This project is funded by
the European Union

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GRASP • PAKISTAN

GROWTH FOR RURAL ADVANCEMENT
AND SUSTAINABLE PROGRESS

Climate change risks in select agricultural value chains of Pakistan

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CONTENTS

ABBREVIATIONS

APF
Adaptation Policy Framework.
DAP
Diammonium phosphate.
FEW
Food Energy and Water.
GB
Gilgit-Baltistan.
GDP
Gross Domestic Product.
GHG
Greenhouse Gases.
GRASP
Growth for Rural Advancement and Sustainable Progress. *See*
IBIS
Indus Basin irrigation System.
IFAD
International Fund for Agricultural Development.
IPCC
Intergovernmental Panel on Climate Change.
KPK
Khyber Pakhtunkhwa.
MAF
Million Acre Feet.
NAMA
National Appropriate Mitigation Actions.
NAP
National Adaptation Plan.
NCCP
National Climate Change Policy.
O&M
Operation and maintenance.
PIDA
Punjab irrigation and Drainage Authority.
PKR
Pakistani Rupee.
PMD
Pakistan Meteorological Department.
SDG
Sustainable Develpment Goals.
UNDP
United Nations Development Programme.
UNFCCC
United Nations Framework Convention on Climate Change.
WRI
World Resources Institute.

1 Background

1.1 Growth for Rural Advanacement and Sustainable Progress

1.2 Specific study objectives

The report will outline the environmental risks to specific value chains identified by during the inception phase of Growth for Rural Advancement and Sustainable Progress (GRASP) and provide the framework to mainstream environmental objectives into the project. The report will acknowledge that although the Food-Energy-Water Nexus is not the focus of the project, the framework provides a good illustration of the need to conduct an environmental risk assessment and the nature of linkages between the three systems. The report will follow a climate change risk management approach based on the United Nations Development Program (UNDP) Adaptation Policy Framework (APF))[1]. The GRASP project has the concept of sustainability embedded in the design of the project and the scoping and design stages have been complete. Section One of the report will assess the current vulnerabilities as well as current and future climate risks. Section Two will focus on the development of adaptation strategies for the selected value chain in the GRASP project.

1.2.1 The Food-Energy-Water Nexus

The approach of the GRASP project focuses on the market and then works towards the farmer; this means from the planting to the market and all the stages in between, looking to increase productivity and profitability. Seeing as the concept of food is critical to the project design the Food-Energy-Water (FEW) nexus provides an insightful approach to understanding the linkages, trade offs and potential risks that can be faced by the project.

The nexus is a much-discussed topic amongst development professionals particularly after the development of the Sustainable Development Goals (SDG). However, academics have identified that the aspect of sustainable livelihoods are missing from traditional analysis; this has been developed under the concept of Environmental Livelihood Security. This framework illustrates the interlinked nature of food, energy and water but importantly acknowledges that these three factors are all connected with the ability to directly and indirectly impact livelihoods. [2]

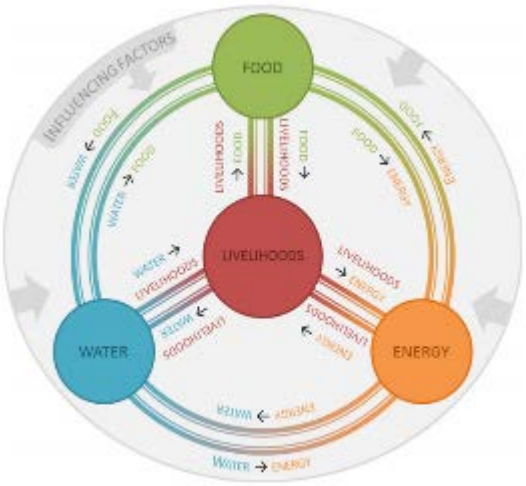

Figure 1: Environmental Livelihood Security (Biggs, et al., 2015)

The framework also provides guidance as to how to balance any intervention/policy and the need to adopt a systems-based approach.

Economic growth and livelihood development is a critical component for sustainable poverty alleviation but it needs to be understood that strategies that promote economic growth and livelihood development if poorly designed do not always lead to sustainable poverty alleviation;[3] it is for this reason understanding the linkages between water, energy, food and livelihoods is important. In Pakistan, a country where a majority of the population is involved in the agricultural activities, yet, malnutrition and stunting are rife, water availability is falling and power outages common place, this framework takes increasing importance. Recognizing the need to balance priorities across these areas is prudent planning in order to ensure sustainable development.

Any project focusing on sustainable livelihoods, particularly around agricultural value chains needs to consider the linkages between energy, water and livelihoods; ignoring one aspect or the other in project design can result in interventions that are unsustainable and may not lead to enhanced resilience and adaptive capacity of the target beneficiaries.

[1] (Lim, Spanger-Siegfried, Burton, Malone, & Huq, 2004)

[2] (Biggs, et al., 2015)

[3] (Biggs, et al., 2015)

1.3 Methodology

1.3.1 Environmental Mainstreaming

Environmental mainstreaming is the process of integrating linkages between economic development and the environment into all phases of the project cycle. It involves analysing the relationship between economic activities and the environment to identify the ways in which one can impact the other, whether negatively or positively. This includes the study of climate change, how it impacts industries and livelihoods, and how a given economic activity might worsen or mitigate climate change phenomena. During development of the GRASP project this was the approach adopted in the design of the project. It was recognized that specific policies and activities would need to be developed within the programme in order to address the environmental risks and opportunities that have been identified. In order to ensure environmental mainstreaming a two-stage process was adopted.

Step 1: Involved the development of a comprehensive review of environmental vulnerabilities and green market opportunities within the specific value chains. This involved looking at the vulnerabilities of the project and its beneficiaries because of environmental degradation and climate change but also the potential impacts that project activities could have on the environment.

***Step 2*:** The project log frame was developed keeping in mind the environmental outcomes, outputs and potential indicators that can address the environmental risks faced.

Based on these two stages as strategy was developed for ensuring that environmental management is mainstreamed in the project

1.3.2 Incorporating Climate Risks in Value Chains

[4]Climate change goes beyond just changes in the environment; the impacts of climate change will alter the functioning of many various systems which either directly or indirectly are utilized by humans. The functioning of value chains will also be impacted; from a global perspective there may be some value chains that will not be viable within as little as twenty years[5]. This clearly indicates the need to prioritize climate resilience as stakeholders continue to invest in value chain development. It is important to understand that all actors along the agricultural value chain are affected by climate change and that for investments in value chain development to be sustainable and impactful all actors need to be aware and have the adaptive capacity to manage such risks. Lastly, the World Resources Institute (WRI) highlights three core functions that are required to ensure climate resilient value chains

- Climate Risk Assessment; ongoing process assessing current and future risks
- Adaptive Management; implementing, learning and adjusting value chain activities over time
- Responding to shocks; short terms actions to cope with the effects of acute shocks.[6]

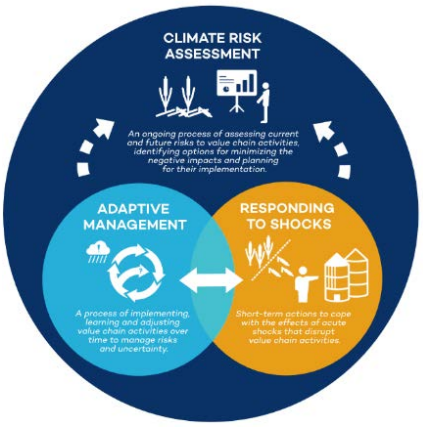

Figure 2 Climate Risk in Value Chains

To build climate resilience into the value chains and the project cycle, the framework developed by International Fund for Agricultural Development (IFAD) will be adopted consisting of three stages;[7]

[4] (International Fund for Agricultural Development, 2015)

[5] (International Fund for Agricultural Development, 2015)

[6] (Daze & Dekens, 2016)

[7] (International Fund for Agricultural Development, 2015)

1. Selection of the value chain
2. Identification of key climate risks in the value chain
3. Choice of the most effective climate interventions
4. Targeting those most vulnerable to climate risk
5. Reaching scale with climate intervention

1.3.3 Stage 1 – Selection of the Value Chain

During the Inception Phase of the GRASP project, a significant amount of consultation and research was conducted into the selection of the value chains. During this time the environmental impact and the water consumptions/saving potential was considered in value chain selection. The value chains selected include;

Value Chain	Products Balochistan	Products Sindh
Vegetables	Onions	Onions
		Tomatoes
Fruits	Dates	Dates
	Olive	Bananas
	Grapes	Mangos
Livestock	Sheep	Cattle/beef
	Goats	Goat
	Backyard Poultry	

Table 1 Selected Value Chains

1.3.4 Stage 2 – Identification of Climate Risks

The general trends related to climate change have been described in Section 2 of the report; this analysis not only included the changes in critical climate indicators such as precipitation and temperature but also provided insights into the functioning of water systems and extreme climate events. This provides the background upon which the analysis of climate risks associated with each value chain will be conducted. It is important to note that even though all stages of production may be facing climate risks, the difficulty in predictability and quantification makes it essential to prioritize risks. It is also important to acknowledge that the majority of research in relation to climate change impacts on value chains has been focused on the production side rather than impacts on non-production stages. The climate risks presented for each value chain will not be a comprehensive list of all potential environmental risks, but will represent a prioritization of climate risks based on the subjective opinions of experts, climate information and the potential impact on the functioning of the value chain. It is expected that during the project, new insights and baselines

1.3.5 Stage 3 – Choice of effective climate interventions

Recognizing that GRASP is not a climate change project, developing pure climate change adaptation interventions would not be within the mandate of the project; however, the inclusion of climate change adaptation within the intervention designs is core to the way that the GRASP project will be implemented. In selecting the appropriate climate interventions, the following elements will be considered;

- *Diversification:* an approach to increase the number of options farmers have in terms of livelihoods and practices.
- *Climate Proofing*: designing of interventions and adaptation strategies to build the resilience of value chains and livelihoods
- *Supply chain efficiencies*: looking at efficiencies in inventory/waste management in order to improve competitiveness and build resilience of actors in the value chain while also looking towards mitigation

There are a few principles underlying the implementation approach which include:

- "Do no harm" – where clear environmental benefits cannot be accrued, the project will still ensure to minimize the environmental impact of the project.
- Water Security takes precedence over water productivity– the project will look to maximise the productivity of current water resources but remains cognizant of the need to ensure rural agricultural development does not negatively impact water security in project areas.
- Gender inclusive adaptation/mitigation strategies– there is consensus that the impacts of climate change are not equal between women and men and the project will recognize this developing specific approaches in order to build adaptive capacity of women, in line with local cultural practices. – consider the aspect
- Access to Finance – for the above elements to provide adaptive options to farmers sustainably, the inclusion of the financial sector is critical. Many sustainable technologies require significant capital investments and having the support of the financial sector and green finance will facilitate innovation.
- Mitigation – although agriculture is a major greenhouse gases (GHG) contributor, per capita emissions in Pakistan are low. The strategic decision was made to focus efforts on improving productivity per tonne of CO_2 rather than reducing absolute quantities.

The report includes a review and analysis of relevant peer reviewed, technical and 'grey' literature on environmental and climate challenges in Pakistani agriculture. Qualitative information was gathered through interviews and consultative workshops conducted with a broad array of relevant stakeholders.

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2 Climate Hazards and Vulnerability in Pakistan

2.1 Pakistan climate overview

Globally the importance of climate change is being recognized and Pakistan is one of the countries which is considered extremely vulnerable to the impacts of climate change[8][9]. The Intergovernmental Panel on Climate Change (IPCC) notes that particularly for Asia the vulnerability arises from a distinct geography, demographic trends, socioeconomic factors and a lack of adaptive capacity[10]. The natural geographic terrain of Pakistan is extremely unique, extending from sea level to 8,611m,[11] resulting a in a plethora of variations in ecological zones as a consequence of variations in temperature and precipitation patterns.

The IPCC noted that the South Asian region's warming will be above the global mean, particularly impacting the timing of the monsoons and precipitation patterns.[12]

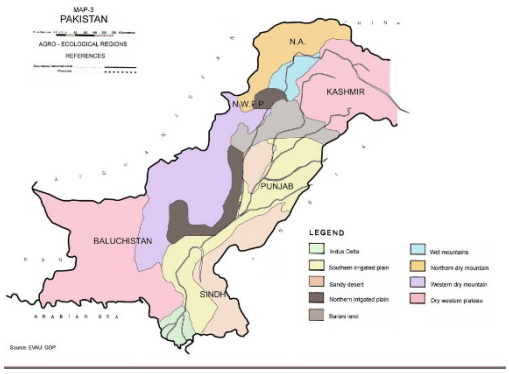


Figure 3 Agro-Ecological Zones

This diversity of Pakistan's natural endowments opens up a door of possibilities in terms of sustainable development but also results in the need for a deeper understanding at a local level, a need to understand the differences in the changes taking place, appropriate adaptation strategies and of course the capacity of communities to adapt. Communities are not only facing long term changes in the fundamental functioning of various ecosystem services but are also impacted by extreme events due to variations in rainfall patterns, storms, floods and droughts.[13] The vast variation in agro-ecological zones is indicative of such diversity in the landscapes of Pakistan.

The Pakistan Meteorological Department (PMD) divides the year based on seasonality; December – February are considered winter months and May-September are considered summer months. When looking at temperature trends and comparing various analysis it is important to consider the time frame in which these comparisons are being made. Between 1901-2000 Pakistan felt a 0.57C increase which falls below the mean of 0.75C felt in the region, however the temperature increase of 0.47C between 1961-2007 indicate a much faster rate of acceleration.[14] Based on the report developed by PMD a clear increase in temperature can be observed across the regions; maximum temperature increased by 0.87C and minimum temperatures by 0.48 degrees between 1960-2007[15]

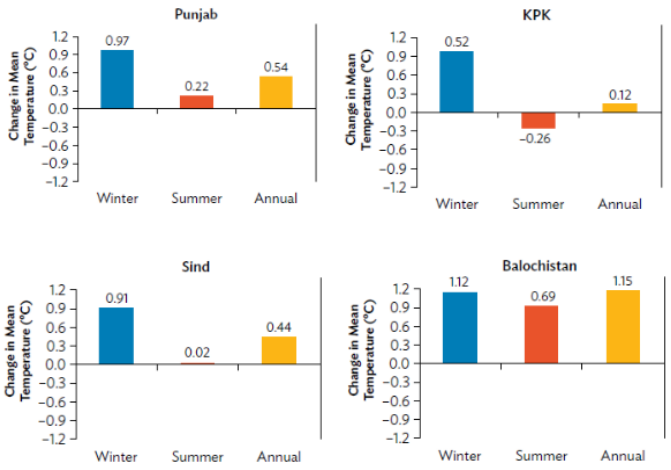


Figure 4 Change in mean temperature (Asian Development Bank (ADB), 2017)

Figure 4 clearly illustrates the differences in **mean** temperatures between 1960-2007. The first observable trend is clearly that the mean temperature during the

[8] (Eckstein, Hutfils, & Winges, 2018)

[9] Although there are various models which develop forecasts for various scenarios, this report will not ascertain the efficacy of the various models, but will make observations based on trends and analysis from existing literature

[10] (IPCC, 2014)

[11] (Asian Development Bank (ADB), 2017)

[12] (Asian Development Bank (ADB), 2017)

[13] (Asian Development Bank (ADB), 2017)

[14] (Ahmed & Suphachalasai, 2014)

[15] (Ch., Mahmood, Rasul, & Afzaal, 2009)

winter months shows the greatest increase across all the provinces. The summer temperature variations are much more region specific, with Punjab and Sindh facing small increases in the mean temperature, while KPK faced a reduction in mean summer temperatures. Balochistan faced the highest change in mean temperatures across both winter and summer months; this also reaffirms the fact that the various ecological zones will not face the impacts of climate change uniformly.

Changing temperature patterns not only have long term effects as described above but the impacts can also be felt in the form of climate extremes. Heatwaves are phenomenon that have increased in frequency globally and Pakistan is no exception.

Pakistan has been facing an average of seven heat waves a year. Heat waves in 2015 killed over 1,200 people, while in 2018, 65 people were killed in Karachi.[16] Heatwaves as defined by the PMD as ; '*the location during summer months (APR-JUN), with a normal maximum temperature >40C is considered to be under moderate heatwave when the maximum temperature is 3-4C above normal.'* When the maximum temperature exceeds the norm by 5C it is considered a severe heat wave.[17] Pakistan has experienced 126 heat waves between 1997-2015; some projections state a 75% increase in the number of heat waves with significant increases in heat accumulation during monsoons. It was also identified in the study that according to projections Sindh and southern Punjab was mostly affected by heat accumulation[18].

It is clear that Pakistan is facing an upwards trend in the temperature both during winter and summer months although the impacts during the winter months are stronger. Balochistan from the provinces faces the biggest temperature changes. Also linked to the temperature variations are the incidences of heat waves which have also been on the rise; further studies indicate an increasing frequency by 75% by 2030 (when compared to 126 incidences between 1997-2015).

2.1.1 Rainfall

When precipitation patterns are discussed in the context of Pakistan it is often divided into two seasons, the summer/monsoon and winter rains. As mentioned earlier Pakistan has hugely varied landscape and topography and this results in varied patterns across the country. Various researchers have identified that the regions of Balochistan and Khyber-Pakhtunkhwa received majority of their rainfall during the winter season (Dec-Marc) while Punjab and Sindh receive over 50% during the monsoon season. When looking at precipitation from a national context the long term trend is for an increase in precipitation; between 1901-2007 monsoon rains increased by 22.6mm while winter precipitation increased by 20.8mm. [19] The upward trend comes with a caveat, for statistical purposes the study excludes the drought that Pakistan faced in 1998-2000. if this is included in the analysis, some researchers observe an overall decreasing trend; the Ministry of Climate Change observed the fact that there has been an overall increasing trend, however it should be noted that 1994-2000 showed a decreasing trend and year 2000 had some of the lowest precipitation levels on record.[20] This clearly indicates there is a need to unpack the precipitation patterns and looking at the average annual rainfall may not be the best tool for policy development and decision making. It also important to note the variations in the summer and winter rainfall patterns.

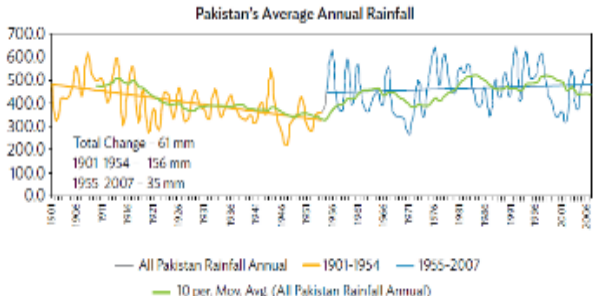


Figure 5 Time Series Annual Average Precipitation, 1901-2007 (Ch., Mahmood, Rasul, & Afzaal, 2009)

[16] (Chaudhry, Rasul, Kamal, AhmadMangrio, & Mahmood, 2015)

[17] (Rasul, Afzal, Zahid, & Bukhari, 2012)

[18] (Nasim, et al., 2018)

[19] (Asian Development Bank (ADB), 2017)

[20] (Ministry of Climate Change, 2013)

	Mean Annual Precipitation Change (%)		
Climatic Region	***Annual***	***Jun-Sept***	***Dec-Mar***
Greater Himalayas	0.49	1.73	-0.04
Summountain	0.3	0.38	0.53
Western highlands	-0.02	0.22	0
Central and Southern Punjab	0.63	0.57	0.99
Lower Indus Plains	0.22	0.45	0.27
Balochistan Plateu (East)	1.19	1.16	1.14
Balochistan Plateu (West)	0.1	0.2	0.4
Coastal Areas	-0.82	-1.34	0

Table 2 % Precipitation change (Asian Development Bank (ADB), 2017)

Several important observations can be made from the regional variations depicted in Figure 5. Overall there is a general increasing trend in precipitation except in the coastal areas and to a smaller extent in the Western Highlands. During the summer months Balochistan (West) and the coastal areas face a decreasing trend in precipitation in contrast to the rest of the country. Winter precipitation patterns show a decreasing trend in the Lower Indus Plains and Balochistan (West.) These trends are based on long term data between 1951-2000 and although this provides critical information for long term planning, this means of analysis often covers over extremes that may be felt through the calculation of averages. Therefore, although a long-term trend may be for an increase in rains, the reality is that large portions of Pakistan regularly face drought conditions. [21]

2.1.2 Flooding and Flash Floods

Flooding in Pakistan is not a recent occurrence; between 1947-2015 the country has experienced 23 flood events, including the super flood in 2010. [22] The various floods Pakistan faces again are impacted by the changing terrain, with riverine floods, flash floods, glacial floods, coastal floods and urban floods all taking place. Although the occurrence of floods is not a new phenomenon the intensity, predictability and frequency are on the rise. This is due to several reasons, but climate change is not only part of the cause but exacerbates other issues as well. Both riverine floods and flash floods are linked with the monsoon rains. For riverine floods this is when there are intense rains in the catchment areas, whereas flash floods have greater linkages to rains in the mountainous regions of Kashmir, Gilgit-Baltistan (GB), Khyber Pakhtunkhwa (KPK), Balochistan and South Punjab. [23] Coastal flooding is linked to cyclones and storm surges; these occur in the coastal regions of Sindh and to a lesser extent in Balochistan during the months of May, June, September and October. However, as the patterns around these change the predictability of such events are changing; historically Tropical Cyclones developed in the Bay of Bengal, with very few reaching the coasts of Pakistan. Due to global climate patterns, there is a trend of the North Arabian sea becoming warmer than the Bay of Bengal and thus becoming a hotbed for cyclogenesis.[24]. Pakistan faced 14 cyclones between 1997-2001 but in 2007 Balochistan faced two consecutive cyclones.[25]

2.1.3 Drought

The incidence of drought has also been on the rise indicative of climate extremes taking hold in Pakistan. Droughts can be classified into three types, meteorological, hydrological and agricultural, however all three are directly linked to precipitation. Pakistan's dependence on agriculture, a single river system and seasonal rains means small variations in precipitation can have large impacts. Records show that droughts hit every four out of ten years in Pakistan; 1967-1969, 1971,

[21] (Asian Development Bank (ADB), 2017)

[22] (Federal Flood Commission, 2015)

[23] (Aslam, 2018)

[24] (Rasul, Afzal, Zahid, & Bukhari, 2012)

[25] (Aslam, 2018)

1973-1975, 1994 and 1998-2002 are all considered severe droughts in the recent history of Pakistan. The drought between 1998-2002 led to decreased in yields for rain fed crops by 60-80%, irrigation crops by 15-20% and the death of almost two million animals.[26] Droughts are severely impacting both regions of Sindh and Balochistan and will be explored in greater detail.

