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**MASTER THESIS**

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# Climate Change and Internal Migration Patterns: A Case Study of Rural Pakistan

**MASTER THESIS**

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## Zásady pro vypracování

This study intends to investigate the relationship between the changing weather patterns of erratic rainfalls and extreme heat stress on internal migration of rural households through channels of loss in farm output, stock value, and assets. Using the link between asset ownership and migration it would reflect on the various coping strategies available to individuals of various social classes in rural areas of Pakistan. The study intends to use the Pakistan Panel Household Survey which is a longitudinal survey conducted in 16 rural and peri-urban districts of Pakistan in 2001, 2004 and 2010.

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Seznam doporučené literatury:

1.Abid, M., Scheffran, J., Schneider, U.A. and Ashfaq, M., 2015. Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. Earth System Dynamics, 6(1), pp.225-243. 2.Auffhammer, M., Hsiang, S.M., Schlenker, W. and Sobel, A., 2013. Using weather data and climate model output in economic analyses of climate change. Review of Environmental Economics and Policy, 7(2), pp.181-198. 3.Bohra-Mishra, P., Oppenheimer, M. and Hsiang, S.M., 2014. Nonlinear permanent migration response to climatic variations but minimal response to disasters. Proceedings of the National Academy of Sciences, 111(27), pp.9780-9785. 4.Brown, O., 2007. Climate change and forced migration: observations, projections and implications (No. HDOCPA-2007-17). Human Development Report Office (HDRO), United Nations Development Programme (UNDP). 5.Change, I.C., 2007. Synthesis Report, Intergovernmental panel on climate change. 6.Durr-e-Nayab and Arif, G.M., 2012. Pakistan Panel Household Survey Sample Size, Attrition and Socio-demographic Dynamics. Pakistan Institute of Development Economics. 7.Findley, S.E., 1994. Does drought increase migration? A study of migration from rural Mali during the 1983-1985 drought. International Migration Review, 28(3), pp.539-553. 8.Homer-Dixon, T.F., 1994. Environmental scarcities and violent conflict: evidence from cases. International security, 19(1), pp.5-40. 9.Mearns, R. and Norton, A. eds., 2009. The social dimensions of climate change: equity and vulnerability in a warming world. The World Bank. 10.Mueller, V., Gray, C. and Kosec, K., 2014. Heat stress increases long-term human migration in rural Pakistan. Nature climate change, 4(3), p.182

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## Declaration

I declare that this thesis, which I submit to GLODEP Consortium for a pre-requisite of "Erasmus Mundus Joint Master's Degree in Global Development Policy" is original and my own personal effort. Furthermore, I took reasonable care to ensure that the work is original, and, to the best of my knowledge, is not in violation of copyright law, and has not been taken from other sources except where such work has been cited and acknowledged within the text.

**Signature: ______________________________________**

**Date: May28th, 2019**

**Place: Clermont Ferrand**

**The data files and do files for the analysis are available at:**

**https://www.dropbox.com/sh/r25nvg3p9ohai2e/AACA3JanJDu8dMhds6_PyOfHa?dl=0**

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Using the small type that does not reflect the size of my dept I would like to acknowledge some things.

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# Abstract

*In a changing natural environment, rural households adapt to increased risk in several ways. Sending one or more household members to a far off usually urban location is an adaptation strategy used in numerous developing countries across the world. The study analyses the extent of rural migration occurring due to climate change in Pakistan and examines how the migration patterns differ across genders. The study creates a unique longitudinal panel using the out-migration module of a nationally representative survey i.e. Pakistan Demographic and Health Survey (PDHS) 2017-18 and Standardised Precipitation Evapotranspiration Index (SPEI) and finds that there is a significant and positive association between changing weather and migration out of rural areas. Moreover, this relationship is significant for both drought and floods where the probability to migrate across a longer time is higher for middle drought, heavy flood, and very heavy flood. The relationship between migration due to climate change and gender is also significant and the probability of females to migrate out of rural areas due to climatic shocks is high.*

**Keywords**: Rural, Migration, Pakistan, SPEI, Adaptation, Climate Change, Gender.

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# 1 INTRODUCTION

The IPCC Report (2014, pp. 38) states that with changing climate the prevalence of adverse weather events would increase. Human security would almost immediately be threatened through the loss of livelihoods and loss of cultural identity forcing people to have recourse to unwanted forms of migration. The risk of displacement increases when people lack the resources to partake planned migration, live in rural areas of low-income countries and are increasingly subjected to extreme weather events (IPCC 2014).

According to the Global Climate Risk Index, Pakistan is among the countries most affected by climate change and its adverse impacts (Eckstein, Künzel, & Schäfer 2017). In recent history, Pakistan has suffered from numerous natural disasters which have affected the lives of more than 20 million of its inhabitants. Incidences such as massive floods of 2010 in Punjab, KPK, and Sindh claimed the lives of more than 1700 people and displaced millions. In the following year much of the Sindh province was flooded again causing repeated colossal losses. In addition to floods, the country is prone to other natural disasters e. g. earthquakes such as the Kashmir earthquake of 2005 claiming almost 800,000 lives and displacing more than 3 million (Free et al. 2016) , land degradation and landslides leading to massive natural disasters like the formation of Ataabad lake in Hunza Valley in 2010.

In addition to natural disasters, Pakistan is affected by the slow on setting effects of climate change i.e. droughts, rainfall variations and changes in temperature. According to estimates (Xie et al. 2013) droughts are not only frequent but are prevalent across large areas. Moreover, they have a reoccurrence period of 16 years and there has been a significant drought in almost every decade since the 1960s. Over the past two decades, the country has experienced great variation in monsoon rainfall. Estimates (Ikram et al. 2017) suggest there has been a significant increase in the number of dry days which are followed by extreme spells of rainfall. Such extreme rainfalls not only make the soil more prone to floods as it is unable to absorb moisture but also affects crop planning.

Agriculture plays a key role in the economy of Pakistan. It not only absorbs more than 42 percent of its workforce but also contributes up to 19 percent of its GDP (MOF 2018). It is also an important source of foreign exchange for the country and provides valuable resources to the manufacturing industry. According to the latest census more than 67 percent of the country’s total population is living in rural areas and depend largely on agriculture, and agricultural related activities for their livelihood (PBS 2017). In addition to that, the World Bank states that 4 out of every 5 of the countries’ poor live in rural areas (Mansuri et al. 2018). Numerous studies (Lohano 2018; Healy and Manusri 2008) show that for the case of Pakistan weather related shocks affects the lives of people living in rural areas the most. These effects might be natural disasters like floods or slow on setting changes like droughts, salinity, and changes in temperatures (Sattar 2014). All of these have the potential to affect the livelihood of the rural poor and force them to adapt accordingly.

Households and communities adapt to these events through several coping strategies, such as changing cropping patterns by plowing drought-resistant crops, relying on savings (Haley and Mansuri 2005), reducing the household size (Findley 1994; Rosenswig & Stark 1989) and migration (Henry Shoumker et al. 2004; Gray and Mueller 2012; Grey, Mueller and Kosec 2014). Sending of one or more household members to a far off,usually urban location reduces the risk between the origin and eventual destination and allows the household to spread the risk of a potential loss in livelihood (Nawrotzki, Riosmena & Hunter 2013).

Several studies such as (Memon 2005; Arif 2005) have identified the migration from rural to urban areas to be the more prevalent form of migration in Pakistan. Surveys focusing on migration such as Labour Force Survey (2017-18) and Pakistan Demographic and Health Survey (2017-18) cite employment as the main source of migration from rural to urban areas for males and marriage for females. While these surveys report the self-reported reasons for migration they rarely investigate the underlying causes which leads to such levels of migration out of rural areas.

Overall, the literature analyzing the link between changing weather outcomes and resulting out migration is limited for Pakistan. With the exception of Gray, Mueller and Kosec (2014) and Lohano (2018) a few studies (Haley and Mansuri 2005; Eskander et al.2018, etc) analyze other forms of adaptation mechanism available to the households in the face of climatic shocks and loss of livelihood. While simulation-based studies predicting future climatic events and resulting migration streams exists for a number of countries (such as for Bangladesh by Hassani-Mahmodei & Paris 2012, and Burkina Faso by Kniveton, Smith & Wood 2011), there are almost nil for Pakistan.

Moreover, studies like Eskandar et al. (2018) analyze the adaptation mechanisms available to households and communities immediately after an adverse weather effect such as floods, studies analyzing the slow-onset effects of climate change created through drought, changing temperatures and rainfall variations are limited. A few studies (Lohano 2018; Grey, Mueller, and Kosec) analyses these effects through changes in “agricultural output” and are unable to isolate the migration occurring simply because of climate change. This study attempts to fill in this gap by analyzing the association between slow on setting changes in climate and the resulting out-migration from rural areas while controlling for various background factors of age, gender and household endowment measured by the wealth index, and attempts to see how migration out of rural areas differs for both males and females due to adverse weather events.

The study uses the Standardised Precipitation Evapotranspiration Index (SPEI) to detect the changing weather patterns across the country. Studies analyzing the link between climate change and migration in Pakistan mostly used rainfall data (Hailey and Mansori 2005; Lohano 2018) with the exception of

Grey, Mueller, and Kosec (2014) who have used Standardised Precipitation Index (SPI). The SPEI detects both dry and wet conditions and it is an improvement over using only rainfall or temperature data and other indices like SPI (Vicente-Serrano et al. 2010). The index incorporates both temperature and precipitation data and accurately represents the impact which both have on household adaptation and migration decision. In addition to that, the study uses the latest household survey data covering a large representative sample across the whole country. The SPEI values across 12 and 24 months are matched exactly to the original district of each migrant since his or her birth and the eventual migration episode to see how weather variability interacts with the final migration decision. The district wise matching of individuals accurately accounts for the weather variation across arid, semi-arid and humid areas and therefore accurately indicates the exact weather conditions prevailing across time and space.

The study is divided as follows: Chapter 2 provides a detailed review of literature divided across the commonly occurring themes on the climate change and migration discourse, chapter 3 consists of a brief discussion of migration patterns across Pakistan, chapter 4 consists of a climate change profile of Pakistan. Chapter 5 provides a detailed overview of the data, variables, theoretical framework and methods used in the study, chapter 6 consists of both the bivariate and multivariate results and chapter 7 provides the discussion, conclusion, and limitations of the study.

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# 2 REVIEW OF LITERATURE

Migration is a highly contextualized phenomena, differing across countries, regions, cultures, and gender. Therefore, it is difficult to come up with findings which are always generalizable across all people in all countries. However, in the literature, there are a few patterns emerging which allows for analyzing the broad themes. This chapter has a summary of empirical findings from diverse sources of literature analyzing the association between the changing climatic conditions and using migration as an adaptation strategy. Some of the generalizable conclusions found across literature are below.

## 2.1 HOUSEHOLDS PARTAKE CIRCULAR OR SEASONAL MIGRATION

The adaptive capacity of small-scale farmers in the face of climate-induced risks is limited due to their dependence on natural resources and poor access to capital both human and physical (Ahmed at al. 2012). The situation becomes even more intense upon the onset of suddenly occurring natural hazard which destroys potential harvests and jeopardizes livelihood. While a member of a relatively wealthy households have an option to opt for permeant migration, poorer individuals partake short-term and often circular migration (Findely 1994). Such short-term migration has the potential to ameliorate food insecurity and food consumption to an extent. For instance, in rural Mali women and children are sent on extended visits to reduce the food consumption burden of the households (Findley & Diallo 1993). Similarly, in rural Mali girls might get married earlier to reduce the family size and its food demands (Findley 1994).

Similar results have been reported by Deshingkar & Start (2003) for the case of India where they state that the prevalence of circular migration is particularly high in chronically poor people living in remote rural areas of Madhya Pradesh in India. According to their estimates, almost 300,000 laborers migrated from the drought-prone areas of Madhya Pradesh and Andhra Pradesh. The migration streams for scheduled castes, on the other hand, is limited showing that even circular or seasonal migration might not be an option for poor and socially disadvantaged people.

## 2.2 THE DECISION TO MIGRATE IS STRONGLY INFLUENCED BY THE HOUSEHOLD'S ENDOWMENTS

Access to land, livestock, and assets might act as a barrier against out-migration from rural areas. People having access to physical and capital assets can mitigate the effect of the climate-induced hardships and are able to adopt various coping mechanisms such as crop switching, asset depletion, and credit (Bhatta et al. 2016). One of the earliest case studies proving this is from the Canadian province of Alberta in the 1930s. Gilbert & McLeman (2006) analyzed the out-migration of households from rural areas in the Canadian Province of Alberta, due to prolonged drought in the 1930s. The study proves that while household tried to adapt in a few ways such as relying on wild game and changing water conservation methods the decision to migrate was taken as a last resort. Moreover, there were significant differences between the people who eventually migrated to other districts and the ones who stayed in terms of access to capital and networks. The migrant households tended to have little access to economic capital than non-migrants but had strong network's which extended to eventual destinations.

