity and magnitude of disasters, are moving towards strategies to offset the vulnerabilities related to livelihood stress (Samee et al. 2015). These strategies and their effectiveness may differ based on socio-economic characteristics such as geographic areas, income level, size of landholdings, and gender. According to Khan et al. (2011), the varied strategies adopted by farmers include borrowing money, shifting to new crop varieties, changing the cropping calendar, reducing consumption, sale of livestock and migrating for alternative economic opportunities. Iqbal et al. (2015) also highlight that in climate sensitive disaster-prone areas of Pakistan, migration (seasonal, temporary or permanent) is a common livelihood strategy. Framing migration in the context of vulnerability is nuanced as it is one of the important strategies adopted by rural agricultural households in the wake of climate change impacts and related disasters and therefore, a deeper insight is needed to understand its effectiveness in building resilience among communities.

Considering the threats that climate impacts (such as high temperatures, erratic rainfall patterns, heat waves and floods) introduce for semi-arid areas, rural livelihoods that rely on natural resources are under serious stress (Qaisrani, 2015). With lack of alternative economic opportunities in rural areas, rural out-migration often becomes inevitable (Salik et al. 2017). Despite the potential resilience enhancing outcomes of migration, policy focus on this area is lacking and the Government is, thus, struggling to manage the opportunities and challenges presented by internal migration (Ishfaq et al. 2017). Furthermore, there is still a lacuna in understanding the linkages between climate change and human mobility, especially rural out-migration.

In this backdrop, emerging trends of climate change are correlated with out-migration from rural areas via the impact on rural livelihoods, with special focus on agricultural livelihoods. The vulnerability of rural livelihoods is assessed in relation to climate change and climate extremes, such as increasing frequencies and intensities of floods, heat waves, smog, and irregular rainfalls. This allows us an ex-post analysis of the vulnerability of livelihoods to climate impacts while also throwing light on the potential of migration as an adaptation strategy to such vulnerabilities.

3. Methodology

3.1. Analytical framework

The Third Assessment Report of the IPCC (2001) defines climate change vulnerability as:

'The degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.'

The most recent definition of vulnerability given by IPCC in its Fifth Assessment Report (AR5) states:

'The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt' (IPCC, 2014).

Furthermore, IPCC Ar5 includes vulnerability, along with hazard and exposure as a component of risk that refers to the likelihood of adverse effects by disasters in the future. In risk assessment, vulnerability includes the role of socio-economic factors that determine the extent of being adversely affected by a disaster and for managing and responding to risk, it is essential that one understands how 'vulnerability is created, how it increases and builds up' (Cardona et al. 2012). In its most simple form, vulnerability is the tendency to be adversely affected (Kelly and Adger, 2000; IPCC 2001; Fussel, 2007; Opiyo et al. 2014).

Since the primary aim of this study is to understand vulnerability as an outcome, rather than as a factor that shapes an outcome (i.e. risk), we consider vulnerability of a system within three components:

1) Exposure to a risk or a hazard.
2) Sensitivity to that risk or hazard.
3) Capacity to respond to that hazard either by coping, recovering or adapting from the situation (IPCC, 2001; Smit and Wandel, 2006; Reed et al. 2013).

The combination of these attributes determines the level of vulnerability of a system (at individual, household or community level). These drivers of vulnerability differ according to geographic location, economic situation, socio-political scenarios, psychological conditions, infrastructural development, institutional capacities as well as individual characteristics such as gender, age, health, and education (Zarafshani et al. 2016).

Based on the IPCC's working definition of vulnerability, Hahn et al. (2009) developed a methodology for assessing the livelihood vulnerability of a population through an index approach. This methodology categorises incidence of natural disasters, climate variability, early warnings and monetary loss due to climate events under exposure; food, water and health conditions under sensitivity; and socio-demographic, livelihood strategies and social networks under adaptive capacity. Hahn et al. (2009) proposed an indicator-based vulnerability assessment technique which can easily be customised to suit the context (also followed by Panthi et al. 2015).

In the IPCC Livelihood Vulnerability Framework, household capital is defined in terms of five assets: natural, human, physical, social and financial. Households with greater access and control over these resources are generally less vulnerable to impacts of disasters as compared to others. Keeping this framework in mind, this research applies the IPCC Livelihood Vulnerability Index to study the risks imposed by climate-related extreme events on rural people, whose livelihoods are predominantly natural-resource based, particularly agriculture. We take guidance from work done by Hahn et al. (2009) and Panthi et al. (2015) and apply it to the specific context of semi-arid regions of Pakistan. This study presents a holistic picture of rural agricultural households' vulnerability to climate change and climate extremes in three semi-arid sites of Pakistan. The research team adopts a case study approach for each site to define its vulnerability in terms of exposure, sensitivity and adaptive capacity, while also throwing light on the adaptation strategies available to the farmers, with special focus on migration.

The findings of this research will feed into results of an earlier PRISE study in which the potential of migration was calculated in improving the resilience of rural households. The conclusions drawn from both these studies will provide an overall understanding of the climate change vulnerabilities of rural households and how internal

migration may act as a resilience-enhancing adaptive strategy.

3.2. Study sites

With respect to the focus on semi-arid regions of Pakistan, the study areas include two districts of Punjab (Faisalabad and D.G. Khan) and one district of Khyber Pakhtunkhwa (KP) (Mardan).[3] Corresponding to the earlier study (Salik et al. 2017), the study districts remained the same, initially selected on the basis of their:

1) Geographic location in semi-arid regions of Pakistan.
2) Heterogeneity in the level of economic development, and,
3) Vulnerability to climate change impacts.

In addition, stakeholder consultations were also important in identification of the study sites. It is important to mention here that although the study districts remained the same as Salik et al. (2017), the Union Councils (UCs) and villages chosen are different. This is so because in the first study, the aim was to understand the drivers of migration, while elucidating the resilience-enhancing potential of migration, irrespective of the motivation behind migration. The choice of UCs in that case was random. However, in this phase, those rural UCs within the district were purposely selected that had witnessed climate extreme events in the past:

1) UC 108 Rattar Chattar, Faisalabad.
2) UC 28 Kala, D.G Khan.
3) UC 34 Bala Garhi, Mardan.

These UCs were identified in consultation with subject expert stakeholders as well as by drawing on the knowledge of locals. This is in line with the second research question of this project that calls for an understanding of the increase in livelihood vulnerabilities as a result of climate extremes. The following section provides a brief overview of the select sites regarding their agricultural activities. [4]

Faisalabad

Located in Central Punjab, District Faisalabad has a comparatively thriving economy as compared to the other two study sites. 52.2% of the district's population resides in the rural areas (PBS, 2018). Drawing on the descriptive facts from the survey, it is evident that 64% of respondents in Faisalabad had diversified incomes. About 66% of the households were headed by individuals with at least secondary level education. Wheat is commonly grown as a winter crop, cultivated by more than 90% of the respondents. During the summer season, sugarcane is the most popularly grown crop, often in combination with cotton or fodder. A small percentage of the respondents also grow maize (8.2%), rice (4.2%) and sesame (4.1%). Farmers in Faisalabad primarily cultivate winter and summer crops for the sale of products, while saving some portions of wheat and maize for household consumption. 46% of farmers use a combination of both canal water and tube-well extracted water for irrigating their lands, while 40% only rely on canal water. Furthermore, livestock and poultry owners also derive some income from the sale of products (e.g. milk and eggs), while also saving some for household consumption. 10% households had women actively involved in labour force activities. Working women in Faisalabad district were mostly salaried, engaged in government jobs (such as village school or local health clinic) as well as private jobs (including work as domestic help).

D.G. Khan

Located in South Punjab, in the semi-arid region of Pakistan, District D.G. Khan hosts 80.9% of its population in rural areas (PBS, 2018). A descriptive analysis from the survey depicts that even though 80% of the respondents rely on more than one source of income, agriculture is still the main lifeline of their livelihoods. Wheat is the most popular winter crop grown in the district (harvested by 94% of the respondents) which is often coupled with sugarcane as a secondary crop. In summers, cotton is the most commonly harvested crop (grown by 68% of respondents) which is often grown in combination with rice and fodder. Wheat grown in the winter season is commonly used for household consumption, especially by small farm-holders (farm size < 12.5 acres), whereas cotton harvested in the summer is mainly for commercial use. About half the farmers (48%) use tube-wells for land irrigation, while another 48% use a combination of canal water and tube-well as a source of irrigation. Many households own livestock and poultry, however, majority use their products (e.g. milk, and eggs) for household consumption. About 30% of the households surveyed had at least one female member active in the labour force. Majority of these women were involved in agriculture i.e. managing livestock or helping their male household members in farming activities.

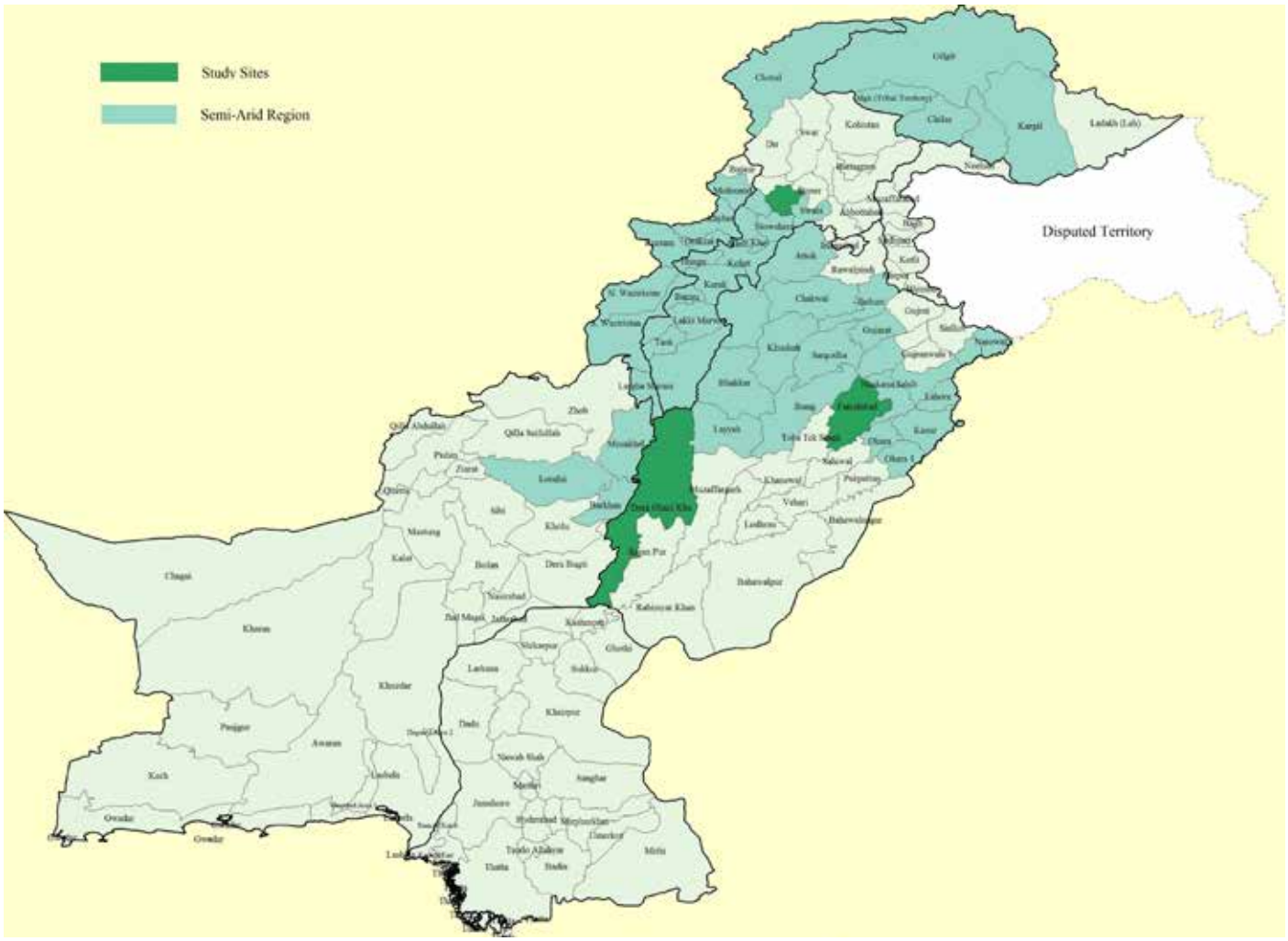
3 For more details about site selection, refer to Salik et al. (2017).

