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# Coping with Drought in a Changing Climate: An Empirical Analysis of Farmers' Adaptive Behavior in North-West Balochistan

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**Abstract** Pakistan is ranked the 8th most vulnerable country to climate change in the Global Climate Risk Index Report, posing a serious threat to food security. The objective of this article is to assess the coping and adaptive behavior of farmers to climate induced drought in the North-West of Balochistan. The paper utilizes both primary and secondary data. The primary data is collected using 377 sample-size (households) through random sampling technique. The paper also employed multiple regression model to identify the factors influencing farmers adoptive and coping behavior for drought disasters. The results reveal that farmers tried on their own without any support to cope with long persistent spells of drought by using pipes for watering, dividing their gardens into small plots, giving water at night time, preserving stock supplies to adopt to the climatic changes however, at the same time, they sold their land and assets to cope with the situation. The results further reveal that despite selling their assets and land, people have migrated towards urban centers due to single sources of income. The multiple regression model indicates the most significant variables affecting the farmers coping and adaptive behavior for drought. These variables include age of the household head, employment occupation and daily wages occupation. The paper provides policy guidelines for provision of opportunities for diversified sources of income, capacity building, providing extension credit services to the farmers for better adoption that may increase the resilience of the farming communities to climatic risks.

**Keywords:** drought, climate change, adaptive behavior, coping, Balochistan

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## 1. INTRODUCTION

In the last one hundred years, significant shifts have been observed in Earth's climate due to global environmental change. These shifts have drastic effects on natural ecology, precipitation, evapotranspiration, human environment and other hydrological processes (Wu & Yang, 2024). Climate variability and human activities are the most significant factors resulting in the global climate change (Rawat, 2012). Many countries and communities prone to the impacts of climate change and socio-economic vulnerabilities require a well-coordinated landscape of disaster risk reduction (Lopera et al., 2023). The global environmental change has resulted pronounced impacts on the natural ecosystem in the recent decade (Organization-WMO, 2020), At the same time, an increased attention has been given to climate change associated consequences around the globe for climate resilience and adaptation (Tang, 2019). Such consequences have increased both the number and frequency of extreme events like droughts, floods, storms, heat and cold waves (Skoglund & Jensen, 2013). These consequences are further aggravated by the behavioral shortcomings by the decision makers in times of drought, resulting in insufficient preparedness at community level (Sharma, 2024). IPCC in its 5th report also confirms that agriculture production is likely to reduce due to climate change impacts (IPCC, 2014). Agrarian societies particularly the Asian Countries are more vulnerable to the impacts of climate change which results in many secondary issues reducing the well-being of the communities and farming communities (Lee et al., 2015). As result, these effects are widespread and have long term implications such as famine, health hazards, poverty and food insecurity (Bekele, 2024). In the current climate change discourse, drought poses pressure on environmental resources and peoples' livelihoods (UNDRR, 2021). The report further informs that drought periods can be longer or shorter, but affect all sectors particularly the water resources and agriculture sectors. Climatic variations take precedence when it comes to agricultural matters particularly in the context of crops production. Furthermore, this risk in agriculture sector is well connected with industry and food security (Hazzan et al., 2023). The contemporary research on climate change also reveals that drought events may increase in future and it would be difficult to predict and would have drastic impacts on the overall economy particularly the agriculture sector in many countries across the world (Hussain, 2022; Bekele, 2024). Additionally, these unpredictable changes in the global climate will certainly enhance the impacts on various other sectors as well (Veettil, 2023; Wongsit, 2021). As of today, drought affected 2.8 million people with 1.3 million human losses around the globe (Salama, 2012). Drought relates directly to climate change (Ajak, 2018) and it has altered the natural ecological activities to a greater extent that effects regions across the globe (Alkhalidi, 2023).

In the context of Asia, an increase in the frequency and intensity of extreme events are observed throughout the 20th century. The third Assessment report predicted an increase of 3°C in 2050s and 5°C in the decade of 2080s over Asian continent (Lal et al., 2001). The rise in surface temperature in some parts of Asia during recent decades ranged between less than 1°C to 3°C per century. In South East Asia, extreme weather events reported to be more frequent in the last 20 years (Ahmad et al., 2004). Similarly, increased frequency and intensity of droughts in Asia are largely due to rise in temperatures especially during summers and direr

months. Increased temperature and decline in precipitation has also threatened the wetlands in Asia, particularly, the wetlands in Pakistan, India, Bangladesh and China are drying up with severe degradation of ecosystem (Pan et al., 2003). Drought affected countries like India, Tajikistan, Iran, Afghanistan and Pakistan severely in the recent decade (Ur Rahman & Hamza, 2024). In southwest Asia and central Asia, a number of countries are affected by multi-year droughts from 1998-2002, such as Western Pakistan, Afghanistan, Uzbekistan, Tajikistan and Turkmenistan (Hussain, 2022). Poor adaptation strategies to climate change have threatened and caused adverse impacts on the production and livelihoods of millions of people in the developing countries. especially the agrarian communities (Wayal, 2023). These impacts are widespread and evident in rural agricultural areas around the globe (Agrwal, 2020). Drought impacts are more in Asia pacific affecting, the production of rice, wheat and maize on a large scale. Production loss is due to increasing water stress, increased temperature and El- Nino events that has decreased the number of rainy days in these countries (Taubenbock, 2008).

Pakistan too is no exception to it and its adverse effects across all sectors are observed particularly, the drought of 1998-2002, which affected the agriculture sector and livelihoods of people. A number of areas of the country were severely affected however, the impacts in Baluchistan and Sindh provinces were enormous, resulting in negative growth rate. Certain crops such as cotton, wheat and rice have shown the negative growth up to 10 percent during the drought period of 1998-2002 in Balochistan (Soomoro, 2011). Pakistan is one of the most severally affected countries and ranks 5th in the world, affected by impacts of climate change. In Pakistan droughts are overserved in every four to ten years (Anjum et al., 2012). Severe droughts in Pakistan are recorded in 1967–1969, 1971, 1973–1975, 1994. Additionally, the drought of 1998-2002 was the most devastating event that affected economy, people's livelihoods and reduced crop yields by 80%.

Balochistan province is particularly vulnerable to droughts and its impacts as it falls in semi-arid and arid agro-ecology type of land therefore, droughts occurrence in Balochistan are more sever in terms of magnitude and impacts in the recent climatic history of the province (Ahmed, 2016). The province is severely affected in 1998-2002, affecting 22 districts out of 29 (Government of Pakistan Bureau of Statistics, 2013). The dry spells of drought even started in 1996 but its worst shape was observed in 2002 during which the annual rainfall in the northern Balochistan reached to 60 to 150 mm (Shafiq & Kakar, 2007). During the drought periods, Balochistan province received 50% rain in summer and winter turned to only 37%. Provincial reports indicate that the drought of 2002 reduced the economic growth rate to 2.6% and affected 1.9 million people and 9.31 million livestock (Relief Commissionerate Balochistan, 2000-02). The province has significantly experienced the decline in ground water levels due to low precipitation, extended periods of droughts and proliferation of tube well installations for the last three decades. The number of tube wells in Balochistan escalated from 5,000 to over 40,000, causing substantial reduction in ground water levels (Ul-Haq et al., 2024). District Pishin is one the most vulnerable districts in the North-West Balochistan and suffered the most having agro-based economy where this study is conducted.