The ownership of assets plays an important role in the decision to migrate. Land serves both as a natural and financial asset (Curran & Meijer-Irons 2014) and play a two-way role in the final migrating decision i.e. serving as a natural capital it provides a continues form of employment and security and prevents people from migrating (Curran & Meijer-Irons 2014). On the other hand, it also acts as a financial capital where people can mortgage it and underwrite expensive migration trips (Curran & Meijer-Irons 2014). Eskander et al. 2018 investigated the adaptation response available to households following the 2010 floods in Pakistan. Their results show that income and land ownership played a significant role in the coping strategies available to households. More affluent farmers were able to explore a wider set of adaptation choices and were not forced to leave their ancestral lands and move to internally displaced person camps.

## 2.3 OUT-MIGRATION IS A HIGHLY CONTEXTUALIZED PHENOMENON

Out-migration in the face of extreme weather events is a highly contextualized phenomena and depends on agricultural conditions, political situation and prevailing cultural norms and different studies produce different, sometimes conflicting results (Curran & Meijer-Irons 2014).

Ezra 2001 & Hampshire (2002) concluded that in many Western African Communities out-migration occurs in years with no drought or other extreme weather events. Similar results have been proven by Grace et al. (2018) for the case of Rural Mali where rainfall variability is not necessarily associated with extreme or higher than average rates of out-migration across genders, even after controlling for known sources of variation in terms of age, gender and migration history. This can be attributed to the adverse climatic conditions prevailing in the area which are experienced collectively.

On the other hand, Nawrotzki & Bakhtisyarava (2017) report contrasting results by using representative census and climate data to see the impact of heatwaves, drought, and rainfall on the probability of out-migration at a household level in Senegal and Burkina Faso. Their results show that while increased rainfall increased the probability of international outmigration in Senegal, in Burkina Faso heatwaves reduces this probability. They were able to detect a clear pattern between changing weather anomalies and out-migration and stated that the effects are strongest when heatwaves overlap the growing season of groundnut and when excessive rainfall occurs right before growing season.

## 2.4 MIGRATION CAN BE TEMPORARY OR PERMANENT

Temporary displacement can turn into permeant migration due to the social vulnerabilities within communities (Adgar et al. 2011). This has been proven in the case of Hurricane Katarina in New Orleans by Fussell et al. (2011) where they analyzed the level of repartition fourteen months after the storm. They concluded that the repatriation of the black residents was much slower than white residents, even after controlling for socioeconomic and demographic variations. This was since Black residents were living in more flood-prone areas and therefore sustained greater damage and therefore were slow to return. Suckall et al. (2015) analyzed the patterns of rural out-migration for Malawi. They state that the changing weather conditions in Malawi are reducing livelihood opportunities in rural areas and are encouraging people to migrate to urban areas for longer periods of times. Thus, leading to rapid urbanization and stressing the available infrastructure.

On the other hand, Henry, Schoumaker & Beauchemin (2004) state that people living in areas of high rainfall vulnerability in Burkina Faso are more likely to migrate to other rural areas as compared to urban ones. This is mostly due to the short-term nature of such migration. Similarly, Penning-Roswell, Sultana & Thompson (2013) analyzed the push and pull factors of migration due to adverse weather events in flood-prone areas of Bangladesh. The results show that the probability of permeant migration out of areas which are hazard-prone is limited, except where the land is permanently eroded or saline. They state that the limited mobility may be due to "anchoring" effect of communities and the migration occurring immediately due to a natural hazard may be temporary and the permeant migration may occur as a last resort despite the perceived threat of the hazard.

Similar patterns were observed in the case of Pakistan by (Eskander et al. 2018; Gaurav et al. 2011) where people undertook temporary migration after flood-induced displacement and in the case of Bangladesh by Gray & Mueller (2012) where people returned to their homes after flooding probably because of the rebuilding work which had started in the origin communities.

## 2.5 MIGRATION DUE TO CHANGING WEATHER CONDITIONS DIFFERS ACROSS GENDERS

The adaptation response of both males and females might also differ. Both men and women are differently propelled out of rural areas and must modify both their time and other activities differently due to the changing migrant structure (Curran & Meijer-Irons 2014). A study conducted by (Massey et al. 2016) states that due to the rapid deforestation in Nepal more men of forest communities are migrating to urban areas and the number of females headed households is thus increasing. Henry, Shoumaker, & Beauchemin (2004) state that men in rural Malawi are more likely to migrate out of rural areas due to rainfall variability. South Asia also exhibits similar trends of male out-migration. Bhatta et al. 2016 state that in the Indian province of Bihar almost all households reporting distress migration involved male migration. Similarly, in coastal Bangladesh, almost all occurring migration was predominantly male (Gray & Mueller 2012). Mueller, Gray, & Kosec (2014) reported that in rural

Pakistan, the risk of male migration increases when exposed to increased temperature. In general, male migration is predominant during agricultural distress in South Asia. Prevalent gender norms, lack of education and the fear of harassment are the prime reasons for no or low rates of female migration (Bhatta et al. 2016). However, in the case of Rural Mali in times of extreme drought, both women and children are likely to partake in circular migration to reduce the family's food demands (Findley 1994).

Similar results were reported in a seminal paper reflecting on the migration patterns differing across gendered lines for India by Rosenzweig & Stark (1989), where they report that marriage of daughters across a long distance is a form of mitigating risk and smoothing consumption in the face of increased crop variability. The households reporting a higher level of crop variability also reported long-distance migration of daughters for marriage purposes.

## 2.6 CHANGES IN AGRICULTURAL PRODUCTIVITY ENHANCE OUT-MIGRATION

Numerous aspects of climate change lead to changes in migration patterns prevailing in an area (Perch-Nielson, Battig & Imboden 2008). One important aspect is the losses in agricultural productivity which lead to outmigration from rural areas. Changes in crop yields occurring from changing climatic conditions take place over broad geographical areas and have the potential to cause significant, and long-term population shifts (Feng, Krueger, & Oppenheimer 2010). The changes in the population structures are significant and often permeant, as opposed to transitory changes which result from events like flooding and cyclones. This phenomenon is more prevalent in developing countries which have large rural populations directly deriving their livelihoods from agriculture.

One of the earliest examples of the impact of changing environmental conditions on the agricultural productivity and resulting human migration is that of the "American Dust Bowl", considered to be one of the greatest environmental disasters in the history of the United States (Cook, Miller, & Seager 2009). In the 1930's persistent drought and land degradation significantly reduced agricultural output in the Great Plains and led to a massive out-migration from those regions. According to the estimates by Mc Leman (2006) between 1935 and 1941 almost 30,000 people had migrated from the Great Plains towards California.

The decline in productivity not only had ramifications for the farmer but had implications extending beyond the agricultural sector in the sense that much other business-like banking and insurance are directly linked with the agricultural sector. Hornback (2009) argues that during the Great Depression the economy mainly adapted through outmigration and did not adopt through other mechanisms like adjustment within the agricultural sector or increases in the industry. The "American Dust Bowl" happened under very different conditions from today, since than the American agricultural sector has gone through structural transformations and farmers have other access to other forms of adaptation mechanism such as improved mechanization, access to credit, insurance (Feng, Oppenheimer &

Schlenker 2012) and they don't necessarily need to adapt to the changing weather conditions by outmigration.

While farmers in developed countries like the United States have opportunities to choose from numerous adaptation mechanisms; farmers in developing countries don't have many options. A study conducted by Kubik & Maurel (2016), investigated the association between declining crop productivity and migration in rural Tanzania. The results show that the impact of weather shocks have a negative impact on the agricultural productivity and a one percent decline in agricultural income due to weather shocks increases the probability of migration by thirteen percent within the following year. However, the migration decision depends on the initial endowment of the household and well-endowed households are more migrate in the face of a weather shock.

The changing patterns of climate are not expected to alter population structures locally but also across international borders. Feng, Krueger, & Oppenheimer (2010) examined the linkages between climate variations, agricultural yields and international migration across the US-Mexico border. Their results show that a 10 percent reduction in agricultural yield in Mexico induces an additional 2 percent of the population to emigrate to the United States. Depending on the warming scenarios and the assumed adaptation levels the authors predict that by the year 2080 climate change is expected to induce 1.4 to 6.7 million of adult Mexicans to emigrate due to a reduction in agricultural productivity alone. Similar results have been reported by Coniglio & Pesce (2015) where they examined international migration towards OECD countries as an adaptation strategy to both sudden and gradual climatic shocks. The results indicate that the occurrence of adverse climatic events in the origin countries has significant implications on the levels of emigration from poor to rich countries. These effects are even more significant in countries which has a direct dependency on the agricultural sector.

Marchiori et al. (2012) investigate the role of environmental migration as a possible adaptation strategy to local environmental changes across Sub-Saharan Africa. Using changing weather patterns as a proxy for climate change they report that changing weather patterns can influence both internal and international migration. They conclude that an increase in urbanization levels in countries could reduce environmentally induced international migration. Majority of the countries across the Sub-Saharan region rely mainly on agriculture, and reduction in agricultural productivity in rural areas constitutes as a major driver for rural-urban migration. However, such massive rural-urban migration could lead to increased stress on urban infrastructure, increased urban unemployment and creation of a large shadow economy. A study conducted by Suckall et al. (2015) state that the rate of rural-migration in Malawi has increased possibly due to climate change and loss in rural incomes. The migrants tend to stay longer as opposed to the trends of circular migration which have been popular in many Sub-Saharan countries.

## 2.7 TEMPERATURE VARIATION HAS SIGNIFICANT IMPLICATIONS ON OUT-MIGRATION

The key assumption of Borjas (1985) migration decision model is that income of poor and middle-income countries is highly dependent on agriculture and is, therefore, more sensitive to weather variability. Cattaneo and Perri (2016) explore the link between changing temperature, reducing crop yields and subsequent migration for 116 countries. They conclude that the rate of emigration across national and international boundaries is significant for middle-income countries dependent on agriculture. On the other hand, for poorer countries even though the association between increased temperature and reduced crop yields is positive, it not necessarily leads to outmigration due to liquidity constraints.

Similar results were reported by Lohano (2018) for the case of Pakistan where they proved that changing temperature has a non-linear effect on the crop revenue per hectare, and with changing temperature the crop revenue initially increases and then decreases. The declining agricultural productivity due to temperature variations further reduces the in-migration rate into a district. Similar results were reported by (Mueller, Gray & Kosec 2014) who reported that in Pakistan the agricultural income is greatly diminished when the temperature is extremely hot due to which over a third of farm income is eliminated which acts as a driver of out-migration for males out of rural areas.

A possible explanation for this is provided by Wrathall et al. (2018) who state that the extreme levels of heat enhance the evaporation of the topsoil, whose water content is important for shallow root crops which are mostly associated with subsistence agriculture. Moreover, extreme heat leads to water shortages and when water does not meet the demands of the agricultural sector it leads to a reduction in crop production.

# 3 MIGRATION DUE TO ENVIRONMENTAL STRESS IN RURAL PAKISTAN

Due to its unique geographical position between the Indian Subcontinent and Central Asia, Pakistan historically has high levels of both internal and external migration. One of the earliest estimates of Helbock (1975) suggests that according to 1961 almost one in every 7$^{th}$ person was an internal migrant and had come to the current place of residence from a different district.

Pakistan is a predominantly agricultural country and frequently farmers have partaken internal migration to mitigate the effects of changing weather conditions. A prime example is the migration of farmers to Punjab from the rain-dependent Eastern districts upon the introduction of a canal irrigation system by the British (Sattar 2014). In the post-colonial era, a watershed example of farmers using migration as an adaptation mechanism was the creation of the Mangla Dam, where the British government, as one of the guarantees of the project agreed to resettle farmers displaced from the construction of the Dam in the United Kingdom (Sattar 2014).