Although long term trends may indicate a small increase in mean precipitation levels this analysis recent trends indicate a decreasing rate. This furthers the need to understand precipitation patterns in greater details and from a more focused perspective. What is also evident is that Pakistan is facing extremes and variability in the precipitation patterns with both droughts and floods impacting the country as whole.

2.1.4 Declining water availability

There is little need to reiterate the importance of water for the importance of life and the functioning of an economy. However particularly when working across value chains linked to the agricultural sector, understanding the systemic issues facing the water sector in Pakistan can provide invaluable insights in ensuring more resilient intervention design while building the adaptive capacity of the target beneficiaries. Pakistan is currently a water stressed country (1,100m^3/capita) [27] and well on its way to be classified as a water scarce country, where per capita water availability is below 1000m^3; besides the potential human impact, as an economy which is dependent on the sustained availability of water resources this is an alarming situation. Pakistan besides being a water stressed country is also highly insecure. Water availability per capita has been falling through a combination of population growth and mismanagement.

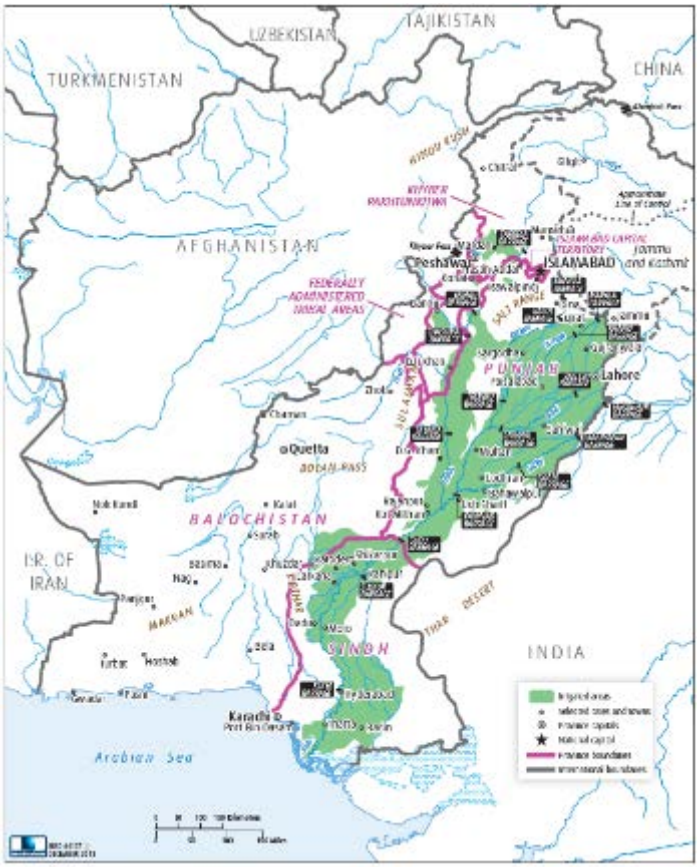


Figure 6- Irrigation map of Pakistan (Young, et al., 2019)

As an arid country with limited and variable rainfall, the Indus river system, including its tributaries is often referred to as the 'lifeline' of Pakistan. The river system itself is fed through limited precipitation, primarily relying upon snow and glacier melt in the Himalayas as well as from bordering countries. Unlike other countries with multiple river systems and/or basins, Pakistan's dependency on a single river system leaves it extremely vulnerable to any shocks to this ecosystem service. At present, rain fed agriculture is not feasible across the country and therefore agriculture in the country is dependent on irrigation systems; one of the largest contiguous irrigations system in the world[28].

Investments in the Indus Basin Irrigation System (IBIS) has been to the tune of USD 300 billion while the contribution to gross domestic product (GDP) had been accounted as USD 21.2 billion, approximately 20% of GDP in 2015-2016.[29] Currently data around water resources face significant gaps; although surface water inflows are measured adequately, runoff particularly outside the

[26] (Ahmed K. , Shahid, Harun, & Wang, 2015)

[27] (Young, et al., 2019)

[28] (UNDP Pakistan, 2016)

[29] (UNDP Pakistan, 2016)

Basin itself is not measured adequately. The same applies for groundwater, where withdrawals are measured but often resulting in double counting, [30] and this is further hampered by not having adequate mapping of groundwater resources available.

Figure 7 depicts the water balance related to the Indus basin. When one looks at the withdrawals in Pakistan, it shows a very high proportion of the available resource is extracted. Even if the withdrawal per capita is adjusted for the double counting of groundwater use, Pakistan withdraws 655m^3 when compared to 600m3, 420m3 and 560m3 for India, China and Turkey respectively[31]. Projections show that there may not be a major change in inflows soon, however the population is continuing to increase exceeding 300million by 2047. Therefore, demand is expected to increase while supply stays consistent resulting in an increase in the level of water stress, while the availability of water will remain variable.

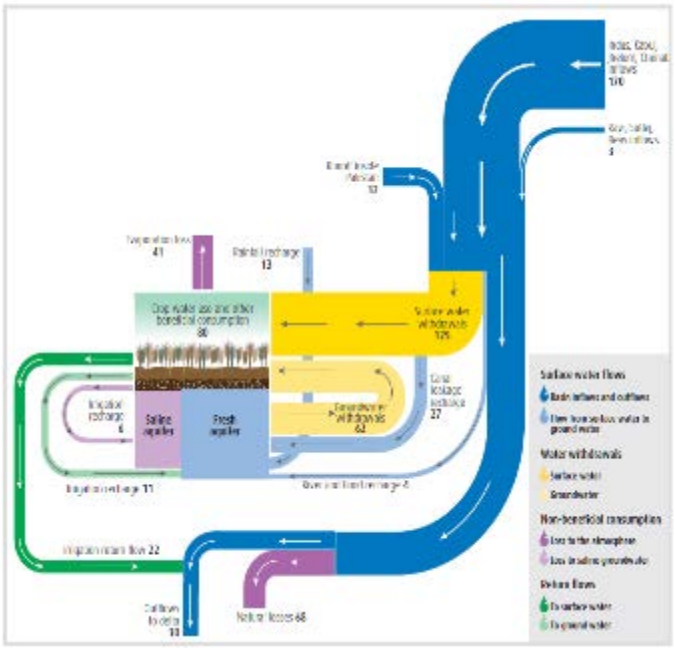


Figure 7 Annual Withdrawals from the Indus Basin (Young, et al., 2019)

The provinces have signed flows from the Indus. Under this accord certain assumptions underpin the division, these include a flow of 114.35 million acre feet (MAF) a year and 3 MAF ungauged canals. The subsequent division between provinces shows Punjab with 55.94 MAF (77% irrigated area), Sindh 48.76 MAF (14% irrigated area), KPK 8.78 MAF (5% irrigated area) and Balochistan 3.87 MAF (4% irrigated area) [32].

The largest consumer of the available water resources is agriculture; 91.6% of total annual water use can be attributed to agriculture; almost 23 million hectares of land has been cropped over the last yen years and of which 80% is irrigated; irrigated agriculture accounts for 90% of major crop production including wheat, small grains, sugar cane, cotton and the horticulture sector[33].

The fact that Pakistan is trending towards water scarcity is enough of an indicator that water insecurity persists but understanding water management and agricultural practices will help in understanding how to ensure livelihoods remain sustainable.

The main crop irrigation practice remains flood irrigation, regardless of crop type. The preference for the majority of farmers has been to use irrigation water from canals, however when it is short (dry seasons) the secondary source is to use tube wells. The intermittent and unpredictable nature of water supplies often means that farmers use as much as possible when it is made available (a few days a week). The lack of storage units means farmers are compelled to use the water when it is made available, further negating the desire to partake in efficient practices.

When water from tube wells is the main source of water for irrigation there are negative impact on ground water levels, but this has further resulted in reduced soil quality due to the prevalence of brackish ground water, which directly impacts the pH levels of the soil; as a consequence, yields decrease as well as increasing costs for fertilizers such as Diammonium phosphate (DAP) which do not actually impact pH levels.

Groundwater extraction is another major source of water both for domestic and agricultural use. Currently approximately 50.2 MAF annually of ground water is extracted for agriculture, doubling from 25.6 MAF in 1976. Although tube wells are relatively high cost, it is estimated approximately 1

[30] (Young, et al., 2019)

[31] (Young, et al., 2019)

[32] (Kamal, 2009)

[33] (Mangrio, Mirjat, Keghari, Zardari, & Shaikh, 2015)

million tube wells are scattered across Pakistan, running on electricity or diesel with a recent proliferation of solar tube wells. The use of tube wells was subsidized to a value of PKR 28 billion per annum in Balochistan; the unforeseen consequence of such policies has been the fact that the water table has fallen significantly. The importance of groundwater can further be emphasized by the fact that it now contributes to 47% of water available at the farm head[34]. Although this does improve water availability at a farm level the impact on ground water levels can be devastating as shown in Balochistan which has sever impacts to long term water security. If solar tube wells are to be promoted it needs to be done in such a way that the extracted resources are regulated which practically is a very difficult proposition.

In regards for paying for water, canal Irrigation in supplied to farms weekly through a *warabandi* system; this system results in farmers getting full flow of water from the watercourse at a given time each week based on the size of the landholding and the rights to these are provided to those farmers with land within the canal command area. Within the Punjab the fee is locally referred to as an *Abiana* which are assessed in collaboration with Farmers Organizations; It is these FOs which are also responsible for the collection of the *abiana* and depositing it to Punjab Irrigation and Drainage Authority (PIDA). It is important to note that the *abiana* rates are not based on volume of water but a combination of crop types (there are 49 groups) and land holding size. The result is that often the recovery rates only cover 30-35% of operation and maintenance costs and when combined with poor budgeting practices there can be huge variances in the availability of funds for operation and maintenance (O&M).[35]

Water resources in Pakistan are facing multiple pressures which are exacerbated by a growing population. Resources are mismanaged with inefficient irrigation practices prevailing across the country; crop selection also places greater stress as they are thirsty crops. The river system feeding the irrigation system is fragile and facing multiple pressures impacting its flows; over extraction often results in the tail end users not receiving water. The interprovincial nature of the issue ensures that sentiments can run high when dealing with the issue. Groundwater resources are an alternative source of irrigation but are also under pressure due to over extraction and creating other issues such as water logging and salinity.

2.1.5 Key issues – climatic conditions of Pakistan

- High dependency on monsoon rains, with summer monsoons contributing over 60% of annual precipitation
- Arid to semi arid environment
- Highly dependent on the world's largest contiguous irrigation system, the Indus Basin irrigation System
- Balochistan plateau covers majority of South-West Pakistan, a mountainous area which is receives less than 210mm of rainfall annually.
- Increased frequency of climatic events such as floods, droughts, glacial lake outburst floods,

[34] (UNDP Pakistan, 2016)

[35] (Planning Commission, 2012)

2.2 Climate change vulnerability in Balochistan

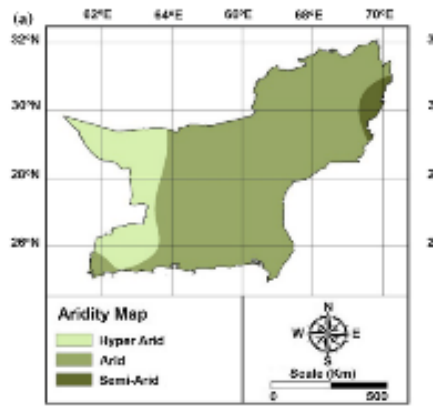


Figure 8 Aridity Map (Ahmed, Shahid, & Harun, 2014)

Working in Balochistan provides unique challenges and opportunities due to its unique geology, topology and climate. While being the largest province in Pakistan the province can be divided into five ecological zones, i.e. the Upper Highlands, Lower high lands, the Plains and Deserts.[36]

The Upper Highlands are those districts that have the valley floor above 1,500m and can rise to 3,700m and the lower high lands range from 600-1200m. The terrain of Balochistan is dominated by mountains thus the plains occupy only a small percentage of the area, while the coastline is almost 760km^2 [37]. The result is a combination of hyper arid and semi-arid environments with mean annual rainfall as low as 155mm in areas. Temperatures in the north can be quite low in winter and high in summer, becoming milder as you move towards the coast [38]

2.2.1 Temperature Patterns in Balochistan

As mentioned earlier, Balochistan faced the highest change in mean temperatures across both winter and summer months; however how does this translate across the regions. With only 4 meteorological stations data is limited but the increase was reflected in all stations, Dalbandine, Pasni, Sibbi and Panjgur (in increasing order). Overall Balochistan between the years of 1960-2007 has increased its temperature by 1.2 degrees Celsius. Regarding minimum temperature, Balochistan has faced an increase in the average minimum temperatures by 0.99 degrees Celsius. The diurnal temperature range is varied across the province, with areas such as Zhob (Upper Highlands) and Jiwani (coastal) showing increasing trends, while the Quetta and Dalbandine showed minor insignificant decreases. The change in mean temperatures is slightly impacted by seasonality in Balochistan. The winter months are facing an increase in mean temperatures by almost 1.12 degrees Celsius; the summer months face a smaller increase of 0.69 degrees Celsius which is still a considerable increase[39].

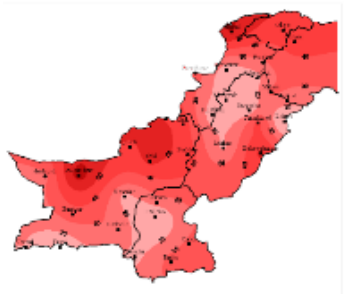


Figure 10 Frequency of Hot Days (Ch., Mahmood, Rasul, & Afzaal, 2009)

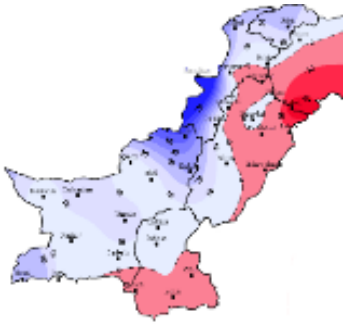


Figure 9 Frequency of Cold Days (Ch., Mahmood, Rasul, & Afzaal, 2009)

Heat Waves are on the rise in Balochistan, focused predominately in the west. The map shows the total change in heat wave days and how Balochistan is one of the most impacted areas in the country. In the mountainous north of Balochistan there has been an observed increase in 30-60 days in cold waves; the rest of Balochistan has also faced an increase in the number of cold waves but to a lesser extent. [40]

[36] (LEAD Pakistan, 2017)

[37] (Balochistan, 2019)

[38] (Ahmed, Shahid, & Harun, 2014)

[39] (Ch., Mahmood, Rasul, & Afzaal, 2009)

[40] (Ch., Mahmood, Rasul, & Afzaal, 2009)

2.2.2 Precipitation Patterns in Balochistan

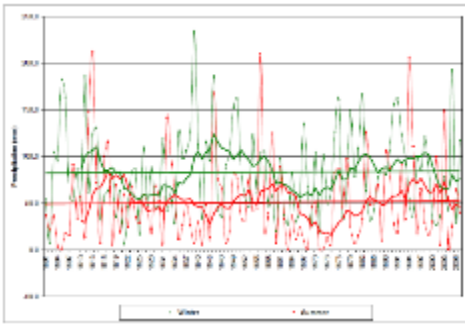


Figure 11 Seasonal Annual Rainfall Balochistan (Ch., Mahmood, Rasul, & Afzaal, 2009)

Balochistan is quite unique from the rest of Pakistan when it comes to its precipitation pattern as it generally does not rely on the monsoon rains for majority of its rain. Sometimes the monsoons do reach Balochistan and bring with it heavy rainfall, but that is not the common trend; overall Balochistan has seen a slightly upward trend in annual precipitation, particularly when observed between 1955-2007, which showed a net change of 56.4mm which is drastic when compared to 2.2mm change between 1901-1953. Although there is no major upward or downward trend each season when analysed from a period between 1901-2007.[41]However as mentioned earlier simply observing averages does not necessarily paint the full picture. The vast crests and troughs indicate huge variability in the precipitation patterns; this indicates incidences of drought years and instances where large amounts of rain can lead to issues such as flooding.

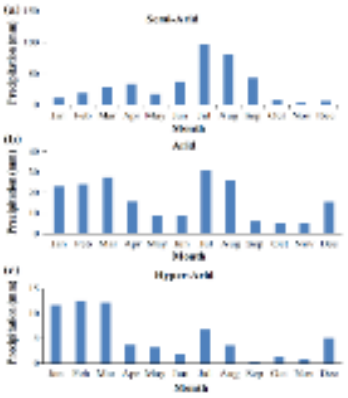


Figure 12 Seasonal distribution of rainfall in different climatic zones (Ahmed K. , Shahid, Harun, & Wang, 2015)

Figure 12 shows the monthly variation in rainfall in the various environments of Balochistan. In the semi-arid areas, the rains are predominately in the months of July and August, while winter rains are minimal. The arid areas receive significantly less precipitation overall but have larger rain spells in the winter followed by the largest rains in July and August. The hyper-arid areas seem to receive very little summer rainfall and are predominately dependent on winter rains.[42]

2.2.3 Climate Extremes

Looking at precipitation patterns provides an opportunity to identify trends that need further analysis; what is clear that within Balochistan that the precipitation trend remains relatively even when the mean is taken, but individual years' experience large crests and falls, years where rains are almost non-existent. Drought is not uncommon in the region and most districts are impacted by drought, not only because of the climatic situation but also due to the lack of water storage or irrigation in the province. The topography of the province impacts the rainfall patterns significantly, with the highlands receiving greater precipitation than the coastal areas. Between 2013-2015 Balochistan faced drought conditions, where food prices increased by 65%, 76% reduction in fodder output leading to the death of almost 85% of livestock in select districts. Lack of irrigation led to the destruction of 63% of apple, 48% of apricot, peach and plum orchards.

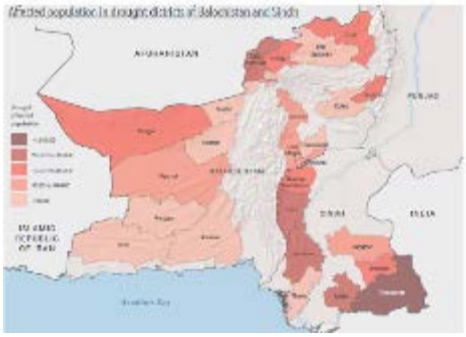


Figure 14 Drought Prone Areas of Balochistan (OCHA, 2019)

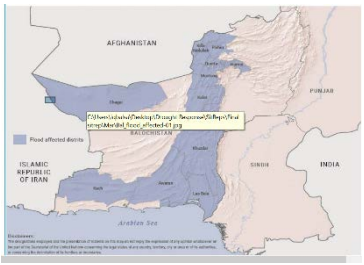


Figure 13 Flood affected districts of Balochistan (World Health Organization, 2019)

[41] (Ch., Mahmood, Rasul, & Afzaal, 2009)

[42] (Ahmed K. , Shahid, Harun, & Wang, 2015)

Drought is unpredictable but adaptation strategies can go a long way in building the resilience of the community. [43]

Areas of Balochistan, particularly the southern areas have been prone to flash floods, usually because of heavy monsoon rains rather than riverine flooding. The Districts of Turbat and Gawadar are particularly vulnerable.[44] Flooding in 2019 was highlighted by the World Health Organization (WHO), where heavy rainfall in Lasbella resulted in extreme flash floods in February. The nature of the topography in Balochistan are such that the impact was felt beyond Lasbella, with Killa Abdullah, Turbat, Pishin and Khuzdar also impacted. [45] Although a series of over 300 dams (check dams and delay action dams) exists these have burst due to heavy rains causing damage to lives and livelihoods; flash floods have also damaged the Makran Coastal Highway, and important transport links.[46]

ADB created an overview of the hazards faced by districts nationally. A rating of 5 indicates a significant hazard. The topography means Balochistan a hotbed for seismic activity, however of importance and associated with climate change can be the flood risks which dominate as well as those of drought, which both impact the largest number of provinces. [47]

Table 3 Disaster Risk Rating (Asian Development Bank (ADB), 2017)

District	Flood Risk	Landslide	Earthquake	Tsunami	Cy1clone	Drought	Avalanche	GLOF	PDMA Policy	Total Risk
Bolan	4	3	3		2	3	1	1	5	20
Jaffarabad		1	3		2	3	1	1	5	18
Nasirabad	5	1	3		1	2	3	1	5	18
Quetta	3	1	5		2	5	1	1	1	17
Jhal Magsi	4	1	2		2	2	1	1	5	16
Sibi	3	1	2		1	3	1	1	5	15
Loaralai	3	2	3		2	4	1	1	1	15
Killa Saifullah	3	3	3		1	3	1	1	1	14
Kech	3	1	1		4	4	1	1	1	14
Kalat	3	3	3		1	1	1	1	1	12
Pishin	2	1	4		1	3	1	1	1	12
Harnai	3	1	2		1	3	1	1	1	11
Barkhan	3	1	3		1	2	1	1	1	11
Mastung	2	2	3		1	2	1	1	1	11
Killa Abdullah	3	1	3		1	2	1	1	1	11
Khuzdar	3	1	1		1	4	1	1	1	11
Gwadar	1	1	2	1	3	1	1	1	1	10
Lasbela	2	1	1	1	3	1	1	1	1	10
Ziarat	1	1	4		1	1	1	1	1	9
Kohlu	2	2	2		1	1	1	1	1	9

[43] (Islamic Relief Pakistan)

[44] (Balochistan Disaster Management Authority)

[45] (World Health Organization, 2019)

[46] (Balochistan Disaster Management Authority)

[47] (Asian Development Bank (ADB), 2017)

Chagai	2	1	1		1	2	1	1	1	8
Washuk	2	1	2		1	1	1	1	1	8
Zhob	2	1	2		1	1	1	1	1	8
Panjgur	1	1	1		1	3	1	1	1	8
Nushki	2	1	2		1	1	1	1	1	8
Kharan	2	1	2		1	1	1	1	1	8
Dera Bugti	1	1	2		1	1	1	1	1	7
Sherani	1	1	2		1	1	1	1	1	7
Musakhel	1	1	2		1	1	1	1	1	7

2.2.4 Water Management

Even though Balochistan is the largest province the unique terrain results in relatively limited cultivation. The low precipitation and lack of major surface water sources ensures that the people of Balochistan have already developed adaptation strategies to make the most of the available water. Recent estimates indicate that the province has 21.493 MAF of potential water resources of which 8.490 MAF is surface water, 2.210 MAF is groundwater and 10.793 MAF flood generated runoff.[48]

The province relies on three forms sources of water, floodwaters from seasonal flows, irrigation water and groundwater. Balochistan still relies heavily on the use of traditional irrigation method of *kareze*. These are underground channels that utilize the topography and gravity to transport water over vast distances; with the capacity to irrigate 10-20hecatres and serve 200 shareholders it represented a critical water source for large portions of Balochistan. However, the proliferation of tube wells and unregulated groundwater mining has meant that these traditional water management resources are degrading, with the total area being irrigated with karezes falling from 14.2% in 1980 to 7.5% in 2000.[49]

Table 4 Area Irrigated by Different Sources of Irrigation in Balochistan from 1995-1996 to 2016-2017 (Bureau of Statistics, 2017)

District	Total	Area Irrigated By canal				Wells				Karez e and Others	%
		GOVT	PVT	TOTAL	%	Wells	%	Tube Well	%		
Balochistan	**1,109,560**	**442,884**	**92,767**	**535,651**	**48%**	**63,138**	**6%**	**481,676**	**43%**	**29,095**	**3%**
Quetta	9,168	0	0	0	0%	60	1%	8,925	97%	183	2%
Pishin	23,860	0	0	0	0%	305	1%	22,690	95%	865	4%
Killa Abdullah	11,550	0	0	0	0%	126	1%	10,743	93%	681	6%
Chaghi	8,009	0	0	0	0%	4,844	60 %	3,165	40%	0	0%
Nushki	16,517	0	0	0	0%	1,904	12 %	14,413	87%	200	1%
Loralai	28,782	0	0	0	0%	0	0%	27,952	97%	830	3%
Musakhail	3,745	0	0	0	0%	0	0%	2,985	80%	760	20 %
Barkhan	19,895	0	0	0	0%	0	0%	14,325	72%	5,570	28 %

[48] (Irrigation Department Government of Balochistan, 2014)

[49] (Majeed & Ali).