Adaptation and coping strategies to drought mitigation have been a major concern over the past few decades, within the global impacts of climate changes (Mardy et al., 2018). Adoptive

behavior and coping of the farmers decrease drought vulnerability and impacts over a single event however, increases drought risks due to continuous spell of droughts (Kalthof et al., 2025). Drought mitigation through coping and adoption is time consuming and requires subnational investment (Abbass, 2022). In Pakistan, several drought adaptation and coping strategies are diffused to other communities such as time of planning, rainwater harvesting and drought resistant verities (Ahmad & Afzal, 2020). The efforts for drought mitigation have attracted a number of studies on coping and adoption in Balochistan. One study (Ashraf et al., 2014) evaluated the coping and adoption behavior of farm households. The study findings indicate that several on-farm and off-farm adoption strategies are employed by the farmers, including crop management, water management, income diversification and agricultural inputs. Another study conducted by Ahmad et al. (2024) on negative effects of drought hazard and coping behaviors of farmers. The study reveals reveal that farmer employed a number of coping techniques to reduce the drought impacts, include crop diversification, efficient water management, and assets' depletion. In additional to that another study (Durrani et al., 2023) evaluated and explored the farmers' coping and adopting during extended periods of drought in Balochistan. The study employed binary logic regression which identified the farmers adaptation strategies including, reducing the number of domestic animals, selling household assists, borrowing money from relatives and sessional migration.

The aforementioned studies have considered generic adoptive and coping strategies for drought mitigation in Balochistan and have not addressed a number of feasible adoptive strategies to cope with drought by the farmers, which is not properly addressed in the literature. In such a scenario, to detect this research gape, the current study pays attention to examine the coping and adoptive behavior of farmers in Balochistan. hence there is great need to understand the specific coping adoptive strategies that farmers employ during drought at the farm level as well as the factors influencing the farmers' choice of coping strategies. Specifically, the study addressed and identified that coping strategies, farmers employed in times of drought their preparedness to drought and identified the factors influencing the farmers' adoptive and coping strategies. The study further provides insights into the processes that are intensely needed to overcome the challenges which may sensitize the policy makers to work on comprehensive approaches for sustainable development and drought resilience in the province.

## 2. LITERATURE REVIEW

Drought is a relative term and is defined in a variety of ways hence, requires a working definition depending on specific situations (Bekele, 2024). Therefore, this paper defines drought as "A deficit of rainfall in a particular region to the long term mean of atmospheric elements that affects a wide spread area by reducing the agricultural production and affecting livelihoods of people attached to agriculture sector" (Slegers, 2008). Drought affects all climatic zones and is observed over arid and semi-arid regions of the world. The duration of drought is from few weeks to years (Hazzan et al., 2023). Byun and Wilhite (1999) notes that drought starts from the low precipitation which affects the hydrological cycle, affecting the

water bodies on the surface and below, which ultimately reduces the production of agriculture. He further explains that low agriculture production leads to food security issues, poor nourishment and finally leads to famine (Hyman et al., 2005). Therefore, various definitions in a nutshell agree that drought is a condition of insufficient moisture caused by deficit in participation over some period of time (Osbahr et al., 2008; Sharma, 2024). The recent literature on drought and projections of climate change indicate that drought will likely to be very frequent across the globe due to increase in temperature and decrease in precipitation therefore, it is extremely important to improve the drought preparedness, awareness and monitoring to decrease the drought vulnerability and make the communities aware to take actions at the local levels to mitigate its effects at the community level (Lopera et al., 2023). Despite advances in research and technology, droughts still remain a major challenge worldwide for the researchers and policy makers, however the potential drought assessment and evolution in a proper fashion can facilitate the drought adaptation and preparedness at all levels (Mechler et al., 2010). Furthermore, it is evident from the literature that 50 percent of the earth terrestrial areas are vulnerable to the direct and indirect effects of droughts (Nadmani, 2016). In the recent past, a number of continents are severely affected by droughts and its long-lasting effects on social and economic sectors (Hesam, 2021). Due to its wide spread effects across all sectors, drought is getting more international and natural attention by the concerned departments and agencies.

In most of developing countries, agriculture is the backbone of their economies and livelihood option for rural communities (Bahta, 2021). Agriculture sector accounts for the larger share due to global environmental change, as the Sixth Assessment Report of Intergovernmental Panel on Climate Change argues that economic loses occurred for sectors with high direct exposure to climate change includes the regional losses of agriculture sector (Givsti, 2023). A part from that Kafy (2023) argues that most of the people from Asia-pacific suffer from food insecurity due to global environmental change in shape of drought which is an alarming indicator for the sustainability of the region. Additionally, devastating impacts are also observed in agriculture production, rearing of animals and water resources. As evidenced, agricultural droughts of 1980s and 1990s have affected a number of nations. These effects can well be observed in African continent (Ajak, 2018). In Africa alone, above 90% of the production is due to rainfall that is extensively affected by climate change. In south Asia particularly, the agriculture sector depends on ground water and river flow. In the back drop of climate change, droughts also possess challenges to risk management (Brill et al., 2024). Hence, more diverse strategies and approaches are required to address these unexpected consequences with the support of political will and well-informed disaster management institutions at the local levels (Chiba & Nagamatsu, 2023).

Addressing drought response, two main approaches are essential to mitigate the impacts by reducing greenhouse gasses and coping & adopting to new conditions (Wang et al., 2024). Adoption and coping to drought hazards are crucial for mitigating the adverse effects, particularly in developing countries, where farmers are key to effective management (Shabanali Femi et al., 2020). A scan of relevant literature reveals that an enormous range of potential adoptive responses to cope with drought. For example, Austen et al. (2002) conducted

a study with 62 farmers and found 33 different approaches for coping and adoption to drought hazards. Their study focused on only on-farm responses to drought excluding responses at the family and community levels. In addition to that Khan et al. (2018) argue that, farmers create coping mechanisms to cushion abrupt shocks and strains in their farming systems, and these mechanisms frequently coexist with longer-term adaptive techniques. In the context of Balochistan serval studies are conducted such as Ahmad et al. (2004), Shafiq and Kakar (2007), Ashraf (2013) and Ashraf et al. (2014). Some of these studies have focused on annual rainfall and capabilities of the government, farmers, and communities to cope with droughts. For example, Anjum et al. (2012), conducted study to analyze the available literature and rainfall to identify the drought prone zones. The study concludes that the frequency of drought is much higher in Balochistan and Sindh provinces compared to rest of Pakistan. Another study conducted by Mazhar and Nawaz (2014) analyzing the mean rainfall data of 36 weather stations across Pakistan and Balochistan for mapping meteorological drought intensity. The study findings reveal that Balochistan was the most arid part of the country and had the probability of extreme events in the future. (Ashraf & Routray, 2015) conducted study on drought preparedness and adaptation of farmers in Balochistan by analyzing 34 weather stations data on rainfall. The study reveals that Balochistan is highly vulnerability to future impacts of climate change due to poor monitoring of weather data collection and weather prediction. The study findings further reveal that due to poor awareness of the farmers regarding drought, irrigation methods and cropping pattern, the area will be more affected in the future drought events.

## 3. SELECTION OF THE STUDY AREA

Tehsil Karezat is located in District Pishin as shown in Figure 1 and has been selected as study area for this research work. This tehsil is most affected among other tehsils of the district and is still under the influence of drought spell (Ur Rahman & Hamza, 2024). The district has a number of valleys and its elevation from sea level is 1,370–1,680 meters. Lora River is the main river along with its tributaries flowing through Pishin district. The name Karezat is referred to Karezes (Underground channels of water used to transport water in from the hilly areas to the settled areas in Balochistan). In the past this area was irrigated by these Krezes but by the passage of time due to low precipitation and drought conditions, the rest of the karezes gone dry leaving two karezes which are present today (Ashraf et al., 2014). One is located in village khusab and other one is located in village Murgha.