Water stress, drought, and rainfall variability have long been the feature of life for communities in the region. Historically the communities have adapted by sowing drought resistant and water efficient crops such as sorghum and millet (Sattar 2014). Rural populations have also relied on livestock as main sources of income and have often depleted assets to adapt to crop failures. A study conducted by Oxfam Great Briton in 2013 (cited in Sattar 2014, PP 23-24) analyzed the adaptation mechanism available to farmers in the drought-prone Tharparkar region. The study concluded that gender norms, caste systems, and class hierarchy all affect people's ability to adapt to water stress. Households with access to financial capital are less likely to suffer and can use the money to purchase fodder and food items. Lack of financial capital force the poorer households to incur debts, delay medical expenses and reduce food intake. These are the people who have consciously used long term or permeant migration to adapt to environmental stress. One or two members from lower-income families migrate to towns and send back remittances to support extended families.

In the case of Pakistan, access to land greatly reduces the probability of migration. This has been observed in several studies, such as Memon (2005); Arif (2005); Haq, Jahangeer and Ahmad (2011). The ownership of land acts as a potential source of employment and can provide a guaranteed level of earnings in rural areas. These act as security and households might prefer these as compared to the expected earnings in potential urban destinations. In a traditional society like Pakistan, the agricultural land is more of a bond between rural communities and their geographical origins and therefore increases the social costs of migration. Recent fieldwork conducted by Oxfam Great Britain (2013) as cited by (Sattar 2014, pp 23-24) in the arid regions of Pakistan has shown that in the wake of delayed monsoon rains, the landless farmers were more likely to migrate in search of farm work to irrigated areas as compared to those who owned assets such as land and cattle.

Despite the pull of urban centers, the mobility of individuals from drought-prone regions like Tharparkar is constrained by financial capital needed to undertake the journey, limited education and skills, and high levels of debts. An important coping strategy adopted by households in drought areas is that of seasonal migration to canal irrigated areas. A study conducted by Lefebvre (1990) in the barani (rainfed) areas of Upper Punjab also reports that farmers are more likely to undertake seasonal migration to canal irrigated areas in years where the crop yields are low due to rainfall variability.

In the Tharparkar region, seasonal migration also has gender and caste dimensions. Both Muslim and Non-Muslim women of higher castes do not leave their villages for seasonal work except in extreme drought conditions (Sattar 2014). The migration patterns of Pakistani women of the Tharparker region are not the only one segmented along gender lines. Numerous data sources such as Pakistan Census 1998, Labour Force Survey 2017-18 and Demographic and Health Survey 2017-18 report that while most of the males migrate for economic reasons, females tend to migrate for marriage and accompanying other family members. The very low proportion of female migrants suggests that while female migrants lack the skills needed to find a job in migrant destinations, the labor market of the country is highly segmented along gender lines (Memon 2005). Even though most of the women migrate as tied migrants, this does not imply that their potential participation in the labor market is not included in the pre-migration decision. Therefore, it can be assumed that for tied migrants such as women the underlying cause of migration can be the changes in labor participation, even though the reported reason may be family or marital (Memon 2005).

In addition to drought and floods, salinity and waterlogging are a major problem which leads to land degradation and crop loss (Sattar 2014). The salinization of land, rising sea water levels, and river erosion have greatly reduced the fertility of the Indus Delta is the leading cause of out-migration along the Sindh coast (Yu et al. 2013). Towns like Thatta and Badin has seen repeated migration of families to the nearest urban center of Karachi since the 1970s. Unlike the seasonal migration of the Tharparkar district, this migration tends to be permeant and provides the network effect for future migrants (Oxfam 2010) as cited by (Sattar 2014, pp 18-19).

# 4 Climate Change and Natural Disasters in Pakistan

Pakistan is extremely vulnerable to climate change and its associated risks. It is ranked 7th on the Global Climate Risk Index, and extreme weather events are expected to grow in severity entailing both human and economic costs (MoCC 2013). The National Disaster Management Authority estimates that the climate-related disasters on average lead to economic losses of US$3.99 billion per year between 1994 and 2013 (MoCC 2015). According to estimates of the World Bank (2019) on average 3 million people are adversely affected by natural disasters every year, with 77 percent of the population being affected by floods, 14 percent by droughts and 4 percent by earthquakes.

Due to the unique geographical position of the country, it is extremely sensitive to climate change and its associated risks (Sattar 2014). The freshwater resources are provided by Monsoon rains and by melting glaciers in the Himalayan and Karakoram ranges. Pakistan is home to the largest number of glaciers in the world, however, these glaciers are retreating faster than ever (Jillani, Haq & Naseer 2007). The retreating glaciers are expected to increase the flow of the river system and cause flooding. In addition to that, the monsoon patterns are rapidly changing due to the "Asian Brown Cloud" phenomena, which is derived from increased levels of air pollution (Sattar 2014). The changing monsoon patterns and increased flow in the river system make the country extremely vulnerable to floods.

The floods of 2010 affected an estimated 14-20 million people, killing over 1700, displacing millions and causing damage worth of $9.7 billion (Kirsch et al. 2012). The UN estimates that the humanitarian crises ignited by these floods were much larger than the combined effects of the three worst disasters in recent history i.e. the Asian Tsunami and earthquakes in Kashmir and Haiti (World Bank 2019). According to the World Bank (2019), the impact of flooding annually is expected to be between US$1.2 billion and US$1.8 billion, which is almost 0.5 to 0.8 percent of the national GDP. A few simulation studies show that major flooding events like the flood of 2010 are expected to occur every few years. Such events could potentially cause losses up to US$15.5 billion, equating to almost 7 percent of the national GDP.

The Indus river which is a primary source of irrigation for the agricultural-based economy of the two largest provinces of Pakistan i.e. Punjab and Sindh are the most prone to flooding. A study conducted by Gaurav et al. (2011) states that faulty river management, high sediment deposits, and construction on river embankments would cause flooding even in times of low discharge. It is estimated that two-third population of Punjab and one-third population of Sindh is extremely vulnerable to future floods. The losses due to the damage inflicted on infrastructure and agricultural production are expected to be around 0.6 percent of GDP per year (World Bank 2019). The overall incidence of this estimate is expected to be much larger given the prevalence of poverty and the vulnerability of the poor to natural disasters (MoCC 2013).

Pakistan has an arid and a subtropical climate with historically low levels of natural precipitation. The average rainfall is under 240 mm and more than half the country receives less than 240 millimeters (Anjum et al. 2012). The precipitation is unevenly distributed across seasons and reasons and most of the precipitation occurs in the 3 months of the monsoon season (Sattar 2014). Therefore, large parts of the country are prone to droughts, which have increased in frequency over the past few decades (Xie et al. 2013).

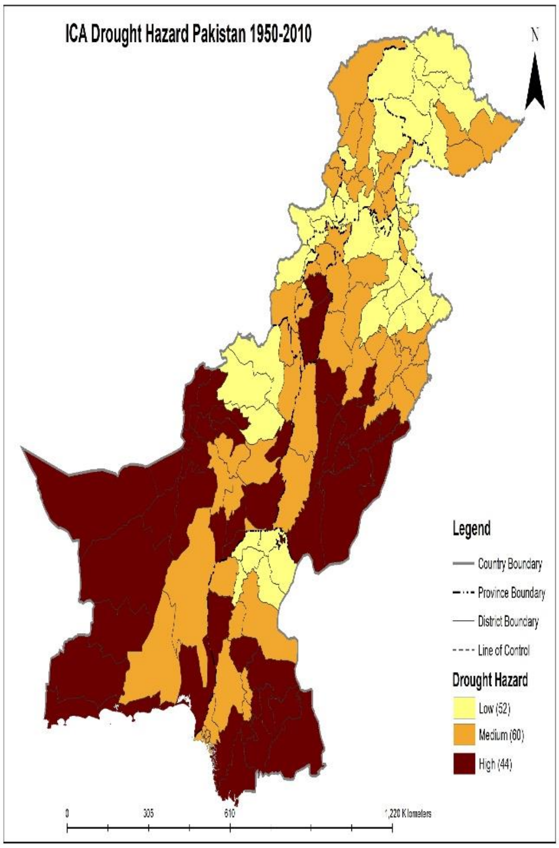
The rapidly increasing population growth, urbanization, industrialization and agricultural development are increasing the demand for the countries depleting water resources (Xie et al. 2013). The country is rapidly moving from being classified as "water-stressed" to "water scares" with less than 1000 cubic meters of water being available per person per day (MoCC 2013). This along with the perspective floods is increasingly concerning for a country whose highly dependent on agriculture and land irrigation. The share of agriculture is almost 22 percent in the country's GDP (Economic Survey of Pakistan 2018) and with more than 64 percent of the population living in rural areas (Economic Survey of Pakistan 2018) who depend mostly on agriculture for their livelihood and will be immediately affected by the changing natural environment.

In addition to the floods and depleting water resources, the countries expected temperature increase is expected to be higher than the global average (Asian Development Bank 2018). This increase in temperature is also expected to cause deadly heatwaves such as the heatwave of 2015 which killed almost 2000 people in Pakistan's largest port city i.e. Karachi (MoCC 2015). According to the ADB projections by 2040, the rise in temperature by 0.50 to 2.0 C will decrease the agricultural productivity by 8 to 10 percent.

The following figures show the districts prone to floods, droughts and both floods and droughts in Pakistan. The figures show that the districts are both prone to floods and droughts making them even more vulnerable. Due to lack of river management and infrastructure gaps the districts which are flooded in the monsoon season are water stressed for the rest of the year.

**Regions prone to Droughts in Pakistan estimates from 1950 to 2010**

**Regions prone to Floods in Pakistan estimates from 1950 to 2010**



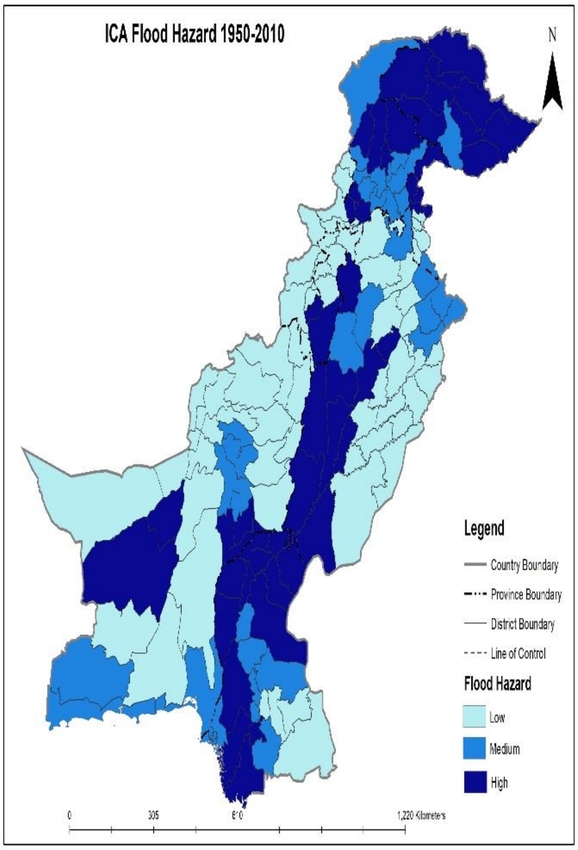




*Figure 1 Flood prone Regions of Pakistan*

*Figure 2 Drought Prone Regions of Pakistan*

**Regions prone to both Droughts and Floods in Pakistan estimates from 1950 to 2010**

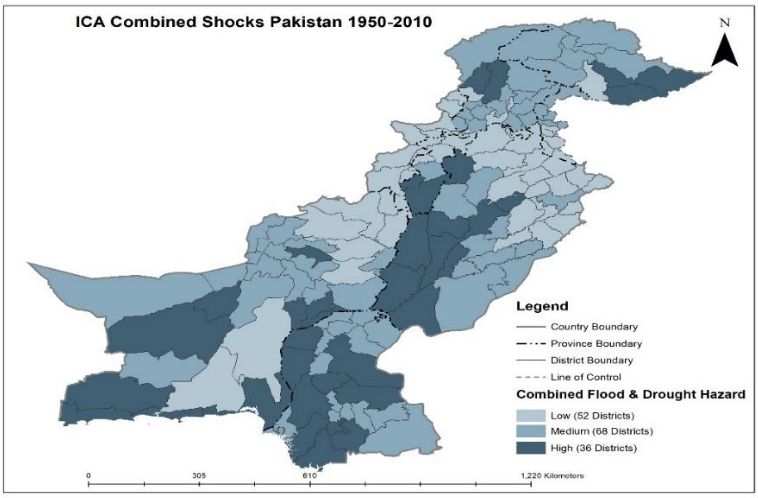



*Figure 3 Regions affected by both Flood and Droughts in Pakistan*[1]

[1] GIS projections done by Sara Bashir from UNWEP on PMD dataset based on soil moisture and precipitation data available from 1951 to 2010. This is used to calculate three parameters i.e. dependency on seasonal (winter/monsoon) rainfall. Drought frequency (derived through the Standardised Precipitation Index or SPI) and soil moisture.