Zhob	18,197	4,000	13,000	17,000	93%	144	1%	908	5%	145	1%
Sherani	1,578	0	0	0	0%	0	0%	410	26%	1,168	74%
Killa Saifullah	92,900	0	0	0	0%	0	0%	92,770	100%	130	0%
Sibi	22,616	0	5,314	5,314	23%	0	0%	17,302	77%	0	0%
Harnai	7,186	0	0	0	0%	464	6%	1,632	23%	5,090	71%
Ziarat	6,608	0	0	0	0%	2,492	38%	3,768	57%	348	5%
Kohlu	3,206	0	0	0	0%	0	0%	2,415	75%	791	25%
Dera Bugti	23,096	4,399	0	4,399	19%	3,178	14%	13,064	57%	2,455	11%
Nasirabad	217,278	216,598	0	216,598	100%	0	0%	680	0%	0	0%
Jaffarabad	218,050	217,370	0	217,370	100%	0	0%	680	0%	0	0%
Kachhi	21,785	0	11,157	11,157	51%	0	0%	10,628	49%	0	0%
Jhal Magsi	70,255	0	44,255	44,255	63%	0	0%	21,009	30%	4,991	7%
Kalat	17,531	0	0	0	0%	0	0%	17,499	100%	32	0%
Mastung	20,287	0	0	0	0%	0	0%	20,281	100%	6	0%
Khuzdar	86,857	0	7,190	7,190	8%	19,532	22%	59,550	69%	585	1%
Awaran	26,110	0	0	0	0%	1,830	7%	23,520	90%	760	3%
Kharan	16,678	0	0	0	0%	5,548	33%	11,130	67%	0	0%
Washuk	10,132	0	0	0	0%	4,480	44%	5,592	55%	60	1%
Lasbela	37,380	517	841	1,358	4%	1,419	4%	34,603	93%	0	0%
Turbat (Kech)	41,830	0	11,010	11,010	26%	15,912	38%	14,849	35%	59	0%
Punjgoor	25,937	0	0	0	0%	900	3%	21,651	83%	3,386	13%
Gawadar	2,537	0	0	0	0%	0	0%	2,537	100%	0	0%

The use of dug wells and tube wells is also common in Balochistan. For open/dug wells wind power is often used to extract the water but it has limited use in agriculture. Tube wells on the other hand have been increasing in their use across the province and details regarding this are discussed below. Another aspect showing the natural resilience of the populations is the use of spate irrigation; this is where floodwaters are diverted and channelled to irrigate crops by using small check dams and diversions. This requires hilly topography and deep soils; the flows are of ten the resultant of summer monsoons in the north between June and September for growth in October and February; the intensity of such farming is less than 20%.[50]

[50] (Majeed & Ali)

From an agricultural perspective, of the total area of 34.72 million hectares (mha), 2.09 mha is cultivated, 0.98 mha is irrigated, 0.85 mha is *Sailaba* and 0.26 mha is *Khushkaba.* Flood/ runoff utilized and conserved through dams and structures is 2.222 MAF while 8.571 MAF of runoff goes to waste due to a lack of storage capacities and harnessing capabilities.[51] The most common irrigation practice is to utilize flood irrigation which is extremely inefficient both in orchards and field crops. Through rainwater harvesting similar to spate irrigation Balochistan is able to cultivate almost 50% of its cultivated area. *Khushkaba* is where rainwater or localized flows are directly used to irrigate crops; cropping takes places immediately after the rains and it is hoped that the soil retains enough moisture to support growth until the next rains. This results in low intensity of cropping and high risk of crop failure. *Saliaba* is similar to spate irrigation but uses smaller constructions such as bunds to divert rainwater for irrigation purposes. This form of cultivation is also practiced in areas with higher summer rainfall such as Loralai, Kohlu and Sibi; cultivation intensity may be higher than under *Khushkaba* but remains low with high risk. [52]

Ground Water Management

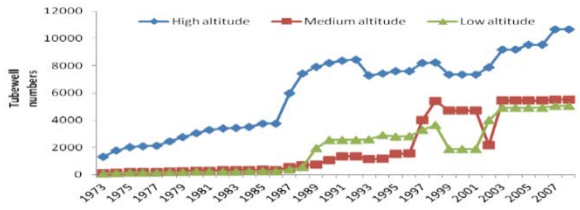


Figure 15 Tubewell growth in Upland Balochistan (Khair, Culas, & Mushtaq, 2012)

Groundwater in Balochistan plays an important role is sustaining agricultural activity; with variable precipitation many households rely on underground sources such as dug wells, tube wells, springs and karazes to irrigate both orchards and cash crops; it can be considered the main source of water for irrigation in many instances.[53]

There has been a trend to move towards tube wells, this is not only a consequence of necessity (droughts) but also due to subsidies for electricity and solar tube wells. Huge increases can be seen where there were almost 40,000 tube wells in Balochistan. Balochistan possesses very low reserves of groundwater; the annual decline in the water table due to overdraft is 2-5 m. [54] According to Balochistan Irrigation Department's 2013 estimates the annual potential of the groundwater in the province is about 2.210 MAF. At present, ground water withdrawal is 2.659 MAF and the per annum overdraft is 0.45 MAF with a projection of 1.01 MAF overdraft within the next ten years.[55] Tubewell extraction can cost between13-38% of variable cost of production and while it can range between 15-69% for those purchasing water[56].

Without delving into the ecological aspects impacting groundwater recharge, an effective analysis of groundwater depletion is to take the perspective of basins. From Figure 16 it is evident that eleven of eighteen basins are in fact overdrawn, Pishin, Zhob, Kaha and H-e-Lora facing the highest levels of overdraw. What is also an interesting point to note is that it is likely the reasons for overdraw are complex and consist of socio-economic factors unique to various regions. Zhob as an example has relatively smaller land area and relatively high precipitation yet is one of the most overdrawn river basins.

River Basins	Area Km²	DAD's		Precipitation Ave. mm	GW Balance Mm³			
		No	Storage Mm³		Recharge	Utilization	Overdrawn	Surplus
Dasht	27,690	20	31	125.4	100	94	-	6
Guj	6,025	4	8	203.1	70	72	2	-
Gawadar	17,065	5	95	65.7	40	25	-	15
H-e-Lora	84,916	1	0	129.2	40	141	101	-
H-e-Mashkel	8,260	14	33	120.9	300	27	-	273
Hingol	35,736	5	4	167.2	200	168	-	32
Hub	8,610	10	11	175.8	80	88	8	-
Kachhi	31,495	13	4	116.6	180	169	-	11
Kadanai	4,274	0	0	209.2	30	115	85	-
Kaha	11,995	9	5	281.3	190	319	129	-
Kand	1,115	0	0	245.6	10	19	9	-
Kunder	6,224	5	1	244.6	50	48	-	2
Mula	16,262	6	6	142.9	120	129	9	-
Nari	22,298	47	24	243.7	270	180	-	90
Pishin	18,133	132	45	199.9	170	566	396	-
Punali	18,540	17	21	171.5	140	146	6	-
Rakhshan	12,339	5	10	125.4	50	81	31	-
Zhob	16,425	33	34	235.2	160	270	110	-
Total	347,402	26	352	-	2,200	2,657	886	429

Figure 16 The Groundwater balance in an average year of River Basins (Bureau of Statistics, 2017)

Government policies promoting the groundwater extraction to ensure sustainable agricultural growth are well intentioned and have had a

[51] (Irrigation Department Government of Balochistan, 2014)

[52] (Majeed & Ali)

[53] (Ashraf & Sheikh, 2017)

[54] (Ashraf & Sheikh, 2017)

[55] (Irrigation Department Government of Balochistan, 2014)

[56] (Khair, Culas, & Mushtaq, 2012)

positive economic effect. However, the unregulated nature of the extraction is causing significant environmental stresses leading to collapses of environmental systems in various regions. Climate migrations due to water shortages in Balochistan are not uncommon[57] and continued extraction particularly around Quetta and Pishin will not only have impacts on economic activity but for life. The unregulated groundwater extraction and poor irrigation practices result in water logging and the build up of salinity; this is exacerbated when deeper wells are tapped.

The problems associated with water resources have largely been created through a combination of mismanagement and a lack of coordination between communities, inefficient management by provincial agriculture and irrigation departments and extreme climatic variations. Boring of deep wells in the vicinity of Karezes and shallow wells has adversely affected the production of these traditional irrigation systems threatening their sustainability. Changing and variable rainfall patterns will impact some of the main sources of irrigation water

2.2.5 Climate Projections

Although climate change projections can take various trajectories based on the basis upon which the projections were developed. i.e. business as usual, balanced and ideal world scenarios. Table 5 shows the various projections for temperature and precipitation changes in different areas of Balochistan. [58]

Table 5 Climate Projections Balochistan (Asian Development Bank (ADB), 2017)

Region	Precipitation			Temperature		
	A2	A1B	B1	A2	A1B	B1
High Balochistan	+1.48	+0.92	-0.57	+0.15	+0.26	+0.03
Lower Balochistan	-1.8	-0.98	-0.05	+0.5	+0.27	+0.01

Balochistan will be facing rising temperatures through the year, with extended number of hot days; the increase in temperature will be more substantial in the winter months. There are great variations in the precipitation patterns across the province both in terms of the timing of the rains as well as the quantity. Although policy makers may see the increase in precipitation the great variability in quantity and timings of rain has severe impacts on the ability of farmers to plan and adapt their economic activities.

2.2.6 Key issues – climatic conditions in Balochistan

- Small semi-arid areas but large arid and hyper-arid areas in the province
- Mountainous landscape creates large variations in ecological conditions across the province
- Increased frequency in hot days as well as cold waves
- Large variations in precipitation results in extended periods of drought followed and flooding without large hanges in mean annual precipitation
- Highly dependent on groundwater resources that are depleting at an alarming rate.

[57] (Kakar, Shah, & Khan, 2018)

[58] (Asian Development Bank (ADB), 2017)

2.3 Climate Change Vulnerability in Sindh

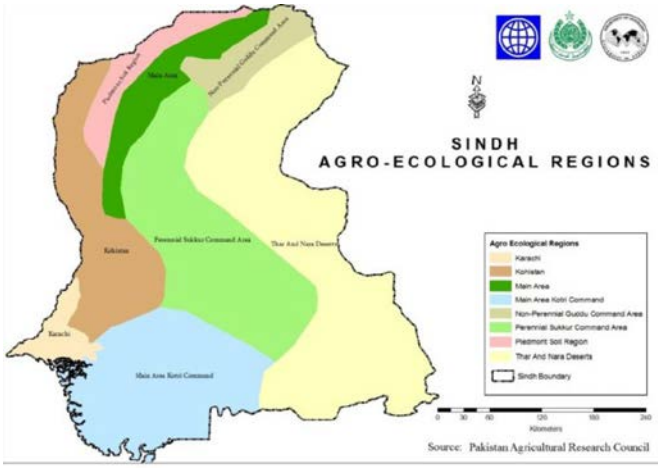


Figure 21: Agro - Ecological Regions Source: PARC (2000)

Sindh can be described as an arid area, with the exception being the coastal areas. The precipitation is relatively low and highly dependent on the monsoons. Temperatures vary across the province but it can be described as having high temperatures with mild winters and high levels of humidity. It is also useful to understand the topopgraphy, with the east representing desert areas, the west representing mountainous areas and central plains.[59]

Figure 17 Progress report of GIS Project of SERP

2.3.1 Temperature Patterns in Sindh

Temperature patterns in Sindh have remained relatively constant when compared to the other provinces in Pakistan. Although there is a general decrease in mean temperatures across Sindh there is still evidence of regional variability; further it is important to note that the temperature decrease is found to be statistically insignificant. The conclusion that can be drawn is that within the Lower Indus Plains the variations in temperature are unlikely. The potential exceptions to this are the regions of Badin, Jacobabad and Hyderabad which observed the largest decreasing trends with Hyderabad also showing decrease in the frequency of warm days. Karachi showed increasing maximum temperatures; this is in line with the increase in heat waves in the region and the possible effect of urbanization. The trend is slightly different when considering the mean minimum temperatures; this has proven to be significant, showing an increase of 0.54 degrees Celsius. The increase in mean minimum temperatures has coincided with a fall in the frequency of cool nights of between 4-16 days. Regarding the diurnal temperature range, Sindh has shown a decreasing trend.[60]

These trends may make it seem like there are not a lot of changes happening when it comes to temperature variations in Sindh; however, when looking at the seasonality there is a trend that becomes clear. Although the summer months in Sindh are not experiencing large variations in temperature, the change in the annual mean is being driven by the change in the winter months; Sindh shows 0.91 degrees increase in the mean temperature for the winter[61].

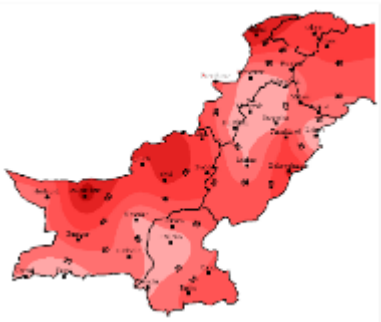


Figure 18 Frequency of Hot Days (Ch., Mahmood, Rasul, & Afzaal, 2009)

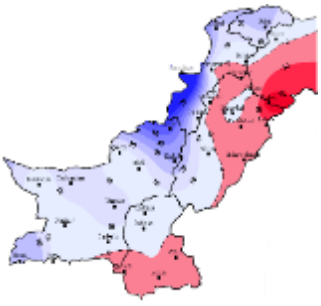


Figure 19 Frequency of Cold Days (Ch., Mahmood, Rasul, & Afzaal, 2009)

as Sindh, similarly, to the rest of the country is facing an increase in the number of heat waves its faced. Although the situation is not alarming as that in Balochistan areas of Sindh in the east and north are facing 30-60 day increase in heat wave days. Regarding cold days, the southern tip of the province is facing a decrease in the number of cold days while the interior shows a small increase.[62] In Karachi a single heat wave killed 65 people in 2015[63] illustrating the severity of the situation

[59] GIS PAPER

[60] (Ch., Mahmood, Rasul, & Afzaal, 2009)

[61] (Asian Development Bank (ADB), 2017)

[62] (Ch., Mahmood, Rasul, & Afzaal, 2009)

2.3.2 Precipitation Patterns in Sindh

Between 1914-2007 Sindh has shown two different trends. Between 1914-1969 there has actually been an increase in mean annual rainfall, however when looked at from the period of 1961-2007 a vastly different picture is portrayed; during this time Sindh has experience a fall in annual rainfall by 10.2mm, The second observation to note regarding the precipitation is the heavy reliance on the monsoons to the point that annual rainfall trends closely follow that of the monsoon. Recent trends have shown a fall in precipitation levels but the average evens out by heavy precipitation events. The coastal areas of Sindh such as around Karachi and Jacobabad receive some of the lowest levels of rainfall in the region but the rains they do receive were between June and August. The rest of Sindh is more influenced by the monsoons and have historically received much of their rainfall between June and Sept. [64]

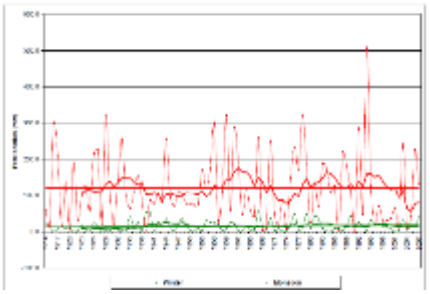


Figure 20 Seasonal Annual Precipitation (Ch., Mahmood, Rasul, & Afzaal, 2009)

What is evident is that in all scenarios South Eastern Sindh will not face great variations in mean temperatures but have an increase in mean precipitation. The rest of Sindh faces a different story, with projections showing a fall in mean temperatures and an increase in mean precipitation; however understanding the time frames with which these projections were developed means one should still be weary of the alarming decreasing trend in precipitation in the recent past.

2.3.3 Climate Extremes

Sindh is prone to flooding and generally experience two forms of floods, riverine and torrential. Torrential floods are harder to predict and are associated with monsoon (July- August) rainfall hitting the eastern border of Balochistan; the topography means there are number of hills at the border between Sindh and Balochistan and these create the hill torrents which can lead torrential floods along the western boundary in Sindh. With a lack of effective communication between the provinces and the short lead time that torrential floods provide mean that communities are particularly vulnerable to such disaster events[65].

Riverine floods are the second type of flood that impacts Sindh and probably with slightly more regularity. There are many factors that have resulted in the increased damage from flooding, but one must remember that flooding and the flood plains are part of a natural cycle for any river. Human encroachment along the banks and mismanagement often exacerbate the impacts of the floods. Regarding the flow it is important to note that in the lower basin, the riverbed runs slightly higher than the adjoining land; the result is that river flows often do not flow back into the river, but rather stay standing on the flood plains. This not only creates more damage but increases impacts such as water logging and prevents the quick removal of water[66]. Further what happens in the provinces above Sindh and how effective their flood management tools are also impacts the ability of Sindh to manage flood peaks. In 2013 floods that impacted Sindh resulted in the deaths of 47 people and 88 heads of cattle, impacting 246,590 acres of crop land[67]. In 2017 in June Sindh received 197.2% above normal rainfall for the month[68].

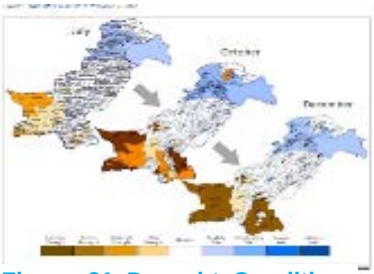


Figure 21 Drought Conditions in 2018 (National Drought Monitoring & Early Warning Centre , 2017)

However, since 2015 Sindh has not faced a major flood rather, it has been in the grip of a drought like conditions since 2013. These observations are in line with the falling trend in precipitation

[63] (Shaikh, 2019)

[64] (Ch., Mahmood, Rasul, & Afzaal, 2009)

[65] (Memon)

[66] (Federal Flood Commission, 2013)

[67] (Federal Flood Commission, 2013)

[68] (National Drought Monitoring & Early Warning Centre , 2017)

towards the end of the data availability and moreover with the fact that winter temperatures are increasing and precipitation falling. What is important to note is that the drought situation is far worse in the west where access to irrigation canals is limited. A study on select districts identified cultivation area decreased from FY17-FY18, drought affected areas were impacted with decreased yields, by 17% for wheat, rice by 70%, cotton by 16%, cluster beans by 30%, millet by 38% and pulses by 45% while the actual fall in yields exceeded the drop-in acreage. For livestock 25% noted death of cattle, 54% reported death of goats, 45% death of sheep, 21% for buffalos, 20% camel, 18% for donkeys and 57% for poultry. The death of livestock can be associated with a lack of fodder, disease prevalence and a lack of water[69].

The coastal areas face an additional challenge of sea water intrusion because of environmental degradation but is exacerbated by sea level rise and increased level of cyclone activity and storm surges. This in turn has exacerbated coastal erosion, where there is now visible impact of changing habitats.[70]

ADB created an overview of the hazards faced by districts nationally. A rating of 5 indicates a significant hazard. The topography means Balochistan a hotbed for seismic activity, however of importance and associated with climate change can be the flood risks which dominate as well as those of drought, which both impact the largest number of provinces. [71]

Many of the districts within the province are prone to a flooding and drought, with an alarming number of districts receiving a category 5 level for droughts. Due to the coastal belt being much flatter than that in Balochistan and the changing patterns in the development of cyclones, significant portions of the province can face such risks. Lastly points of note are the fact that Karachi and Thatta as coastal cities also face the threat of tsunamis; as a mega city and hub for economic activity the prevalence of a tsunami could have catastrophic impacts.