### 3.1 Justification of the Selection of Study Area

Pishin is one of the drought prone districts in Balochistan, it has been severely affected from the drought of 1998-2002, affecting the agricultural sector which is the most prominent economic activity of the district. Almost 80% of the district population is engaged in agriculture activities. The selection of this study was based on the analysis of rainfall study conducted by

Ashraf (2015) in Baluchistan as well as study conducted by UNDP highlighting Pishion as one of the most drought prone region. It is also in line with the PDMA analysis report which endorses that the selected study area is highly prone to the drought. The current situation of the study area is not encouraging in terms of annual rainfall received and water supply through precipitation in the recent years. Furthermore, the district is still under the influence of the drought spell resulting in poor agricultural products, affecting the socio-economic life of the people whose livelihoods are attached with agriculture. In addition to that, tehsil Karezat is selected for primary household survey due to the following reasons. The area is most affected and vulnerable to drought events because of the non-availability of karezes which used to provide water for irrigation and other purposes. Apart from that, tehsil is severely affected in the drought period of 1998-2002. The tehsil is also selected due to its agro-based economy, because more than 80% of the people of the tehsil are engaged in agricultural activities and their livelihoods are attached with the agricultural production.

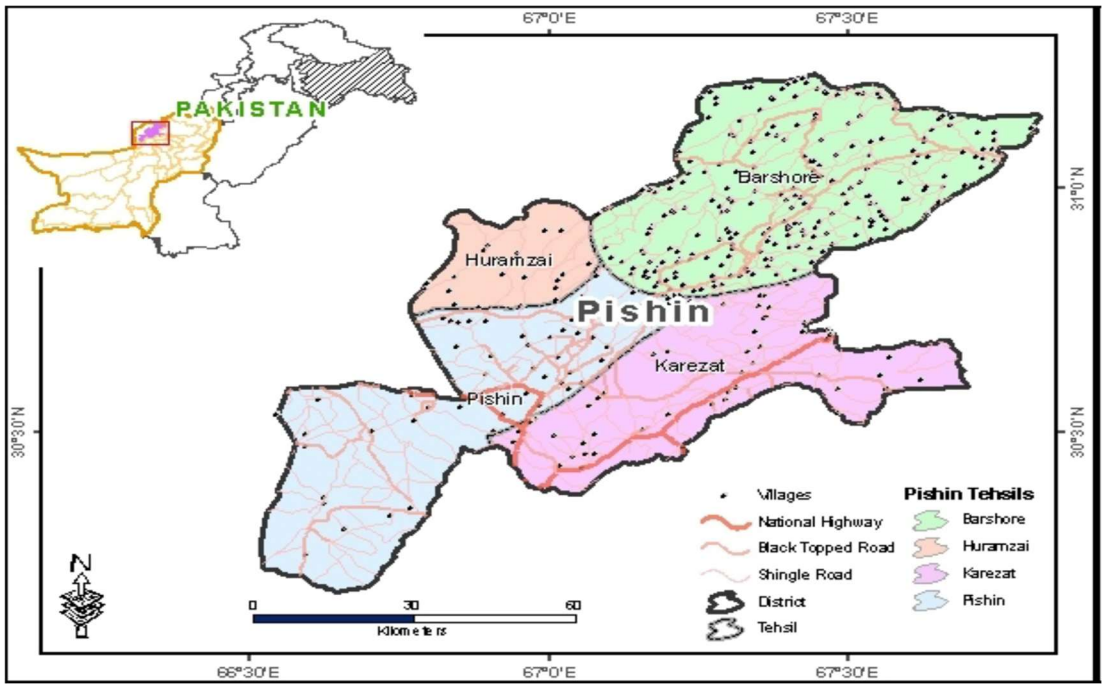


**Figure 1.** Study area map

## 4. METHODOLOGY AND DATA COLLECTION

### 4.1 Data Collection Methods

This research is basically exploratory in nature utilizing, both primary and secondary data and sources. The primary data is collected through a survey questionnaire focusing households to achieve the set objective. The study administered a structured questionnaire survey in the study area to get the details of the farming households, their adoptive measures which community applied during the drought periods. The questionnaire is designed based on the previous studies and extensive literature for identifying the correct variables to ensure that the collected data would contribute to research objective. The questionnaire was pre-tested before

the actual survey was conducted. Randomly selected households participated in the pre-testing of questionnaire to cheek the responses that could be anticipated in the field finally. After the pre-testing phase, the questionnaire was modified and irrelevant questions were removed. A total of 377 questionnaires were filled from the farming households with proportionate allocation method in the three Patwar Circles and Municipal Corporation of khanozai. Secondary data is important to understand the past history and trend of the drought impacts and farmers coping strategies during drought periods. The secondary data is collected from the published scientific journals, Books, Policy documents, online achieves, UN reports etc.

### 4.2 Sample Selection

Tehsil karezat was selected for the primary data and household survey. The said Tehsil is administratively divided into three patwar circles and Municipal corporation khanozai according to Pakistan Census Department. A total of 377 households were selected for the primary household survey according to Arkin and Colton (1963) Formula. A random sampling technique is employed using proportionate allocation method due to the heterogeneity of the area in terms of population in the three Patwar Circles and Municipal Corporation. The calculation of the sample size is given below with proportionate allocation method. Out of 377 households 115 households were selected for Bostan Patwar Circle, 25 for Khanozai Patwar Circle, 121 for Mugha Patwar Cirle and 116 for Khanozai Municipal Corporation.

The Overall sample size (Karizat tehsil) is as given under:

$$n = \frac{NZ^2 \times P \times (1-P)}{N_{e^2} + \{Z^2 \times P \times (1-P)\}} \quad (1)$$

$$n = 377 \quad (2)$$

Proportionate Allocation method, based on administrative unit

Bostan Patwar Circle

$$n_k = \frac{N_k}{N} \times n \quad (3)$$

$$n_{BP} = \frac{7126}{23314} \times 377 \quad (4)$$

$$n_{BP} = 115 \quad (5)$$

Khanozai Patwar Circle

$$n_{kP} = \frac{1532}{23314} \times 377 \quad (6)$$

$$n_{KP} = 25 \quad (7)$$

Murgha Patwar Circle

$$n_{MP} = \frac{7507}{23314} \times 377 \quad (8)$$

$$n_{MP} = 121 \quad (9)$$

Khanozai Municipal Corporation

$$n_{KM} = \frac{7149}{23314} \times 377 \quad (10)$$

$$n_{KM} = 11 \quad (11)$$

Where,
N = Total number of Households = 23314 (12)
Z = Confidence Interval (95 %) = 1.96 (13)
P = Degree of Variation = 50% = 0.50 (14)
E = Margin of error = 5 % = 0.05 (15)

### 4.3 Data Analysis

For the data analysis, Statistical Package for Social Science (SPSS) is employed. Descriptive and inferential statistics were utilized to get the results. Descriptive statistics include frequencies, graphs and tables for the coping and adoptive measures of the farmers in the study area while multiple regression model was used for the factors influencing the adoptive behavior of the farmers. Multiple regression model allows a systematic examination of the factors affecting farmers' adoptive behavior and coping strategies. Furthermore, it also provides valuable insights for policymakers, researchers, and agricultural practitioners to develop informed strategies to enhance the resilience of farmers in the face of environmental challenges.

### 4.4 Respondents' Profile

Family structures of the respondents were categorized into three different categories as mentioned in Table 1. Traditionally people living in rural areas of Balochistan province prefer to live in joint family system. Especially Pashtoon tribes are having strong cultural and traditional norms. The same has been observed from the study area that most of the respondents have joint family systems with almost 68%, whereas 17%, 15% of the respondents were having nuclear and extended family system respectively.