4 Ibid.

Mardan

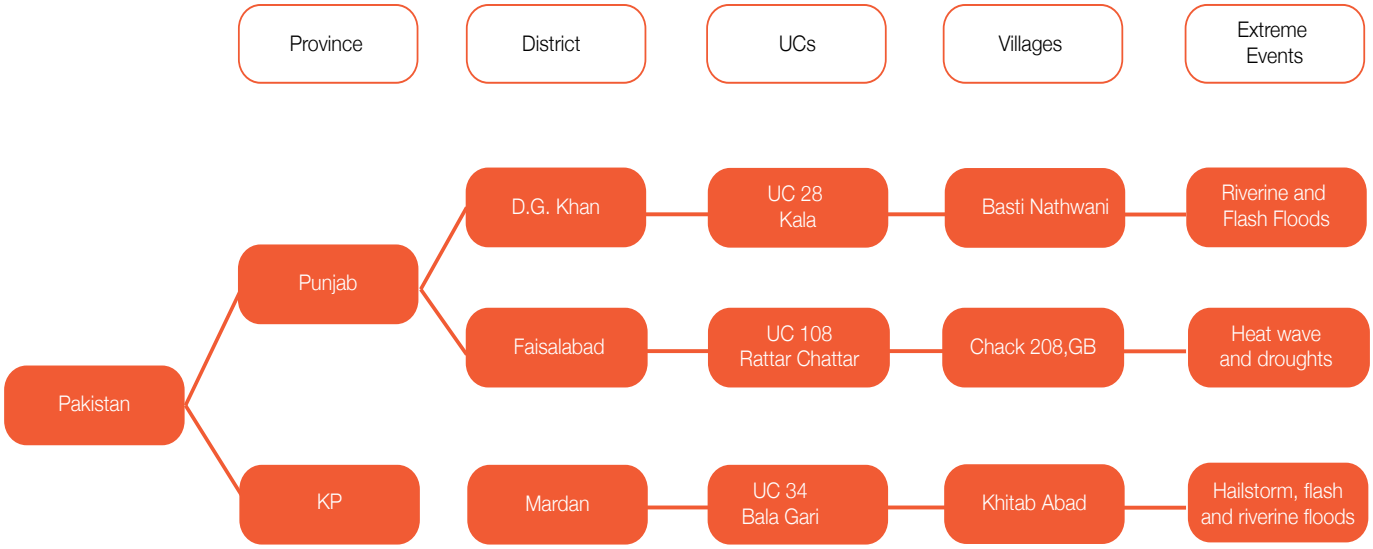
Mardan is a semi-arid district located in the Khyber Pakhtunkhwa (KP) province of Pakistan. 81.5% of the population resides in rural areas (PBS, 2018). 82% of the households surveyed showed income flows from more than one stream, while the prime occupation remained agriculture. Most households had one or more member working as daily wage labour in the non-farm sector. Only 18% of the household heads had education up to secondary school level or higher. Like the other two districts, the most commonly grown winter crop is wheat, while in summer cultivating maize is popular, sometimes in combination with rice. The main purpose of farming both summer and winter crops is for household consumption. 84% of the households surveyed relied on canal water for irrigation of their land, while only 12% used tube-wells. Although female members of households in Mardan were better educated than women in D.G. Khan, none of them were actively participating in labour force activities.

Figure 2: Study sites in semi-arid Pakistan



Source: Authors' own.

Figure 3: Study sites and climate extremes



Source: Authors' own.

3.2.1. Data collection

Data was collected during December 2016 and January 2017. In the sample rural areas, the research team focused on agricultural households i.e. those households whose primary source of income is from the agriculture sector. In each district, 50 rural households were interviewed, regardless of their land ownership status. The respondents were household heads chosen randomly from among the agricultural households in the villages and consent was taken from them by giving a brief introduction regarding the purpose of the survey. As the target respondents were household heads, the survey team mostly came across male respondents. However, females were involved through qualitative in-depth interviews to understand their lifestyle in the villages.

The survey was conducted in the local language of each site with the help of local enumerators (four male and 4 female enumerators at each site). The enumerators were given a two-day training prior to the survey to familiarise them with the field research ethics, study objectives, questionnaire and data collection methods. The questionnaire was pre-tested for any gaps in obtaining information as well as in-field training of enumerators. Each interview took about 40 minutes. The household survey was intended to reflect on farmers' perceptions and experiences related to climate change, agricultural risks they are exposed to, coping mechanisms, livelihood strategies and adaptation options being used.

Secondary data was also used for estimating climate indicators. The study used monthly data for temperature and precipitation for the time period 1961-2014 obtained from the PMD. Faisalabad and D.G. Khan districts have meteorological stations, however, due to the absence of any meteorological station in Mardan, data from the nearest meteorological station of Risalpur was used, which is at a distance of 17km from Mardan. Standard deviations of monthly temperature and precipitation were used to measure variations from their mean, i.e. how much the values of temperature and precipitation are spread out from the average. Furthermore, the frequency of extreme hot months, i.e. months during which temperature surged over 30°C was used. Summer months in which precipitation was less than 5mm, and spring months during which precipitation was 0mm were recorded as extreme dry months.

Key Informant Interviews (KIIs) were conducted with key experts and government officials in district development and agriculture departments. The purpose of conducting these KIIs was to develop an understanding of the departments' initiatives in addressing climate change, agriculture and migration concerns, as well as the challenges they face. In total, 9 KIIs were conducted:

Table 2: List of departments for KIIs

District	Department
Faisalabad	Faisalabad Development Authority
	District Office Agriculture
	Technical Education and Vocational Training Authority
D.G. Khan	District Office Agriculture
	Technical Education and Vocational Training Authority
	Zarai Taraqiati Bank Limited (Agricultural Development Bank)
Mardan	District Office Agriculture
	Technical Education and Vocational Training Authority
	Zarai Taraqiati Bank Limited (Agricultural Development Bank),

Source: Authors' own.

3.3. Construction of Livelihood Vulnerability Index

Taking guidance from Hahn et al. (2009) and Panthi et al. (2015), IPCC's working definition of vulnerability was used which explains it in terms of exposure, sensitivity and adaptive capacity. Variable selection for each of these components is based on extensive literature review. Table 3 presents the selection of indicators for these three components and provides their criteria for justification:

Table 3: Indicators for IPCC Livelihood Vulnerability Index

Indicators and sub-components	Explanation	Functional relationship	References
Exposure			
Climate extremes/disaster	Average number of frequent climate extreme events in the last 10 years (based on survey)	More frequent events lead to higher exposure	Panthi et al. (2015). Hahn et al. (2009). Salik et al. (2015).
Temperature variability	Monthly variability in temperature	Increase in temperature variability increases the risk to crop yield	Porter et al. (2005). Salik et al. (2015).
Hot months	Number of extreme hot months with temperature above 30°C`	Higher the frequency, higher will be the exposure	Salik et al. (2015).
Precipitation variability	Monthly variability in total precipitation	Increase in the variability of precipitation increases the risk to crop yield	Porter and Semenov. (2005). Salik et al. (2015).
Extreme dry months	Number of extreme dry months explained as the month during spring season having precipitation < 5mm and in summer precipitation = 0 mm	Higher the frequency of dry months higher will be risk of droughts/water shortage which leads to enhanced exposure	Salik et al. (2015).
Monetary loss	Average monetary loss incurred due to last extreme event`	Higher the loss, greater will be the exposure to climate change impacts	IPCC. (2001).

Indicators and sub-components	Explanation	Functional relationship	References
Crop failure	Percentage of households facing complete crop failure due to climate extreme	Higher the crop loss, greater will be the exposure to climate change impacts	Powell and Reinhard, 2016
Physical damage to human body	Percentage of household with an injury or death as a result of natural disaster (Used to assess the physical impact of any disaster on human body)	More injuries or death reflect higher exposure to climate change impacts	Hahn et al. (2009).
Sensitivity			
Source of irrigation	Percentage of households that do not have access to canal water	Higher sensitivity because of lower access to diverse fresh water resources for irrigation	Zachariadis (2016).
Access to water	Percentage of households not having access to good quality drinking water	Limited access to good quality drinking water implies higher sensitivity	Salik et al. (2015).
Physical disability	Prevalence of any permanent disability in the household	More disabled persons in the household lead to higher sensitivity	Panthi et al. (2015).
Cost on health issues	Average health-related cost per month for the household	Higher cost implies higher sensitivity	Hutton and Menne (2014).
Professional skills	Percentage of households not having any skill other than farming	This is to assess the occupational diversity of the households Less diverse the skills, higher will be the sensitivity	Hahn et al. (2009).
Type of house	Percentage of households having house made of temporary material	Houses made of concrete are more resistant to extreme events that leads to lower sensitivity	Brooks and Adger (2005).
Average crop diversity index (range= 0-1)	The inverse of (the number of crops grown by the households +1) e.g.: a household that grows sugar cane, rice, wheat and maize will have crop diversity index =1/ (4+1)= 0.20	More crop diversity, higher will be adaptive capacity	Hahn et al. (2009). Zarafshani et al. (2016).
Adaptive capacity			
Dependency ratio	Ratio of the population 0-14 and 65 years and above of age over the population between 15 to 64 years of age	Higher the age dependency ratio, lower will be the adaptive capacity	Barr et al. (2010). Panthi et al. (2015).

Indicators and sub-components	Explanation	Functional relationship	References
Education	Percentage of household heads who have secondary and above level of education	More education of household heads, higher will be the adaptive capacity	Himes-Cornell and Hoelting (2015).
Income diversification	Percentage of households who have more than one source of income	Income diversification increases adaptive capacity	Panthi et al. (2015).
Access to media/ information	Percentage of households having access to phone, Internet and TV	Communication media helps to enhance awareness of hazards and preparedness which ultimately contributes to adaptive capacity	Panthi et al. (2015).
Social networking	Percentage of households who are actively involved in: local politics, social relief work, local level associations and have a strong friendship circle	Social networking enhances adaptive capacity by providing support in the form of physical help, information and experience sharing etc.	Hahn et al. (2009).
Savings	Percentage of households who have savings of any kind	More saving enhances the capacity of the household to adjust more quickly to any shock and stressor	Cutter et al. (2008).
Government initiated disaster management plans	Percentage of households aware about or have access to government initiated climate disaster management plans	These services helps to improve adaptive capacity	Hahn et al. (2009).
Use of remittances for investment	Percentage of households willing to invest their remittances on agriculture	Investments in agriculture will raise the adaptive capacity of households	Scheffran et al. (2011).
Purpose of agriculture production	Percentage of households that use agriculture production for sale of product	Commercial agriculture reflects agriculture as a source of income which contributes to adaptive capacity	Adger et al. (2002).