Table 6 Disaster Risk Ratings (Asian Development Bank (ADB), 2017)

District	Flood Risk	Landslide	Earthquake	Tsunami	Cyclone	Drought	Avalanche	GLOF	PDMA Policy	
Karachi	4	1	5	5	5	5	1	1	5	30
Hyderabad	5	1	4		4	5	1	1	1	20
Thatta	4	1	2	3	4	1	1	1	5	20
Tando Muhammad Khan	5	1	4		4	5	1	1	1	20
Dadu	5	1	2		2	5	1	1	5	20
Qamber and Shahdakot	5	1	3		2	4	1	1	5	20
Badin	4	1	3		5	2	1	1	5	20
Tando Allahyar	4	1	4		4	5	1	1	1	19
Matiari	5	1	3		2	3	1	1	5	18
Kashmore	5	1	3		2	5	1	1	1	17
Jamshoro	5	1	2		3	5	1	1	1	17
Jacobabad	5	1	3		2	5	1	1	1	17

[69] (National Disaster Consortium, 2019)

[70] (Rasul, Afzal, Zahid, & Bukhari, 2012)

[71] (Asian Development Bank (ADB), 2017)

Shikarpur	5	1	3		2	5	1	1	1	17
Nawabashah	5	1	2		3	5	1	1	1	17
Naushahro Feroze	5	1	3		2	5	1	1	1	17
Mirpur Khas	4	1	3		4	4	1	1	1	17
Khairpur	5	1	2		2	5	1	1	1	16
Ghotki	5	1	2		2	5	1	1	1	16
Sukkur	5	1	2		2	5	1	1	1	16
Tharparkar	3	1	2		4	4	1	1	1	15
Larkana	5	1	2		2	4	1	1	1	15
Umerkot	3	1	2		3	3	1	1	1	13
Sanghar	4	1	2		3	2	1	1	1	13

Sindh is likely to face an increasing trend in climate extremes, both in the forms of floods and droughts. Although flooding and droughts have existed in the past, poor management of natural resources is impacting the resilience of communities and ecosystems to come back from exogenous shocks. Areas of Sindh will also have to brace for an increased number of cyclones hitting the coast as well as very localized risk of tsunamis.

2.3.4 Water Management

Regarding water availability, as mentioned in earlier sections, Sindh is heavily reliant on canal irrigation and the monsoon rains; however, the rains are not sufficient to support agriculture and the dependence on canal irrigation is enhanced during droughts.

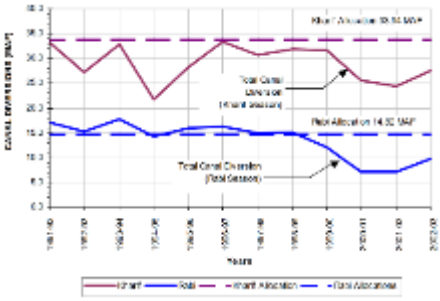


Figure 22 Actual vs. Allocated Diversions (Azad, Rasheed, & Memon, 2003)

A water accord between the provinces established allocations of Worryingly the trend in the recent past is for Sindh to get significantly lower volumes than allocated under the 1991 accord. During both growing seasons since 1990 diversions to Sindh have been well below the allocated amount by almost 10MAF[72]. The reliance on irrigation water which is variable also has disproportionate impacts on the poorer segments of the population; pricing was discussed briefly in regard to water as each province has their own regime but in Sindh to extract water in FY16 from the canal cost PKR 181.9/acre whereas the cost to access water from a tube well was closer to PKR 1,837.5/acre[73]. With irrigation demand expected to increase by 50% by 2025, and operating close to 90% means that an additional 30 MAF will need to be extracted from river diversions[74]

[72] (Azad, Rasheed, & Memon, 2003)

[73] (State Bank of Pakistan)

[74] (Azad, Rasheed, & Memon, 2003)

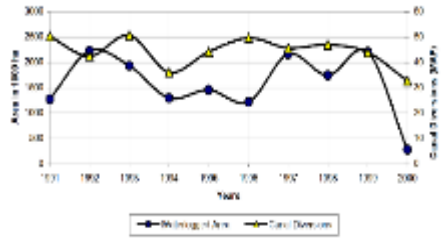
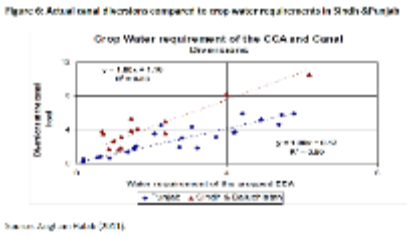


Figure 23 Waterlogging and Canal Diversions (Azad, Rasheed, & Memon, 2003)



Irrigation practices are traditional with low irrigation delivery and an application efficiency of 35%; these issues are exacerbated by the fact that there are inefficient cropping patterns, poor agronomic practices, lack of levelled field and the impact of political influence in increasing diversions. When compared to Punjab it is visible that Sindh river diversions are at 160% of actual canal diversions. This is not only representative of crop selection and traditional irrigation practices but also due to the issues of water logging and salinity[75]. The rivers naturally carry a high level of salts, almost 73% of the naturally occurring salts are retained in the basin and accumulate in the soils and underlying aquifers. The inefficient use of canal water promotes water logging and thereby depositing greater levels of salts in the soil; the problem is exacerbated in Sindh due to the way the irrigation system has developed[76]. The lack of effective drainage and a relatively high-water table means that water logging persists in large areas of Sindh and exacerbate issues of salinity.[77]

Table 7[78] shows the various areas under different forms of irrigation. Wells are not common in the provinces and little analysis will be conducted regarding the use of wells.

Table 7 Area under different forms of Irrigation (Bureau of Statistics, 2017)

District	Total Area Sown	Un-Irrigated	Irrigated					
			Total	Canal	% of Irrigated	Well	Tube well	% of Irrigated
Sindh	**2,256,735**	**569,731**	**1,687,004**	**1,324,218**		**359**	**362,427**	
Sukkur	61,236	2,428	58,808	47,632	81%		11,176	19%
Khairpur	170,311	7,279	163,032	135,672	83%		27,360	17%
Ghotki	134,824	27,956	106,868	1,147	1%		105,721	99%
S.B. Abad	162,325	70,571	91,754	80,021	87%		11,733	13%
Nausheroferoze	156,341	10,299	146,042	132,920	91%		13,122	9%
Larkana	44,636	19,390	25,246	16,674	66%	9	8,572	34%
Jacobabad	22,364	13,298	9,066	4,582	51%		4,475	49%
Shikarpur	54,326	4,469	49,857	47,629	96%		2,228	4%
Mirpurkhas	154,726	27,945	126,781	85,561	67%		41,220	33%
Sanghar	216,589	91,444	125,145	122,324	98%		2,821	2%
Umerkot	76,926	28,350	48,576	35,224	73%		13,352	27%
Tharkparkar	176,469	142,995	33,474	27,471	82%		6,003	18%
Hyderabad	30,448	4,413	26,035	18,978	73%		7,057	27%
Badin	233,539	57,703	175,836	175,070	100%		766	0%
Thatta	180,170	16,263	163,907	157,064	96%		6,843	4%

[75] (Sindh Water Sector Improvement Project, Fourth Draft)

[76] (A, McCornick, Qadir, & Aslam, 2007)

[77] (Sindh Water Sector Improvement Project, Fourth Draft)

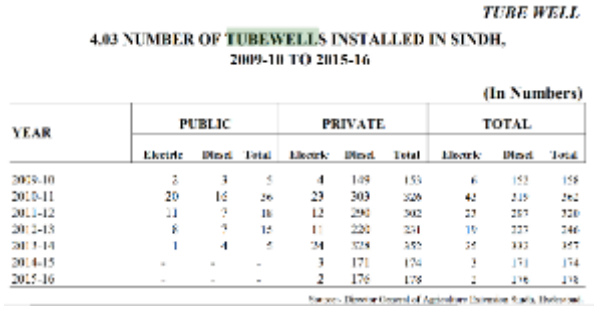
[78] (Bureau of Statistics, 2017)

Daddu	120,437	60,379	60,508	52,231	86%	214	7,613	13%
Kashmore	37,861	4,742	33,119	25,373	77%	16	7,730	23%
Kambar Shahadkot	60,685	6,008	54,677	52,892	97%		1,785	3%
Jamshoro	61,762	15,520	46,242	38,558	83%	120	7,564	16%
Matari	66,709	10,692	56,017	15,592	28%		40,425	72%
T.A. Yar	85,987	33,746	52,241	28,232	54%		24,009	46%
T.M. Khan	58,325	27,335	30,990	21,133	68%		9,587	31%
Karachi	5,145	1,912	3,233	2,238	69%		995	31%

What is clear from the data is a heavy reliance on canal diversions for irrigation, however spatial variations do exist. For example, the District of Ghotiki has almost a 100% reliance on groundwater, while Badin is at the opposite end of the spectrum relying almost exclusively on canal irrigation, in fact only Matari and Ghotki utilize greater than 50% of their irrigation water from ground sources.

However fundamentally these issues are pinned down by the inefficient pricing mechanism currently operating in Pakistan; with such limited price on water resources there is little incentive for farmers to invest in the most minimal of water saving technologies, let alone expensive solutions such as drip.

Ground Water Management



TUBE WELL

4.03 NUMBER OF TUBEWELLS INSTALLED IN SINDH, 2009-10 TO 2015-16

(In Numbers)

YEAR	PUBLIC			PRIVATE			TOTAL		
	Electric	Diesel	Total	Electric	Diesel	Total	Electric	Diesel	Total
2009-10	2	3	5	4	149	153	6	152	158
2010-11	20	16	36	23	303	326	43	319	362
2011-12	11	7	18	12	290	302	23	297	320
2012-13	8	7	15	11	220	231	19	227	246
2013-14	1	4	5	34	328	362	35	332	367
2014-15	-	-	-	3	171	174	3	171	174
2015-16	-	-	-	2	176	178	2	176	178

Source: Bureau of Agriculture Extension & Agric. Education

Figure 24 Number of Tubewells Installed in Sindh 2009-2010 to 2015-2016 (Bureau of Statistics, 2017)

Groundwater resources in Sindh have not developed to as a great an extent as in other provinces like Punjab and Balochistan; this is in line with the issues of reduced canal flows as well as the persistence of drought. What can be observed is that there was a sharp increase in the number of installations, but the rate of growth has slowed. However there are now in excess of 100,000 tube wells operating in the province, predominately privately owned, extracting almost 4.2 MAF/year.[79] This extraction bring an additional 3.2Mg in Sindh[80]. The issue of salinity from groundwater extraction is not as intensive as in Punjab or even Balochistan, however due to the higher water tables and lack of drainage the issue is creating serious issues. If the quality of the ground water is observed, areas surrounding the main river channel are facing hazardous quality of groundwater; this is not only harmful for human consumption but also impacts agricultural productivity.[81]

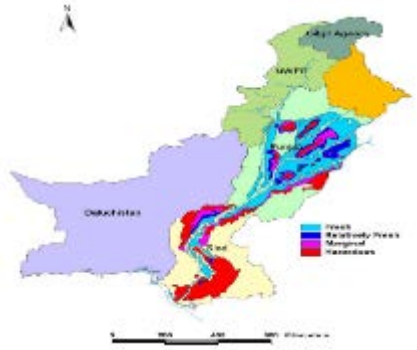


Figure 25 Spatial Distirbution of composite groundwater quality in the Indus Basin of Pakistan (A, McCornick, Qadir, & Aslam, 2007)

Water management in Sindh is critical to sustain the livelihoods of much of the rural population. The high dependence on variable river flows and inefficient utilization means those individuals at the tail end of the system often do not receive adequate irrigation. Further issues of water logging and salinity with hazardous groundwater quality impact large portions of the province making the land unsuitable for agricultural activity. There is scope to improve the productivity of water even when compared to provincial neighbours

[81] (A, McCornick, Qadir, & Aslam, 2007)

2.3.5 Climate Projections

Although climate change projections can take various trajectories based on the basis upon which the projections were developed. i.e. business as usual, balanced and ideal world scenarios. Table 8 shows the various projections for temperature and precipitation changes in different areas of Sindh.[82]

Table 8 Climate Projections Sindh (Asian Development Bank (ADB), 2017)

Region	Precipitation			Temperature		
	A2	A1B	B1	A2	A1B	B1
South Eastern Sindh	+5.1	+3.0	-0.1	0.00	-0.1	+0.01
Sindh	-1.8	-0.98	-0.05	+0.5	+0.27	+0.01

2.3.6 Key issues – climatic conditions in Sindh

- Agircultre highly dependent declining irrigation system
- Region is dependent on summer monsoons which have bcome increasingly erratic
- Prone to drought and floods with additional coastal hazards
- Water logging and salinity a significant threat to agriculture
- Highly dependent on groundwater resources that are depleting at an alarming rate.

[82] (Asian Development Bank (ADB), 2017)

3 Climate Risks in Selected Value Chains

3.1 Climate Risks in Selected Economic Sectors

3.1.1 Climate Risks in the Horticulture Sector

Keeping in mind the concept of Rabi (Oct-Dec sowing, with harvest in March-April, usually wheat) and Kharif Crops (Feb-Aug). The broad nature of horticulture crops means that specific crops may be impacted by variations in temperature and precipitation. Overall it was observed that an increase in temperature by (0.5-2degrees) can reduce overall productivity by 8-10% by 2040.[83] This is not only due to changes in the length of growing seasons but also issues such as water availability, pesticides, labour supply, household characteristics and exposure to extreme events; it is noted that high summer rainfall is critical for winter crop productivity.

Changing climate can impact agriculture in several ways both positively and negatively. Positive effects include increased productivity from warmer temperatures, decreased moisture stress, possibility of growing new crops, accelerated maturation rates, longer growing seasons and increased productivity from enhanced CO2. However, the negative effects far outweigh these, to include crop damage from heat, difficulties in planning, increase insect infestation, drought, rain, weed growth, moisture stress, disease, strong floods, waterlogged land, and decreased efficiency of pesticides and herbicides. [84]

Climate Risks	Impact
Changes in growing period	increasing temperatures can impact growing period in two ways. Firstly, the span of the growing period can increase but the cycle of growth for the crop will fall; since plants reach maturity earlier, they are unable to develop fully, and yields will not be optimal.
Increased evapotranspiration	The increased temperatures not only increase evaporation from the soil but also the leaves of the plant; this increases the amount of water required to ensure optimal production.
Changing River Flows	although in the short run more water may be available and increase water availability for tail enders, this would not be sustainable, and the flows will eventually slow because of glacial melt increasing dependency on precipitation (particularly considering the minimal storage capacity Pakistan and the provinces have). The changing river patterns will impact the frequency of floods as well through the reduction in natural reservoirs.
Water Logging and Salinity	The build up of the water table creates water logging that can impact the ability of plants to absorb nutrient while preventing the proper aeration of soil hampering plant growth. Water logging also increases salinity, which increases wilting in plants as well as growth patterns. Salinity also impacts the ability of crops to absorb nutrition and changes the composition of soil
Water Shortage	Although water shortages are not only a direct consequence of environmental parameter but rather mismanagement of resources, it is an important environmental risk to consider.
Extreme Climate Events	Incidences such has flash floods, heavy precipitation, droughts, hail and dust storms as well as cyclones have increased in the recent past. This impacts agricultural activities not only by destroying standing crops, but it can damage stored grain through fungus development and diseases.

Table 9 Climate Risks in the Horticulture Sector

[83] (Dehlavi, Gorst, Groom, & Zaman, Climate Change Adaptation in the Indus Ecoregion, 2015)

[84] (Raza, et al., 2019)

3.1.2 Climate Risks in the Livestock Sector

While the livestock sector represents one of the greatest portions of agricultural output there is little empirical evidence on the impact of climate change on the livestock sector. The impact of livestock on climate change however is documented, almost 90% of emissions of GHG emissions associated with agriculture and 40 % of overall emissions are associated with the livestock sector.[85] Even though Pakistan does not contribute a great amount of emissions per capita, the effective management of livestock waste and/or productivity increases can reduce the footprint of the livestock sector. Another important consideration for the livestock sector in the utilization of rangelands; almost 93% of the Balochistan province is classified as rangeland; [86]however this does not mean that all the rangelands are equal, the north proves to be much more suitable to grazing. However, the north also carries a significant proportion of the livestock population but with nomadic populations moving south following the winter rains.

Figure 26 Rangelands of Balochistan (Ahmad & Islam)

Climate change and poor management of common resources is hampering the ability to the vast rangelands of Balochistan support the livestock population in the region. This is due to the changing precipitation patterns hampering water availability for livestock and people, the frequency of heat waves causing stress to animals and increasing the water requirements while rangelands degrade during drought conditions and because of overgrazing. Even the vegetation cover is changing as perennial grasses and shrubs are being replaced by less preferred nutritious species. Vegetation is removed not only through grazing but the fact that many communities rely on fuel wood extracted from grazelands due to lack of availability of alternate fuel and heating sources. An important point to note is that rangeland management the world over requires significant community participation; the erosion of traditional management and community regimes in Balochistan has not only impacted water management regimes in the area but also the way in which common resources such as rangelands are managed.

In Sindh rangelands again play a vital role in providing forage for livestock, particularly sheep and goat. In the arid zones that cover almost 60% of the total land area in the province,[87] around Thar, Nara and Kohistan rangelands provide more than 70% of the forage requirements of the animals. These communities have been made more vulnerable to climate change through a combination of social and economic pressures. This migratory communities used to follow the rains and graze

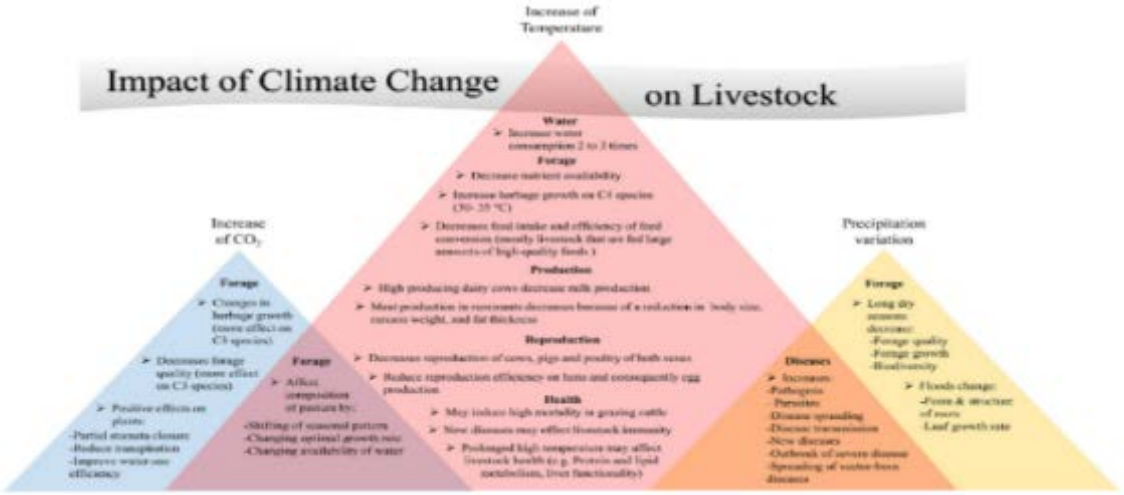


Figure 27 Impacts of Climate Change on Livestock (Rojas-Downing, Nejadhashemi, Harrigan, & Woznicki, 2017)

[85] (Asian Development Bank (ADB), 2017)

[86] (Ahmad & Islam)

[87] (Forest Department Government of Sindh, n.d.)

along the flood plains, particularly during times of drought; not only did this provide communities with alternate feeding grounds it also allowed the rangelands to recover. Due to changes in landholding rights and the social structure of agriculture in Sindh many communities are restricted from accessing flood plains, increasing their dependence on overgrazed rangelands. The impacts of climate change are furthering hampering the regeneration of important range lands that not only provide fodder for livestock but are also important habitat for flora and fauna. The increasing population and size of herds all contribute to the environmental impacts reducing the quality of rangelands[88].

There has not been a vast amount of research on adaptions strategies for farmers regarding livestock management and those that are available are limited and face high costs. However, there is scope and the main concern from an environmental perspective is how to ensure enough feed and water is available for livestock considering a changing climate; this can be through increased productivity of the animals as well as improved management of rangelands/feed.

Climate change can impact livestock through several ways, primarily though the true the greatest number of impacts can be traced back to increased temperatures. [89]

Climate Risks	Impact
Temperature Increase	Decreases feed intake, efficiency of feed conversion and productivity
	Decreased reproductivity of cows and poultry:
	Inducing higher mortality rate particularly for grazing cattle
	Reduced health and increased incidence of disease
Precipitation Variation	Increased length of dry seasons and reduced forage quality
	Flooding Patterns
CO2 Variation	Can change forrage patterns, growth and nutrition

Table 10 Climate Risks in LIvestock

Some of these impacts and others that are likely to impact Balochistan and Sindh are discussed below in the context of the changing climate.

3.2 Climate Risks for Horticulture and Livestock Sectors in Balochistan

3.2.1 Horticulture value chain climate and environmental risks in Balochistan

Changes in growing period : As the temperatures increase in both seasons' farmers must adapt their cropping patterns to be in line with the extended summers and shorter winters. The increase in winter temperatures is substantial and changes in agricultural practices are essential to ensure sustained economic growth. Prolonged extreme temperatures can exacerbate drought which impacts water availability. The increased temperature will impact other issues such as evapotranspiration and land degradation. Although droughts are not only due to the temperature increase, the increased temperatures place greater stress on all resources during drought periods. Cold waves are also a risk that needs to be highlighted; although not as frequent as droughts this can have impacts on standing crops.