**Table 1.** Respondent's family structure

| Categories | Frequency | Percent |
|---|---|---|
| Extended Family | 57 | 15.1 |
| Joint Family | 256 | 67.9 |
| Nuclear Family | 64 | 17.0 |
| Total | 377 | 100.0 |

Source: Field Survey

Education is one of the important social indicators for human development index (HDI). In this study respondent's education level is categorized into 7 categories as starting from illiteracy to higher level of education as shown in Table 2. Almost 20% of the respondents were illiterate in the study area. Respondents with Primary, Middle and Matriculation level of education were recorded 25% collectively. Twenty-five percent of the respondents were having Bachelor level education (14 years of education). only 9% of the respondents were having higher level of education in the study area.

**Table 2.** Respondent's educational level

| Respondent educational level | Frequency | Percent |
|---|---|---|
| Illiterate | 74 | 19.6 |
| Primary | 18 | 4.8 |
| Middle | 23 | 6.1 |
| Matriculation | 53 | 14.1 |
| Intermediate | 81 | 21.5 |
| Bachelor | 95 | 25.2 |
| Master | 33 | 8.8 |

Source: Field Survey

Respondent's occupation was taken with multiple responses. Agriculture is observed the main occupation of the respondents with 63%. Due to poor economic condition, 18% of the respondents were engaged with daily wages occupation as shown in Table 3. The socio-economic conditions of such group were extremely vulnerable. Based on past data, some thirty years ago livestock was the major source of income in the study area. But due to climate change impacts, this figure has drastically decreased to 23% as mentioned in Table 4. This major shift in occupation has left only 23% people engaged with livestock occupation. Almost 35% of the respondents were government employer.

**Table 3.** Occupation of the respondents

| Occupation | Yes (Percent) | N0 (Percent) |
|---|---|---|
| Business | 52 | 48 |
| Employment | 35 | 65 |
| Daily Wages | 18 | 82 |
| Agriculture | 63 | 37 |
| Livestock | 23 | 77 |

Source: Field Survey

The analysis of the data depicts that; the average age of the sample respondents were almost 42 years. The average household size in the study area was 10.64 as indicated in Table 4 below. The ratio of family members was slightly tilted toward male population as 5.50 and 5.16 were male and female respectively. 12 out of 1000 persons were disabled in the study area. The monthly income of the farmers in the study area was 45684 Pak Rupees which indicates that majority of the farmers were below poverty line. According to the Global Climate Risk Index report of 2020, Pakistan is severally affected by climate change impacts. Pakistan is 8th most vulnerable country affected by climate related catastrophes i.e. drought, flood, and cyclone. The ongoing spell of drought forces people to migrate from their native places towards urban areas to find out the alternate sources of their income. In the context of migration, result of the data in Table 4. respondents reported that, almost 21% of their neighbors had migrated permanently from their villages towards urban areas like Quetta, Karachi and other parts of the country. Almost 17% of the respondents temporarily migrate from their native places toward other regions of the province with respect to change in weather conditions.

**Table 4.** Household Characteristics of respondents

| S.N | Variables | (Average) Results |
|---|---|---|
| 1 | Average age of the Respondents | 42.02 |
| 2 | Household family members | 10.64 |
| 3 | Male Members | 5.50 |
| 4 | Female Members | 5.16 |
| 5 | Disabled Members | 0.12 |
| 6 | Average Monthly Income Per household | 45684 |

**Migration Status**

| | Migration Categories | Percentage |
|---|---|---|
| 1 | Temporary Migration | 16.7 |
| 2 | Permanent migration | 20.7 |
| 3 | No Migration | 62.6 |

Source: Field Survey

## 5. RESULTS AND DISCUSSION

### 5.1 Coping and Adaptive Behavior of Farmers

In Pakistan, agriculture is the most important sector for livelihood and is considered to be the back bone of the country's economy but climate change has affected it to a larger extent. The large-scale impacts of climate change will be a constant threat particularly for small land holder farmers whose key source of livelihood is mainly based on agriculture. Farmers' adaptive behavior and their responses against climate change are more important as feedback for policy makers to design more effective strategies and planning against these impacts. Therefore, it is necessary to address these adverse impacts of climate change to reduce and prevent the losses of this vulnerable group. Due to frequent occurrences of drought events, the farmers have also devised adaptive measures and coping strategies to minimize the negative impacts of the drought based on their local and indigenous knowledge. It is important to note a slight difference between adaptation and coping in the contemporary hazard literature which is considered as time factor. According to Ashraf (2013), "farmers devised coping strategies to buffer short term shocks and stress for their farming system and some time these adaptive measures exist for a long period of time". Rasul (2012) suggested that adaptation is better suited and sustainable in term of long term changes as compared to coping strategies, whereas coping strategies are more effective for a short period of changes in the farming system. In the study area farmers used various adaptation and coping strategies for their farming system to mitigate the negative impact of climate change and drought. Some of them are illustrated below.

#### 5.1.1 Households Assets and Water Management

The results displayed in Figure 2 show that, about three-quarters of the respondents have sold their household assets (Tractor, Livestock, etc.) to cope with persistent spells of drought and 17% of the farmers have sold out even their lands to mitigate the adverse impacts of drought in the study area. Similarly, 78% farmers' used pipes for watering system instead of open channels in order to save water wastage from evaporation. Additionally, digging more than one tube well to reach more water for fields was also observed as coping strategy in the

study area. The results further reveal that cutting of extra branches of trees to minimize the water consumption has found commonly used adaptive strategy by farmers in the study area. 77% farmers used this strategy to address the impacts of drought and climate change. It can be inferred from the above results that selling assets and lands for coping with drought periods reduce the social wellbeing of the community and resultantly becoming more vulnerable to the impacts of drought in the future. These results are line with Ur Rahman and Hamza (2024) and Ashraf et al. (2014). Furthermore, in order to manage the shortage of water, use of drip/sprinkle system, give water at night time narrowing and leveling the channels of the drain from the source of water, cemented pond construction are the important strategies devised by (67%, 69% and 75%) farmers in the study area respectively. However, due to high cost of cemented pond construction and installation of pipes, some farmers were not able to construct and install them for their fields instead of flood irrigation.

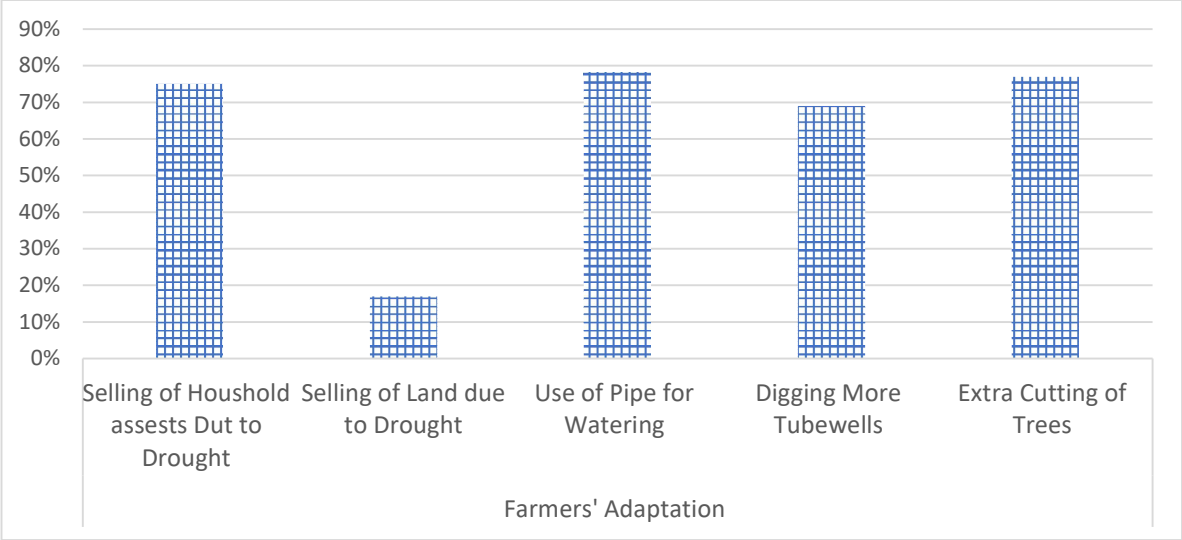


**Figure 2.** Households assets and water management
Source: Field Survey Data

In addition to that, Figure 3 also confirms that, 75% farmers stated that, they cultivated low delta crops which are resilient in drought condition such as Apricot, Gaja apple, American grapes and vegetables instead of foremost apple varieties like Shin Kolo and Tor Kolo which consumes more water. Similarly, including these all efforts, about two-third of farmers divided their gardens into small plots. Those farmers who practiced this strategy argue that different vegetables such as Onion, Potato and Peas are grown along with apple trees in their fields for an effective water and fertilizer adjustment as well as to maximize the profit.