## 4.1 CLIMATE CHANGE CAUSES AND CONSEQUENCES

Much of the climate degradation in Pakistan could be attributed to the policies adopted by its Colonial Masters. For instance, during the 18th Century failure to secure the Khyber Pass in the North Western Province of the country, which would have led to a lucrative trade route to Central Asia and Europe, via Afghanistan, The British turned their attention to cutting down the massive softwood forest of blue pine, spruce, and fir which covered much of the region. The wood and forest products were then used to satiate the vast appetite of the Raj's infrastructure (Matthew & Zalidi 2002). To retain control and maintain colonial influence, the forestry system developed relied heavily on bribery and political influence, much of it is still in place today (Matthew and Zalidi 2002). Dijik and Hussain (1994) believe that the irrigation system developed by the British is highly inefficient, whose access depends on bribery and corruption. According to them the rapid deforestation and the inefficient irrigation system are the main drivers of environmental stress being faced by the country.

Post-independence the situation did not change, the ruling elites were quick to fill in the vacuum left by the British and the decisions were now taken in Islamabad, rather than London (Matthew and Zalidi 2002). According to Gizewski and Homer-Dixon (1996), the environment of the country has rapidly deteriorated since independence and most of it is perforated by the state policies. The scarcities are demand induced i.e. due to a growing population, supply induced i.e. due to rapid resource depletion and environmental degradation and structural, i.e. due to the unequal distribution of income and wealth across the country. This has been accompanied by resource capture, exacerbated by the prevailing inequalities in the society, allowing powerful groups to alter the distribution of natural resources for their own personal interest. This leads to resource scarcity and isolation of the most marginalized groups and, they must mitigate the effects by partaking migration to either urban or rural areas.

The migrants migrating to urban areas generally settle in slums and shanty towns, characterized by high levels of population densities and rudimentary living conditions (Gizewski & Homer-Dixon 1996). The rapid population growth, high levels of urbanization and scarcity of land has led to a rapid increase in land prices and rents (Hasan 2015; Hassan 2016). The poor migrants, therefore, have no choice but to settle in areas which are at risk of natural disasters such as floods, fires and lack basic services. Even these lands are subjected to resource captures by the mafia and the elites. An example is the prevailing land Mafia in Karachi[2] which is often involved in land tilling and purposely degrading land to leave it inhabitable.

[2] For more on land mafias in Karachi look into the detailed story by Dawn.
Dawn.April, 2013. *Land Mafia*. Dawn Newspaper. Available at: https://www.dawn.com/news/794612

# 5 DATA, VARIABLES, AND METHODOLOGY

## 5.1 DATA

The phenomena of internal migration have not comprehensively been researched in Pakistan, primarily due to lack of data. The paucity of data can be elaborated by the fact that the population census of 1998 and 2017 had a gap of almost 20 years and both failed to have information on the place of birth needed to analyze the direction of the migration flows.

A few studies have been conducted such as Arif (2005) who combined the information of the population census 1998 with the 2001 Pakistan Socio-Economic Survey and concluded that more than 40 percent of the migrants are rural to urban migrants, and most of the male migrants cite economic reasons for migrating. Similar results were reported by Khan and Shehnaz (2000) for the 1996-97 Labour Force Survey, where they concluded that most form of migration is rural to urban, followed by urban to urban. Memon (2005) analyzed the HIES and Census data for a district level study. He concluded that Punjab was the main source of migrants, with Sindh being the only province with net inflow. Ali et al. (2015) conducted an almost similar exercise for KP where he stated that most of the migration is occurring due to non-economic reasons and is mostly done by females citing marriage and accompanying family members.

Studies aiming to see how environmental characteristics influence the migration decision are mostly longitudinal, which allows for gauging the effect of changing weather conditions on the final migration decision over time. In Pakistan, such studies are rarely conducted. The two openly accessible longitudinal data sets are the Pakistan Panel Household Survey (PPHS) and Pakistan Rural Household Survey (PRHS). The PPHS was conducted by Pakistan Institute of Development Economics with funding from the World Bank in three rounds of 2001, 2004 and 2010 where detailed information relevant to household and farm level characteristics, as well as detailed migration history was collected. However, this data set is relatively old and is not representative as it only covers a few districts of three provinces, with the largest province of Baluchistan not being covered due to security reasons. On the other hand, the PRHS is conducted by the International Food Policy Research Institute (IFPRI) in two rounds of 2011 and 2012 to see how the households cope up after the floods of 2010. This survey is also done in three provinces and was done immediately after the floods of 2010 and 2011 and therefore is correlated with the flood.

Recently the Pakistan Demographic and Health Survey 2017-18 included a detailed migration module in their household roaster. The survey has both in-migration and out-migration module. The in-migration module provides household level information on the incidence of in-migration, the duration of continuous residence among in-migrants, the direction of the population movements across regions and the reasons for these movements. The out-migration module profiles the out-migrant population within Pakistan and abroad during the past ten years and the individual level characteristics of migrants.

The study uses the out-migration module of PDHS 2017-18 to analyze if the members of the households are migrating due to changing natural enviorment. The out-migration module has detailed information related to age, gender, migrant's relationship to the head of the household. the purpose for moving away, remittances and the exact destination of travel. A detailed overview of the out-migration module is given in Appendix 1 (Sample Characteristics).

## 5.2 CLIMATE DATA

Climate data is not available for many developing countries. The data available is often unreliable and only covers a limited time span, forcing the researchers to use estimations or extrapolate the data based on the few available observations (Kubik 2018). Numerous studies such as (Shoumaker & Beauchemin 2004; Bohra-Mishra et al. 2010; Findley 1994) use rainfall data only, despite the detrimental impact of changing temperatures on agricultural productivity and subsequent migration of people from rural areas e.g. (Gray, Muller, & Kosec, 2014; Lohano 2018).

The study uses the SPEI i.e. Standardised Precipitation Index. As compared to only using temperature or rainfall data, the SPEI incorporates the effect of evaporative demand and is, therefore, a suitable indicator to analyze the effects of global warming on the prevalence of drought (Vicente-Serrano et al 2010; Beguria et al. 2010). As compared to other indices available such as the Palmers drought severity Index, the Standardised Precipitation Index, Self-Calibrated Palmer's drought severity index, the SPEI is a better representative of the extreme values and can identify droughts of extreme values (Vicente-Sorrano et al. 2010). Moreover, the SPEI does not rely on the water balance of a specific system (Beguria et al. 2010). The SPEI can be calculated for several different time scales and gives the user the ability to decide on a time frame where the response to the drought of the system is the highest (Beguria et al. 2010). This study uses SPEI of two-time scales i.e. 12 months and 24 months. The 12 months shows the changing weather conditions over a time scale of one year and 24 months of two years. As compared to shorter time spans of 1 month, 3 months, 6 months and 9 months. The time of 12 and 24 months would allow the individuals to change their behavior accordingly due to weather anomalies.

The SPEI index is derived for 143 districts of Pakistan from the period of 1901 to 2015 using the Vicente-Serrano et al (2010) gridded dataset. Even though SPEI is often used as a drought index the study does not assign it a drought condition threshold; and instead uses the whole range of possible outcomes of both dry (negative values) and wet (positive values).

The study uses SPEI as a categorical variable. Due to the increased number of observations in the longitudinal data, the study tries to account for each kind of weather condition as reported by the SPEI. Following the guidelines of (Shan, Li & Wen 2018) the study uses SPEI in the categories of light drought, middle drought, heavy drought, very heavy drought, normal, light flood, middle flood, heavy flood, and very heavy flood. The following table shows the exact classification of SPEI.

**Table 1: SPEI Classification**

| SPEI Code | SPEI Value | Weather Classification |
|---|---|---|
| 1 | $-1 < SPEI \leq -0.5$ | Light Drought |
| 2 | $-1.5 < SPEI \leq -1$ | Middle Drought |
| 3 | $-2 < SPEI \leq -1.5$ | Heavy Drought |
| 4 | $SPEI \leq -2$ | Very Heavy Drought |
| 5 | $-0.5 < SPEI \leq 0.5$ | Normal |
| 6 | $0.5 < SPEI \leq 1$ | Light Flood |
| 7 | $1 < SPEI \leq 1.5$ | Middle Flood |
| 8 | $1.5 < SPEI \leq 2$ | Heavy Flood |
| 9 | $SPEI \geq 2$ | Very Heavy Flood |

*Table 1SPEI Classification*

Moreover, following the guidelines of Kubik (2018), the study also uses SPEI only in extreme values of extreme dry , normal and extreme wet. This allows for the creation of more defined weather events and would allow for a clearer outlook on the resulting migration.

## 5.3 BACKGROUND VARIABLES

The migratory behavior in rural areas strongly depends on individual and household level characteristics; such as age, occupation, a household endowment in terms of land and livestock ownership, gender and occupation. When analyzing the association between climate change and out-migration various studies such as (Shoumaker & Beauchemin 2004; Findley 1994, Bohra-Mishra et al. 2014) have included household and in individual-level characteristics in their model so that the effects of climate change and the resulting migration decision could be isolated from other push factors. Furthermore, the characteristics of the place of residence in the origin area have a significant role in the migration decision (Shoumaker & Beauchemin 2004). Place-related factors provides both opportunities and restraints which make an area attractive to an individual (Shoumaker & Beauchemin 2004). The factors include the availability and accessibility of land, conditions of the local labor market and level of agricultural production. Therefore, the study incorporates both individual and household level characteristics along with environmental ones.

The study uses background characteristics of age at which the migration took place and restricts it to the working age group of 15 to 65 as defined by the Labour Force Survey of Pakistan 2017-18, the gender of the migrant, the place where the migration took place from in terms of the urban or rural district and the wealth index. The wealth index is reported in Demographic and Health Survey data and indicates the standard of living of a household. The wealth index is a composite measure of a household’s assets such as television, vehicles and livestock; materials used for the construction of the dwelling, types of water and sanitation facilities (DHS 2019). The wealth index is calculated through the principal component analysis (PCA[3]). The categories of the wealth index are reduced to poor, middle and rich household for an accurate representation of the relative endowment of the migrant households. A limitation to using wealth index as a proxy for the household endowment is this that the wealth-index reflects the current levels of household endowment while the migration occurred during the past ten years. The relative endowment of the household might have changed i.e. it might have improved due to the remittances sent by the migrant or worsened due to some other factor or have remained the same. Therefore, it is assumed that the household's endowment was almost similar in the past ten years and has not significantly changed. This is a strong assumption but due to data limitations, it must be made.

The study uses a longitudinal approach to analyze the determinates of migration in rural Pakistan. As people are likely to migrate in response to changing individual or contextual conditions, and longitudinal data and methods are therefore well suited to incorporate such factors in the migration model (Shoumaker and Beauchemin 2004). The model, therefore, incorporates individual longitudinal data on migration and community and environmental level characteristics based on the exact district where the individuals lived in the past, at every point in time since they were born.

## 5.4 CREATION OF LONGITUDINAL PANEL

Migration decision is a time related dynamic event. Since it is not static, it is important that the causality leading to the event is identified with time-varying characteristics and relevant patterns are established (Polyhart & Vandenberg 2010). Cross-sectional data place the migration variables and the associations between them in a static form, where the association cannot be observed over time and causal links established (Lynn 2009). To observe the dynamic nature of the migration decision it is important that this is done with time-varying characteristics which are provided by longitudinal data.

Longitudinal data allows has numerous advantages over cross-sections and even repeated cross-sections. It allows for the analysis of gross change as opposed to net change, unit level changes, aggregate changes and time-related events or circumstances where the frequency, duration, and timing of an event is significant to the research question. The migration decision is a time-related event and numerous studies such as (Shoumaker & Beauchemin 2004; Bohra-Mishra et al. 2010; Gray,Mueller & Kosec 2014) have used repeated cross-section and panel data to analyze the migration occurring due to varying weather events over time.

There is a dearth of data in Pakistan and to my knowledge, there is no longitudinal data available. A few exceptions are the PPHS 2001,2004 and 2010 and PRHS 2011-12, but their limitations are explained above. The study overcomes this limitation by creating a unique longitudinal panel through

[3] Appendix 3 has more information about the exact assets used in the computation of the wealth index.

the PDHS 2017-18 out-migration module. The out-migration module collected information on the out-migration at the household level by asking the following questions i.e. The household reporting an out-migrant was asked follow up questions about the gender of the migrant, the date at which he or she moved away, the main reason for moving away, relationship to the head of the household and the destination (city, district or country). The households were also asked if they had sent money or received money from the migrant in the past year.