Source: Authors' own.

Data obtained for different indicators varied in their units and scales, therefore, it was imperative to normalise them before using them in the Index. To normalise variables, the min – max normalisation technique (Patro and Sahu, 2015) was followed:

$$Index_{sd} = \frac{S_d - S_{min}}{S_{max} - S_{min}}$$

Here S_d is defined as the original value of a variable, and Smin and Smax reflect the minimum and maximum values of that variable, respectively. Using a correlation matrix for the selected variables, highly correlated variables (R>0.70) were excluded from the list. In addition, in order to determine the internal validity of the identified variables, Chronbach's Alpha Test was applied. With the test score of 0.675 , it is drawn that the

included variables are internally consistent.[5] The balance weighted average approach was, then, applied (Beccari, 2016) which provided equal weighted index for each sub-component. Following that, method of aggregation was employed to find out the values of exposure, sensitivity and adaptive capacities by using the following equation:

$$CF_d = \frac{\sum_{i=1}^{n} w_{Pi} P_{di}}{\sum_{i=1}^{n} w_{pi}}$$

Here, CFd is defined as the contributor factor like exposure, sensitivity and adaptive capacity for each of the districts. The major components of each of the contributing factor are expressed by Pdi, wpi representing the weights of each of the major component and n reflects the number of major component in each of the contributing factors. After obtaining the values of the latter factors by using the above equation, the following IPCC formula was applied to obtain the results of IPCC-LVI for each of the districts (Deressa et al. 2008). IPCC-LVI ranges from -1 (least vulnerable) to 2 (most vulnerable).

IPCC-LVI=(Exposure+Sensitivity)-Adaptive Capacity

Table 4: IPCC-LVI scores

Ranges	Remarks
2	Most vulnerable
-1	Least vulnerable

5 Co-efficient values close to 0.70 or higher represent internal consistency (Babin and Zikmund, 2015).

4. Results

This section gives an overview of the agricultural livelihoods in the study areas and highlights farmers' vulnerabilities in the three study sites by analysing the components of LVI. The sub-section focuses on the various coping strategies and adaptation measures taken by farmers in response to climate change impacts, while exploring the potential of migration as an effective adaptation response.

4.1. Livelihood Vulnerability Index

Results of IPCC-LVI show varying levels of vulnerability experienced by farmers in the three study sites (Table 5). Detailed results of the sub-components of the IPCC-LVI for each of the study site are given in Appendix 1. The Index entails components reflecting the farmers' exposure to climate change and climate-induced events, their sensitivity to climate impacts and their levels of adaptive capacity that reflects their abilities to cope with climate shocks.

Table 5: IPCC-LVI scores for Faisalabad, D.G. Khan and Mardan

IPCC-LVI	Faisalabad	D.G. Khan	Mardan
Exposure	0.336	0.406	0.251
Sensitivity	0.382	0.412	0.274
Adaptive Capacity	0.699	0.504	0.467
IPCC-LVI	0.019	0.314	0.058

Source: Authors' own.

The vulnerability triangle in Figure 3 shows scores of each district. A composite score shows that D.G. Khan has the highest livelihood vulnerability (0.314), followed by Mardan (0.058). Faisalabad is the least vulnerable of the three districts with a score of 0.019. D.G. Khan shows the highest levels of exposure and sensitivity, and is better than Mardan in terms of adaptive capacity. Despite being more exposed and sensitive to climate change, related extreme events and impacts as compared to Mardan, Faisalabad has comparatively higher scores of adaptive capacity that decreases its overall livelihood vulnerability.

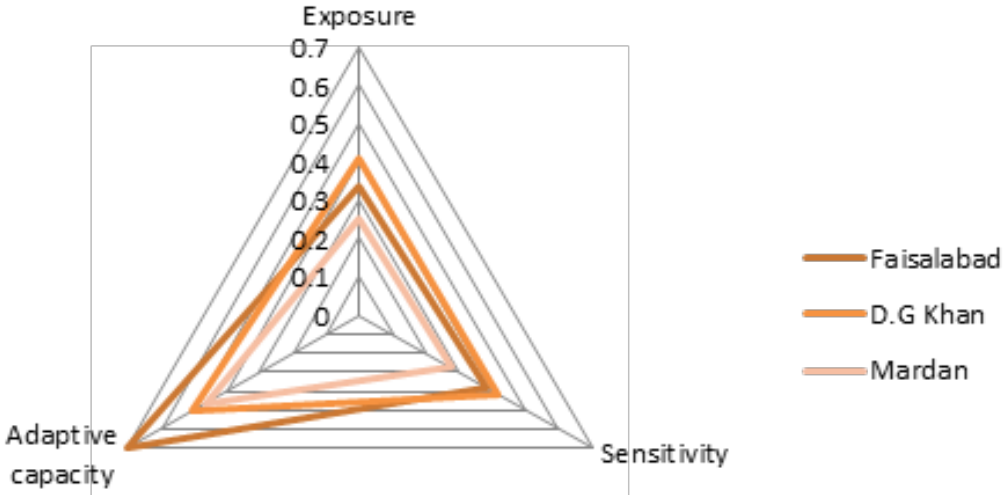
Indicators for climate exposure include frequency of climate extremes experienced by farmers, losses incurred as a result of extreme events in terms of money, crop failure and physical harm to individuals, and access to early warning systems. In addition, analysis of climatic data on temperature and precipitation has also been used. A composite of the exposure indicators shows that D.G.Khan (0.406) is the most exposed district to climate risks, followed by Faisalabad (0.336) and then Mardan (0.251). The prime factor leading to D. G. Khan's higher sensitivity is the highest experience of complete crop failure. All the farmers who participated in the survey lost their standing crops during the floods of 2010 and 2011. In comparison, in both Faisalabad and Mardan, 70% of farmers experienced complete crop failure. D.G. Khan's higher exposure is also a result of higher number of extreme hot months that it experiences as compared to the other two districts. The district has also endured longer and more frequent dry spells which add to its higher exposure. Furthermore, the Index shows that loss in monetary terms was also highest in D.G. Khan as a result of climate extreme events. This also raises its degree of exposure considerably as compared to Faisalabad and Mardan. Higher exposure of both, Faisalabad and D. G. Khan is also explained by the higher level of variability in precipitation and temperature that may reflect more intense impacts of climate change in these areas. Comparatively, however, Mardan has experienced more incidences of climate extreme events as compared to D. G. Khan and Faisalabad.

Similarly, D.G. Khan (0.412) is the most sensitive district to climate change impacts, followed by Faisalabad (0.382) and then Mardan (0.274). D.G. Khan has the higher percentage of people who do not have access to canal water for irrigating their agricultural lands. As compared to Faisalabad and Mardan, about 96% farmers in D. G. Khan lack canal water. This percentage is generally low in Mardan, with only 16% farmers without access to canal water, while the remaining 84% irrigate their crops through a canal. The type of housing structure also shapes the sensitivity of households to climate impacts. In D.G. Khan, about 50% households reside in mud or thatch houses, leading to their greater susceptibility to destruction during extreme events. Faisalabad ranks second in terms of sensitivity owing to a high percentage of people who do not have access to safe drinking

water and fewer people with diversified professional skills i.e. skills other than farming. Proper access to canal water lowers Mardan's sensitivity to climate change and related events.

In terms of adaptive capacity, Faisalabad scores (0.699) far better than the other two districts (0.504 for D.G. Khan and 0.467 for Mardan). Faisalabad's higher adaptive capacity is primarily due to more than 60% households with head of households having above secondary-level education. This remarkably improves their adaptive capacities. Additionally, Faisalabad also boasts better connectivity as more than 70% households have access to information and communication technology. The district also demonstrates higher saving patterns with more than 80% households having savings of some kind as compared to D. G. Khan and Mardan where approximately 60% households have savings. Mardan has the lowest adaptive capacity among the three districts. The two main features that shape this low adaptive capacity are the strikingly low level of awareness about government initiated plans for disaster risk management and low reliance on agriculture for income generating purposes. Figure 4 illustrates the scores of the three districts in terms of their exposure, sensitivity and adaptive capacity to climate change and related extreme events:

Figure 4: IPCC-LVI for Faisalabad, D.G. Khan and Mardan

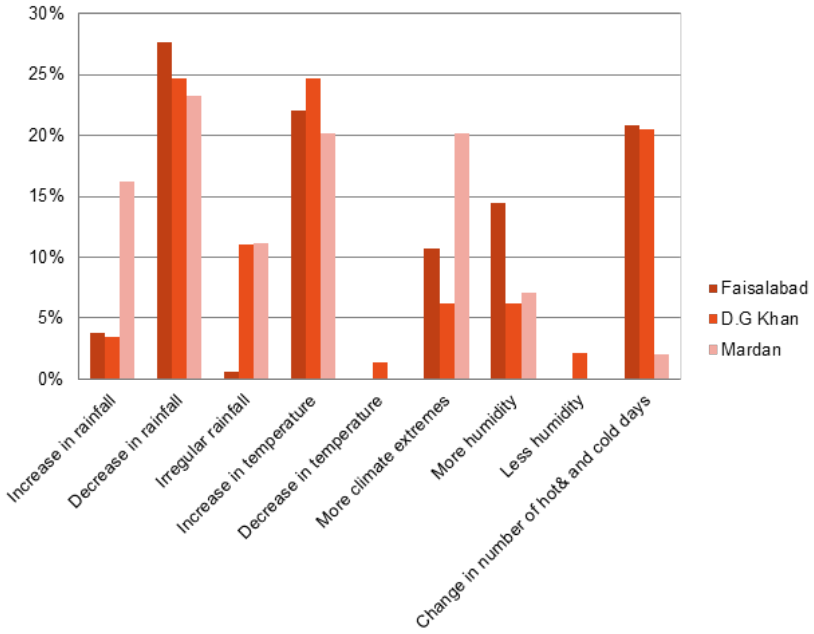


Source: Authors' own.

4.2. Farmers' vulnerability experiences

This study inquired about farmers' perceptions about climate change and weather variability that reflects their understanding of the changes that are taking place and the expected impacts these changes might have on their livelihoods. Figure 5 shows the common changes that farmers have observed in the climate of their respective locations. In Punjab districts (Faisalabad and D.G. Khan), a significant percentage of farmers (approximately 21%) perceived changes in the number of hot and cold days.

Figure 5: Changes in climate as observed by farmers



Source: Authors' own.

It was insightful to know that the most common source of climate information among the farmers varied in all three regions. In Faisalabad, the most common source was media through which 43% people obtained information related to climate change. In D.G. Khan, 40% people relied on their social networks for climate information, while in Mardan, 66% people perceived changes in the environment through their own personal experiences. Similarly, majority of the people in Faisalabad and D.G. Khan obtained extreme event information and warnings through social networks and the media; while in Mardan, the main source of climate extreme information was personal observations and experiences. This reflects that while households in all three districts are aware of changes in the climate, the quality and accuracy of such information may vary depending upon the source of information.