### 5.1.2 Harvesting Changes and Migration

In order to manage water related issues with an effective manner, Figure 4 shows that about 66% farmers constructed paved water channels and divided them while 44% farmers were not able to construct such paved water channel due to non-affordability of high cost. Results further reveal that 67% farmers have brought changes in harvesting dates during the drought period. Additionally, permanent or short-term migration towards cities, i.e., Quetta, Karachi, Peshawar, and other parts of the country, is used by farmers as a coping mechanism to find out the

alternative sources of income. These findings are well supported by Hussain (2022) and are in line with the findings of Mazhar and Nawaz (2014). People migrated from study area usually work in restaurants in Karachi or Quetta on the basis of daily wages. Results further indicate that 37% of their family members migrated from their native places towards other urban areas to find out the sources of income.

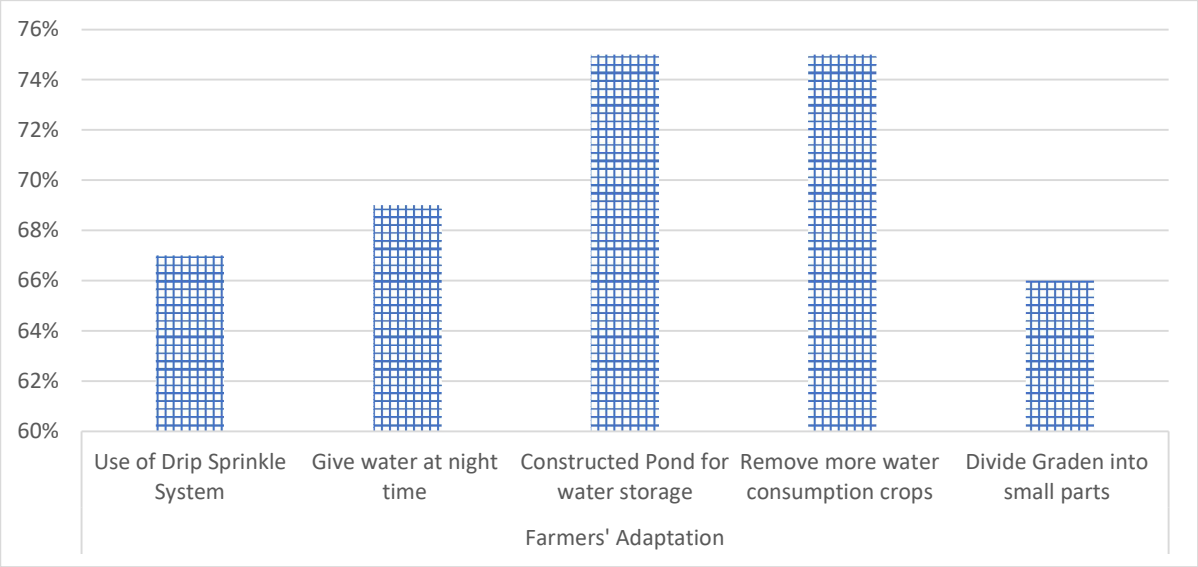


**Figure 3**. Water management and low delta crops
Source: Field Survey data

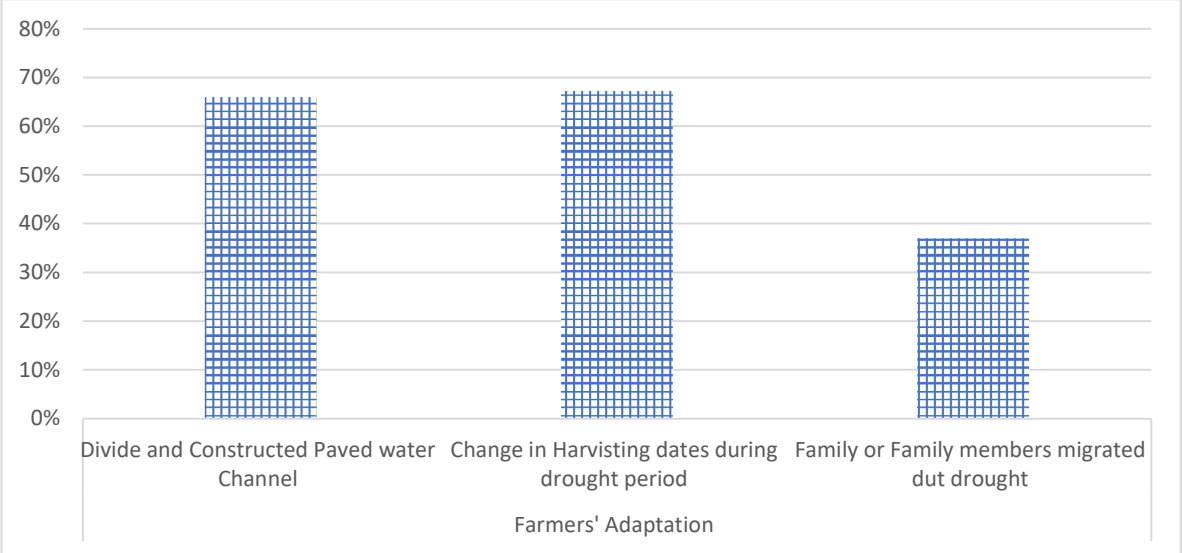


**Figure 4**. Harvesting changes and migration
Source: Field survey data

### 5.1.3 Farmers Preparedness about Drought

A natural hazard like drought cannot be prevented but it can be mitigated through proper planning, strategies and preparedness (UNDRR, 2021). Drought preparedness planning involves making resilient environments, stocking of supplies, well-coordinated arrangements, information and trainings to minimize the adverse impacts of drought as shown in Figure 5.

Preparedness planning also involves dealing drought and climate change related issues with proactive approach that could strengthen community resilience and reduce farmers' vulnerabilities. Regarding the preparedness, the results reveal that about (16%, 41% and 25%) farmers have stocking of supplies, strong coordination arrangements and information sharing among them respectively. It is inferred that Such efforts enable coordination and communication among the farmers and other stakeholders through different activities that support farmers' learning, engagement, stocking of supplies and policy change collectively respond to drought condition. These findings are in line with the studies conducted by Lopera et al. (2023) and Shafiq et al. (2007).