The total number of individuals out-migrating in the past ten years were 4811, the study creates an individual level data for everyone since the time of his or her birth and final migration in the past ten years and merges it into the panel. The migration event is characterized as a dummy variable where 0 is for the year the individual stayed in the district and 1 is for when the migration event took place.

The individuals are allocated to the district they were born in and it is assumed that the only migration they have partaken is in the past ten years and prior to this migration he or she was living in the same district since birth. It is further assumed that the person is not a seasonal or a cyclical migrant and only migrated once in the past ten years. This is a strong assumption given that most of the migration in Pakistan is seasonal, however, due to the limitations of data it must be made.

The SPEI of 12 and 24 months is then matched with these districts from the time of birth and the time of migration[4]. For instance, if a person is born in 1989 and migrates in 2010 the panel matches the SPEI for each year since the time of birth[5] to final migration to see the aggregate effect of weather variations on the final migration decision. This modelling technique is often applied in hazard modeling and time event history models where the events leading to the person exiting the population from the time of his or her entry into the panel is analyzed (Bocquier et al. 2017).

As the SPEI is available only till the time of 2015 the study analyses the migration decision taken in the past eight years only. The migration events occurring for the year 2017 and 2018 are not analysed.

## 5.5 METHODOLOGY

### 5.5.1 Theoretical Framework

Human capital theory of migration states that the individuals who migrate are often those for whom the difference between the expected income at the destination and actual income is the greatest and the migration costs are the lowest (Taylor & Martin 2001). Todaro (1980) states that migrants have certain characteristics which make them different from the rest of the population i.e. they are younger, better educated, skilled, less risk-averse, more achievement-oriented and have better networks than their counterparts. Such differences increase their success at the destination and allow for better assimilation

[4] The SPEI is merged based on year and the district where the individual lived, however the SPEI is not available for all the districts reported in the survey therefore some observations were lost.

[5] The SPEI is matched for the period 1951 to 2015. 1951 is the date of birth of the oldest migrant in the sample.

at the destination. The human capital theory though relevant is outlining the characteristics of migrants assumes that the migration decision is taken independently by the individual migrating. However, in the case of less developed countries migration decision are usually taken by households and even communities, and it is a joint decision through which the utility of the entire household is expected to increase.

The theories of "*new economics of labour migration*" presented by Stark & Levhari (1982) and Stark & Bloom (1985) shed light on the motivation behind the rural to urban migration where a member of a household is relocated ideally to a destination where the income is not correlated with that of the origin and the risk is mitigated. The migration decision is taken jointly by family members and in some cases by entire communities and therefore people act collectively and not individually to maximize the expected utility (Taylor & Martin 2001). Through this joint decision making the costs and returns are shared, and the migrant has a mutually agreed obligation of sending back remittances (Stark & Levhari 1982). The remittances, in this case, are more of an intertemporal contractual arrangement between the migrant and the family and not purely based on the individual's motivation. Moreover, the migrant and the household voluntary enter a mutually beneficial contract with each other rather than a third party due to enforcement issues and the migrant is mostly obligated to send back remittances. Therefore, the migration decision is a calculated strategy on part of the household to reduce the risk and increase the return.

Farmers in rural areas are subjected to several risks which are beyond their control such as rainfall variation, pests, and crop failure. In the absence of efficient credit and insurance market, a small-scale farmer controls the risk by diversifying its income portfolio and sending a household member to an urban area. This is based on the that the earnings in the urban areas would be positive and the benefits would exceed the costs (Stark and Bloom 1985).

In the presence of increased variation in weather events and the associated changes in agricultural productivity, absence of insurance and efficient credit markets, households in rural area's needing to diversify their income portfolio send one or more of their members to urban or other rural areas, preferably in areas where the incomes are not correlated with origin. Such incidence of migration is expected to increase with changing climate and increased occurrence of adverse weather effects.

### 5.5.2 Estimation Strategy

#### *5.5.2.1 Theoretical*

The empirical strategy comprises of two steps. Firstly, it analyses the weather variation as a risk factor for migration out of rural areas in Pakistan and interacts it with various background factors of age, wealth index and gender. The weather variable is used as a continuous variable, as a categorical variable reporting a wide range of weather outcomes and as a categorical variable where only the extreme weather outcomes are outlined. The model for weather variation as a risk factor in migration is as follows:

$$Yit = \propto + \beta 1_{-1} SPEIdist(12{,}24)_{t-1} + \beta 2 Age_{it} + \beta 3 Gender_i + \beta 4 Wealth_i + \varepsilon_{it}$$

Where the migration episode for individual i in time t depends on the weather variations prevailing in the district from which migration took place in the year before migration reported by SPEI of 12 and 24 months, age of the migrant at the time of migration, the wealth status of the household where the individual migrated from at the time of the survey and gender of the migrant. The SPEI is used as a lagged function to allow for establishing the cause and effect link between the weather variation and the final migration episode.

Since the migration episode varies across gender in the second stage the study attempts to account for this variation by interacting gender with the weather conditions. This would allow for effectively capturing the effect of variation in genders and would allow for seeing the response of both males and females across a range of weather events. The model for weather variation interacted with gender is as follows:

$$Yit = \propto + \beta 1_{-1} SPEIdist(12{,}24)_{t-1} + \beta 2 Age_{it} + \beta 3 Gender_i + \beta 4 Wealth_i + \beta 5 Gender_i * SPEIdist(12.24)_t + \varepsilon_{it}$$

Where the migration episode for individual i at time t depends on the weather conditions prevailing in the district the previous year of the migration event as captured by SPEI 12 and 24 months., age of the individual at the time of migration, the wealth status of the household where the individual migrated from at the time of the survey and gender of the migrant. The adaptation of males and females varying across adverse weather outcomes are captured by interacting the gender with the SPEI of prevailing year. The SPEI of 12 and 24 months interacts with the year the migration event took place to avoid issues of multicollinearity.

#### *5.5.2.2 Empirical*

The study uses both linear probability model (OLS) and logit regression to see if the migration event is occurring due to weather variations when controlled for background variables of age, gender, and household endowment measured by the wealth index.

The Linear Probability Model is an OLS application to binary outcomes of 0 and 1, instead of the standard continuous outcomes (Deke 2014). The linear probability model allows for comparison across groups and estimates the conditional expectation of the outcome (Holmes, Ejrnæs, Karlson 2015). The major advantage of LPM is that the parameter estimates can be easily interpreted as “mean marginal effects” of the independent variable on the outcome variable and therefore provide clear-cut interpretations of the covariates on the outcome (Von Hippel 2015; Holmes, Ejrnæs, Karlson 2015).

However, the LPM assumes that the relationship between the covariates and the outcome variables is inherently non-linear (Deke 2014) and that the functional form of the LPM might not be correctly specified leading to biased estimates. In extreme cases the mis-specified functional form could lead to predicted probabilities which are less than 0 or greater than 1 (Deke 2014). Moreover, for group comparisons and analysing the difference in effects the coefficients of LPM suffer from scale identification problems and has limitations related to outcome truncation i.e. the values might lie above or below a specific threshold or range (Holmes, Ejrnæs, Karlson 2015). In addition to that, the estimates of LPM also suffer from robustness issues and the residuals might be heteroskedastic. To correct for that the study also incorporates a logit regression model for the binary dependent variable of migration to account for the correct functional form and provide side by side comparisons of the estimates of the two methods.

# 6 RESULTS

## 6.1 BIVARIATE ANALYSIS

**Age at which Migration took Place**

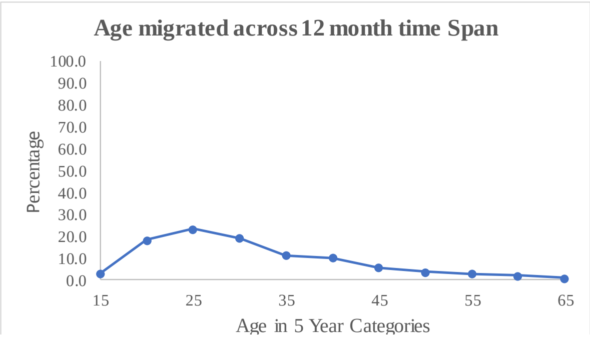



*Figure 4 Line graph showing the age of migrants*

**Wealth Status of Migrants**

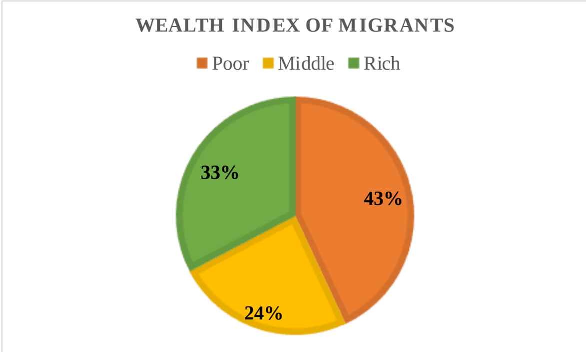



*Figure 5 Pie-Chart showing the wealth status of migrants*

**Gender of Migrants**

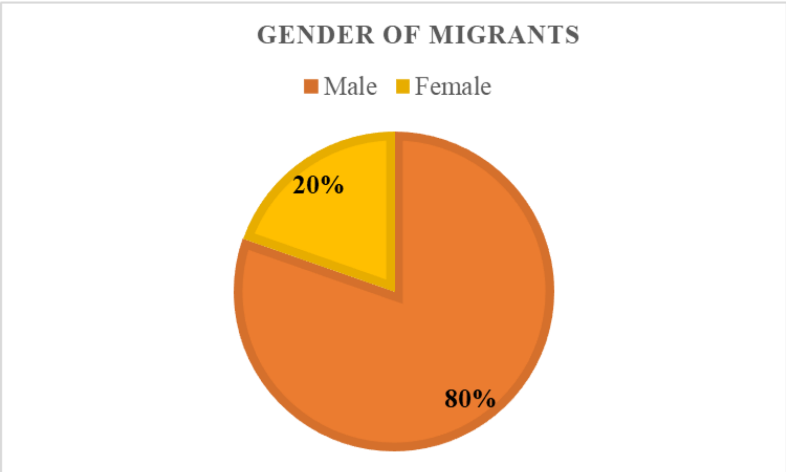



*Figure 6 Pie-Chart showing the Gender of Migrants*

**SPEI in Extreme Values**

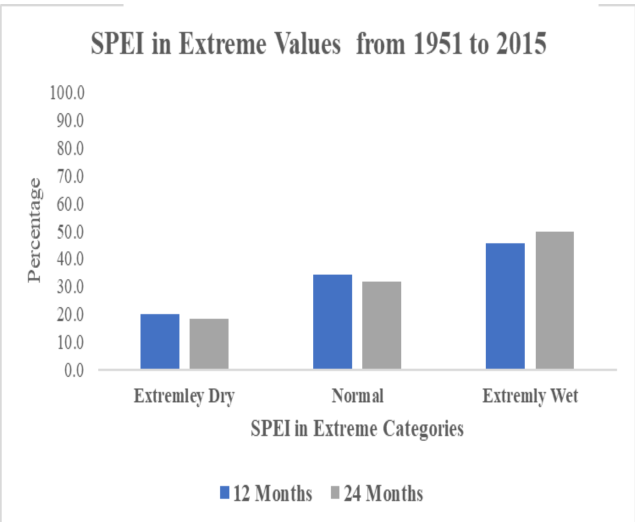



*Figure 7 Bar Chart Showing SPEI in Extreme Values*

**SPEI in Categories**

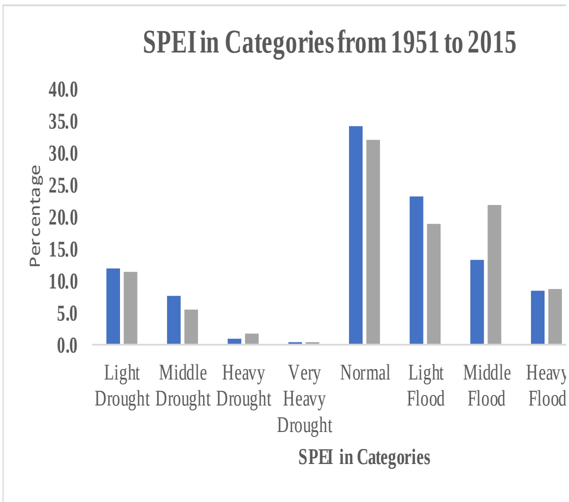



*Figure 8 Bar Chart Showing SPEI in Categories*

**Table 2: Descriptive Statistics**

| Variables | SPEI 12 Months | | | | | SPEI 24 Months | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Rural Sample | | | | | | | | | |
| | N | Mean | SD | Min | Max | N | Mean | SD | Min | Max |
| **Migrants** | 28980 | 0.020 | 0.140 | 0 | 1 | 28980 | 0.020 | 0.140 | 0 | 1 |
| **Age in 5 Year Categories** | 28980 | 31.312 | 10.742 | 15 | 65 | 28980 | 31 | 10 | 15 | 65 |
| **Gender** | 28980 | 1.196 | 0.397 | 1 | 2 | 28980 | 1.196 | 0.397 | 1 | 2 |
| **Wealth Index** | 28980 | 2.467 | 1.328 | 1 | 3 | 28980 | 2.467 | 1.328 | 1 | 3 |
| **SPEI Continuous** | 28980 | 0.391 | 1.298 | -2.489 | 9 | 28980 | 0.391 | 0.883 | -2.804 | 2.571 |
| **SPEI Categorical** | 28980 | 5.077 | 2.073 | 1 | 9 | 28980 | 5.257 | 2.053 | 1 | 9 |
| **SPEI Extreme** | 28980 | 2.254 | 0.771 | 1 | 3 | 28980 | 2.313 | 0.763 | 1 | 3 |

*Source: Pakistan Demographic and Health Survey 2017-18 out-migration module and Vicente-Serrano et al (2010) gridded dataset*

*Table 2 Sample Characteristics of Longitudinal Data*

The results of the bivariate analysis are shown in Table 2 and Figure 4, 5,6,7 and 8.