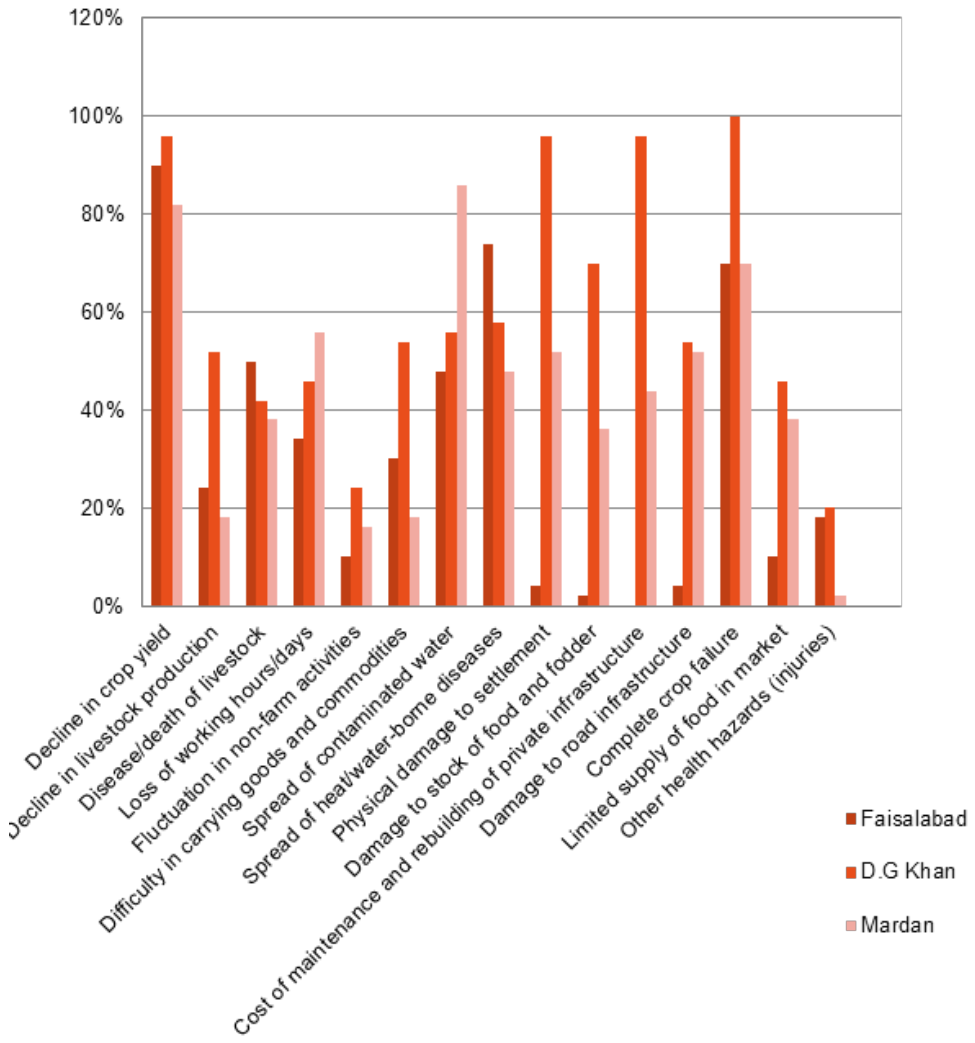
In Faisalabad, shortage of water due to in-frequent rains stood out as the most severe climate-related issue, which is also closely tied to intense heat waves over the past ten years. Resultantly, as many as 80% respondents reported a decline in crop productivity and in some cases complete crop failure (Figure 6). Spread of contaminated water was also cited as a major issue, and 44% farmers reported that they experienced disease or death of livestock, 53% experienced loss of working hours, and thereby, decline in income following a climate extreme event. During the last climate event, about 40% farmers incurred financial losses of less than PKR 50,000 (USD 500), and about 22% suffered from losses between PKR 50,000 to 100,000 (USD 500 to 1000). 16% farmers even bore monetary losses amounting PKR 400,000 (USD 4000) and above. These figures show that impacts of climate events not only inflict monetary losses in terms of decline or loss of income, but also cause heath issues for household members and their livestock.

In D.G. Khan, floods, including flash-floods and riverine floods, were ranked as extreme events with the most severe impacts on farmers' livelihoods. 96% people reported complete crop failure as the severest climate impact that makes them vulnerable. 60% experienced decline in crop productivity as a result of extreme heat, water shortage and climate-related disasters. Health hazards and injuries, and infrastructural damages were also common issues faced by 60% and more than 80% farmers, respectively, due to flood water. 77% farmers also lost their stock of food and fodder as a result of floods (Figure 6). The last flood in D.G. Khan inflicted losses of PKR 400,000 (USD 4000) and above to 36% of the respondents in the sample.

Torrential rains in Mardan have led to flash and riverine floods affecting the district severely. Hailstorms in the district have also led to heavy losses to the farmers. 83% farmers faced complete crop failure due to floods, and 63% farmers were severely affected due to disease or death of livestock (Figure 6). Rising temperatures were regarded as one of the important factors leading to livestock diseases. As a result of supply shortage and difficulty in access, 63% complained that food stocks in the village markets declined. Heavy rains also damaged the stock of food and fodder for about 67% of households. These statistics indicate the inter-linkages between climate extreme events and potential rise in food insecurity. 60% of the respondents incurred monetary losses under PKR 50,000 (USD 500), while 30% had to bear losses from PKR 50,0000 to PKR 100,000 (USD 500 to 1000).

Figure 6 demonstrates the various livelihood vulnerabilities experienced by farmers in the past ten years due to climate extremes. These also include physical and social vulnerabilities that households may have faced as well as infrastructural vulnerabilities that adversely affected their livelihoods.

Figure 6: Livelihood vulnerabilities experienced by farmers due to climate change



Source: Authors' own.

4.3. Adaptation strategies for farmers in semi-arid areas and potential of migration as a risk management strategy

With the rise of climate change risks, farmers have developed diverse measures to reduce their livelihood risks and vulnerabilities. In case of sudden extreme events, farmers use certain coping strategies to manage the losses and damage faced. While some responses are similar among all locations, their nature may vary for the type of shock experienced as per the geographic location, in addition to other factors (such as socio-economic status, education, and institutional support). For instance, as per the survey, borrowing money from friends and family is the most common strategy used in all three sites in the wake of any kind of disaster.

In D.G. Khan, 88% of respondents claimed being displaced from their settlements for some time as a result of a climate extreme event (mostly floods), reflecting their high susceptibility to such events. As an emergency coping mechanism, many farmers (26%) tend to sell their livestock for getting ready-cash to fulfil their immediate needs. 11.2% of farmers reported that in such hard times, they rely on government provided support in the shape of relief initiatives to sustain themselves. Furthermore, to compensate for the loss in agricultural production, farmers reported increasing their use of inputs such as fertilisers and pesticides (51%) and diversifying their crop production (28%). 11% also reported increasing the use of labour and technological input in efforts to increase production (Figure 7). In fact, it was observed that in about 4% households, women were more involved in labour activities after the massive floods of 2010.

6.1% farmers in the survey reported that they do not use any adaptation measure against adverse climate impacts and 50% shared that they do not see the need to adapt. They explained that even if they use any adaptive measures, they all go to waste when floods hit and wash away all their crops, damage their settlements and result in death of family members and livestock. Given the situation that climate impacts

continue to rise in frequency and intensity, only 28% farmers responded that they would consider shifting away from agriculture to another source of income. On investigating further, it was found that farmers in D.G. Khan believe that they have no means to shift to another livelihood source and agriculture is the only activity that they are familiar with. Nevertheless, those who would choose to switch to another livelihood reported they would work as daily wage labour.

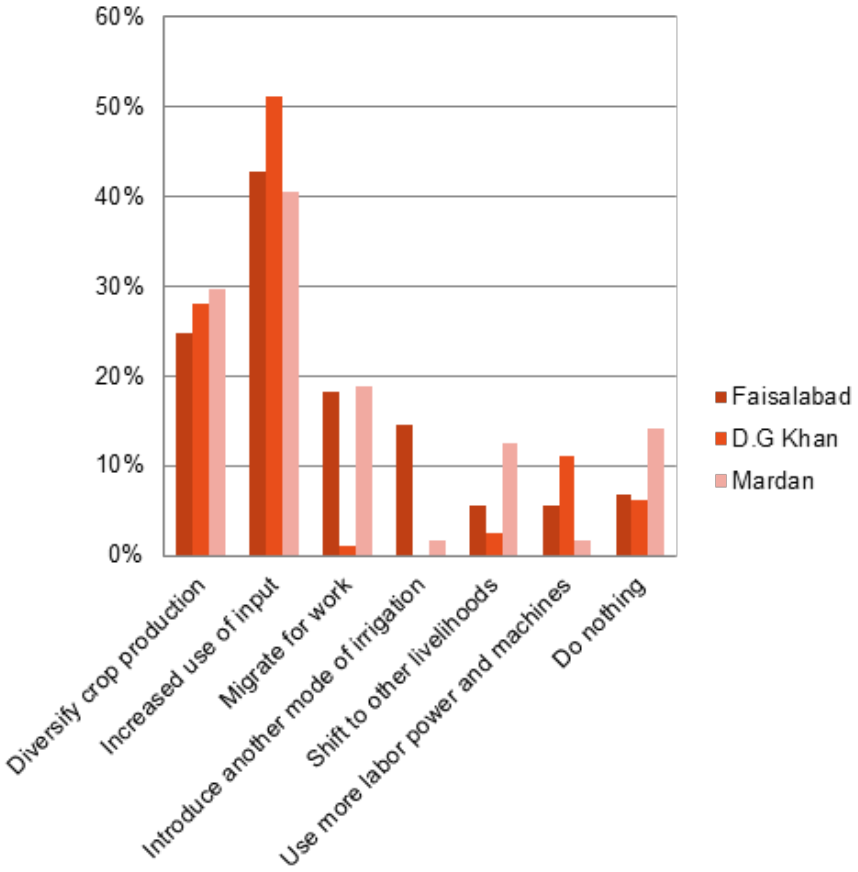
In Faisalabad, the most common response to cope with climate extremes (after borrowing money from family and friends) is selling livestock (16%) and other assets such as jewellery and motorbike etc. (10%). Many farmers complained that in such difficult times, they have to sell their livestock at cheaper rates in order to have enough to feed themselves. On the other hand, to manage the losses being incurred due to the slow onset climate changes - rising temperatures, erratic rainfall, declining soil fertility - farmers tend to intensify their use of inputs such as fertilisers and pesticides (42.7%). Diversifying crop production is the second most common measure, while 18% farmers reported that members of their households have migrated to other locations as a means of diversifying their income sources. 14% farmers reported introducing an alternative mode of irrigation to compensate for water shortage (Figure 7).

In contrast, 6.7% farmers communicated that they are not doing anything to adapt to climate change impacts for their agricultural livelihoods. 57% of farmers who did not take any adaptive measure reported that they do not have the required skills or knowledge about the kind of strategies to use, while 29% responded that they cannot afford to use adaptive measures as they are expensive (Figure 7). To the question whether farmers would prefer to stay involved in agriculture if climate-related events continue to become more frequent and intense or would they like to switch their income source, 48% expressed their interest in shifting to another livelihood source with high preferences for attaining a salaried job or starting their own small business (that includes establishing a small shop or providing transport services).

Similar to the other two districts, farmers in Mardan who have experienced climate extreme events cope with disastrous impacts by borrowing money from their friends and relatives (39.2%), selling livestock (17.6%) and other assets such as motorbike, jewellery and property (9.5%). 12.2% also reported reducing their consumption levels in response to the difficult situation. With regards to long-term adaptation strategies, increasing the use of inputs was the most common (40.6%), followed by diversification of crop production (29.7%), similar to the trend in other sites. 19% farmers also reported that as agriculture becomes less profitable due to climate change impacts, they migrate from the villages in search of economic opportunities elsewhere for diversifying their livelihoods, while 12.5% reported shifting to other sources of incomes while staying in the villages (Figure 7).