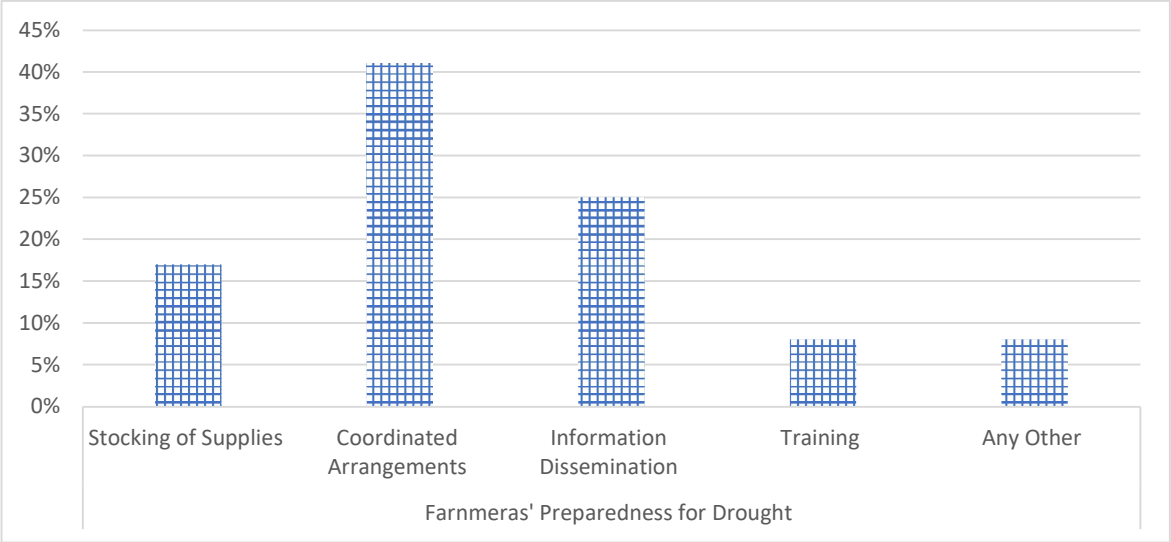


**Figure 5**. Farmers preparedness about drought
Source: Field Survey Data

## 5.2 Factors Influencing Farmers 'Adaptive Behavior & Coping Strategies

The dependent variable in this study is annual economic loss, which represents the financial loss incurred by farming households each year as a result of drought and climate-related stressors. This loss is used to assess the household's coping and adaptive capacities, with the underlying assumption that households with greater adaptive capacity suffer fewer economic losses, whereas those with less capacity suffer more. Although both natural (primary) and human (secondary) factors influence farmers' adaptive behaviors, the multiple regression model focuses solely on secondary (human) factors because they are more directly related to household-level decision-making and adaptive responses. The selected independent variables include the age of the household head, family size, the number of male and disabled household members, farming experience, land ownership, total agricultural land area, monthly household income, employment status, and participation in daily wage labor. These socioeconomic and demographic characteristics are important in determining a household's ability to deal with and adapt to climate-related challenges. Higher income and landholding, for example, may allow for investment in drought-resistant practices, whereas off-farm employment provides additional income during times of agricultural stress. Thus, the multiple regression model seeks to statistically evaluate how these secondary factors influence annual economic loss,

identifying key household-level indicators that influence farmers' adaptive and coping behaviors in the face of drought and climate change.

To measure this variable, data was collected through household surveys in which respondents were asked to estimate the total financial loss (in Pakistani Rupees) they experienced during the last year due to drought or insufficient rainfall. Where possible, these self-reported figures were cross-checked with available local agricultural records or trends to improve accuracy. The variable was treated as a continuous numerical variable in the multiple regression model, allowing us to assess how variations in key household characteristics (independent variables) influence the magnitude of annual economic loss. This approach provides a quantifiable measure of vulnerability and adaptive capacity, enabling a direct analysis of the socio-economic factors that contribute to or mitigate drought-related losses.

The model is

$$Y=\alpha+\beta1X1+\beta2X2+\beta3X3+\beta4X4+\beta5X5+\beta6X6+\beta7X7+\beta8X8+\beta9X9+\epsilon \quad (16)$$

Where,

$Y$ = Dependent Variable (Annual Economic Loss) (17)

$\alpha$ = constant term (18)

$Xi$ = Are independent variables and βs' are the coefficients of independent variables (19)

$X1$ = Age of household head (20)

$X2$ = Family Members (21)

$X3$ = Male Members (22)

$X4$ = Disable Members (23)

$X5$ = Monthly income of the household (24)

$X6$ = Farming Experience (25)

$X7$ = Total agriculture/farm area in acre (26)

$X8$ = Employment occupation of the respondent (1= for Government Job, 0 otherwise) (27)

$X9$ = Daily wages occupation (1= for daily wage occupation, 0 otherwise) (28)

$\epsilon$ = Error term (29)

The regression model results in Table 5 show that the age of the household head (-2.21, p = 0.000) has a strong negative relationship with annual economic loss, implying that older individuals are better able to adapt and thus incur lower losses. Similarly, male household members (-0.57, p = 0.002) and farming experience (-0.16, p = 0.003) are significantly associated with lower economic losses, indicating that labor availability and agricultural knowledge improve coping capacity. Total farm area (-0.09, p = 0.025) also has a negative effect, implying that households with larger landholdings may experience greater economic stability and resilience.

On the other hand, family size (0.60, p = 0.003) and the presence of disabled family members (0.16, p = 0.005) are positively associated with higher economic loss, indicating increased dependency burdens and decreased adaptive efficiency. Daily wage occupation (0.23, p = 0.000) is also positively associated with economic loss, emphasizing the vulnerability of

households that rely on volatile income sources. In contrast, regular employment (-0.25, p = 0.000) significantly reduces economic loss, most likely due to financial security and access to alternative income streams. Interestingly, monthly household income (-0.07, p = 0.901) is statistically insignificant in this model, implying that income variations alone have no significant direct impact on annual economic loss, possibly due to overlaps with other socioeconomic variables.

Overall, the regression model is statistically significant (F = 9.52, p = 0.000), indicating that specific human factors have a significant impact on annual economic loss. However, the R-squared value of 0.18 indicates that these variables account for 18% of the variation in the dependent variable, implying that, while household characteristics are important, other external or unobserved factors (e.g., institutional support, access to climate information, or natural disaster intensity) may also play a critical role in shaping farmers' adaptive capacity and economic resilience.

**Table 5**. Regression model

| Variables | Coefficients | Standard Error | T-Statistic | P-value | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Constant | — | (0.70) | 7.268 | 0.000 | — | — | — | — |
| Age of Household Head | -2.21 | (0.54) | -4.123 | 0.000 | 42.02 | 12 | 22 | 75 |
| Family Size | 0.60 | (0.20) | 3.007 | 0.003 | 10.64 | 3.1 | 2 | 14 |
| Male Members in Family | -0.57 | (0.18) | -3.097 | 0.002 | 5.10 | 1.6 | 1 | 7 |
| Disabled Member in Family | 0.16 | (0.06) | 2.831 | 0.005 | 0.12 | 0.50 | 0 | 2 |
| Monthly Income (PKR) | -0.07 | (0.56) | -0.124 | 0.901 | 45684 | 10,000 | 8K | 80K |
| Farming Experience (Years) | -0.16 | (0.05) | -2.984 | 0.003 | 15 | 8.5 | 1 | 40 |
| Total Farm Area (Acres) | -0.09 | (0.05) | -1.849 | 0.025 | 4.8 | 2.5 | 0.5 | 15 |
| Employment Occupation | -0.25 | (0.07) | -3.821 | 0.000 | — | — | — | — |
| Daily Wages Occupation | 0.23 | (0.05) | 4.688 | 0.000 | — | — | — | — |
| R-Square | 0.18 | | _____ | | 0.000 | | | |
| F-Value | 9.52 | | _____ | | 0.000 | | | |

Field Survey Data 2021.