Increased evapotranspiration: With consistently increasing temperatures increased rates of evapotranspiration can be expected in both winter and summer seasons. This will impact crop water requirements but also soil moisture. Keeping in mind the scarce and variable precipitation, this can have large impacts due to limited water availability. Particularly in arid areas soil moisture will be severely impacted and this can lead to lower capacity for recharge and faster flows exacerbating flood risks. In areas with heavy use of tube wells, there is a likelihood that increased

[88] (IUCN Pakistan)

[89] (Rojas-Downing, Nejadhashemi, Harrigan, & Woznicki, 2017)

evapotranspiration rates will result in faster build-up of salinity due to the salts extracted from groundwater

Changing River Flows: Certain districts of Balochistan are highly dependent on irrigation received from canals. The potential changes in flows of the mountain streams and from the main irrigation system can impact the availability of irrigation water to farmers in the area with little alternatives. The changing river flows can also impact the perennial rivers that scatter across the province, impacting flash floods and the functioning of farming systems such as Saliaba. Increased temperatures can also impact the melting of snows and the resultant flows.

Water Logging and Salinity: Although sea water intrusion along the coast is not that great due to the topography, excessive water mining and the proliferation of tube well based irrigation is resulting in increased salinity levels across the province. The water table rising before boring to deeper depths causes water logging in areas as well as inefficient irrigation practices; this in turn builds up This not only actively hampers the natural resistance of plants to extreme weather conditions but also reduces the yield, which in turn reduces the productivity of water in an already water scarce environment. Drought conditions exacerbate this by placing further stress on groundwater resources

Extreme Climate Events: The incidence of drought is a recurring theme in terms of natural calamities that hit Balochistan. Variable rainfall places immense pressure on already depleted ground resources, reducing water availability for livestock and agriculture. Flash floods persist due to hill torrents and the prevalence of short heavy bursts of rain; these floods can devastate standing crops and represent a lost resource in terms of water; the construction of check dams is unregulated to a certain extent and better planning and storage will need to be developed. Coastal areas face the risks of cyclones although the topography is such that tsunamis are unlikely to impact.

Water Shortage: The quickly depleting and falling ground water table with large basins being overdrawn is an extremely alarming issue in Balochistan. With variable scant rainfall and limited rainfall there is a large dependence on groundwater extraction to ensure sustainable cultivation. Although this has brought economic benefits the limited recharge at the basin level can result in catastrophic impacts on the lives and livelihoods of communities dependent on them. As groundwater levels fall the cost of extraction rises making water inaccessible to the poor. Further extracting water from deep regions results deteriorating quality and the extraction of salts. The mining of water also results in the collapse of traditional irrigation systems in the region. All of this can have devastating impacts on the population with climate induced migration already persisting in the province. The increased persistence of hot days and droughts adds to the pressure already placed on groundwater resources and the costs associated with extraction mean the poor are particularly vulnerable. Reliance on precipitation is not an option in the province and effective management is an urgent requirement.

The horticulture sector in Balochistan will face several challenges associated with climate change and environmental risks in the province. Balochistan will be facing increased temperatures across both the winter and summer months, altering the lengths of growing seasons for various crops. The dependence on rainwater harvesting puts many farmers at risk as although mean precipitation is not significantly altering, there is large short-term variability which can result in drought and floods. As a province receiving limited rainfall there is a high dependency on precipitation, irrigation and groundwater for cultivation purposes; a consequence the variable precipitation has been an increasing dependence on groundwater which has led to unsustainable levels of extraction and a quickly depleting water table. The sector will need to adapt to a situation where water is scarce while demand increases due to an increasing population but also climate impacts on crop requirements.

3.2.2 Livestock value chain climate and environmental risks in Balochistan

Temperature Increase: Balochistan is facing an increase in both summer and winter temperatures as well as an increased incidence of heat eaves, this can have several effects on livestock The stress of increased temperatures and sustained hot days will mean that livestock are likely to need an increase in water consumption. With the animals already receiving less water than necessary this can have lasting impact. It has already been noted that drought has resulted in the loss of livestock and with the incidence of drought persisting ensuring adequate water is available for livestock will becoming increasingly difficult. Groundwater is becoming increasingly difficult to

extract for poorer segments of society and nomadic tribes will be severely impacted. There may be a need to change migratory routes and the times at which tribes move.

Decreases feed intake, efficiency of feed conversion and productivity: A consequence of the sustained increase in temperatures will likely decrease the amount of feed that they will intake. The reduced water availability for livestock will exacerbate this issue and lead to lower efficiency in feed conversion. This essentially means that for the animal to convert their food they will utilize a greater amount of energy; to provide as much yield each animal will require a larger amount of feed. When the animal is unable to feed adequately yields both in terms of dairy and meat will fall; the input costs for rearing livestock will increase just to ensure the same level of productivity. Yields will also be impacted by the shortages in water and beyond the economic impacts this can have implications on food security in the region.

Decreased reproductivity of cows and poultry: The ability for livestock to reproduce is one of the reasons it is an attractive proposition for many segments of the population. The ability for a herd to grow ensures that the investments made in the health and wellbeing of an animal will reap rewards beyond and are in line with the idea that many people view the animals as assets. Reduced reproductivity may not be noticeable and immediately impact farmers but this will be a slow process and herd sizes may begin to shrink. This impacts the long-term sustainability of livestock rearing if adequate adaptation measures are not taken. The stresses placed on the animals by other climate effects such as reduced feed intake and a lack of adequate water will also impact the health and reproductive capacity of livestock. Poultry animals will also lay fewer eggs and the widespread dependence on eggs as a source of protein can also impact health and nutrition.

Inducing higher mortality rate particularly for grazing cattle: Grazing is common practice for livestock and the vast tracts of land are traversed in order to find good grazing grounds. In the instance of high temperatures as well as other climate effects including increased water requirements and inability to convert feed effectively means animals will be placed under immense stress. The long travel without adequate shelter and resources can result an in increase in mortality rates amongst livestock. Competition for grazing areas will intensify as will competition for water resources furthering the degradation of rangelands. Impacts of extreme weather events will be more severe in conjunction with the other climate impacts.

Reduced health and increased incidence of disease: Cattle in Balochistan is already susceptible to several diseases due to the limited availability of veterinary services in the region. The climate impacts mentioned above will all work towards reduced health of livestock. Due to the inadequate management practices and the poor health of the animals the incidence of disease is likely to increase. The high temperatures will also aid in the ability of diseases to be transmitted and thrive. The extraction of poor-quality water if used for cattle will also impact the health of the animal. As climate patterns change the timings and prevalence of new diseases in the region is possible.

Precipitation Variation

Increased length of dry seasons and reduced forage quality: The prevalence of drought and vast fluctuations in precipitation levels has already resulted in stresses being placed on the livestock sector. With summers becoming longer and monsoon patterns changing there may be a reduced period of high-quality grazing available to farmers. The impacts of rangeland degradation and changes in rainfall are already showing signs as the type of vegetation cover and type change. The ability to of rangelands to restore or rebalance will be impacted and the impacts of degradation will be more severe. This will result in farmers becoming more vulnerable to any shifts in rainfall, potentially changing migratory patterns and consequentially a socio-economic dynamic.

Flooding Patterns: Although Balochistan is not severely impacted by riverine floods, flash floods are commonplace and provide less time to respond. This means changing climate patterns will impact snow melt and increase the instances of heavy rains. The dependence of many herders on following the rains for good grazing lands will put them in threat of potential flash floods. If the patterns of these floods begin to alter many of the mitigation measures in places may become redundant and new investments will have to be made in adjoining areas.

CO2 Variation: Changes in atmospheric CO2 levels can impact of vegetation and water use efficiency but the lack of available data and long-term impacts of such changes, further analysis will not be conducted.

The livestock sector in Balochistan will face several challenges associated with climate change and environmental risks in the province. The increase in temperatures will have the largest impact on livestock in the region altering water consumption, feed intake, reproductivity and the general health of the animal. Combined with extreme climate events such as drought and a water shortage the ability to livestock farmers to fulfil the nutritive requirements of their livestock will be tested. The rangelands which support much of the livestock in the region are being degraded and the rate of degradation is likely to increase in the face of climate change.

3.3 Climate Risks for Horticulture and Livestock Sectors in Sindh

3.3.1 Horticulture value chain climate and environmental risks in Sindh

Changes in growing period: Although the mean temperatures are not increasing substantially nor the temperature in the summer months, there is evidence of warming in the winter months. This will impact crops sown in the rabi season and farmers will need to be aware of the changes in climate patterns. Sindh is also facing an increase in the duration of hot days and that may need to be considered, particularly kharif crops. The increase in temperatures is also an indicator for the onset of drought and during the drought itself, increased temperatures place greater stress on resources such as water.

Changing River Flows: Sindh depends largely on the irrigation to support the agricultural system Therefore the impacts of climate change felt in the north do reach the delta. It is anticipated that through the melting of glaciers, in the short run flows may in fact increase in the Indus. This has scope to create disasters in the form of flooding; increased flows, that natural topography and a lack of storage capacity can lead to flooding threatening lives and livelihoods. Further the tail end has experienced low flows in recent history, the folly of farmers not adapting their irrigation practices considering short term increases in supply can have disastrous effects in the long run, severely impacting their resilience.

Increased evapotranspiration: It is anticipated that the rates of evapotranspiration will increase in the Sindh region. The increase in temperatures in the winter months will impact winter crops, but the increase in frequency of hot days is also likely to increase stress levels on crops and soils. Further due to the natural composition of the river water, increased evapotranspiration is likely to increase the salinity levels in the soil, exacerbating an issue that is already impacting crop productivity in the region. In the face of drought and increased temperatures increased evapotranspiration rates would result in crops requiring greater quantities of water, ensuring overall water requirements to increase. The south east will face issues with ensuring soil moisture as the area is particularly prone to hot spells.

Water Logging and Salinity: Water logging reduces plant growth and increases incidences of root diseases. The anoxic condition can also lead to denitrification reducing nitrogenous fertilizer in soil which in fact contributes to GHG's with greater warming potential than CO2. Water logging also increases salinity which is that the accumulation of salts in the soil. Salinity impacts germination and reduces crop standing and resistance to drought as well as their growth patterns and ability to absorb nutrients. [90]

Impacts in Sindh: Sindh faces serious issues regarding water logging and consequently salinity. Traditional (flood) irrigation, poor drainage, lack of salt exit and unsustainable groundwater extraction all impact the water table. Not only does this reduce yields for standing crops but can also lead to areas being unsuitable for agricultural activity and increase the incidence of disease and pests.

The coastal areas face the unique situation of sea water intrusion as the protection mangroves provide is lost due to over extraction and environmental degradation. The coastal areas are particularly vulnerable to salinity to the point where it is at dangerous levels in certain areas, particularly around the south east and delta. There are examples of fresh water sources essentially becoming unusable due to the levels of salinity now present. Areas surrounding the main river also face significant levels of salinity and water logging, mainly due to the irrigation practices in the province and poor management. Salinity can be disastrous for agriculture, making large tracts of

[90] (Machado & Serralheiro, 2017)

land essential uncultivable. This has and will continue to create huge economic losses for individuals and even creates the possibility of large-scale migration. Canal water extractions are also well above the actual crop requirements as farmers utilize water for seepage and in attempts to drain the salts from the soil. Reversing salinity is not possible without significant changes at policy, implementation and infrastructural levels. Farmers will need to learn to adapt to the quality of water made available or significant tracts of one cultivable land will no longer be cultivable.

Extreme Climate Events: The natural flooding in the riverine areas creates fertile soils but unregulated development and encroachments along the banks of the river leave populations particularly vulnerable. Further the flooding intensifies the issues of waterlogging due to the lack of drainage and appropriate seepage which in turn exacerbates salinity issues. The floods also provide a missed opportunity for the storage of water in times of drought; the lack of storage results in large amounts of flows reaching the sea. However equally dangerous to the province is the persistence of drought. Many of the districts are vulnerable to drought and this can have devastating impacts on the economy; drought years will result in an increased reliance on canal water, which would already be stressed due to low flows, and harmful groundwater. Droughts with increased temperatures and evapotranspiration rates are going to place immense stresses on crop production, decreasing yield and quality of produce. Sindh as a coastal zone also must face the new dynamics associated with cyclones and the increased frequency with which they are hitting the mainland.

Water Shortage: Sindh is facing a dire situation when it comes to water availability, with high variability across the province. The reliance on a single irrigation source which is reducing its flows leaves farming communities extremely vulnerable to any shocks. The poor groundwater quality further reduces the adaptive capacity of farmers leaving them increasingly dependent on precipitation. It was shown that precipitation patterns are variable, in the summer with drought not uncommon. The limited options in terms of access to water and lack of storage to benefit from periods of increased availability the population and the agricultural economy is left extremely vulnerable.

The horticulture sector in Sindh will face several challenges associated with climate change and environmental risks in the province. Sindh will not be facing immense changes in temperatures, but the duration of hot days is increasing as well as the incidence of drought. The changing precipitation patterns are resulting in periods of heavy rains that exacerbate flooding as well as long periods with almost no precipitation prompting droughts. Water shortages will play a significant role in the sustainability of the horticulture sector in Sindh. The dependence on canal irrigation that already is being utilized more than initially designed while flows may reduce in the long term leaves the population vulnerable to shocks to the irrigation system. High levels of water logging and salinity will impact crop productivity and continue to rise. Communities in coastal regions will also be facing the unique threats of cyclones that will increase in frequency in the light of a changing climate.

3.3.2 Livestock value chain climate and environmental risks in Sindh

Temperature Increase: The mean temperatures in Sindh are not showing great variation and even possibilities of a fall in mean temperatures in the future. However, there are increased duration and frequency of heat waves in the province showing that there are still significant temperature increases. The South East which shows an increase in projected temperatures is also more prone to heat waves.

Increasing water consumption up to 2-3 times: The stress of sustained hot days will mean that livestock are likely to need an increase in water consumption, particularly during this period. The general shortage in water availability is likely to exacerbate this issue as farmer will struggle to provide adequate hydration for their animals; this will further impact both health and productivity of the animals. It has already been noted that drought has resulted in the loss of livestock and with the incidence of drought persisting ensuring adequate water is available for livestock will becoming increasingly difficult. Groundwater is becoming increasingly difficult to extract for poorer segments of society and nomadic tribes will be severely impacted. There may be a need to change migratory routes and the times at which tribes move. The fact that there is less precipitation in winters, yet the region faces increased temperatures can lead to the need to ensure greater water consumption than in the past.

Decreases feed intake, efficiency of feed conversion and productivity: The impacts in Sindh will be sporadic in that the real impacts of the increased in temperatures will be during extreme

days, particularly during heat waves and droughts. During these times animals will likely reduce their consumption of fodder as well as produce less (meat and dairy). The quality of fodder will become increasingly important during these times as rangelands are degraded; farmers will need to ensure that the right quantity and right types of food are reaching their livestock. When the animal is unable to feed adequately yields both in terms of dairy and meat will fall; the input costs for rearing livestock will increase just to ensure the same level of productivity. Yields will also be impacted by the shortages in water and beyond the economic impacts this can have implications on food security in the region.

Inducing higher mortality rate particularly for grazing cattle: Grazing is common practice for livestock and the vast tracts of land are traversed in order to find good grazing grounds. In the instance of high temperatures as well as other climate effects including increased water requirements and inability to convert feed effectively means animals will be placed under immense stress. Particularly for migratory groups the lack of proper shelter and protection from the elements places animals at greater risk. Degraded rangelands and deforestation mean there is less shade available to animals and instances of extreme heat and a lack of precipitation will lead to greater mortality rates. As waterlogging and salinity also plague the landscape there is the likelihood of increased incidence of disease and pests that can impact the livestock. Competition for grazing areas will intensify as will competition for water resources furthering the degradation of rangelands. Impacts of extreme weather events will be more severe in conjunction with the other climate impacts.

Reduced health and increased incidence of disease: Cattle in Sindh are already susceptible to several diseases due to the limited availability of veterinary services in the region. The climate impacts mentioned above will all work towards reduced health of livestock. Due to the inadequate management practices and the poor health of the animals the incidence of disease is likely to increase. The high temperatures combined with waterlogging will also aid in the ability of diseases to be transmitted and thrive. The extraction of hazardous water if used for cattle will also impact the health of the animal. As climate patterns change the timings and prevalence of new diseases in the region is possible.

Precipitation Variation

Increased length of dry seasons and reduced forage quality: The prevalence of drought and vast fluctuations in precipitation levels has already resulted in stresses being placed on the livestock sector. With summers becoming longer and monsoon patterns changing there may be a reduced period of high-quality grazing available to farmers. Rangelands are continuing to degrade across the province and waterlogging and salinity plague the province further restricting the available land for grazing. Those farmers that do receive feed may need to adapt to changing availability of crops such as maize as well as potential higher prices because of increased demand; further groundwater resources are considered hazardous in vast tracts of Sindh. Farmers will struggle to provide the basic nutrition animals require, particularly amongst nomadic communities. Drought is common in Sindh and this will also impact the availability of fodder available in rangelands and from agriculture sources; Sindh's dependence on variable flows from the Indus mean communities are particularly vulnerable to the increased dry seasons and the impact that it will have on food and water security.

Flooding Patterns: Sindh faces severe riverine floods as well as floods from heavy rains. July-August represent the peak times for torrential floods which are harder to predict. Riverine floods and the impacts of these are often a case of mismanagement with encroachment along banks common. It has been observed that there has been reduced grazing along the plains, but it persists, and these communities will be vulnerable if adequate warning systems are not in place. However, the riverine and torrential rains, provide a missed opportunity to the water stressed province. These large freshwater flows can significantly supplement the availability of water in the region to support livelihoods in the region. However, as erosion takes place the banks are moving and underground aquifers as well; changing flooding and river patterns can also impact the water logging and salinity in the area which can impact the ability of farmers to feed their livestock.

The livestock sector in Sindh will face several challenges associated with climate change and environmental risks in the province. The increase in the duration of hot days and heat waves will have significant impact son livestock in the region altering water consumption, feed intake, reproductivity and the general health of the animal. Although these issues may arise during climate extremes this means farmers are particularly vulnerable as the ability to adapt is restricted. Combined with extreme climate events such as drought and a water shortage the ability to livestock farmers to fulfil the nutritive requirements of their livestock will be tested. The rangelands which support much of the livestock in the region are being degraded and the rate of degradation is likely to increase in the face of climate change; salinity and water logging are serious issues that will not only impact the quality of rangelands but the long term survival of these ecosystems.

3.4 Climate Risks, Mitigation and Adapatation Strategies Along the Value Chain

3.4.1 Climate Smart Agriculture and the role of technology

A recently completed study on developing the Climate Smart Agriculture profile for Punjab[91] represents a critical study that provides guidance to project practioners and researchers and how to approach ClimateSmart Agirculture in Pakistan. Although the study focuses on Punjab, current studies are being conducted for Sindh and Balochistan and thus will not be duplicated in this report. The approach the study took and lessons learnt can inform regarding the adaptive capacity potential climate smart practices that can be adopted; although the focus in this study is not specific to horticulture many of the adaptation strategies can be utilized in climate smart interventions during the implemtnation of the GRASP project.

Crop Selection	CSA Practices and Technologies
Wheat	Balanced use of fertilizer
	Use of heat tolerant varities
	Increase in sowing density
Cotton	Drip irrigation
	Sowing in ridges and raised beds
	Integration on biocontrol agents for pest management
Rice	Synchronization of transplantation and fertilization time
	Alternate wetting and drying.
Fruits	Use of blubber irrigation
	Addition of Gypsum to treat pH of Soil
	Use of heat tolerant varieties
Poultry	Use of latest weather forecast technology to plan activities
	Manual feeding in controlled shed
	Automatic feeding in controlled shed

Table 11 CSA Practices and Technologies[92]

Table XYZ provides a few examples of climate smart agricultural activities, with the study providing an overview of a greater number of crops. Punjab's agriculture sector has proven to be more advanced than that of Sindh and Balochistan and one can assume that they will have greater adaptive capacity; however some of the issues being faced by the provinces such as salinity can provide similar solutions i.e. gypsum.

Other technologies will aso be considered to tackle the key issues of

- Increasing access to water
- Increasing productivity of water
- Mechanization
- Information avialability

[91] (CIAT: FAO, 2018)

[92] (CIAT: FAO, 2018)

3.4.2 Developing Markets for Climate Smart Agriculture and the Role of Technology

Many of the climate smart agricultural practices require technologies and/or advancements in practices in order to be implemented. However equally important is the development of markets around these technologies. These markets ensure that necessary inputs and tools are available beyond the project life. Importantly these new technologies provide opportunities for a number of support services to be developed opening up the agrientrepenural space.

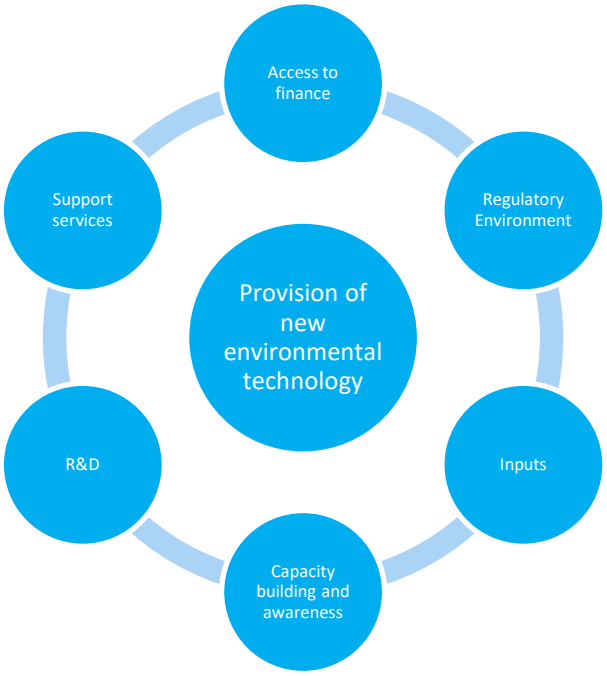


Figure 28 Market for Environmental Technologies

3.4.3 Mainstreaming Climate Risks in Value Chain Interventions

To effectively mainstream environmental and climate risks it is important to take an additional step in planning and identify value chain intervnetions that can result in enhanced climate resiliences.