In comparison to the other locations, the percentage of farmers who do not make any efforts to adapt to climate change were highest in Mardan (14%). 69% of the farmers who do not opt for adaptive measures also responded that they do not find it useful to take up adaptation measures. Most of them were of the view that adaptation strategies are not effective when a disaster hits and if they invest in adaptation, then they have to bear greater losses. In response to the scenario if adverse climate impacts continue to increase, 64% farmers reported that they would prefer to shift away from agriculture to other means of earning incomes. Most farmers voiced their preference of investing in their own small start-up if they have to move away from agriculture.

Figure 7: Adaptive measures adopted by farmers



Source: Authors' own.

Government provided facilities were reported more in districts of Punjab, whereas in Mardan, people reported that there were no government initiated facilities available for climate adaptation. In Faisalabad, 35% people reported that they had access to government provided early warning systems and 23% reported that they received trainings on how to adapt to changing climatic scenario. In D.G. Khan, 37% farmers stated that they had received some subsidy, credit or insurance from the government owing to the district's repeated exposure to floods. 35% also reported that the government has provided them with new crop varieties that are more resistant to climate change impacts. Table 6 provides an overview of the government facilities provided in the study sites based on KIIs with the Agriculture Extension Departments of the respective districts.

Table 6: Salient features of agricultural support provided by District Office of Agricultural Extension

Faisalabad	D.G. Khan	Mardan
Training of farmers on cropping practices and usage of pesticides (after lab testing)	Provision of new seed varieties to major farmers (large landholders are willing to take risk. If new varieties give good results, small farmers are also encouraged to try new seeds)	Awareness raising through publication of agricultural newsletter (Zarat Nama), electronic messages, trainings, seminars, and field work
Provision of new seed varieties to 191 villages in the district	Soil sampling of land to advise what to grow due to changing soil quality	Provision of door-to-door consultancies to farmers regarding crop productivity, fertilisers, price/marketing schemes
Provision of farm implements/ agricultural tools (4-5 per UC)	Implementation of Punjab Kisaan Package (interest-free loan scheme)	Provision of new wheat seeds at subsidised rates

Faisalabad	D.G. Khan	Mardan
Provision of 4000 vegetable toolkits for kitchen gardening with a subsidy of PKR 50 per packet	Registration of farmers for E-credit that provides small farmers (with up to 5 acres of land) with loan of up to PKR 25,000 per acre.	Provision of early warning systems (However, the agriculture officer reported a lack of capacity to provide trainings on flood adaptation mechanisms).

Source: Authors' own based on KIIs.

To summarise, it has been found that in semi-arid regions of Pakistan, the most common methods of adapting agricultural livelihoods to climate impacts are intensifying the use of agricultural inputs such as pesticides and fertilisers, and diversifying crop varieties. In addition, migration is a common adaptation response to climate impacts, yet its incidence varies for different locations. Climate extremes over time generally tend to weaken income generation from agriculture, in response to which many households decide to send a family member to the city to seek economic opportunities. In contrast, high costs of adaptation and lack of information on how best to adapt to certain climate impacts came out as the main impediments for those farmers who do not take any adaptive measures for their livelihoods.

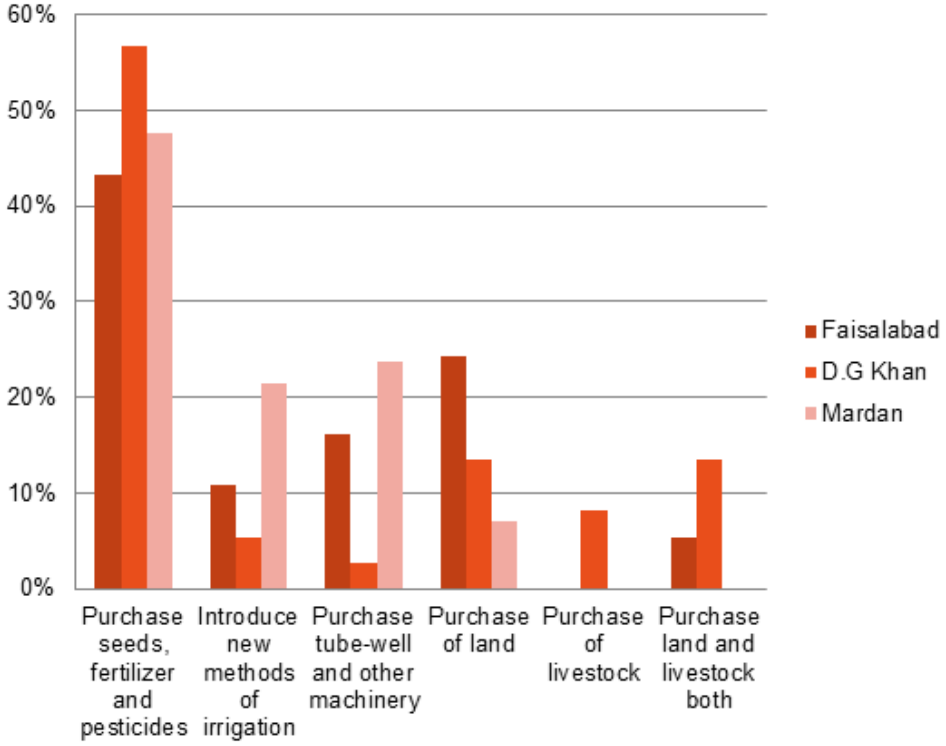
4.3.1. Migration as an adaptation strategy

About 20% of respondent households reported a family member migrating to other areas as a means to diversify income generating activities. Among these, the highest percentage was from Faisalabad, followed by Mardan. In D.G. Khan, migration as an adaptation strategy directly in response to climate change impacts was currently not as common as in the other two locations. However, displacement as a result of a disaster was a commonly experienced phenomenon. Since climate extremes are becoming more frequent and intense, all the farmers responded that they would prefer to migrate away from their current locations as their livelihoods will be threatened. The general preference was moving to a city to escape the vulnerabilities brought upon them by climate events. For farmers in Faisalabad, their social networks, distance between the city and the current location (more preference for nearer cities), economic affordability of cities (more preference for smaller cities that are generally more affordable), and availability of economic opportunities, are some of the factors that play an important role in determining the destination. Farmers in D.G. Khan and Mardan gave more weightage to moving to cities where they already have a strong social network.

Migration is costly. In Faisalabad, majority of people responded that to cover the costs of migration, they would either use their savings and/or sell some of their assets (including land and property). In D.G. Khan and Mardan, people were generally of the view that if they have to migrate due to persistent climate extremes, they would rely on loans to cover the costs.

In general, majority of the farmers at all three study sites quoted that they would prefer to invest the remittances they send back home in agriculture. In all three sites, the main area of investment was agricultural inputs like new seed varieties, pesticides and fertilisers. Other popular agricultural investments included purchase of land (in Faisalabad and D.G. Khan), purchase of both land and livestock (in D.G. Khan) and installing a tube-well or purchasing a tractor (in Mardan). Figure 8 shows the choice of agricultural investments from remittances in the three study sites:

Figure 8: Aspirations of investing remittances in agriculture



Source: Authors' own.

5. Discussion

5.1. Climate change, extreme events and agricultural vulnerability over time

As defined in the methodology section, livelihood vulnerability to climate change is not merely a function of exposure to climate impacts. It is defined by a number of pre-existing factors - poverty levels, education, awareness, and livelihood diversification - all of which shape the sensitivity and adaptive capacity of a household. This research reflects that each study site has varying associated factors that determine the level of livelihood vulnerability experienced by farmers. A striking finding is that rural livelihood vulnerability can be caused by a lack of adaptive capacity, despite its exposure and sensitivity to climate change impacts being lower. This is reflected by Mardan's vulnerability score that is higher than Faisalabad district despite its exposure and sensitivity being lower than both D.G. Khan and Faisalabad. This implies that high exposure and sensitivity to climate risks can be offset by a stronger adaptive capacity, rendering the population better positioned to counterweigh the negative effects.

Compared to the past, farmers reported experiencing and observing clear changes in the climate of their respective areas. A common observation in all three locations was that temperatures are rising and rainfalls are declining. The rise in temperatures is in line with the climate projections for semi-arid regions (IPCC, 2014) and declining precipitation trends (Salma et al. 2012), however, the latter has not been empirically established. This study plotted graphs for past and projected temperature and precipitation over time for the three study sites. These plots were generated based on data obtained from KNMI Climate Explorer with RCP8.5 (business as usual scenarios). Figures 9 (a - f) show temperature and precipitation data plotted over time for the three study sites:

Figure 9a: Temperature over time in Faisalabad

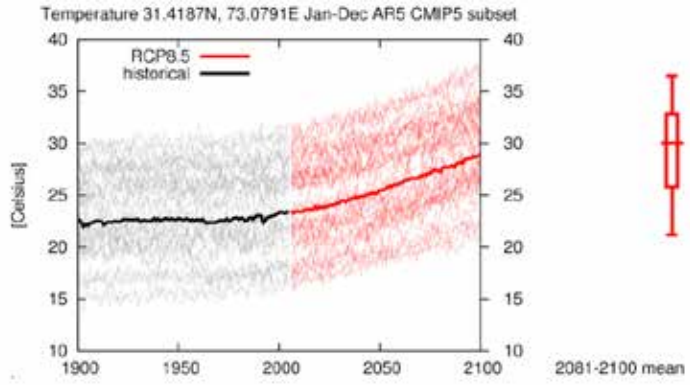


Figure 9b: Precipitation over time in Faisalabad

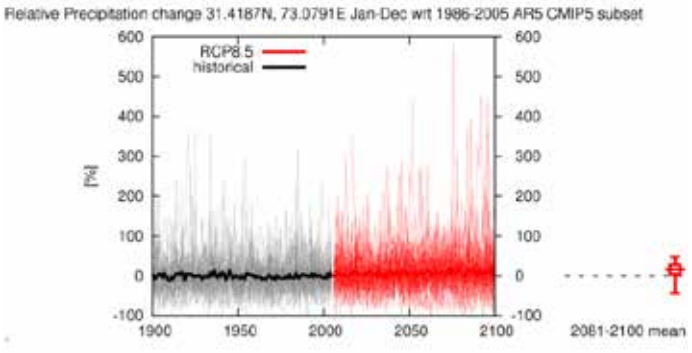


Figure 9c: Temperature over time in D.G. Khan

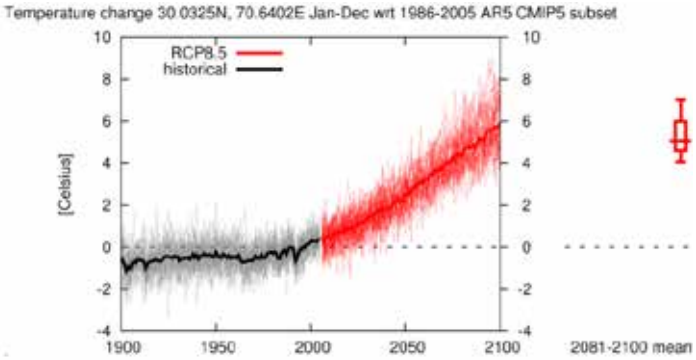


Figure 9d: Precipitation over time in D.G. Khan

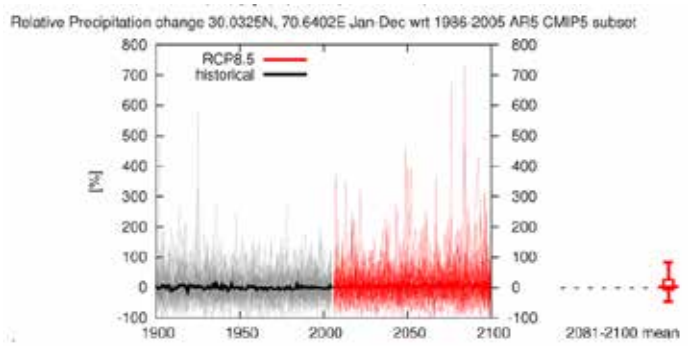


Figure 9e: Temperature over time in Mardan

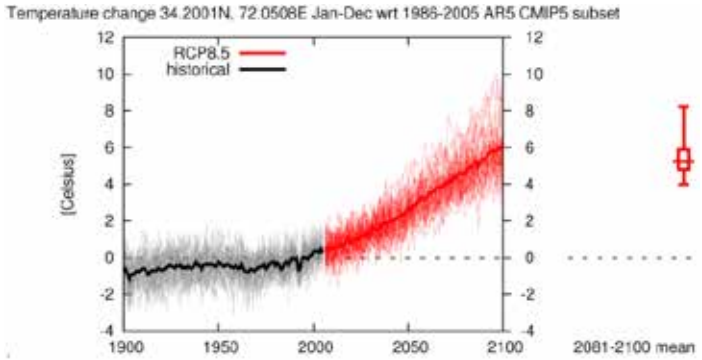
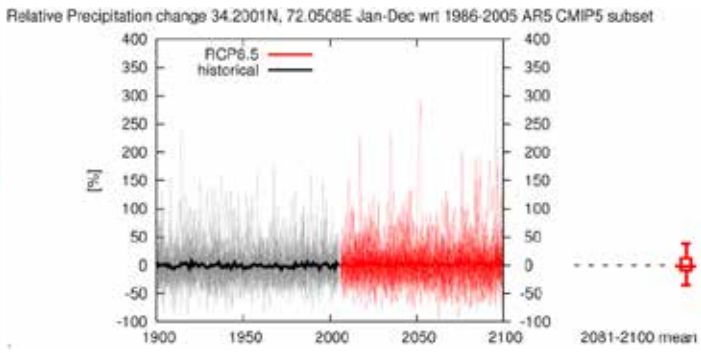


Figure 9f: Precipitation over time in Mardan



Source: KNMI Climate Explorer with RCP 8.5.

Recurring floods and prolonged droughts not only depreciate peoples' livelihood earning capabilities, they also hamper the government's development efforts and poverty reduction initiatives, thus, pushing vulnerable communities into perpetual states of deprivation. In this context, climate extremes not only negatively affect livelihoods in the short-term (in the shape of crop destruction, loss of lives and productive assets, and spread of diseases), they also lead to a cascade of long-term impacts such as rise in food prices and loss in agricultural productivity leading to food insecurity over the years (Wilkinson and Peters, 2015).

Thus, it is important to identify the factors that can support farmers in reducing their vulnerability to climate change impacts. This research highlights key aspects that contribute to high vulnerability in different semi-arid sites based on households' exposure and sensitivity to climate change impacts and their adaptive capacity to respond to them. For instance, results indicate that sensitivity of agricultural livelihoods is highly dependent upon the source of water for irrigation, making those who do not have reliable irrigation sources more vulnerable. This is particularly important when the agricultural dependency on water is high but infrastructure is either poor or inaccessible to marginalised farmers (Panthi et al. 2015).

According to the findings, the most pronounced impact of climate disasters that defines the exposure of livelihoods is complete crop failure. As observed in the study sites, climate extreme events such as hydrological disasters (rain storm, floods and drought-like conditions) and heat waves have caused instability in agriculture-based livelihoods through complete crop failure. Floods and torrential rains wash away the standing crop, while intense heat impacts the rate of evapotranspiration and soil moisture, often resulting in decline in crop production (Rasul et al. 2012). This is particularly alarming as the increasing magnitude and intensity of such events erode the livelihoods of small landholders, depleting their agricultural assets such as crops, seeds, and soil fertility and amplifying their vulnerabilities. In addition, as small farmers mainly fulfil their household food requirements from farms, loss of crops may worsen food insecurity (Wilkinson and Peters, 2015). On a macro scale, increasing incidents of crop failures resulting from climate extremes can have detrimental impacts on national food and fibre production and affect the whole agricultural value chain and may even result in setbacks for the industrial sector, considering that Pakistan's industrial sector is largely agro-based (FAO, 2015).

In terms of sensitivity of livelihoods to climate change impacts, human capital plays a fundamental role, especially if taken in terms of health. Health issues decrease the working capacities of labour and result in reduced number of working days (Hahn et al. 2009). Respondents (males and females) in all three sites were dissatisfied with the health facilities available at the village level. They reported that the dispensaries and/or the basic health units available in the villages were not equipped with sufficient medicines and the availability of doctors in the facilities was also irregular, which often forced them to travel long distances to the next towns or district capital to consult a doctor or purchase medicines. While this issue was raised by both men and women, the latter seemed to be more concerned about the deficit in health provisions in their areas on account of their children and family members suffering from diseases that can be prevented if health facilities are adequately available.

Sensitivity to climate vulnerability is also defined by the skill diversity of the population. This study assumed that households that possess skills and capacities in addition to farming are less vulnerable to climate change impacts as they can easily use these additional skills to be absorbed in another profession in case climate change renders farming more and more susceptible (Hahn et al. 2009).This is also reflected in the study wherein many households in all three sites were concerned about not having any skill other than farming in case they decide to migrate to the cities.

As mentioned, higher adaptive capacity of a population may balance out the high exposure and sensitivity to climate change. Factors that contribute to higher adaptive capacity included education of household head, access to information and communication technologies and strong social networks. Higher education level reflects higher ability to receive, interpret and comprehend risks and hazards, thus, it positively impacts adaptive capacity (Byrne, 2014). As the household head is responsible for making the final household level decisions, his/her education level determines the capacity of the household to anticipate risks and respond to them through changes in livelihood strategies (Ibid.).

At the household level, access to information is important in determining a household's ability to anticipate any changes that may need to be introduced in response to upcoming risks (Panthi et al. 2015). In the study sample, the population of Faisalabad had more access to information and communication technologies than D.G. Khan and Mardan, reflecting its higher ability to obtain information quicker in case of any climatic or non-climatic risks. Similarly, social capital is an important pillar in defining adaptive capacity of a household (Salik et al. 2015; Qaisrani, 2015). Kinship, relationships and strong community networks can act as a support system at times of distress and can also reflect stronger flow of information and news. People with strong social networks have been observed to survive calamities and rebuild their lives with the help social capital (family ties, relatives, and community networks) faster than those whose social ties are weak (Adger et al. 2003). D.G. Khan, with the lowest score in the social network indicator, has lower adaptive capacity as compared to Faisalabad. This indicates that community members are less integrated in terms of reliance on each other for support during times of need.

It was assumed that higher rates of female labour force participation would reflect less vulnerability (Muthoni and Wangui, 2013). However, the impacts on vulnerability are structured by the type of labour force activity that women are involved in. For instance, by comparing the cases of Faisalabad and D.G. Khan, it can be concluded that higher labour force participation of women in agricultural activities in D.G. Khan actually enhances the overall vulnerability of the community due to higher dependence on natural resources, whereas involvement in activities that are not too natural resource-intensive reduces their vulnerability. Women in D.G. Khan were generally more involved in livestock management, crop sowing, weeding and harvesting, water management, collecting wood and biofuel. In Faisalabad, women were more involved in services sector and in education and health sectors or serving as domestic helpers in private homes.

While labour force participation is higher, women generally are less involved in decision-making processes and have limited access to information and facilities (Samee et al. 2015). Education levels of women in D.G. Khan are also lower than those in the other two districts. In contrast, though fewer women were economically active in Faisalabad, they were more educated and involved in government or private sector jobs. This reflects weaker impact of climate change on their livelihood activities, thus, their lesser vulnerability. In Mardan, despite higher education levels of women as compared to D. G. Khan, women did not partake in any income-generating activities given the culture and norms of the village.

5.2. Adapting agriculture to climate change and climate extremes

In light of the above vulnerability scenario, identification of the most suitable adaptation measures is pivotal to determine the pathways to resilient economic development in semi-arid regions. This research finds that most farmers are already adjusting their livelihoods to climate impacts. These adjustments include short-term, distress responses known as coping strategies as well as long-term modifications in their livelihood activities that can reduce their risk to climate impacts in the future.

In the wake of a climate shock, farmers tend to adopt distress measures such as borrowing from friends and family, selling livestock and other assets or reducing household consumption. These measures are generally meant to buffer for the immediate adverse impacts (Smith et al. 2000). Such responses, in fact, reduce farmers' future capacity to invest and render their livelihoods more insecure (Boansi et al. 2017). In this study, the most popular modes of climate adaptation are increasing use of farm inputs such as pesticides and fertilisers and using more improved (heat-resistant or drought tolerant) crop varieties, in addition to various site-specific measures such as shifting to other livelihoods, migrating for work, and introducing other modes of irrigation. As numerous climate change impacts manifest themselves on populations, they often adopt multiple strategies to offset future risk. For example, in D.G. Khan, farmers are exposed to recurring floods as well as intense heat waves. In such a scenario, opting one strategy may not ensure security of livelihoods in a sustainable manner. Using a mix of heat and flood tolerant crop varieties and getting crop insurance may benefit the farmers more in times of oscillating weather and climate conditions.

Institutional support is also pivotal in shaping farmers' adaptive capacity. This can be drawn from the case of Mardan, where despite low exposure and low sensitivity to climate change and extreme events, underlying low levels of adaptive capacity has affected its livelihood vulnerability adversely. A major factor behind low adaptive capacity is the lack of government support to the community. Although the District Office of Agriculture in Mardan claims to provide agricultural extension services in the district, yet the community surveyed was not receiving any government support to help them buffer against climate manifestations. In contrast, communities in Faisalabad and D.G. Khan were receiving government support in the shape of training and awareness sessions, early warnings, provision of new crop varieties, access to insurance, subsidies and credit. The district agricultural department of D.G. Khan was appreciated for the soil sampling they conducted for agricultural land and held awareness raising sessions on what to grow on the soil with respect to the changing soil quality. The district administration was also said to be active in disseminating early warnings in case of riverine floods through the police and announcements in mosques. Communities were cognizant of the positive impacts of these services provided to them, but demanded enhanced government support in terms of subsidy on purchase of inputs. They admitted receiving information about new and improved seeds to withstand changing climatic conditions, but complained that those new seeds were not affordable for the small farmers. In Mardan, farmers expressed their need of loan and credit to support agricultural activities.

Besides the farmers who are taking adaptation measures, there were also some who were not taking any action to adapt to climate change. It was observed that lack of employing an adaptive strategy stems from two main reasons:

1) Lack of financial resources to introduce a change in practices.
2) Lack of awareness of the effectiveness of an adaptation strategy.

Generally, farmers who did not adapt, especially those in D.G. Khan and Faisalabad, perceived that it is unfruitful to invest in agricultural adaptation as climate extremes erode all their efforts. This implies that these farmers may not have enough information regarding the usefulness of adaptation strategies that can withstand extreme events. Abid et al. (2015) also came to the conclusion that usually farmers are unaware of the type of adaptation needed and therefore, believe that adaptation will be ineffective in their case. While some farmers admitted receiving government provided training as mentioned earlier, this finding indicates that some proportion of farmers are not receiving relevant trainings in the context of climate disasters. This highlights the need of the local and district government emphasising more on trainings and awareness sessions about adaptation practices and ensuring that these trainings are imparted to all farmers, especially targeting areas that are hard-hit by climate extremes. Affordability of applying adaptation strategies is another facet that constrains farmers from using the most effective methods. High input prices, high prices of new weather resistant crop varieties, low penetration of credit facilities and widespread poverty in rural areas also restricts farmers' capacities to invest in adaptation practices.