## 6. CONCLUSION

This study investigated the coping and adoptive behavior of the farming communities from North-West Balochistan, which is affected by drought severely for the last two decades. The study area is being faced by long standing drought spells due to climate change. The results of the current study focusing on farming communities are not encouraging to cope with the recent impacts of drought and climate change in the study area rather, the farmers are trying to use

their indigenous knowledge to cope and mitigate the impacts of droughts to secure their livelihoods options for sustenance. The study results reveal that farmers are using pipes for watering their fields to avoid the loss of water. Additionally, they divide the gardens and fields into small parts and irrigate their fields and gardens at night. The results further reveal that farmers preserve stock supplies for food crisis during the future drought events. These findings are supported and are in line with Shafiq and Kakar (2007) and Ashraf et al. (2014). The findings are also supported by Ur Rahman and Hamza (2024) by arguing that, the recent impacts of climate change in the province have increased the livelihoods vulnerability of small farmers in Balochistan. The multiple regression model shows that some of the following are the most significant variables affecting the formers coping and adopting behavior for drought in the study area. These variables include age of the household head, employment occupation and daily wages occupation. These findings are in line with the results from the study conducted in Jamba South Africa (Bahta, 2021). The findings are also in line with Ahmad et al. (2004). This study recommends that the government shall provide opportunities for farming communities to enhance the diversification of their income sources. The paper further recommends the capacity building of farmers and agriculture extension offices to update the farmers with the current trends in agriculture farming under changing climate. Apart from that provision of credit services, use of low delta crops and improved irrigation methods may increase the resilience of the farming communities to cope and withstand to the impacts of droughts in the future.

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## ETHICAL STATEMENT ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The research study is conducted under the guidelines of the Research Ethics Committee of the University of Balochistan, Quetta, which was approved under No. RUB/Esstt/T-08:598-05, dated on 15-05-2022. This research has nothing with the animals however the research is conducted with the participation of the people in the study area.

## COMPETING INTEREST

The Authors do not have any conflicting Interest in this Research.

## CONSENT FOR PUBLICATION

The Consent of All authors are taken for this research study.

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## AVAILABILITY OF DATA AND MATERIALS

Data of this study will be made available on request.

## REFERENCES

Abbas, S. (2022). Climate change and major crop production: evidence from Pakistan. *Environmental science and pollution research, 29* (4), 5406-5414. https://doi.org/10.1007/s11356-021-16041-4

Agrwal, N. E. (2020). Risk and Resilience: A case study of perception versus reality in flood management. *water (Switzerland), 12*(5), 2015-2030.

Ahmad, S., Hussain, Z. A., Qureshi, S., Majeed, R., & Saleem, M. (2004). Drought mitigation in Pakistan: Current status and options for future strategies. Working Paper 85. International Water Management Institute, Colombo, Sri Lanka.

Ahmad, D., & Afzal, M. (2020). Climate change adaptation impact on cash crop productivity and income in Punjab province of Pakistan. *Environmental science and pollution research, 27*, 30767-30777. doi: https://doi.org/10.1007/s11356-020-09368-x

Ahmad, N., Ashraf, M., & Murtaza, G. (2024). Farmers' Coping and Adaptive Behavior toward Drought Hazard in the North-West Region of Balochistan, Pakistan. *Pakistan Social Sciences Review, 8*(3), 231–245. https://doi.org/10.35484/pssr.2024(8-III)17

Ahmed, K. S. (2016). Characterziation of Seasonal Drought Balochistan Province. *Stochastic Environmental Research and Risk Assessment, 30*(2), 747-762

Ajak, B. J. (2018). Livelihood resilience and adaptation to climate variability in post-conflict South Sudan. A review. *Agriculture Review, 39*(3), 193-201.

Alkhalidi, A. A. (2023). Integrated Innovative technique to asses and priorities risks associated with Drought impacts, Measures/strategies and actions: global study. *International Journal of Disaster Risk Reduction, 94*(103800).

Anjum, S., Saleem, M., Cheema, M., Bilal, M., Khaliq, T. (2012). An assessment to vulnerability, extent, characteristics and severity of drought hazard in Pakistan. *Pak J Sci, 64*(2):138–143

Ashraf, M. R. (2015). Spatio-Temporal Characteristics of Precipitation and Drought in Balochistan, Province, Pakistan. *International Journal of Disaster Risk Reduction, 77*(1), 229-254.

Ashraf, M. R. (2013). Perception and Understanding of Drought and Coping Strategies of Forming households in North-West Balochistan. *International of Disaster of Risk Reduction, 5*, 49-60.

Ashraf, M., Routray, J., Saeed, M. (2014). Determinants of farmers' choice of coping and adaptation measures to the drought hazard in northwest Balochistan, Pakistan. *Nat Hazards, 73*(3):1451–1473. doi:10.1007/s11069-014-1149-9

Arkin, H, & Colton, R. R. (1963). *Tables for statisticians* (2nd ed.). Barnes and Noble Books. New York. (contributed by National Library of Australia).

Austen, E.A., Sale, P.W., Clark, S.G., Graetz, B. (2002). A survey of farmers' attitudes, management strategies and use of weather and seasonal climate forecasts for coping with climate variability in the perennial pasture zone of south-east Australia. *Australian Journal of Experimental Agriculture, 42*, 173– 183.

Bahta, Y. T. (2021). Perspective of Agricultural drought resilience in south Africa: A case of smallholder livestoke farmers, Jamba. *Journal of Disaster Risk Studies, 12*(1), 1-11.

Bekele, M. (2024). Effects of Desert Locust Plague on Disaster Management in the Subsistence Agriculture of Ethiopia: Do Ex Ante or Ex Post Policy Measures Are More Appropriate in Agricultural Risk Management? An Analytical Review. *IDRiM Journal, 14*(1). https://doi.org/10.5595/001c.117270

Brill, F., Alencar, P. H. L., Zhang, H., Boeing, F., Hüttel, S., & Lakes, T. (2024). Exploring drought hazard, vulnerability, and related impacts on agriculture in Brandenburg, *Nat. Hazards Earth Syst. Sci., 24*, 4237–4265.

Byun, H. R., & Wilhite, D. A. (1999). Objective quantification of drought severity and duration. *Journal of Climate, 12*(9), 2747–2756. https://doi.org/10.1175

Chiba, Y., & Nagamatsu, S. (2023). Increasing the Resilience of Japanese Companies to Address Multi-hazard Risks. *IDRiM Journal, 13*(2). https://doi.org/10.5595/001c.91475

Durrani, H., Ainuddin, S., Gourdji, S., Murtaza, G., & Mengal, A. (2023). Exploring farmers' coping strategies and adaptive measures against the extended drought in Balochistan, Province of Pakistan. *Environment, Development and Sustainability, 27*, 6663-6682. 10.1007/s10668-023-04161-5

Givsti, G. G. (2023). Assessing the impact of drought on carbon footprint of soybean production from the life cycle perspective. *Journal of Cleaner Production, 425*(138843).

Government of Pakistan Bureau of Statistics. (2013). Agricultural Statistics of Pakistan Graham, L., S. Hagemann, S. Jaun, and M. Beniston (2007), On interpreting hydrological change from regional climate models, *Climatic Change, 81*(S1), 97–122.

Hazzan, O., Lawal, O., Elendu, C. C., Abdulraheem, M. I., & Pei-Gao, D. (2023). Modelling Maize Yield Vulnerability to Climate Variability. *IDRiM Journal, 13*(2). https://doi.org/10.5595/001c.91437

Hesam, M. R. (2021). Comparative assesment of formers' perception on drought impacts: the case of coastal lowlands versus adjoining mountainous forelands region of Northern Iran. *Theoretical and Applied Climatology, 143*(2), 489-503.

Hussain, A. J. (2022). Analysing the impact of drought on agriculture: evidence from Pakistan using standardized precipiation evapotranspiration index. *Natural Hazard, 115*, 389-408.

Hyman, G., Larrea, C., & Farrow, A. (2005). Methods, results and policy implications of poverty and food security mapping assessments. *Food Policy*, *30*(5-6), 453-460. https://doi.org/10.1016/j.foodpol.2005.10.003

IPCC. (2014). Climate Change. Fifth Assessment Report of the Intergovernmental Panel.