Figure 4 shows the age at which the migration takes place out of rural areas. The figure shows that in the rural sample there is a peak in migration between the age of 15 and 30, with the average age of the migrant being 31 years of age (Table 2). This could be attributed to the limited number of opportunities available in rural areas and most of the working age individuals must migrate to other urban or rural areas.

Figure 5 shows the wealth index which measures the household's endowment at the time of the survey. The figure shows that in rural areas the tendency to out-migrate is higher for poorer individuals as compared to relatively better off individuals. This could be due to the limited number of employment opportunities available in rural areas and losses in livelihood due to changing weather patterns. Moreover, in rural areas of Pakistan seasonal migration is common and household members often migrate to nearby cities and villages during harvest season.

Figure 6 shows the gender of migrants. The prevalence of migration is higher for males as compared to females and it is in accordance with male migration patterns prevailing across South Asia where men mostly migrate to urban areas for better livelihood opportunities.

The climate variable i.e. SPEI is used as a continuous variable, a categorical variable where all ranges of dry, normal and wet conditions are incorporated and as an extreme weather variable where extreme weather i.e. extremely dry, extremely wet and normal is incorporated. Figure 7 and 8 show the SPEI in Categories and SPEI in Extreme weather across the time period of 1951 to 2015 for both a 12 month and a 24-month time period. Figure 7 shows that the prevalence of extreme wet condition's i.e. flood is higher for rural Pakistan as compared to extremely dry conditions i.e. drought and even normal weather conditions across the 12- and 24-month period. These results are supported by figure 8 where after normal weather conditions most of the rural areas suffered from light and middle flood in both the 12- and 24-months' time period.

## 6.2 MULTIVARIATE ANALYSIS

### 6.2.1 Model 1

The regression results for LPM and Logistic Regression Model are shown in Table 3 and 4 (Appendix 2) for the period of 12 and 24 months respectively. In both the LPM and logit model's SPEI is added as a continuous variable, as a categorical variable measuring a range of wet and dry conditions and as an extreme weather value where the association between extreme weather events and migration are analysed. Though this might seem repetitive, it provides a deep insight into the migratory behaviour of individuals firstly by establishing that migration is taking place due to weather events and secondly by predicting the migration pattern across a wide range of extreme weather outcomes.

In the first model (1) of LPM and logit analysis, SPEI is added as a continuous variable for both 12 and 24-month. The results show that across a 12-month time there is a positive and significant association between migration and extreme weather events. The effect size ratio indicates that a one Sd increase in SPEI (12 months) increases the probability to migrate by 26 percentage points while keeping other things constant. Similar results are shown across the 24-month time where it shows that a one percent change in weather events increases the probability to migrate by up to 30 percentage points

A parallel trend is observed in the logit model across a twelve- and twenty-four-time month time period, the odds of migrating due to extreme weather conditions rises by up to 1.18 times across the twelve-month time period and 1.281 across the 24-month time period. This establishes that weather is a significant push factor for migration out of rural areas. However, the odds of migrating across a 12-month time are higher as compared to the 24 months indicating that across longer time periods people can opt for other forms of adaptation and not necessarily migrate.

In the second model (2) of LPM and logit regression, SPEI is added as a categorical variable where the changes in SPEI are gauged over a wide range of wet to dry outcomes. In the LPM the migration from rural areas is significant for a 24-month period across a range of weather outcomes such as middle drought, heavy flood, and very heavy flood. In the LPM the relationship between middle drought and migration is negative and this could be attributed to the incorrect form of LPM. On the other hand for both heavy and very heavy flood this relationship is positive, and as compared to the reference category of normal weather the probability to migrate out of rural areas rises by 2.5 percentage points in the case of heavy flood and 7.1 percentage points in the case of a very heavy flood. Similar results are portrayed in the Logit model across a 24-month time period where the relationship between migration due to adverse weather conditions is positive and significant for middle drought, heavy flood, and very heavy flood. The results show that as compared to the reference category of normal weather conditions the odds of migrating due to middle drought are 0.378 times less. Moreover, these odds rise significantly for a heavy flood by up to 2.4 times and very heavy flood by up to 5.748 times.

In the third model (3), SPEI is added as an extreme weather variable where migration due to extreme weather events like floods and droughts is analyzed across 12- and 24-month time period. The results show that as compared to the reference category of normal weather conditions the migration out of rural areas is significant for flood conditions in both LPM and logit model across 24 months. Moreover, in the LPM a one percent increase in flood conditions increases migration by up to 0.6 percent and in the logit model, the odds of migrating out of rural areas increases by up to 1.463 times as compared to normal weather conditions.

Age is added as 5-year categories in all the models and only accounts for the people in the working age group of 15 to 65 as prescribed by the Labour Force Survey (2017-18). In both the model's migration out of rural areas is significant but in the LPM the relationship is negative. This again is corrected for in the logit regression model where it is shown that migration out of the rural area is positive and significant across all age groups in both 12- and 24-month times periods. It shows that as compared to the reference category of 15-20 years the probability of migrating out of rural areas slowly is less than one for all categories. This indicates that across the working age group of 15 to 65 more young people are likely to migrate out of rural areas probably due to the limited number of livelihood opportunities.

The wealth index is added as a categorical variable in all the three models across the 12 and 24-month time span and is divided across three categories of poor, middle income and rich. As compared to the reference category of middle income the probability of migration out of rural areas is not significant for both poor and rich households in both the LPM and logit regression models.

Gender is also added as a categorical variable in the model. The results show that as compared to the reference category of males the migration for females is significant across the 12-month time frame in both the LPM and logit model. The results of the LPM show that as compared to the reference category of males a one percent change in weather conditions increases the probability of female migration by up to 0.4 percentage points. The extent of female migration is even more pronounced in the logit model where the odds of female migration increases by approximately 1.2 times due to adverse weather conditions in all the models across the 12 months' time frame.

### 6.2.2 Model 2

As migration out of rural areas in Pakistan varies across gender the study attempts to analyze this variation in detail by interacting gender with weather conditions. This allows for seeing the diverging response of both males and females across a wide range of weather outcomes. The regression results are reported in table 5 (Appendix 2).

In the regression model, the SPEI is added as a continuous variable without any specification to see the difference in adaptation for males and females. The results show that there is a significant positive relationship between out-migration and gender across the 12 -month time in LPM and logit model. The results of the LPM model show that as compared to the reference category of males a one percent change in weather conditions increases the probability of female out-migration by approximately additional 0.6 percentage points across both the 12-month time. Furthermore, as compared to the reference category of males the odds of female migration due to adverse weather conditions rises by an additional 1.2 times across the 12-month time. The relationship between female migration and adverse weather events is insignificant across the 24-month time.

The results are in accordance with the results reported by (Rosenzweig & Stark 1989) for India where daughters are married off to far off locations to reduce the impact of the changing natural environment on them. Similar trends are observed across Pakistan where even females are at risk of migrating from rural areas to the changing natural environment. These results are different for the case of Pakistan where the migration is mostly male, however, due to the ever-changing natural environment better empowerment outcomes even females must migrate from rural areas. Of course, this migration might not necessarily be for economic purposes as most of the females migrate as tied migrants due to marriage or accompanying family members as shown in sample characteristics in Appendix 1.

# 7 DISCUSSION, CONCLUSION AND STUDY LIMITATIONS

Like many other developing countries migration in Pakistan is considered as a potential exit strategy for rural households in the face of risk (Chen,Kosec, & Mueller 2019). This risk is intensified in the face of an ever-changing natural environment which posits a decrease in agricultural income, reduction in crop yields and overall losses in livelihood (Feng, Krueger, & Oppenheimer 2010; Kubik, and Maurel 2016; Feng, Krueger, and Oppenheimer 2010, Lohano 2018; Healy and Manusri 2008). Rural to urban migration is often considered as a likely risk mitigation strategy and for Pakistan, the prevalence of such migration has increased due to climate change and a changing natural environment (Lohano 2018; Grey,Mueller & Kosec 2014). People in rural areas not only have to face natural disasters like flood's but are also prone to the slow on setting effects of climate change in the shape of droughts and changing rainfall patterns.

This study attempts to analyze the patterns of rural-urban migration in Pakistan and examine the underlying factors of climate change which act as push-factors for migration out of rural areas. The study shows that there is a significant and positive relationship between changing weather proxied through SPEI and rural out-migration. The study further classifies SPEI into a wide range of wet and dry conditions and attempts to examines the extent of migration for the exact weather condition across a 12- and 24-month timespan. The results show that migration due to middle drought, heavy flood, and very heavy flood are significant and positive across a 24-month timespan. The study also analyses the extent of migration from rural areas across extreme weather conditions of SPEI. The results show that there is a significant and positive relationship between migration and extreme weather conditions, but the migration due to extreme weather conditions is lower than migration in normal weather conditions.

These results are in accordance with those of (Gray, Mueller & Kosec 2014) where they proved that the extent of male out-migration from rural areas has increased due to heat stress. These are unique results as most of the migration occurring in Pakistan has been due to flood but the study shows that there is migration occurring in drought conditions as well. In recent memory, the floods of 2010 not only caused wide set losses but also displaced thousands. However, the response of both the National and Provincial Disaster Management authority for floods was more effective than for people affected by drought despite the frequently reoccurring droughts in the country (Gray, Mueller & Kosec 2014). This could be due to the imminent nature of the floods where widescale relief activities are needed for evacuation and livelihood regeneration purposes. On the other hand, for a country like Pakistan where agriculture is the backbone of the economy droughts and changing rainfall patterns posit an immediate threat to the livelihood of millions living in rural areas and requires immediate policy action.

The study also proves that there is a significant relationship between migration and age, where the probability to migrate out of rural areas is higher for younger age groups as compared to older ones. This could be due to retarded growth in rural economies and lack of employment opportunities in rural areas which are diminished even further due to the on-setting effects of climate change and young people are forced to migrate. Such an increased level of rural to urban migration causes added stress on an already vulnerable urban infrastructure (Arif 2005; Gizewski & Homer-Dixon 1996). In most cases, migrants out of rural areas are forced to settle in squatter settlements and engage in the informal economy due to lack of jobs in urban areas (Gizewski & Homer-Dixon 1996).

The study also analyses the diverging responses of both males and females to changing weather conditions and migration. The results show that the probability of female migration from rural areas due to changing weather conditions is positive and significant. These are unique results as most of the migration in Pakistan is highly male-oriented (Memon 2005; Sattar 2014) where males being the traditional breadwinners migrate to urban areas for economic purposes. However, due to a changing natural environment female out-migration has also increased in recent years. As compared to their male counterparts who mostly migrate for economic reasons female migrate as tied-migrants due to marriage and accompanying other family members. In the face of an increased risk posited by changing weather conditions, parents might be motivated to get their daughters married in far-off locations where the risk between the destination and the origin is not correlated. This hypothesis has been proved by Rosenzweig & Stark (1989) for India and can also be true for Pakistan.