Livelihood diversification and migration

Livelihood diversification is considered an important strategy among rural households as a means to secure their livelihoods against unforeseen external impacts (Schraven and Rademacher-Schulz, 2015; Khatiwada et al. 2017). As discussed, rural livelihoods in semi-arid Pakistan are largely agricultural which makes them increasingly vulnerable to the rising threats of climate change. Apart from the sudden climate-related extreme events, the creeping risks of water scarcity, soil seepage, soil erosion and salinity tend to render agricultural activities less and less favourable. As such, these impacts take a toll on agricultural livelihoods with farmers preferring to rely on more than one source of income to spread their risk.

This study found that farmers prefer to opt for off-farm activities as a means of diversification. Their preferences vary according to the site, including strategies such as attaining a salaried job, doing non-farm wage labour or starting a small business. However, all respondents mentioned that the prospects of diversifying livelihoods were low in their villages. As previously drawn from Salik et al. (2017), rural areas in the study districts are characterised with limited economic opportunities and extremely low wage rates as compared to cities. Owing to these factors and the prospects of higher income generating opportunities in cities, many villagers prefer to send at least one family member to earn a living in the city. Migration - as a means of livelihood diversification - buffers household income against unforeseen shocks to the rural economy such as climate-related impacts. Through the flow of remittances, information, skills, and expanded social networks, migrant households tend to have higher levels of adaptive, absorptive and anticipatory capacities.[6]

In the current study, about 20% households reported using migration as a strategy to offset the loss of income

6 See Salik et al. (2017) for more insight on how these capacities are defined in the context of Pakistan.

as a result of a climate crisis. This differs from the usual phenomenon of displacement when families are uprooted from their homes to settle in other locations as a result of a disaster (Ferris, 2014). Migration of one or more family members reflects a planned response to a shock in income. However, it was also observed that migration is often considered as a last resort when other strategies fail. For agriculture-based households, when natural resources are pressurised due to factors such as climate change, migration often becomes the last logical option when alternative economic opportunities are limited (Penning-Rowsell et al. 2013; Arseneault et al. 2015). In their decision of where to migrate, social networks, economic opportunities and affordability of the destination area play an important role. This is underscored by the statements from migrants themselves who moved to the district capital owing to its closeness to their villages due to the presence of a strong social network there and because it provides more economic prospects than those available in the villages. The district capitals are also less expensive than the big urban hubs of Pakistan such as Karachi, Lahore, and Rawalpindi.

Salik et al. (2017) found that migration decisions are the result of a complex interplay of economic push and pull factors, food insecurity, civic amenities and environmental reasons. It was proved that planned migration as a result of the interaction of such factors improves households' livelihood resilience. It was also found that the difference in level of resilience among migrants and non-migrants also depends on how the remittances are spent. In the current study, remittances among the poorer households were largely used for consumption expenditures such as food, health, and daily use items. This reduces households' risk to food insecurity and vulnerability, and generates savings. It also reduces poverty. However, it is not sufficient to bring them out of poverty as the migrants from poorer households tend to have lesser human and social capital (education, skills, and social networks) as compared to the more well-off migrants. Generally, the more well-off and large landholders tend to invest remittances in productive purposes such as installing advanced agricultural practices, improving farm inputs and setting up agro-businesses. This reflects that migration outcomes are unequal. Nevertheless, resilience is enhanced for all income groups as a result of migration.

Farmers' attachment to their land is not only due to economic reasons, but also cultural and emotional as they perceive that it defines their identity (Fay, 2015). While respondents voiced their cultural, social and ancestral ties with their land, and claimed their unwillingness to happily leave, they stated that if climate events continue to threaten their rural agricultural livelihoods, they would have no choice but to start sending their family members away to earn a living. However, the kinship ties to their land are deemed important even if people migrate. Land ownership is considered a link for the migrants with their village and relatives. In that aspect, a major proportion of respondents expressed that they would prefer to invest remittances in agriculture which reflects their desire to continue being connected to agriculture instead of abandoning it completely.

Nevertheless, it cannot be claimed in absolute terms that migration enhances resilience for everyone, and in any case, migration is a societal process that has its own trade-offs (Schade et al. 2015). For instance, as found in Salik et al. (2017), at the household level, migration improves livelihood resilience. However, owing to the gendered nature of migration, with male out-migration, women of the household are burdened with additional responsibilities, thereby, resulting in their lower resilience at the individual level. Similarly, while migration improves the resilience of left-behind rural households, the same cannot be claimed for urban host areas where constraints to already insufficient resources for a rising population may add to a decrease in the well-being of urban residents. Despite these trade-offs, the findings of this study are useful to redirect the national policy discourse from considering migration solely as a challenge to infrastructure, social cohesion and security at the destination areas, and highlight the resilience- enhancing potential of migration when used as an adaptation strategy.

6. Conclusion and policy recommendations

Using the IPCC Livelihood Vulnerability Framework, this study relies on an index-based approach to understand the important causal factors behind exposure, sensitivity and adaptive capacity of various rural semi-arid regions in Pakistan that explain farmers' livelihood vulnerability to climate change. Farmers' livelihoods are at stake as a result of rising temperatures, irregular rainfalls and increasing frequency of climate extremes which often translate into monetary losses, crop failure and physical harm to humans. Furthermore, deteriorating or lack of irrigation infrastructure and low levels of human capital of farmers such as health and skill diversity lead to high sensitivity of agricultural livelihoods. Similarly, higher education of the household head, access to information sources and strength of social networks determine the adaptive capacity of farming households. According to this study's IPCC-LVI ranking-based results, D. G. Khan appears as the most vulnerable district, Mardan as the second most vulnerable, while Faisalabad as the least vulnerable among the three districts in Pakistan. An important finding is that (a lack of) adaptive capacity plays quite an important role in shaping households' livelihood vulnerability on any given degree of exposure and sensitivity.

As agricultural livelihoods become increasingly vulnerable to climate change impacts and risks, farmers resort to various strategies to offset the ill-impacts on their earnings. Besides, distress coping strategies adopted to respond to climate extremes, farmers also employ certain long-term adaptive measures to compensate for their depreciating livelihoods. In addition to increasing farm inputs and diversifying crop varieties, rural households also consider diversifying their livelihood through temporary or permanent migration of the whole or part of the family. This highlights the importance of migration as an adaptation strategy to climate change employed by farming families in particular. In this regard, many seek to migrate away from the villages towards the urban centres of Pakistan in search of alternative, non-farm opportunities. However, the relation between climate adaptation and migration is not so straightforward and may have many indirect and direct linkages.

Against this background, this study argues that the relationship between climate and migration should not be considered as linear since it cannot be explained in a simplistic manner. Drawing on the results of this study and Salik et al. (2017), it can be concluded that it is complicated to separate climate change impacts from other socio-economic factors that drive migration. Yet, through its impacts on rural livelihoods, especially agricultural ones, climate change is increasingly driving people to diversify and improve their livelihoods and search for other opportunities elsewhere.

Interestingly, the relation between migration and resilience is also complex, based on differentiated migration outcomes. However, generally, it has been found that the phenomenon of migration (the role of remittances, access and transfer of information, knowledge and skills, diffusion of new ideas and expansion of social networks) leads to enhanced resilience of migrant households.

Furthermore, this study concludes that migration should not be considered as a phenomenon to be controlled and as a problem to be solved, rather, it should be promoted as part of the solution to the many socio-economic threats faced by the rural population, including climate change. Migrants and their interactions with the home regions (villages) should be understood in the perspective of agents of change for enhancing the resilience of rural households and adequate measures should be taken to ensure their integration in the urban economy as contributors to economic development rather than as a burden on urban resources.

Rural economies need people-centric development to build climate resilience, i.e. growth that diminishes poverty and reduces deprivation. Livelihood vulnerability of farmers can be offset by reducing climate sensitivity and enhancing their adaptive capacity to climate change impacts. In light of this study, it is clear that livelihood resilience of rural agricultural households not only needs strengthening of the agriculture sector, but also facilitation in diversifying livelihood activities, particularly through planned migration. Some of the policy measures drawn from the findings of this study and Salik et al. (2017) are given below:

6.1. Improve access to water

An important cause of sensitivity to climate change in rural semi-arid areas of Pakistan is the variability and uncertainty of irrigation water supply for agricultural purposes. This variability might also be caused due to weak and deteriorating irrigation infrastructure. The disruption in water supply can be reduced by adopting innovative irrigation and water-saving/harvesting techniques, and a more effective role of the irrigation

department with enhanced interactions with farmers. Furthermore, farmers' ability to cope, respond to and recover from water-stress conditions need to be enhanced by developing vulnerability and adaptation plans at the district level under different scenarios, considering the impacts of climate change. The irrigation departments should not only provide forecasting on water availability, but also spread awareness about response to extreme events, facilitate access to information, estimate vulnerability and hazards trends, and introduce coping and adaptive mechanisms that farmers can adopt.

6.2. Raise awareness and enhance participatory capacity building

As climate related (extreme) events become more evident and severe, it is increasingly essential to rely on rural youth (including men and women) for coping with these risks, and adapting their livelihoods to climate change. This can be done by improving their capacity to understand vulnerable aspects of rural livelihoods, ability to effectively use new scientific information as well as local knowledge to anticipate and combat climate change risks and stressors such as floods, droughts, and heat waves. Similarly, rural labour also needs to have better and updated skills through trainings so that they are able to choose alternative (non-farm) opportunities which are less or not vulnerable to climate change. The role of district level Technical Education and Vocational Training Authorities (TEVTA) needs to be enhanced to do this. Doing so will reduce households' sensitivity to climate vulnerable livelihoods and allow them to diversify their sources of income. In this regard, agro-based small industries could be established in the proximity of rural areas to provide employment to the labour from adjoining villages. This could be initiated by PPPs between the provincial and district government and the private sector.

6.3. Encourage and support women's role in non-farm activities

Due to women's active involvement in agricultural activities, especially in D.G. Khan, their vulnerability to climate change is high. To encourage their participation in non-farm activities, local governments must create opportunities for them to access well-paid work in villages, such as supporting women-owned cottage industries by providing them trainings and access to credit and markets. PPPs and initiatives by development partners could establish skill development centres for women imparting trainings for stitching, embroidery, and food processing. These centres could be linked to urban markets through a fair-trade model.

Women should also be formally integrated in the value chains and efforts must be undertaken to reduce the wage gap between men and women. In addition, provincial and local governments should also provide infrastructure – including water, fuel (for household consumption) and electricity – to lighten the workload that rural women shoulder. This would not only reduce their sensitivity (as the activity of collecting water and wood is more climate sensitive), but also reduce their responsibilities as males out-migrate.

6.4. Extend, improve and subsidise agricultural extension services to farmers

Decline in crop productivity or loss of harvest is another facet that contributes to high livelihood vulnerability to climate change through an impact on exposure. In such a scenario, the impact of climate change on agricultural productivity can be reduced when potential solutions to prevent harm are available and affordable to farmers. For instance, this study found that climate-resilient seed varieties currently available to small farmers are quite expensive, especially for small farmers. In this regard, agricultural extension services need to provide subsidised crop varieties for farmers at affordable prices, control the spread of pests and diseases and ensure proper storage of farm outputs. Furthermore, agricultural extension services need to broaden their reach, especially in KP, where people are still not receiving government services, and are thus, unaware of the many positive, livelihood enhancing schemes offered by the provincial government.