IFAD has developed a checklist that practitioners should consider for value chain assessments, the framework which is shown in Table 12. [93]

Value chain interventions/outcomes		
Input supplies	**Agricultural Production**	**Post-production : storage, processing, transport and retail**
Fertilizers	Soil Management	Post-harvest management
Animal feed and breeds	Water Management	Siting of processing facilities
Pest Management	On-Farm Energy	Energy in processing
Information Services	Diversification	Water in processing
Financial Services	Livestock	Packaging materials and methods
Tools and Equipment	Fisheries and aquaculture	Procesing infrastructure
	Production	Transport hubs and routes
Soil Management	Landscape-level management	Refigeration and cold chains
Water Management	Skill base of farmers and local institutions	Just in time logistics
On-Farm Energy		Demand from retail and consumers

[93] (International Fund for Agricultural Development, 2015)

		Commodity labelling and certification

Table 12 Value Chain Interventions

This checklist was tailored to local conditions and conducted for each value chain that the GRASP project is working on and can be found in Annex A

4 Climate Policy and Financing in Pakistan

4.1 Policy responses to climate change

Part of the reason that there is a disconnect between the climate policy and implementation is the disconnect between the federal and provincial governments. While the Ministry of Climate Change operates at the federal level many of the actionable policies developed will need to be implemented by provincial governments after the 18th Amendment which devolved many responsibilities to the provinces.

At the national level Pakistan is well equipped with policies that tackle issues of climate change however it is often the lack of implementation, compliance and enforcement that are the biggest hurdles.[94]

Some major national policies/laws include[95]

- National Climate Change Policy (NCCP) 2012
- Framework for Implementation of Climate Change Policy 2013
- National Sustainable Development Strategy 2012
- National Environment Policy 2005
- National Forest Policy 2016
- National Rangeland Policy 2010
- National Disaster Risk Reduction Policy 2013
- National Conservation Strategy
- Biodiversity Action Plan for Pakistan
- Pakistan's Vision 2025
- Guidelines for sensitive and critical areas
- Forest Act

When unpacking the work program developed by the government on Climate Change Adaptation and Mitigation some short term objectives were identified including;

- Development of National Appropriate Mitigation Actions (NAMA)
- Preparation of the second national communication to the United Nations Framework Convention on Climate Change (UNFCCC)
- Development of National Adaptation Plan (NAP)

From the workplan it is evident that particularly in the development of a NAP there needs to be significant engagement at the provincial level; however, the provinces themselves have vastly different capacities to inform such plans. Since the Climate Change Act of 2017 has come into effect Balochistan is unprepared for its implementation; lacking a dedicated ministry the Department of Environment, Sports and Youth Affairs is responsible[96].

Provinces need significant policy and legislative support not only in mainstream strategy but the actual development of said strategies. The Currently Pakistan feels that its adaptation needs range from USD 7 billion – USD 14 billion, but significant investment needs to be undertaken for monitoring and conducting vulnerability assessments.

[94] (Nathan Associates, 2009)

[95] (LEAD Pakistan, 2017)

[96] (LEAD Pakistan, 2017)

4.1.1 Policy Development

Since the GRASP project is focused on value chain development and adaptation strategies are core to the sustainability of a markets based approach; the project will be uniquely positioned to inform climate change policy from an agricultural perspective. The current agriculture policies in place at a provincial level provide high level aspirational objectives; the GRASP project though implementing innovative interventions that can build adaptive capacity will be able to inform NAP with adaptation strategies that should be able to sustain themselves. Therefore, the project can inform several policy areas related to adaptation including;

- Environmental Agricultural Practices
- Water/irrigation management
- Crop selection and varietal development
- Disaster Risk Management
- Coordination mechanism inter and intra provincial

4.2 Cost of climate financing

There is limited research based on empirical evidence on the cost of climate change to rural Pakistan, particularly horticulture farmers. One study conducted for Sindh and Punjab provides attempted to identify the potential costs of climate change and adaptation to rural Pakistan and came across some interesting results.

Firstly based on potential changesin precipitation and temperature increased it was identified that 13% of agricultural productivity can be lost by 2050 through a 13% loss in land alue (PKR 50,000/acre)[97].

In 2018 studies indicated that Pakistan face 19 deaths and faced amost 90million US$ in losses. However when considering the fact that Pakistan has been consistently been facing extreme climatic events for over a decade the report indicates that Pakistan is ranked as facing significant economic losses, the 8th highest globally, almost 31% per unit of GDP[98].

4.3 Sources of climate finance

Pakistan has historically received low amounts of climate finance from international channels and focused on mitigation. Climate Fund Updates identified of the US$ 121.92 million approved from climate funds only 36% was dedicated towards adaptation as shown in figure 30. Also noteworthy is that both Bangladesh and India, close regional neighbours have been abel to access a far larger amount of climate funds at USD 320.8million and USD 1,230 million, respetively compared to USD 121.92 million in Pakistan. [99]

Current projects have been funded by;

- The Adaptation Fund
- Forest Carbon Partnership Facility.
- Global Environment Facility
- Green Climate Fund
- Special Climate Change Fund

[97] (Dehlavi, Groom, & Gorat, The Determinants, Impact and Cost Effectiveness of Climate Change Adaptation in the Indus Ecoregion:, 2014)

[98] (Eckstein, Kunzel, Schafer, & Winges, 2019)

[99] (Heinrich Boll Stiftung, 2020)

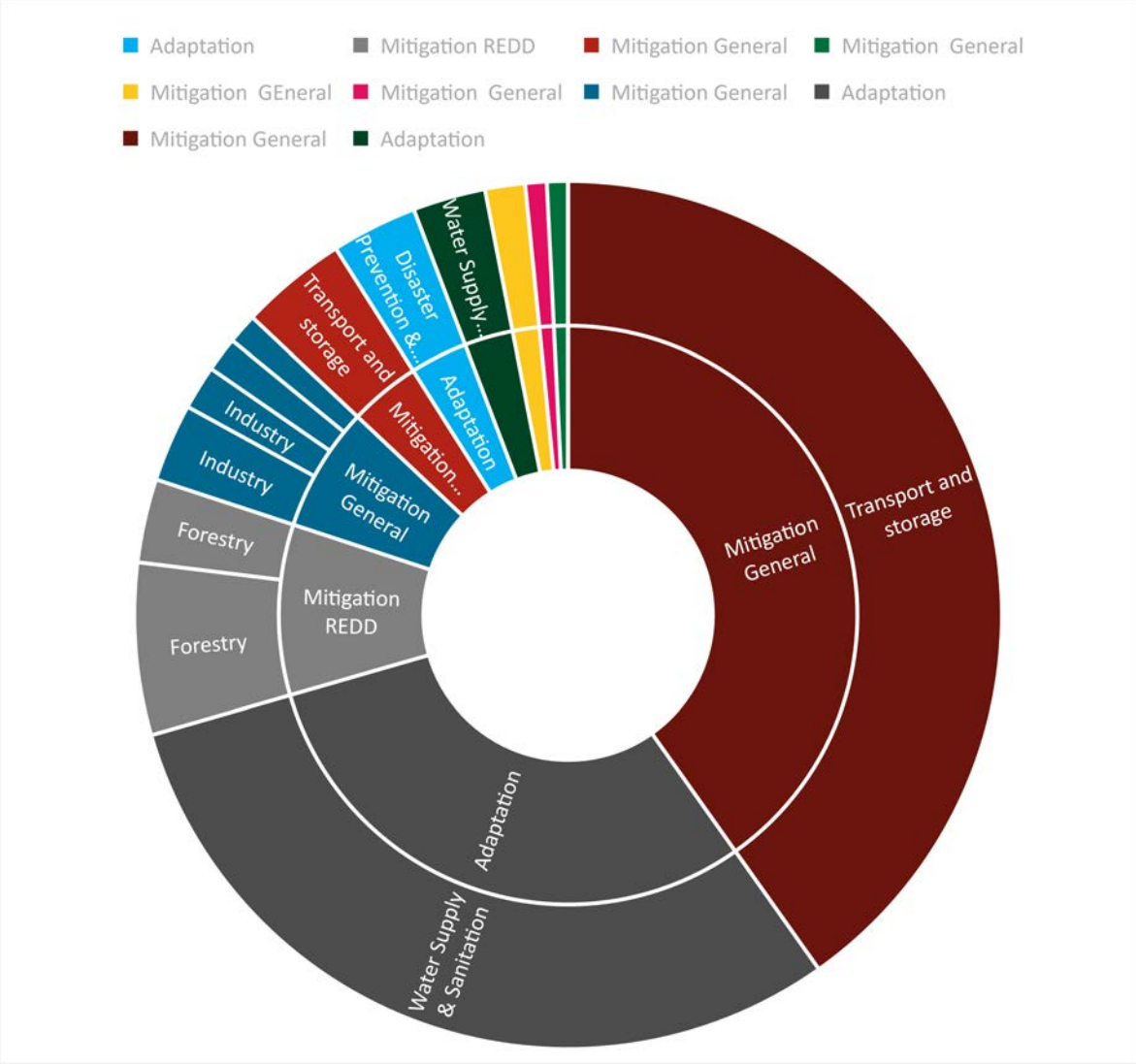


Figure 29 Approved funding from designated multilateral and bilateral cliamte funds by sector and adaptation vs. mitigation (Heinrich Boll Stiftung, 2020)

4.3.1 Institutional Mechanisms

Although after the 18th Amendment many of the sectors that are most impacted by climate change will be managed at the provincial level, the federal ministries play an important role in the climate finance landscape.

The Ministry of Finance, is the main conduit for international climate finance and also responsible to audit the funds. The Economic Affairs Division of the Ministry of Finance coordinates the finances from dnors and approves all development partner activities. The National Economic Council provides interprovincial oversight and a similar role to the Council of Common Interest.[100] Although the Ministry of Climate Change plays an important role in designing and determining the development priorities they are not ddirectly involved with the disbursement of climate funds.

[100] (Asian Development Bank (ADB), 2017)

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Appendix –

6 Horticulture Balochistan

6.1 Dates

The date palm requires the full year for the growth cycle and thrives with long hot summers and mild dry winters, ideally with limited frost. Thus, the crop has thrived in dessert like environments in North Africa, Middle East and Pakistan. Rain or high humidity during the fruiting season can create disease and damage yields during fruiting[101].

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Pollination												
Plantation												
Time of flowering												
Time of harvest												

The date growing areas of Balochistan are hyper-arid and reliant on groundwater levels which are depleting; the persistence of drought like conditions means limited ground water recharge. Although the plant is adapted to deal with water stress, severe conditions can still damage the plant. Water stress is unlikely in the hyper-arid region however, in fact with most rains coming in the winter months, long term projections show a potential decrease in precipitation in the region; without effective ground water management the long term sustainability of any cultivation in the region is under threat. The increasing maximum temperatures in the summer can also be potentially damaging with the increase number of hot days, but the potential increase in winter temperatures may be suitable for date cultivation. [102]

[101] (Shabani, Kumar, & Taylor, 2012)

[102] (Shabani, Kumar, & Taylor, 2012)

Value Chain Intervention / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			
Seeds	Currently yields are low and varieties do not yield high market demand reducing adaptive capacity. Further current cultivation practices mean a long period before initial planting and first yields. Temperatures in the growing regions are already in the extremes and likely to continue to increase; current varieties are prone to pests which will likely increase in the incidence of longer hotter summers	The propagation of tissue culture is proposed and the development of varieties needs to consider the hyper-arid environment that the majority of date cultivation takes place in; drought like conditions naturally persist but with falling ground water tables it will become an increasingly important consideration. Tissue culture will assist the expansion of date cultivation and build resistance to water shortages	Research around tissue culture varieties developed should consider temperature extremes, drought resistance and market demand Utilize date processors and exporters as conduit for dissemination of appropriate cultivars as tissue culture are not necessarily affordable inputs Propagate getting Organic Certification for areas through Farmer Marketing Collectives; considerations need to remain regarding this if tissue culture varieties are developed
Fertilizers	Soils in Balochistan are alkaline in nature and are deficient in Macro and micronutrients; poor quality fertilizers also enter the market which can have adverse impacts on agro-biodiversity and efficacy, however use is still low	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into date growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers
Pest Management	Current available varieties particularly Muzawatty are prone to attacks of dobas bug and mites.	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies and better implementation of quality controls	Leverage input suppliers to expand their reach into date growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Explore organic / agrobiodiversity solutions for specific pests in order to maintain organic production Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing. Getting the information to farmers is discussed below in

			Information Services
Information Services	Extension services are poor across Balochistan and difficulties will remain due to the vast geographic area and difficult terrain; the lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	The availability of information in many regions of Balochistan remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate date is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information
Financial Services	One of the barriers to modernizations is the availability of modern equipment in the province as well as limited capital availability; this prevents greater investment in economic activities	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop financial products for tissue culture Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs
Tools and Equipment	There is low-technology production in Balochistan but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as drought conditions and heat waves increased	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the date palm but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	Development of local service providing entrepreneurs; i.e. Laze levelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop master trainlines/entrepreneurs Support marketing activities for local machinery providers to target the province

Agriculture Production			
Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as more groundwater is extracted for irrigation purposes; potentially increased erosion due to long dry spells.	Salinity although not at extremely harmful levels is increasing and needs to be tackled; the reliance on groundwater makes it increasingly difficult but farmers need to ensure the quality of soil especially considering the long term nature of date palm plantations Soil erosion in the area will need to be curbed and incidence of heavy occasional downpours will exacerbate these issues	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas Promote the regeneration of native species in and around growing areas
Water Management	Flood irrigation is used in Balochistan which holds low running costs and easy application but is less efficient and not sustainable. The area has low precipitation and the increase incidence of heat waves will likely ensure drought persists.	The areas reliance on ground water means that some form of ground water management regime needs to be established. Storage opportunities should be expanded either at individual or community levels Appropriate technologies need to be identified as drip irrigation type of technologies have not proven very popular Increase capacity to benefit from the rains that are present through check dams, sub-surface dams	Build capacity of FMCs in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging diurnal temperature for water collection, bhungroo straw, collection of floodwaters Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Include water management as component of obtaining organic certification Make water monitoring equipment easily accessible and available Water salinity needs to be managed in similar ways to soil salinity Revival of traditional water management bodies
On Farm Energy	Energy availability is variable in the region and impacts on farm capacity for mechanization	Emissions per capita in the context of date farming will be low, however the lack of availability acts a barrier to investing in new energy intensive technologies	Promotion of solar energy solutions where possible (except ground water extraction which has proven to have large negative externalities) promote alternate energy sources, biogas, small wind turbines

Diversification	Monoculture leaves crops more vulnerable to pests and diseases as well as speeding up soil degradation;	Farmers can maximize productivity by selecting appropriate crops do be utilized for intercropping; this will not only provide shade for the soil but also maintain soil health and provide additional income	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods
Production Infrastructure	A lot of traditional processing occurs in Panjgur which is prone to drought and temperature extremes	Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current practices are basic with open sun drying leading to large number of insects, dust and inert material; this means little energy requirements which is well suited to the area	Although the process is energy efficient it leads to low quality produce opportunity to leverage solar energy in more controlled environments ensuring better quality produce. Use of plastic films are promoted and environmental impact needs to be considered of additional plastics	Work with manufacturers to develop local supply of dehydrators and solar dryers Provide financial instruments for investment in new technologies Sourcing of plastic needs consideration when promoting such techniques
Energy in processing	Currently the footprint for processing is low	The locations of any additional processing units being developed, and drying units need to consider the availability of water and energy	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Consider renewable energy sources, utilization of biomass (develop pelleting using trunks if economically feasible)

Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses as zwell as in storage areas	Suitable packaging needs to be developed for increasingly high temperatures and waterproof while maintaining food safety standards	Research into most suitable packaging in conjunction with suppliers of packaging material Increase distribution and marketing activities to reach farmers in date growing regions Develop backward linkages in order to ensure farmers receive information regarding market requirements for improved packaging
Refrigeration and cold chains	The distance to main markets and the high temperatures make will mean that any cold storages developed will likely have a significant footprint and heave energy usage	Optimizing packaging and storage methods will assist in reducing footprint of produce	Cost benefit analysis of investment in renewable energy solutions for cold storage

6.2 Grapes

Vineyards although robust require certain factors, including minimum winter temperatures, the length of the growing seasons and the frequency of frosts. Further the temperatures between April and October should be consistent to provide cumulative growing days[103].

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Plantation												
Time of flowering												
Irrigation			Especially in this period									
Spraying												
Time of harvest												

It can be noted the crops calendar in Balochistan that the period where cumulative growing days are required are also the months in which irrigation is critical; it should be noted that the availability of sun to completely ripen and is often the reason for selection sunny hillsides for grape vine cultivation.[104] Since majority of the cultivation in Balochistan is focused in the hilly north it should be noted that the summers are becoming longer and the rains are focused in June-July. This means that during the months of March-May where irrigation is necessary farmers will be relying on depleting groundwater resources; the areas around Quetta are particularly in a distressed state with regard to ground water levels and that will reduce the adaptive capacity of grape farmers in the region. Projections show an increase in temperature and precipitation in the highlands which can be beneficial for grape cultivation. Particularly beneficial will be the increase in minimum winter temperatures and longer summers; the counter to the benefit is that the increased frequency of cold waves can be particularly harmful for grape cultivation. The selection of varieties is critical different cultivars have adapted to different environments; ensuring the largest yields of high-quality fruit requires the selection of cultivars adapted to the local environment.

Soils with the ability to drain themselves are also important and although waterlogging is not widespread in the region, it is something to be aware of as irrigation and tube well pumping continues.

[103] (Bogash, Muza, Kime, & Harper, 2018)

[104] (Bogash, Muza, Kime, & Harper, 2018)

Value Chain Intervention / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			
Seeds	Current varieties may be suited to the local environment, but their marketability is limited	Development of new varieties is taking place and should consider the long-term temperature increase projected in the region as well as drought tolerance; although a low delta crop the water availability is low.	Research into cultivars with high heat tolerance and low irrigation requirements Utilize grape processors and exporters as conduit for dissemination of appropriate cultivars
Fertilizers	Soils in Balochistan are alkaline in nature and are deficient in Macro and micronutrients; poor quality fertilizers also enter the market which can have adverse impacts on agro-biodiversity and efficacy, however use is still low	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into grape growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers

Pest Management	Pesticides are applied indiscriminately, not only impacting the health of plants and produce but also the long-term efficacy of pesticides	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies Better implementation of quality controls Weather - pest advisory	Leverage input suppliers to expand their reach into grape growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Explore organic / agrobiodiversity solutions for specific pests in order to maintain organic production Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing Getting the information to farmers is discussed below in Information Services

Information Services	Extension services are poor across Balochistan and difficulties will remain due to the vast geographic area and difficult terrain; the lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	The availability of information in many regions of Balochistan remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate data is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information
Financial Services	One of the barriers to modernizations is the availability of modern equipment in the province as well as limited capital availability; this prevents greater investment in economic activities.	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged. beyond irrigation majority of the costs lay with contractors who will need to be targeted	Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs Financial products for production equipment like trellises targeting contractors

Tools and Equipment	There is low-technology production in Balochistan but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as drought conditions and heat waves increased	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the dcrop but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	Development of local service providing entrepreneurs; i.e. Lazer levelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop master trainlines/entrepreneurs Support marketing activities for local machinery providers to target the province Increase availability of basic materials like plastic sheets supported with marketing campaigns
Agriculture Production			
Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as more groundwater is extracted for irrigation purposes particularly in the areas where grapes are grown; potentially increased erosion due to long dry spells. Which will have greater impact on slopes.	Salinity although not at extremely harmful levels is increasing and needs to be tackled; the reliance on groundwater makes it increasingly difficult but farmers need to ensure the quality of soil especially considering the long term nature of grape vineyards Soil erosion in the area will need to be curbed and incidence of heavy occasional downpours will exacerbate these issues	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas Promote the regeneration of slopes with native species in and around growing areas

Water Management	The trench system is the predominant method of application for grapes; this traditional system relied on the *Karez* system which is currently failing. Farmers need to adapt to ensure adequate irrigation is available as the cost of initiating tube wells increases.	The areas reliance on ground water means that some form of ground water management regime needs to be established. Storage opportunities should be expanded either at individual or community levels Appropriate technologies need to be identified as drip irrigation type of technologies have not proven very popular Increase capacity to benefit from the rains and floods that are present through check dams, sub-surface dams	Build capacity of FMCs in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging diurnal temperature for water collection, bhungroo straw, collection of floodwaters Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Introduce best water management practices Water salinity needs to be managed in similar ways to soil salinity Make water monitoring equipment easily accessible and available Revival of traditional water management bodies

On Farm Energy	Energy availability is variable in the region and impacts on farm capacity for mechanization	Emissions per capita in the context of grape farming will be low, however the lack of availability acts a barrier to investing in new energy intensive technologies; The lack of irrigation water increases dependence on tube wells which have relatively high running costs	Promotion of solar energy solutions where possible (except ground water extraction which has proven to have large negative externalities) Promote alternate energy sources, biogas, small wind turbine
Diversification	Monoculture leaves crops more vulnerable to pests and diseases as well as speeding up soil degradation;	Farmers can maximize productivity by selecting appropriate crops do be utilized for intercropping; this will not only provide shade for the soil but also maintain soil health and provide additional income	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods and principles of soil health
Production Infrastructure	There is a lack of processing facilities within the province	Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods and access to water	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area
Landscape-level Management	The landscape is degraded through excessive farming, waterlogging, salinity and overgrazing; regenerative measures need to be taken to ensure the long-term health of the ecosystem and to ensure that vital ecosystem services continue	Although grapes are low delta crops, the increased proliferation of cultivation will likely increase pressure on water resources; as grazing is also prevalent in the region there is a likelihood that the slopes soon become untenable for cultivation	Significant amount of policy work linking the various jurisdictions involved I.e. Livestock, Agriculture, Forestry; Environment. The policies are in place but developing implementable working mechanisms will be required to ensure effective implementation.

Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current harvest cycles are aligned with high rainfall periods; this results in significant losses and the spread of disease	The development of appropriate harvesting techniques and storage to shelter against rains and cold. Promote processing	See tools and equipment
Energy in processing	With limited to no processing in the province current impact is low	The locations of any additional processing units being developed, and storage units need to consider the availability of water and energy	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Cost-benefit analysis for renewable energy sources, utilization of biogas

Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses Due to limited processing most grapes are transported fresh and suffer further losses due to high temperatures and poor road networks	Suitable packaging is already known and can improved shelf life from the farm though to transportation	Promote corrugated cartons Increase distribution and marketing activities to reach farmers in grape growing regions Develop backward linkages with retailers and provide appropriate packaging to contracted farmers Develop backward linkages in order to ensure farmers receive information regarding market requirements for improved packaging
Refrigeration and cold chains	The distance to main markets and the high temperatures make will mean that any cold storages developed will likely have a significant footprint and heave energy usage	Optimizing packaging and storage methods will assist in reducing footprint of produce	Cost benefit analysis of investment in renewable energy solutions for cold storage

6.3 Olive

Olives are generally well adapted to the climate extremes that are inherently part of cultivating in Balochistan; the ideal minimum temperature of -6/-7 Degrees Celsius, with the most common olive growing areas facing temperatures rarely falling below zero with dry, hot summers; however it is important for the plants to sustain temperatures below 16 degrees C for development of flowers while high temperatures during fruit ripening can impact the quality. Above 400MM of rain is considered enough while 1,000mm is good, but extended dry or wet periods are harmful for the plant. [105]

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Plantation												
Time of flowering												
Irrigation												
Fertilizer application												
Time of harvest												

The areas currently highlighted for olive cultivation are considered Arid, with minimal rainfall that peaks in the winter months and again in July-August; the quantities are however well below that required for optimal growth of the plant and thus there is still a reliance on irrigation. This said olives are relatively well adapted to requiring limited water compared to many other locally grown corps and are well suited to the local environment. The mountainous areas where the plant does grow will be facing an increased frequency in cold waves and to a lesser extent heat waves which can negatively impact the crop; but the impact at the foothills where the crops are grown may be localized. One of the biggest concerns will be the impact of a potentially increasing temperatures and the elongated summer; this can have impact on the flowering stage the growth cycle as well as during harvest. Lastly the general area is prone to climate extremes, with flash floods, earthquakes and droughts all with the potential to damage crops and livelihoods in the area. Although water availability is better than the south the area is still facing water insecurity; the presence of urban hubs such as Quetta and a high level of cultivation in the surrounding areas places immense pressure on groundwater resources with the basin being heavily overdrawn. The lack of effective groundwater management can have impact on olive farmers being able to provide the consistent but limited irrigation requirements for their crop.

Value Chain Intervention / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			

[105] (International Olive Council, 2007)

Seeds	Current varieties may be suited to the local environment but elongated summers have the potential to impact flowering	Development of new varieties should consider the increase projected in the length of summer as well as drought tolerance; although a low delta crop the water availability is low.	Research into cultivars with high heat tolerance and low irrigation requirements Utilize olive processors and exporters as conduit for dissemination of appropriate cultivars
Fertilizers	Soils in Balochistan are alkaline in nature and are deficient in Macro and micronutrients; poor quality fertilizers also enter the market which can have adverse impacts on agro-biodiversity and efficacy, however use is still low	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into olive growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers
Pest Management	Very little information and research has been conducted regarding olives and pests; impacts can rise as temperatures increase and summers are longer	Improve information and advisory services regarding pest control.	Leverage input suppliers to expand their reach into olive growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff

		Increase distribution and official channels for input supplier companies	
		Better implementation of quality controls	Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing
		Weather - pest advisory	Getting the information to farmers is discussed below in Information Services
Information Services	Extension services are poor across Balochistan and difficulties will remain due to the vast geographic area and difficult terrain; the lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	The availability of information in many regions of Balochistan remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate data is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information

Financial Services	One of the barriers to modernizations is the availability of modern equipment in the province as well as limited capital availability; this prevents greater investment in economic activities.	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged. beyond irrigation majority of the costs lay with contractors who will need to be targeted	Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs Financial products for production equipment to set up hot-bedded nurseries
Tools and Equipment	There is low-technology production in Balochistan but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as drought conditions and heat waves increased	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the dcrop but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	Development of local service providing entrepreneurs; i.e. Lazer levelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop master trainlines/entrepreneurs Support marketing activities for local machinery providers to target the province Increase availability of basic materials like plastic sheets supported with marketing campaigns
Agriculture Production			

Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as more groundwater is extracted for irrigation purposes particularly in the areas where olives are grown; potentially increased erosion due to long dry spells. Which will have greater impact on slopes.	Salinity although not at extremely harmful levels is increasing and needs to be tackled; the reliance on groundwater makes it increasingly difficult but farmers need to ensure the quality of soil especially considering the long term nature of olive cultivation	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary
		Soil erosion in the area will need to be curbed and incidence of heavy occasional downpours will exacerbate these issues	Improved monitoring and information dissemination regarding salinity levels in growing areas
			Promote the regeneration of slopes with native species in and around growing areas
Water Management	The dependence for irrigation is on the rains which are increasing in variability; however after the roots have set consistent irrigation is not required	Storage opportunities should be expanded either at individual or community levels	Build capacity of FMCs in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging diurnal temperature for water collection, bhungroo straw, collection of floodwaters
			Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment'
		Appropriate technologies need to be identified as drip irrigation type of technologies have not proven very popular	Improved water quality testing
		Increase capacity to benefit from the rains and floods that are present through check dams, sub-surface dams	Introduce best water management practices

			Revival of traditional water management bodies
On Farm Energy	Energy availability is variable in the region and impacts on farm capacity for mechanization	Emissions per capita in the context of olive farming will be low, however the lack of availability acts a barrier to investing in new energy intensive technologies; The lack of irrigation water increases dependence on tube wells which have relatively high running costs Renewable energy based processing	Promotion of solar energy solutions where possible (except ground water extraction which has proven to have large negative externalities) Promote alternate energy sources, biogas, small wind turbine
Diversification	Monoculture leaves crops more vulnerable to pests and diseases as well as speeding up soil degradation;	Farmers can maximize productivity by selecting appropriate crops do be utilized for intercropping; this will not only provide shade for the soil but also maintain soil health and provide additional income	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods and principles of soil health
Production Infrastructure	There is a lack of processing facilities within the province	Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods and access to water	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area

Landscape-level Management	The landscape is degraded through excessive farming, waterlogging, salinity and overgrazing; regenerative measures need to be taken to ensure the long-term health of the ecosystem and to ensure that vital ecosystem services continue	Although olives consume less water than many other crops, the increased proliferation of cultivation will likely increase pressure on water resources; as grazing is also prevalent in the region there is a likelihood that the slopes soon become untenable for cultivation	Significant amount of policy work linking the various jurisdictions involved I.e. Livestock, Agriculture, Forestry; Environment. The policies are in place but developing implementable working mechanisms will be required to ensure effective implementation.
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current harvest cycles are aligned with high rainfall periods; this results in significant losses and the spread of disease	The development of appropriate harvesting techniques and storage to shelter against rains and cold. Promote processing	See tools and equipment
Energy in processing	With limited to no processing in the province current impact is low	The locations of any additional processing units being developed, and storage units need to consider the availability of water and energy	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area

			Cost-benefit analysis for renewable energy sources, utilization of biogas
Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses Due to limited processing most olives are transported fresh and suffer further losses due to high temperatures and poor road networks	Suitable packaging easily accessible to farmers that can improve shelf life from the farm though to transportation	Increase distribution and marketing activities to reach farmers in olive growing regions Develop backward linkages with retailers and provide appropriate packaging to contracted farmers Develop backward linkages in order to ensure farmers receive information regarding market requirements for improved packaging
Refrigeration and cold chains	The distance to main markets and the high temperatures make will mean that any cold storages developed will likely have a significant footprint and heave energy usage	Optimizing packaging and storage methods will assist in reducing footprint of produce	Cost benefit analysis of investment in renewable energy solutions for cold storage

6.4 Onion

The onion crop in general is a crop with great adaptive capacities, globally growing from the tropics to subarctic regions because of its dependence on day length influencing bulbing. Therefore, different varieties will have very different growing and optimal climates[106]. Onions are able to grow throughout the province due to favorable climatic conditions in all major climatic zones of the province with areas highlighted as particularly important falling in the mid-arid zones of Balochistan

Months	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Direct Seeding												
Nursery Raising												
Transplanting												
Irrigation												
Spraying												
Time of harvest												

Current production per acre is low and consequently the water footprint will also remain high for onion crops grown in the region. This indicates the sub-optimal practices with one of the biggest differentiators in irrigation requirements being the nature of seeding that takes place. However, the onion growing areas are arid, with limited rainfall and onion cultivation still consumes significant quantities of water. Although the areas will be facing drought it is in a better position then further in the north close to Quetta. The rains peak in the winter and summer months which aligns with the irrigation requirements for the crop however irrigation patterns indicate many of the onion growing provinces are predominately reliant on tube-wells. The depleting ground water resources have been discussed and this reiterates the impact that this issue will have on all crop systems. With summer lengths increasing and temperatures, varieties will need to be selected with the lengthening days in mind. The increased temperatures are likely to increase evapotranspiration in the soil increasing the water requirements for the crops. Although onion crops are well suited to extreme climates, the selection of varieties will have to consider both the extended number of cold and heat waves that the region faces, particularly the western Balochistan.

[106] (Boyhan)

Value Chain Intervention / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			
Seeds	Currently seeding methods require extra irrigations. Further current cultivation practices mean a long period before initial planting and first yields. Temperatures in the growing regions are already in the extremes and likely to continue to increase reducing short shelf live even further;	The propagation of transplanting is proposed, and the development of hybrid-seed varieties needs to consider the arid environment that the majority of cultivation takes place in; drought like conditions naturally persist but with falling ground water tables it will become an increasingly important consideration	Research into cultivars with high heat tolerance and low irrigation requirements Utilize onion processors and exporters as conduit for dissemination of appropriate cultivars .
Fertilizers	Soils in Balochistan are alkaline in nature and are deficient in Macro and micronutrients; poor quality fertilizers also enter the market which can have adverse impacts on agro-biodiversity and efficacy, however use is still low	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into onion growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers
Pest Management	Pesticides are applied indiscriminately, not only impacting the health of plants and produce but also the long term efficacy of pesticides	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies and better implementation of quality controls	Leverage input suppliers to expand their reach into onion growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time

			information sharing. Getting the information to farmers is discussed below in Information Services
Information Services	Extension services are poor across Balochistan and difficulties will remain due to the vast geographic area and difficult terrain; the lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	The availability of information in many regions of Balochistan remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate data is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information

Financial Services	One of the barriers to modernizations is the availability of modern equipment in the province as well as limited capital availability; this prevents greater investment in economic activities	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs Develop financial products for investments in equipment
Tools and Equipment	There is low-technology production in Balochistan but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as drought conditions and heat waves increased	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the crop but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	Development of local service providing entrepreneurs; i.e. Lazer levelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop master trainlines/entrepreneurs Support marketing activities for local machinery providers to target the province Increase availability of machinery such as ‘Happy Seeder’ that can lead to efficiencies
Agriculture Production			

Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as more groundwater is extracted for irrigation purposes; potentially increased erosion due to long dry spells.	Salinity although not at extremely harmful levels is increasing and needs to be tackled; the reliance on groundwater makes it increasingly difficult but farmers need to ensure the quality of soil	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas Promote the regeneration of native species in and around growing areas
Water Management	Flood irrigation is used in Balochistan which holds low running costs and easy application but is less efficient and not sustainable. The area has low precipitation and the increase incidence of heat waves will likely ensure drought persists.	The areas reliance on ground water means that some form of ground water management regime needs to be established. Storage opportunities should be expanded either at individual or community levels Appropriate technologies need to be identified as drip irrigation type of technologies have not proven very popular Increase capacity to benefit from the rains and floods that are present through check dams, sub-surface dams	·Build capacity of FMCs in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging diurnal temperature for water collection, bhungroo straw, collection of floodwaters Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Make water monitoring equipment easily accessible and available Include water management as component of obtaining organic certification

			Water salinity needs to be managed in similar ways to soil salinity Revival of traditional water management bodies
On Farm Energy	Energy availability is variable in the region and impacts on farm capacity for mechanization	Emissions per capita in the context of data farming will be low, however the lack of availability acts a barrier to investing in new energy intensive technologies	Promotion of solar energy solutions where possible (except ground water extraction which has proven to have large negative externalities) Promote alternate energy sources, biogas, small wind turbines
Diversification	Farmers mix crop but uninformed selection of crops can result in depleted soils.	Appropriate mixed farming crop selection	Research crop combinations that are most suitable for overall soil health.

Production Infrastructure	There is a lack of processing facilities within the province	Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods and access to water	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current harvest cycles are aligned with high temperatures increasing post harvest losses due to a lack of appropriate cold storage and/or sheds	The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	See tools and equipment
Energy in processing	With limited to no processing in the province current impact is low	The locations of any additional processing units being developed, and storage units need to consider the availability of water and energy	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Cost-benefit analysis for renewable energy sources, utilization of biogas

Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses during transportation	Suitable packaging needs to be developed for increasingly high temperatures and waterproof while maintaining food safety standards	Research into most suitable packaging in conjunction with suppliers of packaging material Increase distribution and marketing activities to reach farmers in onion growing regions Develop backward linkages with retailers and provide appropriate packaging to contracted farmers Develop backward linkages in order to ensure farmers receive information regarding market requirements for improved packaging
Refrigeration and cold chains	The distance to main markets and the high temperatures make will mean that any cold storages developed will likely have a significant footprint and heave energy usage	Optimizing packaging and storage methods will assist in reducing footprint of produce	Cost benefit analysis of investment in renewable energy solutions for cold storage

7 Horticulture in Sindh

7.1 Dates

The date palm requires the full year for the growth cycle and thrives with long hot summers and mild dry winters, ideally with limited frost. Thus, the crop has thrived in dessert like environments in North Africa, Middle East and Pakistan. Rain or high humidity during the fruiting season can create disease and damage yields during fruiting [107].

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Pollination												
Plantation												
Transplanting					**ESPECIALLY IN THIS PERIOD**							
Time of flowering												
Time of harvest												

Date cultivation in Sindh will not be facing extreme temperatures but rather increased variability in rain which will have significant impacts on yields; the ability of heavy Monsoon rains to impact harvest can damage large number of standing crops. The lack of appropriate storage and/or protection against these rains leaves farmers particularly vulnerable to such climate extremes. Another issue of concern for date farmers in close proximity to main irrigation channels will be the level of waterlogging and salinity in the area. Already at dangerous levels waterlogging not only decreases productivity but also promotes the incidence of disease. The lack of information about precipitation can also increase post-harvest losses as open sun drying practices prevail in the region.

Value Chain Intervention / Outcomes	**Climate Risks**	**Climate Risk Management Opportunities**	**Implementation Strategies**
Inputs			
Seeds	Currently yields are low and varieties do not yield high market demand reducing adaptive capacity. Current varieties are prone to pests which will likely increase in the incidence of increased waterlogging	The propogation of tissue culture is proposed and the development of varieties needs to consider the arid environment in which production takes place; drought like conditions naturally persist but with increasingly variable	Research around tissue culture varieties developed should consider temperature extremes, drought resistance and market demand Utilize date processors and exporters as conduit for dissemination of appropriate cultivars as tissue

[107] (Shabani, Kumar, & Taylor, 2012)

	and salinity. Yields have been severely impacted by heavy rains	precipitation and drought causing shortages in the availability of irrigation water will require effective management. Tissue culture will assist the expansion of date cultivation	culture are not necessarily affordable inputs
Fertilizers	Soil in Sindh has Mg and P deficiency requiring exogenous application of these elements	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers and micro-nutrients / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into date growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing as market information for input suppliers
Pest Management	Date plantations in Sindh are prone to Red Palm Weevil, sudden decline syndrome (particularly in waterlogged areas), termites and palm lesser moth. The increased length of summers, incidence of flooding and increased evapotranspiration will likely increase the incidence of pests	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies and better implementation of quality controls Develop Integrated Pest Management strategies look at forms of biocontrol	Leverage input suppliers to expand their reach into date growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Explore organic / agrobiodiversity solutions for specific pests in order to maintain organic production Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing. Getting the information to farmers is discussed below in Information Services

Information Services	Extension services are poor across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	New innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate date is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh, Punjab and Balochistan. Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups, Whatsapp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, local land lords etc as a delivery mechanism for critical information
Financial Services	One of the barriers to modernizations is the availability of modern equipment in the province as well as limited capital availability; this prevents greater investment in economic activities	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop financial products for tissue culture Develop financial products for water drainage equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFI

Tools and Equipment	There is low-technology production in Sindh but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as droughts, floods and frequency of heat waves increases	There is a need to modernize farming practices and provide basic tools such as nets in an effort to increase productivity, not only of the date palm but of inputs such as fertilizers and water. The development of appropriate storage with some form of protection against extreme climates with low energy requirements will need to be identified	Development of local service providing entrepreneurs; i.e. Lazerlevelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop master trainers/entrepeneurs Support marketing activities for local machinery providers to target the province
Agriculture Production			
Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as waterlogging issues persist. Salinity management will be very important due the high levels already persisting, various solutions exist, and flushing is already practiced, but irrigation water carries with it further salts.	The management of salinity and waterlogging will be critical in the areas highlighted for date cultivation. Large scale interventions to improve drainage across the province will be required. Farmers can also adapt proper soil management techniques and best practices to ensure soil health. Introduction of new leaching techniques	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas Promote the regeneration of native species in and around growing areas

Water Management	Traditional irrigation practices not only are inefficient but also exacerbate other issues such as salinity Although irrigation from the main river is feasible in the region, variations in flows, extreme climates (floods, drought and heavy rains) will likely impact not only growing but all aspects of the value chain. Waterlogging is a severe problem in the area and needs to be effectively managed for sustained cultivation in the region	Increase storage and infrastructure to make productive use of flood/rain waters Appropriate technologies need to be identified for efficient irrigation as drip irrigation type of technologies have proven to be unpopular Intercropping with crops that can provide assistance to the waterlogging issues Reduce the impacts of sea-water intrusion	Build capacity of communities in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as leveraging dinural temperature for water collection, bhungroo straw, collection of floodwater with sub-surface dams Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Make water monitoring equipment easily accessible and available Water salinity needs to be managed in similar ways to soil salinity Regenerate local vegetation, not only to assist with waterlogging but also with sea-water intrusion
On Farm Energy	Energy availability is variable in the region and impacts on farm capacity for mechanization	Emissions per capita in the context of date farming will be low, however the lack of availability acts a barrier to investing in new energy intensive technologies	Promotion of solar energy solutions where possible (except ground water extraction which has proven to have large negative externalities) Promote alternate energy sources, biogas, small wind turbines
Diversification	Monoculture leaves crops more vulnerable to pests and diseases as well as speeding up soil degradation. Diversification can naturally provide ways for planting that can reduce waterlogging in the area as well	Farmers can maximize productivity by selecting appropriate crops do be utilized for intercropping; this will not only provide shade for the soil but also maintain soil health and provide additional income	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods

Production Infrastructure	The area is heavily prone to flooding and with soils already prone to waterlogging this can have severe impact on productivity	Flood diversions and storage techniques can assist in providing protection to farms against floods Regeneration of native vegetation can also provide further protection against floods/cyclone/sea-water intrusion Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Work with PDMA as well as Agriculture and water management authorities for effective disaster management planning
Landscape-level Management	The landscape is degraded through excessive farming, waterlogging, salinity and overgrazing; regenerative measures need to be taken to ensure the long-term health of the ecosystem and to ensure that vital ecosystem services continue	Increasing the cultivation of dates is a positive in regard to the limited availability of water; however, being grown in areas with irrigation available can result in the inefficient use of water from a food security perspective;	Significant amount of policy work linking the various jurisdictions involved I.e. Livestock, Agriculture, Forestry; Environment. The policies are in place but developing implementable working mechanisms will be required to ensure effective implementation.
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Post Production			
Post Harvest Management	Current practices are basic with open sun drying leading to large number of insects, dust and inert material; this means little energy requirements which is well suited to the area	Although the process is energy efficient it leads to low quality produce opportunity to leverage solar energy in more controlled environments ensuring better quality produce. Use of plastic films are promoted and environmental impact needs to be considered of additional plastics	Work with manufacturers to develop local supply of dehydrators and solar dryers Provide financial instruments for investment in new technologies Sourcing of plastic needs consideration when promoting such techniques

Energy in processing	Currently the footprint for processing is low	The locations of any additional processing units being developed and drying units need to consider the availability of water and energy	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Consider renewable energy sources, utilization of biomass (develop pelleting using trunks if economically feasible)
Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses as well as in storage areas	Suitable packaging needs to be developed for increasingly high temperatures and waterproof while maintaining food safety standards	Research into most suitable packaging in conjunction with suppliers of packaging material Increase distribution and marketing activities to reach farmers in date growing regions Develop backward linkages in order to ensure farmers receive information regarding market requirements for improved packaging

7.2 Mangos

Mango production is across Sindh, with the highest production in Mirpurkhas, Tandoallahyar, Hyderabad and Khairpur. Having moderate temperatures during the start of flowering is important as in ensuring adequate availability of water. Hot and dry conditions are best during the time of ripening. Soil quality is equally important, with deep well drain soils being highlighted as favorable. [108]

Varieties	May				Jun				Jul				Aug				Sep			
Sindhri																				
Chaunsa																				
Dusehri																				
Langra																				
Began Pali																				

The areas dominating the current Mango production are heavily reliant on irrigation water; for the mango crop which requires adequate water during the flowering stages the ability to access irrigation water and to be supplemented by June-Sept monsoons is important. However, there are overlaps with the current monsoon patterns and ripening times in Sindh and these heavy rains can cause significant issues to the standing crops. The unreliability of both these sources of irrigation is of concern and effective water management will need to be in place for the cultivation of mangos. The alarming drop in production in Tharparkar is an example of how the water shortage is already impacting the province. Another issue linked with water in the area is water logging; it has been observed that water logging and salinity are already at quite harmful levels, with groundwater even being considered hazardous. These unfavorable soil conditions are likely to hamper productivity of mangos and importantly highlight a constraint that needs effective structural changes to ensure that soil conditions can improve. Waterlogging combined with high temperatures and humidity also increase the incidence of pests and disease amongst the crops and this will likely impact productivity. Climate extremes are likely to impact mango growing areas with the top producing districts in Sindh all being given a category 5 rating in terms of drought. Adaptive capacity is further reduced due to the high level of waterlogging and salinity impacting the quality of groundwater available. The areas are also prone to flood risks due to the proximity to the river where seasonal riverine floods are not uncommon. The increased incidence of hot days is likely to impact the temperature stress faced on mango crops and that in turn increase evapotranspiration and salinity in the soil.