Overall the findings of the study constitute important theoretical and empirical evidence for migration due to climate change in Pakistan. The results of the study analyses and predicts the extent of migration occurring out of rural areas across a range of wet and dry weather conditions captured by the SPEI. The study adds to the increasing evidence on the drastic and far-reaching impacts of changing temperatures, heat stress and drought on the economy and population and proves that there has been an increase in migration due to drought across longer time periods.

## 7.1 LIMITATIONS

The findings of the study provide an important insight into migration as an adaptation strategy due to adverse weather events in rural Pakistan. The findings of the study even though are representative, they must be reviewed considering the following limitations.

Most of the studies analysing the association between climate change and migration compare the adaptation response across those people who migrate and those who stayed. Such a comparison provides an insight into the characteristics of the migrants and into the various adaptation strategies available to rural households in the face of a changing natural environment. However, due to the limitations of the data such a comparison could not be made. The PDHS 2017-18 has an out-migration module in their household roaster where the out-migration from a household is reported on behalf of the migrant by the household head or any other informed person. This module only reports the people who have left the household and does not account for comparisons with the stayers. Furthermore, as the migration information is not self-reported by the migrant the reporting has the potential for recall error and informant bias.

Moreover, most of the studies analyzing migration due to adverse weather events use longitudinal data where data from the persons birth to various migration episodes is collected. For the case of Pakistan, such data is rare and the two-panel data sets having a migrant module are not representative. The study overcomes this gap by creating a long-format longitudinal data and assumes that the individual has migrated only once in the past eight years and assumes that the person was staying in the same district since birth. This is a very strong assumption, but it must be made due to data limitations.

Apart from that, as the merging of the longitudinal data with the weather data of SPEI 12 and 24 months is done on district and year basis some of the data is lost due to both the data sets not having same districts. In addition to that, the SPEI data is available till 2015 while as the PDHS out-migration module has information about the migration occurring in the past ten years. Therefore, when the data is merged it only accounts for the migration in the past eight years and the data for 2016 and 2017 is not used.

Overall the findings of the study constitute important theoretical and empirical evidence for migration due to climate change in Pakistan. The results of the study analyses and predicts the extent of migration occurring out of rural areas across a range of wet and dry weather conditions captured by the SPEI. The study adds to the increasing evidence on the drastic and far-reaching impacts of changing temperatures, heat stress and drought on the economy and population and proves that there has been an increase in migration due to drought across longer time periods for both males and females.

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# 9 APPENDICES

## 9.1 APPENDIX 1

### 9.1.1 Sample Characteristics

Table 2 shows the level of migration occurring between both the rural and urban area as reported by the PDHS 2017-18 out-migration module. The total number of individuals who migrated are 4811, overall 14 percent of the households had one reported out-migrant. Most of the out-migration is originating out of rural areas i.e. 60 percent, supporting the prevailing trend of rural-urban migration in Pakistan. The prevalence of migration out of rural areas is higher for males as compared to females i.e. 76 percent of the out-migrants from rural areas were male. This is in accordance with the cultural norms of South Asia where males usually migrate looking for work.

The levels of out-migration rate are highest in Punjab province i.e.29 percent owing to the large population density of the area, followed by AJK at 20 percent due to its proximity of the capital city and KPK at 16 percent probably due to the prevailing conflict in the area. Most of the respondents in the survey had left rural areas due to economic opportunities i.e. 57 percent, marriage i.e. 15 percent, study, and job transfers. The trend might support the hypothesis that the livelihood opportunities in rural areas are getting reduced due to climate change and agricultural losses, and people are migrating to urban areas in search of work.

Most of the migrant's households reporting an out-migrant stated that their son or daughter i.e. 67 percent had left the household in the past ten years, followed by husband or wife i.e. 11 percent of the head of the households. The prevalence of migration peaks at the working age group of 20 to 30 years at 11 percent and remains high throughout the working age group. However, the prevalence of outmigration is also high among the elderly and they might be leaving the rural areas as tied migrants or due to health care reasons.

## Table 2: Sample Characteristics

| Variables | Percentage | N |
|---|---|---|
| Rural | 60 | 2871 |
| Urban | 40 | 1940 |
| **N** | 100 | 4811 |

| **Migrated From** | | | |
|---|---|---|---|
| **Variables** | **Rural Area Percentage** | **Urban Area Percentage** | **N** |
| **Gender** | | | |
| Male | 76 | 64 | 1940 |
| Female | 24 | 36 | 2871 |
| **Region** | | | |
| Punjab | 29 | 23 | 1267 |
| Sindh | 4 | 11 | 336 |
| Khyber Pakhtunkhwa (KPK) | 16 | 17 | 775 |
| Baluchistan | 3 | 5 | 195 |
| Gilgit Baltistan | 15 | 6 | 546 |
| Islamabad | 3 | 12 | 335 |
| Azad Jammu & Kashmir (AJK) | 20 | 21 | 983 |
| Federally Administered Tribal Areas (FATA) | 10 | 4 | 365 |
| **Main Reason for Migrating** | | | |
| Better Economic Opportunities | 57 | 44 | 2491 |
| Marriage | 15 | 26 | 919 |
| Accompanying Family Members | 9 | 8 | 416 |
| Study | 13 | 14 | 637 |
| Job Transfers | 4 | 5 | 189 |
| Others | 4 | 3 | 159 |
| Relationship to Head of House | | | |
| Wife or Husband | 11 | 10 | 526 |
| Son or Daughter | 67 | 67 | 3213 |
| Son or Daughter in Law | 3 | 2 | 127 |
| Grandchild | 5 | 3 | 208 |
| Parent | 2 | 2 | 85 |
| Brother or Sister | 8 | 11 | 440 |
| Others | 4 | 5 | 212 |
| **Age Migrated** | | | |
| 0 to 10 years | 10 | 7 | 429 |
| 10 to 20 Years | 10 | 7 | 434 |
| 20 to 30 Years | 11 | 12 | 540 |
| 30 to 40 Years | 7 | 7 | 320 |
| 40 to 50 Years | 10 | 10 | 475 |
| 50 to 60 Years | 9 | 11 | 477 |
| 60 to 70 Years | 13 | 14 | 629 |
| 70 to 80 Years | 11 | 12 | 542 |
| 80 Plus | 20 | 20 | 1021 |
| **Wealth Status** | | | |
| Poor | 56 | 13 | 1868 |
| Middle | 20 | 20 | 972 |
| Rich | 23 | 67 | 1970 |

Table 2Migrant and migrant-sending household characteristics. Sample Characteristics of Out-Migrant module PDHS 2017-18

## 9.2 APPENDIX 2: REGRESSION RESULTS

### 9.2.1 Model 1

#### *9.2.1.1 Linear Probability Model*

**Table 3: Linear Probability Model (OLS) for Model 1**

| SPEI | 12 Months | | | 24 Months | | |
|---|---|---|---|---|---|---|
| **Variables** | **Linear Probability Model (OLS)** | | | | | |
| | **(1)** | **(2)** | **(3)** | **(1)** | **(2)** | **(3)** |
| | **SPEI Con** | **SPEI Cat** | **SPEI Ex** | **SPEI Con** | **SPEI Cat** | **SPEI Ex** |
| **Dep: Migrant Dummy** | | | | | | |
| **SPEI Continuous $_{t-1}$** | | | | | | |
| **SPEI Continuous$_{t-1}$** | 0.00560*** | | | 0.00470*** | | |
| | (0.000634) | | | (0.000932) | | |
| **SPEI Categorical$_{t-1}$** | | | | | | |
| **Normal ®** | | | | | | |
| **Light Drought** | | -0.00225 | | | 0.00458 | |
| | | (0.00277) | | | (0.00283) | |
| **Middle Drought** | | -0.00439 | | | -0.0112*** | |
| | | (0.00332) | | | (0.00381) | |
| **Heavy Drought** | | -0.000735 | | | 0.00390 | |
| | | (0.00999) | | | (0.00672) | |
| **Very Heavy Drought** | | 0.0216 | | | -0.0216 | |
| | | (0.0170) | | | (0.0339) | |
| **Light Flood** | | -0.000514 | | | 0.000357 | |
| | | (0.00222) | | | (0.00239) | |
| **Middle Flood** | | -0.000219 | | | -0.00276 | |
| | | (0.00267) | | | (0.00228) | |
| **Heavy Flood** | | -0.00502 | | | 0.0257*** | |
| | | (0.00317) | | | (0.00313) | |
| **Very Heavy Flood** | | 0.00865 | | | 0.0710*** | |
| | | (0.00746) | | | (0.0120) | |
| **SPEI Extreme Values$_{t-1}$** | | | | | | |
| **Normal ®** | | | | | | |
| **Extreme Dry** | | | -0.00171 | | | -0.00435* |
| | | | (0.00219) | | | (0.00224) |
| **Extreme Wet** | | | 0.00100 | | | -0.00413** |
| | | | (0.00186) | | | (0.00187) |
| **Age in Categories** | | | | | | |
| **15 to 20 Years ®** | | | | | | |
| **20 to 25 Years** | -0.0185*** | -0.0182*** | -0.0183*** | -0.0183*** | -0.0186*** | -0.0183*** |
| | (0.00507) | (0.00507) | (0.00507) | (0.00507) | (0.00506) | (0.00507) |
| **25 to 30 Years** | -0.0259*** | -0.0256*** | -0.0257*** | -0.0262*** | -0.0261*** | -0.0259*** |
| | (0.00499) | (0.00499) | (0.00499) | (0.00499) | (0.00498) | (0.00499) |
| **30 to 35 Years** | -0.0328*** | -0.0325*** | -0.0327*** | -0.0332*** | -0.0329*** | -0.0329*** |
| | (0.00505) | (0.00506) | (0.00505) | (0.00505) | (0.00505) | (0.00505) |
| **35 to 40 Years** | -0.0353*** | -0.0350*** | -0.0352*** | -0.0358*** | -0.0352*** | -0.0354*** |
| | (0.00529) | (0.00530) | (0.00530) | (0.00530) | (0.00529) | (0.00530) |
| **40 to 45 Years** | -0.0354*** | -0.0349*** | -0.0350*** | -0.0358*** | -0.0357*** | -0.0353*** |
| | (0.00536) | (0.00536) | (0.00536) | (0.00536) | (0.00536) | (0.00536) |
| **45 to 50 Years** | -0.0390*** | -0.0387*** | -0.0389*** | -0.0396*** | -0.0392*** | -0.0392*** |
| | (0.00584) | (0.00585) | (0.00585) | (0.00585) | (0.00584) | (0.00585) |
| **50 to 55 Years** | -0.0386*** | -0.0384*** | -0.0386*** | -0.0390*** | -0.0386*** | 0.0387*** |
| | (0.00638) | (0.00639) | (0.00639) | (0.00639) | (0.00638) | |

*Continued*



*Continued*

| | | | | | | |
|---|---|---|---|---|---|---|
| **55 to 60 Years** | -0.0443*** | -0.0438*** | -0.0440*** | -0.0443*** | -0.0447*** | -0.0441*** |
| | (0.00676) | (0.00677) | (0.00677) | (0.00677) | (0.00676) | (0.00677) |
| **60 to 65 Years** | -0.0475*** | -0.0472*** | -0.0475*** | -0.0480*** | -0.0479*** | -0.0476*** |
| | (0.00748) | (0.00750) | (0.00749) | (0.00749) | (0.00748) | (0.00749) |
| **65 Years** | -0.0441*** | -0.0431*** | -0.0433*** | -0.0441*** | -0.0448*** | -0.0435*** |
| | (0.0101) | (0.0101) | (0.0101) | (0.0101) | (0.0101) | (0.0101) |
| **Wealth Index** | | | | | | |
| **Middle ®** | | | | | | |
| **Poor** | -0.00227 | -0.00234 | -0.00237 | -0.00225 | -0.00223 | -0.00234 |
| | (0.00210) | (0.00210) | (0.00210) | (0.00210) | (0.00210) | (0.00210) |
| **Rich** | 0.000725 | 0.000814 | 0.000799 | 0.000612 | 0.000409 | 0.000735 |
| | (0.00222) | (0.00223) | (0.00223) | (0.00223) | (0.00223) | (0.00223) |
| **Gender** | | | | | | |
| **Male ®** | | | | | | |
| **Female** | 0.00422* | 0.00434** | 0.00437** | 0.00432** | 0.00406* | 0.00439** |
| | (0.00216) | (0.00216) | (0.00216) | (0.00216) | (0.00216) | (0.00216) |
| **Constant** | 0.0472*** | 0.0500*** | 0.0492*** | 0.0478*** | 0.0476*** | 0.0515*** |
| | (0.00497) | (0.00509) | (0.00506) | (0.00498) | (0.00510) | (0.00505) |
| **Adjusted R-Squared** | 0.167 | 0.193 | 0.193 | 0.186 | 0.165 | 0.191 |
| **Observations** | 28,979 | 28,980 | 28,980 | 28,979 | 28,979 | 28,979 |
| **Number of Individuals** | 1,099 | 1,099 | 1,099 | 1,099 | 1,099 | 1,099 |