6.5. Develop and integrate policies to facilitate planned migration

Currently, the potential of migration as a resilience-enhancing adaptation strategy is not recognised in development plans. Policies facilitating planned migration could support improved climate adaptation for migrant families, and mitigate their risk of displacement. Since migration is an important response/adaptation strategy, the national and sub-national governments should mainstream migration and climate change adaptation into National Adaptation Plans (NAPs) and sub-national integrated development plans (Local Adaptation Plans of Action – LAPAs). This also requires coordination among various national and sub-national departments dealing with health, education, agriculture, industry, and employment. Furthermore, for the migrants to contribute positively to national economic development and to the resilience of their families in the villages, it is important to equip them with (urban) demand-based skills through vocational training and technical education. This would help in better integration of village migrants to integrate in the urban economy.

6.6. Improve management of migration flows and data

The findings of this research project call for better management of the migration process, especially with regards to internal migration. Climate risks can be reduced by opting for migration as an adaptive strategy in terms of livelihood diversification. However, unplanned migration in itself may lead to various development concerns such as pressure on urban resources, urban poverty, and growth of slum settlements. Proper management of internal migration can only take place if the country collects updated data on peoples' movement and settlement processes. Existing macro-level studies rely on the National Population Census of 1998, which is too out-dated to inform proper decision-making regarding migration and settlement processes. Furthermore, the current Census fails to capture the required statistics on understanding migration patterns.

In order to track migration flows, a comprehensive registration system across administrative boundaries should be devised by the Ministry of Planning, Development and Reform in tandem with the Ministry of Labour and Manpower and the respective line ministries. This could provide deep insight into the actual migratory flows, bringing migration discussion to the forefront of policy discourse and helping in better management of peoples' mobility in Pakistan, including their employment, accommodation, and provision of civic amenities. Improved management of migration will facilitate those who want to relocate to cities, and may help them in sending higher remittances back to their villages that would reduce their livelihood vulnerability.

6.7. Enhance Public Private Partnerships (PPPs)

Through support programmes, PPPs can boost the rural economy by helping rural migrant families channel their remittances into productive uses, such as developing small-to-medium businesses. For example, private banks could partner with the local government to introduce subsidised loan schemes for village households to establish start-ups. Doing so could enable migrants to invest remittances in productive ways, such as setting up small enterprises for agriculture value addition, or the storage and packaging of agricultural products.

6.8. Implement labour laws and minimum wage rates

In addition, implementation of labour laws in the urban centres for migrants and operationalisation of minimum wage rates could ensure that labour migrants are not being exploited in urban areas and their rights are protected, thus, enabling them to send more remittances back to their households. Higher remittances would translate into more resilience of rural household members.

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Appendix 1: IPCC-LVI scores for each study site

Indicators and subcomponents	Explanation	Faisalabad	D.G Khan	Mardan
Exposure				
Climate extremes/disaster	Average number of frequent climate extreme events in the last 10 years (based on survey)	0.129	0.142	0.172
Temperature variability	Monthly variability in temperature	0.232	0.248	0.158
Hot months	Number of extreme hot months with temperature above 30°C	0.519	0.607	0.463
Precipitation variability	Monthly variability in total precipitation	0.209	0.220	0.171
Extreme dry months	Number of extreme dry months explained as the month during spring season having precipitation < 5mm and in summer precipitation = 0 mm	0.667	0.722	0.315
Monetary loss	Average monetary loss incurred due to last extreme event	0.055	0.111	0.012
Crop failure	Percentage of households facing complete crop failure due to climate extreme	0.700	1.000	0.700
Physical damage to human body	Percentage of household with an injury or death as a result of natural disaster (Used to assess the physical impact of any disaster on human body)	0.180	0.200	0.020
	Average	0.336	0.406	0.251
Sensitivity				
Source of irrigation	Percentage of households that do not have access to canal water	0.600	0.960	0.160
Access to water	Percentage of households not having access to good quality drinking water	0.360	0.020	0.000
Physical disability	Prevalence of any permanent disability in the household	0.100	0.100	0.120
Cost on health issues	Average health-related cost per month for the household	0.119	0.085	0.137
Professional skills	Percentage of households not having any skill other than farming	0.700	0.420	0.440
Type of house	Percentage of households having house made of temporary material	0.020	0.500	0.320
Average crop diversity index (range= 0-1)	The inverse of (the number of crops grown by the households +1) e.g.: a household that grows sugar cane, rice, wheat and maize will have crop diversity index =1/(4+1)= 0.20	0.778	0.798	0.738
	Average	0.382	0.412	0.274

Indicators and subcomponents	Explanation	Faisalabad	D.G Khan	Mardan
Adaptive Capacity				
Dependency ratio	Ratio of the population 0-14 and 65 and above year of age over the population between 15 to 64 years of age	0.530	-0.154	0.333
Education	Percentage of household heads who have secondary and above level of education	0.660	0.160	0.180
Income diversification	Percentage of households who have more than one source of income	0.640	0.800	0.820
Access to media/ information	Percentage of households having access to phone, Internet and TV	0.713	0.353	0.433
Social networking	Percentage of households who are actively involved in: local politics, social relief work, local level associations and have a strong friendship circle	0.730	0.595	0.680
Savings	Percentage of households who have savings of any kind	0.840	0.600	0.680
Government initiated disaster management plans	Percentage of households aware about or have access to government initiated climate disaster management plans	0.52	0.52	0
Use of remittances for investment	Percentage of households willing to invest their remittances on agriculture	0.740	0.740	0.857
Purpose of agriculture production	Percentage of households that use agri-culture production for sale of products	0.92	0.92	0.22
	Average	0.699	0.504	0.467
IPCC-LVI	**(Exposure + Sensitivity) – Adaptive**	**0.019**	**0.314**	**0.058**

Source: Authors' own.

Appendix 2: Experiences of rural migrants living in urban areas

A bird's eye view of the experiences of migrants in urban areas is helpful to understand changes in their well-being after migration. Drawing on in-depth interviews with 45 migrants in the urban areas of the three study sites, the study highlights the difficulties farmers experience in the cities. This helps to weigh the positive and negative aspects of rural to urban movement in order to develop more nuanced recommendations for managing migration as an adaptation strategy.

Socio-economic profile of migrants

All migrant respondents in the sample were aged between 19-55 years. Young migrants, mostly aged between 19-21 years were usually low-skilled, and thus, engaged in daily wage work during their early years in the cities. Over the years, as they assimilate in the city and acquire more skills, they may shift to other occupations such as starting a small business or attaining a salaried job.

Income levels also varied depending on the educational level and the occupational group of the respondents. Respondents from Mardan were earning the lowest income among the three districts, with Faisalabad having generally higher wage rates as it is a bigger city compared to D.G. Khan and Mardan.

Generally, migration for work is gendered in the sense that men migrate away from villages first and then bring their families or women accompany their male household members. It is rare for a woman to migrate for work from a village on her own without an accompanying male member; however there is an increasing trend of women migrants from educated families due to more awareness about women's rights and the high opportunity costs of non-earning family members. Once in the cities, women not involved in any economic activity in the village are often found participating in the labour market, mostly in government jobs (e.g. in the education or health sector).

> ‘Due to the lack of economic opportunities in respectable sectors [generally referred to education and health sector] in the village and the narrow-mindedness [patriarchal set-up] of the local people, I felt restricted (to be involved in economic activities). Now that I am in the city, I feel more secure to do a job without being judged by relatives and neighbours.’
>
> – A female migrant factory worker in Faisalabad

This reflects that moving to cities enhances women's sense of empowerment as they partake in economic activities in public spheres and earn an income to provide for their families. Many less educated females start working as domestic helpers to supplement their husbands' incomes. Despite the fewer restrictions to work as compared to the villages, working female migrants face considerable economic and social issues in the cities. A wide male-female wage difference was reported by the respondents, along with longer working hours. Workplace harassment also came out with some respondents reporting being ridiculed for not understanding the urban way of life owing to their village backgrounds. Lack of safe public transport was highlighted as one of the most important concerns by working female migrants. Finding safe and secure accommodation was another major concern. Furthermore, respondents also shared that options for technical and vocational training for females are quite limited, especially those coming from villages facing accommodation problems in the cities.

Reasons for migrating to urban areas

Migrants belonging to different occupational categories came from varied backgrounds prior to migration. While most of the job-holders and business owners were studying before moving to the city, many individuals were helping on their family farms, or working as daily wage labourers in the villages or running a small business (a shop, for instance). Female migrants were either studying when residing in the villages or they were providing care duties for household members, sewing clothes, doing embroidery or looking after the livestock. The main factors leading to male migrants' decision to leave were: lack of economic opportunities in the villages, extremely low wage rates, declining farm incomes, lack of basic facilities for education and health in quantity and quality and fewer opportunities to run successful businesses. These findings underscore Salik

et al. (2017), who explored the fundamental driving forces behind the decision to out-migrate from villages. While in most cases, respondents did not factor climate change as the causal factor behind their decision to move, there were some cases where its impact did contribute to this decision. Respondents, previously working in agricultural fields, reported that as a result of frequent loss in crop yield due to untimely or irregular rainfall, pest attacks, and sometimes, complete harvest failures over the years due to climate extremes (floods in Mardan and D.G.Khan and extreme water stressed situations in Faisalabad), they decided to look for economic opportunities outside their village to ensure stability in their incomes.

Finding residence

Finding residence is the first priority when people move to cities. Most of the migrants lived in rented accommodation. In some cases, salaried migrants were provided accommodation by their employers free of cost. All urban migrants interviewed were of the view that the provincial and local governments should ensure that affordable rental houses are available for new settlers. They claimed that all the major housing schemes developed in the cities cater to the needs of the rich and the poor, new settlers have no option but to take loans and pay the high fees of private property agents in order to find decent lodgings.

Reliance on social networks

The role of social networks was emphasised by all the migrants. In almost all cases, relatives or friends already living in the cities provided tremendous help during the migration process. Their support in finding residence, establishing an income source (finding a job or giving loan to set up business), expanding their social network by introducing them to useful contacts was acknowledged by the migrants as integral to the process of settling down in the cities.

Remittances

Sending remittances back to their families in the villages is a consistent characteristic of the urban migrants. Those having a job or a small business sent higher remittances than migrant labourers. It was found that remittances sent are generally spent on household consumption expenses, utility bills, education of children or siblings, health and commutation expenses. Only 20% of the urban migrants shared that their remittances were used to purchase livestock, buy agricultural inputs or invest in commercial property.

Living standards

The outcome of rural to urban migration was observed through the migrants' post-migration perceptions about changes in their well-being. Almost all of migrants agreed that they experienced improvement in their living standards after settling in urban areas. Major factors leading to this improvement were increased access to basic facilities such as better educational institutions, better transport facilities, improved access to markets, availability of economic opportunities, higher wage rates and incomes, and the ability to support the family through remittances.

Future aspirations

Migrants shared similar future aspirations, regardless of their occupation and gender. Nearly all of them aspire to attain better and stable income sources and own residential property in the city. Male migrants, who live without their families, wish to bring them to the city once they consider themselves well-settled. In case of occupational groups, the majority of the labour and salaried migrants were interested in setting up their own small businesses (grocery shop, pharmacy, and fabric shop). On the other hand, migrants who had established small businesses plan to expand them or invest in real estate. Responses of female migrants in terms of future aspirations were generally including providing good education and employment for their children. Moreover, they were more inclined to share that they would not prefer moving back to their villages since their children are attaining better quality education in the city. Despite stating that their overall household well-being has increased since they migrated, some migrants expressed that they are willing to shift back to the village to re-join their families, and invest in expansion or revival of their agricultural lands if adequate socio-economic facilities are provided.

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