Kafy, A. B. (2023). Assesment and Prediction using Machine learning algorithums. *Science of Total Environment*, 867.

Kalthof, M. W. M. L., de Bruijn, J., de Moel, H., Kreibich, H., and Aerts, J. C. J. H. (2025). Adaptive behavior of farmers under consecutive droughts results in more vulnerable farmers: a large-scale agent-based modeling analysis in the Bhima basin, India, *Nat. Hazards Earth Syst. Sci., 25*, 1013–1035, https://doi.org/10.5194/nhess-25-1013-2025

Khan, A., Pan, X., Najeeb, U., Tan, D. K. Y., Fahad, S., Zahoor, R., & Luo, H. (2018). Coping with drought: Stress and adaptive mechanisms, and management through cultural and

molecular alternatives in cotton as vital constituents for plant stress resilience and fitness. *Biological Research, 51*(1). https://doi.org/10.1186/s40659-018-0198-z

Lal, M., H. Harasawa, D. Murdiyarso, W.N. Adger, S. Adhikary, M. Ando, Y. Anokhin, R.V. Cruz and Co-authors. (2001). Asia. In J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (Eds.), *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Chang* (pp. 533-590). Cambridge University Press, Cambridge.

Lee, H., Kwon, H., Jang, W., & Kim, W. (2015). Future Changes in Drought Characteristics under Extreme Climate Change over South Korea. *Advances in Meteorology, 2016*(1), 9164265. https://doi.org/10.1155/2016/9164265

Lopera, C. C. F., Mendes, J. M., Barata, E. J., & Sandoval, V. (2023). Prioritization of Territorial Areas for Implementing Inclusive Climate Risk Transfer Mechanisms. Colombia as a Case Study. IDRiM Journal, 13(1). https://doi.org/10.5595/001c.77526

Mardy, T., Uddin, M. N., Sarker, M. A., Roy, D., & Dunn, E. S. (2018). Assessing Coping Strategies in Response to Drought: A Micro Level Study in the North-West Region of Bangladesh. *Climate, 6*(2), 23. https://doi.org/10.3390/cli6020023

Mazhar, N, & Nawaz, M. (2014). Precipitation data interpolation for meteorological drought mapping in Pakistan. *Pak J Sci, 66*(4), 356–361

Mechler, R., Hochrainer, S., Aaheim, A., Salen, H., & Wreford, A. (2010). Modelling economic impacts and adaptation to extreme events: Insights from European case studies. *Mitigation and Adaptation Strategies for Global Change, 15*(7), 737–762. https://doi.org/10.1007/s11027-010-9249-7

Nadmani, F. A. (2016). Determents of formers' adaptation to climate change: A micro level analysis in Ghana. *Scientia Agricola, 73*(3), 201-208.

Organization-WMO, W. M. (2020). WMO statement on the state of global climate in 2019. World Meteorological Organization, Geneva 2, Switzerland.

Osbahr, H., Twyman, C., Neil Adger, W., & Thomas, D. S. G. (2008). Effective livelihood adaptation to climate change disturbance: Scale dimensions of practice in Mozambique. *Geoforum, 39*(6), 1951–1964. https://doi.org/10.1016/j.geoforum.2008.07.010

Pan, X.L., Deng, W., & Zhang, D.Y. (2003). Classification of hydrological landscapes of typical wetlands in Northeast China and their vulnerability to climate change. *Research of Environmental Sciences, 16*, 14-18.

Rasul, G. M. (2012). Vulnerability of Indus delta to Climate Change in Pakistan. *Pakistan Journal of Meteorology, 8*(16), 89-107.

Rawat, P. (2012). Impacts of climate Change and hydrological Hazards on Monsoon Crop pattern in the Lesser Himalaya. A water shed Based Study. *International Journal of Disaster Risk Science, 3*(2), 98-112.

Relief Commissionerate Balochistan. (2000). Annual Report 2000 – 02, Civil Secteriate Balochistan Quetta Review, 114, 764-771.

Salama, S. R. (2012). Rainfall trends in different climatic zonez of Pakistan. *Pakistan Journal of Meteorology, 9*(17), 37-47.

Sharma, A. (2024). Behavioral Biases in Disaster Decision-Making: Insights from Drought-Affected Individuals in Madhya Pradesh, India. *IDRiM Journal, 14*(2). https://doi.org/10.5595/001c.123506

Shabana, F., Ghulam, M., Jamal-ud-din, Ainuddin, S., & Achakzai, A. (2021). Factors Affecting the Coping and Adaptive Behavior of Farmers in District Pishin Balochistan, Balochistan Journal of Engineering & Applied Sciences, 4(2), 2518-2706

Shabanali Fami, H., Azizi, S., & Alambeigi, A. (2020). Clarifying the Role of Drought Adaptation 423 Strategies on Changing Farming Mode by Livestock Farmers: Evidence from Komijan Township, 424 Iran. J. Agr. Sci. Tech., 22(2): 333-346.

Shafiq, M., & Kakar, M. A. (2007). Effects of drought on livestock sector in Balochistan Province of Pakistan. International Journal of Agriculture and Biology (Pakistan)

Skoglund, A. & Jensen, T. (2013). Professionalization of ethics in Intergovernmental Panel on Climate Change-from servant of science to ethics master. Sustainable Development, 21(2), 122-130.

Slegers, M. F. W. (2008). Exploring farmers' perceptions of drought in Tanzania and Ethiopia. Doctoral Thesis Wageningen University – with ref. – with summary in English and Dutch ISBN: 978-90-8585-240-7

Soomoro, Z. A. (2011). Drinking water quality Challeneges in Pakistan. Pakistan Engineering Congress, 17-19.

Tang, K. (2019). Climate change in Malaysia: Trends, contributors, impacts, mitigation and adaptations. *Sci. Total Environ., 650*, 858-1871.

Taubenbock, H. P. (2008). A conceptual vulnerability and risk framework as outline to identify capacities of remote sensing. *Natural Hazard and Earth system Science, 8*(3), 409-420.

Ul Haq, A., Qureshi, A., Jamali, M., Zaidi, A., & Jamali, S. (2024). Mapping Groundwater Potential Zones in Quetta Region, Balochistan, Pakistan using Geospatial Techniques.

UNDRR, U. N. (2021). Special report on drought 2021, Available on www.undrr,org.

Ur Rahman, M., & Hamza, A. (2024). Climate Change: Impacts on Balochistan and Suggested Contemplative Responses. *Sociological Research and Innovation, 2*(2), 1-22. https://journals.umt.edu.pk/index.php/SRI/article/view/6708

Veettil, V. A. (2023). Quantifying threshold for advancing impact-based drought assessment using classification and regression tree (CART) models. *Journal of Hydrology, 625*, 129966.

Wang, Y., Wang, Z., Zhao, M., & Li, B. (2024). The influence of technology perceptions on 448 farmers' water-saving irrigation technology adoption behavior in the North China Plain. *Water 449 Policy, 26*(2), 170-188.

Wayal, A. S. (2023). Impact of Climate Change and Land Use Change on Coastal Areas: A Case Study Thane, India. *IDRiM Journal, 12*(2). https://doi.org/10.5595/001c.74306

Wongsit, A. (2021). Analysis and Investigation on Saptio-Temporal Pattern of drought in Thailand. Master Thesis, Burapha University, Thailand

Wu, R., & Yang, Y. (2024). Drought disaster risk assessment and yield insurance pricing of maize: a case study of Liaoning Province, China. *Geomatics, Natural Hazards and Risk, 15*(1). https://doi.org/10.1080/19475705.2024.2420660