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Migration event is added as a dummy, weather variables of SPEI Cat and SPEI Ex are added as categorical variables. ® is the reference categories. Data Source: Pakistan Demographic and Health Survey 2017-18 out-migration module and Vicente-Serrano et al (2010) gridded dataset*

*Table 3 Regression Results of Linear Probability Model for Model 1*

#### 9.2.1.2 *Logit Model*

## Table 4: Logit Model for Model 1

| SPEI | SPEI 12 Months | | | SPEI 24 Months | | |
|---|---|---|---|---|---|---|
| | LOGIT Model | | | | | |
| Variables | (1) | (2) | (3) | (1) | (2) | (3) |
| | SPEI Con | SPEI Cat | SPEI Ex | SPEI Con | SPEI Cat | SPEI Ex |
| **Dep: Migrant Dummy** | | | | | | |
| **SPEI Continuous $_{t-1}$** | | | | | | |
| **SPEI Continuous$_{t-1}$** | 1.184*** | | | 1.281*** | | |
| | (0.0242) | | | (0.0635) | | |
| **SPEI Categorical$_{t-1}$** | | | | | | |
| **Normal ®** | | | | | | |
| **Light Drought** | | 0.892 | | | 1.254 | |
| | | (0.128) | | | (0.175) | |
| **Middle Drought** | | 0.783 | | | 0.378*** | |
| | | (0.145) | | | (0.118) | |
| **Heavy Drought** | | 0.969 | | | 1.223 | |
| | | (0.496) | | | (0.404) | |
| **Very Heavy Drought** | | 1.990 | | | - | |
| | | (1.194) | | | | |
| **Light Flood** | | 0.975 | | | 1.017 | |
| | | (0.109) | | | (0.131) | |
| **Middle Flood** | | 0.990 | | | 0.836 | |
| | | (0.132) | | | (0.109) | |
| **Heavy Flood** | | 0.753 | | | 2.492*** | |
| | | (0.134) | | | (0.311) | |
| **Very Heavy Flood** | | 1.419 | | | 5.748*** | |
| | | (0.447) | | | (1.816) | |
| **SPEI Extreme Values$_{t-1}$** | | | | | | |
| **Normal ®** | | | | | | |
| **Extreme Dry** | | | 0.913 | | | 0.801* |
| | | | (0.106) | | | (0.0939) |
| **Extreme Wet** | | | 1.051 | | | 0.809** |
| | | | (0.0985) | | | (0.0783) |
| **Age in Categories** | | | | | | |
| **15 to 20 Years ®** | | | | | | |
| **20 to 25 Years** | 0.601*** | 0.615*** | 0.610*** | 0.609*** | 0.600*** | 0.612*** |
| | (0.105) | (0.107) | (0.106) | (0.106) | (0.105) | (0.107) |
| **25 to 30 Years** | 0.461*** | 0.467*** | 0.464*** | 0.453*** | 0.452*** | 0.460*** |
| | (0.0807) | (0.0817) | (0.0810) | (0.0791) | (0.0794) | (0.0802) |
| **30 to 35 Years** | 0.326*** | 0.329*** | 0.326*** | 0.316*** | 0.319*** | 0.322*** |
| | (0.0612) | (0.0617) | (0.0610) | (0.0594) | (0.0601) | (0.0603) |
| **35 to 40 Years** | 0.273*** | 0.275*** | 0.273*** | 0.263*** | 0.270*** | 0.269*** |
| | (0.0592) | (0.0596) | (0.0590) | (0.0571) | (0.0587) | (0.0582) |
| **40 to 45 Years** | 0.272*** | 0.275*** | 0.274*** | 0.262*** | 0.262*** | 0.269*** |
| | (0.0608) | (0.0615) | (0.0612) | (0.0585) | (0.0587) | (0.0601) |
| **45 to 50 Years** | 0.191*** | 0.191*** | 0.189*** | 0.182*** | 0.185*** | 0.187*** |
| | (0.0581) | (0.0580) | (0.0574) | (0.0552) | (0.0561) | (0.0566) |
| **50 to 55 Years** | 0.197*** | 0.198*** | 0.195*** | 0.191*** | 0.194*** | 0.194*** |
| | (0.0698) | (0.0702) | (0.0693) | (0.0678) | (0.0687) | (0.0688) |
| **55 to 60 Years** | 0.0747*** | 0.0763*** | 0.0755*** | 0.0742*** | 0.0723*** | 0.0752*** |
| | (0.0448) | (0.0458) | (0.0453) | (0.0445) | (0.0434) | (0.0451) |
| **60 to 65 Years** | 0.0338*** | 0.0341*** | 0.0337*** | 0.0327*** | 0.0327*** | 0.0334*** |



*Continued*

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.0343) | (0.0345) | (0.0341) | (0.0332) | (0.0331) | (0.0338) |
| **65 Years** | 0.0837** | 0.0876** | 0.0868** | 0.0830** | 0.0789** | 0.0860** |
| | (0.0850) | (0.0889) | (0.0881) | (0.0842) | (0.0801) | (0.0873) |
| **Wealth Index** | | | | | | |
| **Middle ®** | | | | | | |
| **Poor** | 0.880 | 0.880 | 0.880 | 0.883 | 0.882 | 0.881 |
| | (0.0966) | (0.0965) | (0.0964) | (0.0968) | (0.0970) | (0.0965) |
| **Rich** | 1.035 | 1.034 | 1.033 | 1.023 | 1.011 | 1.030 |
| | (0.115) | (0.114) | (0.114) | (0.113) | (0.112) | (0.114) |
| **Gender** | | | | | | |
| **Male ®** | | | | | | |
| **Female** | 1.189* | 1.201* | 1.204* | 1.195* | 1.182* | 1.202* |
| | (0.117) | (0.118) | (0.118) | (0.117) | (0.116) | (0.118) |
| **Constant** | 0.0477*** | 0.0544*** | 0.0521*** | 0.0475*** | 0.0484*** | 0.0583*** |
| | (0.00845) | (0.0100) | (0.00952) | (0.00846) | (0.00910) | (0.0106) |
| **Pseudo R-Squared** | 0.115 | 0.108 | 0.106 | 0.116 | 0.141 | 0.108 |
| **Observations** | 28,979 | 28,980 | 28,980 | 28,979 | 28,962 | 28,979 |
| **Number of Individuals** | 1,099 | 1,099 | 1,099 | 1,099 | 1,099 | 1,099 |

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Migration event is added as a dummy, weather variables of SPEI Cat and SPEI Ex are added as categorical variables. ® is the reference categories. The R square in the logit model is McKelvey & Zavoina's R2. Data Source: Pakistan Demographic and Health Survey 2017-18 out-migration module and Vicente-Serrano et al (2010) gridded dataset*

*Table 4 Regression results for Logit Model for Model 1*

### 9.2.2 Model 2

#### *9.2.2.1 Logit and Linear Probability Analysis for Model 2*

**Table 5: LPM and Logit Model for Model 2**

| Variables | 12 Months | 24 Months | 12 Months | 24 Months |
|---|---|---|---|---|
| | Linear Probability Model (OLS) | | Logit | |
| **Dep: Migrant Dummy** | **(1)** | **(2)** | **(1)** | **(2)** |
| **SPEI** | | | | |
| SPEI | 0.00692*** | 0.00601 | 1.248*** | 1.440 |
| | (0.00176) | (0.00417) | (0.0813) | (0.352) |
| **SPEI t-1** | | | | |
| SPEI t-1 | 0.000231 | -0.00199** | 1.010 | 0.889** |
| | (0.000396) | (0.000937) | (0.0207) | (0.0455) |
| **Age in 5 Year Categories** | | | | |
| 15 to 20 Years ® | | | | |
| 20 to 25 Years | -0.0184*** | -0.0182*** | 0.602*** | 0.613*** |
| | (0.00506) | (0.00507) | (0.105) | (0.107) |
| 25 to 30 Years | -0.0258*** | -0.0261*** | 0.464*** | 0.454*** |
| | (0.00498) | (0.00499) | (0.0813) | (0.0794) |
| 30 to 35 Years | -0.0327*** | -0.0332*** | 0.328*** | 0.318*** |
| | (0.00505) | (0.00505) | (0.0616) | (0.0596) |
| 35 to 40 Years | -0.0352*** | -0.0358*** | 0.275*** | 0.264*** |
| | (0.00529) | (0.00530) | (0.0597) | (0.0572) |
| 40 to 45 Years | -0.0353*** | -0.0358*** | 0.273*** | 0.262*** |
| | (0.00536) | (0.00536) | (0.0610) | (0.0586) |
| 45 to 50 Years | -0.0390*** | -0.0398*** | 0.192*** | 0.181*** |
| | (0.00584) | (0.00585) | (0.0583) | (0.0550) |
| 50 to 55 Years | -0.0384*** | -0.0390*** | 0.199*** | 0.191*** |
| | (0.00638) | (0.00639) | (0.0706) | (0.0679) |
| 55 to 60 Years | -0.0439*** | -0.0444*** | 0.0759*** | 0.0739*** |
| | (0.00676) | (0.00677) | (0.0456) | (0.0443) |
| 60 to 65 Years | -0.0472*** | -0.0478*** | 0.0341*** | 0.0331*** |
| | (0.00748) | (0.00749) | (0.0346) | (0.0335) |
| 65 Plus | -0.0439*** | -0.0441*** | 0.0819** | 0.0828** |
| | (0.0101) | (0.0101) | (0.0833) | (0.0840) |
| **Wealth Index** | | | | |
| Middle ® | | | | |
| Poor | -0.00228 | -0.00215 | 0.878 | 0.886 |
| | (0.00210) | (0.00210) | (0.0964) | (0.0972) |
| Rich | 0.000716 | 0.000563 | 1.035 | 1.019 |
| | (0.00222) | (0.00223) | (0.115) | (0.113) |
| **Gender** | | | | |
| Male ® | | | | |
| Female | 0.00423* | 0.00426** | 1.191* | 1.192* |
| | (0.00216) | (0.00216) | (0.117) | (0.117) |
| **Constant** | 0.0457*** | 0.0566*** | 0.0447*** | 0.0795*** |
| | (0.00535) | (0.00647) | (0.00920) | (0.0225) |
| **R-Squared** | 0.165 | 0.184 | 0.117 | 0.119 |
| **Observations** | 28,979 | 28,979 | 28,979 | 28,979 |
| **Number of individuals** | 1,099 | 1,099 | 1,099 | 1,099 |

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Migration event is added as a dummy, SPEI is added as a continuous. ® is the reference categories. The R square in the logit model is McKelvey & Zavion's R2 and the LPM is the adjusted R-Square. Data Source: Pakistan Demographic and Health Survey 2017-18 out-migration module and. Vicente-Serrano et al (2010) gridded dataset*

*Table 5 Regression results of LPM and Logit for model 2*

## 9.3 APPENDIX 3

### 9.3.1 Wealth Index Computation

The wealth index is created through a PCA and shows the relative endowment of the household. The wealth index is comprised of the dwelling characteristics of the household in terms of the material used to construct walls of the dwelling, the type of floor the dwelling has, number of people per room, availability of a toilet facility, type of toilet facility, source of drinking water, availability of drinking water in the dwellings, presence of electricity, number of household's sharing toilet, type of cooking fuel used, food cooked inside or outside the house, the dwelling sprayed with insecticide and presence of a hand washing place (DHS 2019).

It also has information about the ownership of assets in terms of radio, television , telephone (non-mobile), refrigerator, cabinet, chair, Room Cooler, Air Conditioner, Washing Machine, Water Pump, Bed, Clock, Sofa, Camera, Sewing Machine, Computer, mobile phone, bicycle, motor cycle or scooter, animal drawn cart, car or truck, boat with motor, ownership of land in terms of agricultural land and its value, ownership of livestock, herds or farm animals in terms of cows or bulls, horses, donkeys, sheep, goats, chickens buffalo, camels and the household members having a bank account and the household having a domestic servant[6] (DHS 2019).

[6] For more information on the computation of the wealth index.
https://www.dhsprogram.com/programming/wealth%20index/DHS_Wealth_Index_Files.pdf
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