[108] (Usman, Fatima, Khan, & Chaudhry, 2003)

Value Chain Intervention / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			
Fertilizers	Soil in Sindh has Mg and P deficiency requiring exogenous application of these elements - potash is particularly important for Banana cultivation	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into mango growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers
Pest Management	Pesticides are applied indiscriminately, not only impacting the health of plants and produce but also the long term efficacy of pesticides	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies and better implementation of quality controls	Leverage input suppliers to expand their reach into mango growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing. Getting the information to farmers is discussed below in Information Services

Information Services	Extension services have limited efficacy across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	The availability of information in many regions of Sindh remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate data is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information
Financial Services	Extension services are poor across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs Develop financial products for getting testing/certifications done for export

Tools and Equipment	There is low-technology production in Sindh but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as droughts, floods and frequency of heat waves increases	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the dcrop but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	· Development of local service providing entrepreneurs; i.e. Lazer levelling Rental, Local soil testing service providers, irrigation equipment providers Support marketing activities for local machinery providers to target the province Improve post-harvest packaging to increase shelf life and protect against bruising
Agriculture Production			
Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as waterlogging issues persist. Salinity management will be very important due the high levels already persisting, various solutions exist, and flushing is already practiced, but irrigation water carries with it further salts. Nutrient management will be particularly important	The management of salinity and waterlogging will be critical in the areas highlighted for cultivation. Large scale interventions to improve drainage across the province will be requied. Farmers can also adapt proper soil management techniques and best practices to ensure soil health. Introduction of new leaching techniques	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas Promote the regeneration of native species in and around growing areas

Water Management	Traditional irrigation practices not only are inefficient but also exacerbate other issues such as salinity Although irrigation from the main river is feasible in the region, variations in flows, extreme climates (floods, drought and heavy rains) will likely impact not only growing but all aspects of the value chain. Waterlogging is a severe problem in the area and needs to be effectively managed for sustained cultivation in the region	Increase storage and infrastructure to make productive use of flood/rain waters Appropriate technologies need to be identified for efficient irrigation as drip irrigation type of technologies have proven to be unpopular Intercropping with crops that can provide assistance to the waterlogging issues Reduce the impacts of sea-water intrusion	Build capacity of communities in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging dinural tempature for water collection, bhungroo straw, collection of floodwaters with sub-surface Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Make water monitoring equipment easily accessible and available Water salinity needs to be managed in similar ways to soil salinity Regenerate local vegetation, not only to assist with waterlogging but also with sea-water intrusion
Diversification	Monoculture leaves crops more vulnerable to pests and diseases as well as speeding up soil degradation. Diversification can naturally provide ways for planting that can reduce waterlogging in the area as well	Farmers can maximize productivity by selecting appropriate crops do be utilized for intercropping; this will not only provide shade for the soil but also maintain soil health and provide additional income	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods

Production Infrastructure	The area is heavily prone to flooding and with soils already prone to waterlogging this can have severe impact on productivity. Banana plants are particularly vulnerable to strong winds and cyclone activity in the south can severely impact crops	Windbreakers can provide protection against strong winds Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods and access to water	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Introduce equipment suppliers in the region for windbreaks and support marketing activities
Landscape-level Management	The landscape is degraded through excessive farming, waterlogging, salinity and overgrazing; regenerative measures need to be taken to ensure the long-term health of the ecosystem and to ensure that vital ecosystem services continue	Orchards require significant water and the proliferation of mango cultivation on large scale can impact the landscape and soil health.	Significant amount of policy work linking the various jurisdictions involved I.e. Livestock, Agriculture, Forestry; Environment. The policies are in place but developing implementable working mechanisms will be required to ensure effective implementation.
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current harvest cycles are aligned with high temperatures and rains, inadequate sorting and grading facilitities as well as storage will result in high post harvest losses	The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	See tools and equipment Develop processing/grading aggregation points equipped with appropriate storage capacity

Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses during transportation	Suitable packaging needs to be developed for increasingly high temperatures and waterproof while maintaining food safety standards	Research into most suitable packaging in conjunction with suppliers of packaging material Increase distribution and marketing activities to reach farmers in onion growing regions Develop backward linkages with retailers and provide appropriate packaging to contracted farmers Develop backward linkages with retailers and provide appropriate packaging to contracted farmers
Processing infrastructure	Sind being particularly disaster prone to floods, cyclones and heavy rains, processing infrastructure is vulnerable and can create huge losses	Ensure climate proofing of new investments in processing and storage infrastructure	Integrate environmental risk assessment in the planning of new processing and/or storage units Insurance schemes for farmers and processors

7.3 Bananas

From examples in South East Asia, a mean temperature of 27 degrees C is optimal for growth, with minimum temperatures not falling below 16 degrees, maximum temperature for adequate growth is about 38°C, depending on humidity and the radiation intensity. Bananas are day-neutral in their response to day length. Soils should be well drained, with stagnant water promoting diseases and pests; salinity is very harmful for banana growth. 3 months of dry season is the maximum the plant can take before growth can be stunted while colder temperatures impact fruiting. For rainfed irrigation water requirements are between 1200mm-2500mm a year whereas through irrigation the duration between watering can be between 3-15 days[109].

In Sindh many of the banana growers are highly dependent on irrigation water; a recurring theme in Sindh is that this supply is becoming increasingly intermittent and the water requirements are such seasonal monsoon rains are insufficient. The alternate source is to pump groundwater, but the banana plant is particularly vulnerable to salinity and the conditions around heavily irrigated areas is already quite alarming in this regard. Banana farmers will need to identify solutions in order to ensure effective irrigation management, particularly in time of climate extremes where irrigation from the canals is limited. Increased evapotranspiration during heat waves will also impact water requirements, particularly to ensure soil moisture; this has to be carefully done as to not actually increase salinity levels.

The coastal areas are vulnerable to high level winds and the increase prevalence of cyclones; strong winds have the capacity to topple standing crops and inflict significant damage to banana growers. Adaptation is already taking place as windbreaks are spotted on certain farms, but already 15-20% losses are felt in the province and this can be expected to rise[110].

Value Chain Intervention / Outcomes	**Climate Risks**	**Climate Risk Management Opportunities**	**Implementation Strategies and Potential Partners**
Inputs			
Seeds	The banana landscape is dominated by a single variety in Sindh; this variety produces low yields and low quality. Further temperature increases have already begun to result in early maturity taking away seasonal advantages	Research into new suitable varieties and promotion of tissue culture, able to consider maturity cycles, as well as resistance to salinity	Research around tissue culture varieties developed should consider temperature extremes, drought resistance and market demand Utilize banana traders as conduit for dissemination of appropriate cultivars as tissue culture are not necessarily affordable inputs

[109] (Laghari)

[110] (Laghari)

Fertilizers	Soil in Sindh has Mg and P deficiency requiring exogenous application of these elements - potash is particularly important for Banana cultivation	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into banana growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers
Pest Management	Pesticides are applied indiscriminately, not only impacting the health of plants and produce but also the long term efficacy of pesticides	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies and better implementation of quality controls	Leverage input suppliers to expand their reach into banana growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing. Getting the information to farmers is discussed below in Information Services
Information Services	Extension services have limited efficacy across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle	The availability of information in many regions of Sindh remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate date is a precursor to this and forecasts (short, medium	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can

	of the plant but also relates to issues such as varietal selection and labour availability	and long-term) are as accurate as possible and made publicly available	subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information
Financial Services	Extension services are poor across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs Develop insurance instruments against disaster
Tools and Equipment	There is low-technology production in Sindh but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as droughts, floods and frequency of heat waves increases	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the crop but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity	Development of local service providing entrepreneurs; i.e. Lazer levelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop

		will build resilience	master trainlines/entrepreneurs Support marketing activities for local machinery providers to target the province
Agriculture Production			
Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as waterlogging issues persist. Salinity management will be very important due the high levels already persisting, various solutions exist and flushing is already practiced, but irrigation water carries with it further salts. Nutrient management will be particularly important	The management of salinity and waterlogging will be critical in the areas highlighted for cultivation. Large scale interventions to improve drainage across the province will be required. Farmers can also adapt proper soil management techniques and best practices to ensure soil health. Introduction of new leaching techniques	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas . Promote the regeneration of native species in and around growing areas

Water Management	Traditional irrigation practices not only are inefficient but also exacerbate other issues such as salinity Although irrigation from the main river is feasible in the region, variations in flows, extreme climates (floods, drought and heavy rains) will likely impact not only growing but all aspects of the value chain. Waterlogging is a severe problem in the area and needs to be effectively managed for sustained cultivation in the region	Increase storage and infrastructure to make productive use of flood/rain waters Appropriate technologies need to be identified for efficient irrigation as drip irrigation type of technologies have proven to be unpopular Intercropping with crops that can provide assistance to the waterlogging issues Reduce the impacts of sea-water intrusion	Build capacity of communities in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging dinural temperature for water collection, bhungroo straw, collection of floodwaters with sub-surface Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Include water management as component of obtaining organic certification Make water monitoring equipment easily accessible and available Water salinity needs to be managed in similar ways to soil salinity
Diversification	Monoculture leaves crops more vulnerable to pests and diseases as well as speeding up soil degradation. Diversification can naturally provide ways for planting that can reduce waterlogging in the area as well	Increase storage and infrastructure to make productive use of flood/rain waters Appropriate technologies need to be identified for efficient irrigation as drip irrigation type of technologies have proven to be unpopular	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods

		Intercropping with crops that can provide assistance to the waterlogging issues Reduce the impacts of sea-water intrusion	
Production Infrastructure	The area is heavily prone to flooding and with soils already prone to waterlogging this can have severe impact on productivity. Banana plants are particularly vulnerable to strong winds and cyclone activity in the south can severely impact crops	Windbreakers can provide protection against strong winds Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods and access to water	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Introduce equipment suppliers in the region for windbreaks and support marketing activities
Landscape-level Management	The landscape is degraded through excessive farming, waterlogging, salinity and overgrazing; regenerative measures need to be taken to ensure the long-term health of the ecosystem and to ensure that vital ecosystem services continue	Effective coastal and mangrove management Regeneration of natural wind-breaks	Significant amount of policy work linking the various jurisdictions involved I.e. Livestock, Agriculture, Forestry; Environment. The policies are in place but developing implementable working mechanisms will be required to ensure effective implementation.
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current harvest cycles are aligned with high temperatures and rains, inadequate sorting and grading facilities as well as storage will	The development of appropriate storage which can handle high temperatures and maintain humidity	See tools and equipment Develop processing/grading aggregation points

	result in high post harvest losses	will build resilience	equipped with appropriate storage capacity
Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses during transportation	Suitable packaging needs to be developed for increasingly high temperatures and waterproof while maintaining food safety standards	·Research into most suitable packaging in conjunction with suppliers of packaging material Increase distribution and marketing activities to reach farmers in onion growing regions Develop backward linkages with retailers and provide appropriate packaging to contracted farmers Develop backward linkages with retailers and provide appropriate packaging to contracted farmers
Processing infrastructure	Sind being particularly disaster prone to floods, cyclones and heavy rains, processing infrastructure is vulnerable and can create huge losses	Ensure climate proofing of new investments in processing and storage infrastructure	Integrate environmental risk assessment in the planning of new processing and/or storage units

7.4 Tomato

Tomatoes are one of the most common vegetables globally and that is evident from its spread across climatic and geographic regions globally. The plant however is sensitive to temperature extremes, with flowering only occurring between 15degrees and 35 degrees. Soil temperature is also important and should not fall below 10 degrees nor above 35 degrees to ensure seed germination. The pH of soil is important for tomato crop production with the ranges of 5.5-70 being considered optimal. Irrigation is essential during the flowering and fruit formation, with requirements ranging between 20mm-70mm during cool and hot periods respectively.

Months	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Nursery Sowing												
Transplanting												
Harvesting												

Although production for tomatoes is across the province the major growing hubs are in the south of the province. The province is going to face d to face insignificant changes to temperature but an overall increase in precipitation; however, the caveat with this is that these rains are variable and can be a result of heavy concentrated rains. This has significant potential to impact production and reduce supplies. The temperature range in the province is suitable in terms of minimum temperatures and the potential increase is unlikely to impact tomato production; however, the increase in summer temperatures will likely impact crop water requirements, evapotranspiration and the overall growth cycle as summer seasons are extended. Further an important point is the increase in in the number of hot days, although the tomato growing belt is not as severely impacted as the outer areas of Sindh, the ability of extreme heat to damage crops is likely an issue that will be faced. Further the higher summer temperatures are likely to increase the development of pests, diseases and weeds.

The production area is highly dependent on water coming from irrigation canals while being supplemented by ground water and the monsoons. The areas relying on groundwater will be facing difficult situations, particularly Thatta due to its coastal proximity; sea water intrusion and salinity in the soil are likely to continue to increase and that will reduce productivity. Monsoon rains are increasingly unpredictable (as evident through the prevalence of drought) and with canal supplies being often insufficient, the water situation for growing tomatoes in the province will require significant management and adaptation strategies. The top three production areas in the province of Thatta, Badin and Mirpurkhas area also prone to extreme climate events, being prone to droughts, floods and cyclones. These events are increasing, and adaptive strategies are required in order to build climate resilience.

Value Chain Intervention / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			

Seeds	Current varieties of tomatoes grown are already showing signs of early maturity probably due to increased minimum temperatures; this impacts the ability to take advantage of seasonality but may produce better quality fruit. Current varieties also prone to pests and disease	The impact on maturity is already being felt but the impact on quality will need to be observed	Research regarding the total impact of climate change on tomato yields should be conducted
Fertilizers	Soil in Sindh has Mg and P deficiency requiring exogenous application of these elements	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into tomato growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers
Pest Management	Pesticides are applied indiscriminately, not only impacting the health of plants and produce but also the long term efficacy of pesticides	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies and better implementation of quality controls	Leverage input suppliers to expand their reach into tomato growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing. Getting the information to farmers is discussed below in Information Services

Information Services	Extension services have limited efficacy across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	The availability of information in many regions of Sindh remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate data is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information
Financial Services	Extension services are poor across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs Develop financial products for appropriate packaging and post-harvest equipment

Tools and Equipment	There is low-technology production in Sindh but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as droughts, floods and frequency of heat waves increases	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the crop but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	Development of local service providing entrepreneurs; i.e. Lazer levelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop master trainlines/entrepreneurs Support marketing activities for local machinery providers to target the province Windbreak along coastal growing areas in effort to promote vine varieties
Agriculture Production			
Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as waterlogging issues persist. Salinity management will be very important due the high levels already persisting, various solutions exist, and flushing is already practiced, but irrigation water carries with it further salts.	The management of salinity and waterlogging will be critical in the areas highlighted for cultivation. Large scale interventions to improve drainage across the province will be required. Farmers can also adapt proper soil management techniques and best practices to ensure soil health. Introduction of new leaching techniques	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas Promote the regeneration of native species in and around growing areas Promote soil moisture retention techniques, mulching/organic mulch, intercropping

Water Management	Traditional irrigation practices not only are inefficient but also exacerbate other issues such as salinity Although irrigation from the main river is feasible in the region, variations in flows, extreme climates (floods, drought and heavy rains) will likely impact not only growing but all aspects of the value chain. Waterlogging is a severe problem in the area and needs to be effectively managed for sustained cultivation in the region	Increase storage and infrastructure to make productive use of flood/rain waters Appropriate technologies need to be identified for efficient irrigation as drip irrigation type of technologies have proven to be unpopular Intercropping with crops that can provide assistance to the waterlogging issues Reduce the impacts of sea-water intrusion	Build capacity of communities in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging dinural tempature for water collection, bhungroo straw, collection of floodwaters with sub-surface Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Make water monitoring equipment easily accessible and available Water salinity needs to be managed in similar ways to soil salinity Regenerate local vegetation, not only to assist with waterlogging but also with sea-water intrusion
Diversification	Onions are water intensive crops, prone to gluts and consequently low market prices yet farmers continue with the cultivation of onions	Encourage farmers to split available land between onion and other suitable crops to build adaptive capacity and resilience to shocks (natural and economic)	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods
Production Infrastructure	The area is heavily prone to flooding and with soils already prone to waterlogging this can have severe impact on productivity	Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods and access to	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area

		water	
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current harvest cycles are aligned with high temperatures and rains, inadequate sorting and grading facilities as well as storage will result in high post harvest losses	The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	See tools and equipment Develop processing/grading aggregation points equipped with appropriate storage capacity
Energy in processing	With limited to no processing in the province current impact is low	The locations of any additional processing units being developed, and storage units need to consider the availability of water and energy	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Cost-benefit analysis for renewable energy sources, utilization of biogas
Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses during transportation	Suitable packaging needs to be developed for increasingly high temperatures and waterproof while maintaining food safety standards	Research into most suitable packaging in conjunction with suppliers of packaging material Increase distribution and marketing activities to reach farmers in onion growing regions Develop backward linkages with retailers and provide appropriate packaging to contracted

			farmers Develop backward linkages in order to ensure farmers receive information regarding market requirements for improved packaging
Processing infrastructure	Sind being particularly disaster prone to floods, cyclones and heavy rains, processing infrastructure is vulnerable and can create huge losses	Ensure climate proofing of new investments in processing and storage infrastructure	Integrate environmental risk assessment in the planning of new processing and/or storage units

8.5 Onions

The onion crop in genera is a crop with great adaptive capacities, globally growing from the tropics to subarctic regions because of its dependence on day length influencing bulbing. Therefore, different varieties will have very different growing and optimal climates.[111]

Months	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Nursery Sowing LS												
Transplanting LS												
Harvesting LS												
Nursery Sowing US												
Transplanting US												
Harvesting US												

Onion cultivation in Sindh needs to be divided between the upper and lower tracts as the seasonality varies; this is indicative of how important small climatic variations can be as proximity to the coastline and temperature variations impact all aspects of the growth cycle. Within the region nursery sowing takes place between Jun-Sept and Oct-Dec. In the case of LS this is problematic due to the fact that heavy monsoon rains care particularly damaging to nursery seedlings; the frequency of heat waves is also likely to impact both upper and lower Sindh. Soil health is important as is the presence of micronutrients, both the heavily irrigated areas and coastal areas are impacted by salinity and this situation is likely to worsen over time. As relatively thirsty crop onions need consistent availability of irrigation; the heavy reliance on irrigation from the main canal systems means farmers in upper Sindh are less likely to face shortages as compared to growers in Lower Sindh. Onions are particularly susceptible to disease and pests; the increased number of heavy downpours is likely to increase the frequency of pest outbreaks and the lengthening summers and warmer nights will also increase the likelihood of disease and pest outbreaks.

[111] (Boyhan)

Value Chain Intervention / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			
Seeds	Currently seeding methods require extra irrigations. Further current cultivation practices mean a long period before initial planting and first yields. Temperatures in the growing regions are already in the extremes and likely to continue to increase reducing short shelf life even further;	The propagation of transplanting is proposed, and the development of hybrid-seed varieties needs to consider the arid environment that most of the cultivation takes place in; drought like conditions naturally persist but with falling ground water tables it will become an increasingly important consideration	Research into cultivars with high heat tolerance and low irrigation requirements Utilize onion processors and exporters as conduit for dissemination of appropriate cultivars
Fertilizers	Soil in Sindh has Mg and P deficiency requiring exogenous application of these elements	Improve information and advisory services regarding soil management supplemented by availability of soil testing services. Improve availability of fertilizers / build capacity for composting in order to improve soil quality	Leverage input suppliers to expand their reach into onion growing areas supplementing their extension services with soil testing and advisory Input suppliers would require the relevant information about soil etc. in the area in order to recommend appropriate products; promote district wide soil testing (support for organic certification) and as market information for input suppliers

Pest Management	Pesticides are applied indiscriminately, not only impacting the health of plants and produce but also the long term efficacy of pesticides	Improve information and advisory services regarding pest control. Increase distribution and official channels for input supplier companies and better implementation of quality controls	Leverage input suppliers to expand their reach into onion growing areas supplementing their extension services; incentives need to be developed for providing accurate information amongst extension staff Improve reporting and monitoring of pest attacks; through Department of Agriculture and/or FMC and/or input suppliers to cooperation and real time information sharing. Getting the information to farmers is discussed below in Information Services
Information Services	Extension services have limited efficacy across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	The availability of information in many regions of Balochistan remains poor and new innovative channels need to be explored, such as utilizing telecom companies to provide advisory services or leverage local governance bodies; the availability of accurate climate data is a precursor to this and forecasts (short, medium and long-term) are as accurate as possible and made publicly available	Set up mechanisms for improved information exchange between PMD and relevant government bodies in the province; also, a need to increase information sharing between Sindh and Pakistan Develop content in conjunction with telecom providers to create services that farmers can subscribe to (accurate information and local languages are essential) Leverage as many local forums etc - the digital space is active Facebook Groups; WhatsApp groups all provide access to a large number of farmers and information should be made available that is easily

			digestible (and can be shared) in these formats Develop communication campaigns using local institutes such as FMCs, mosques etc as a delivery mechanism for critical information
Financial Services	Extension services are poor across Sindh and the farming systems in place mean that those that are making purchasing decisions are not necessarily those involved in receiving information. The lack of appropriate information not only impacts the growth cycle of the plant but also relates to issues such as varietal selection and labour availability	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop financial products for water conservation equipment Develop financial products for monitoring equipment (i.e. soil testing, water testing, water meters etc.) through MFIs

Tools and Equipment	There is low-technology production in Sindh but the poor infrastructure, lack of appropriate storage and temperature and humidity control will be an issue as droughts, floods and frequency of heat waves increases	There is a need to modernize farming practices and provide basic tools such as nets to increase productivity, not only of the crop but of inputs such as fertilizers and water. The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	Development of local service providing entrepreneurs; i.e. Lazer levelling Rental, Local soil testing service providers, irrigation equipment providers Development of low-tech adaptation techniques: evaporation cooling storage, indirect-direct evaporative (IDEC)cooling systems (Evaporation Cooling) - develop master trainlines/entrepreneurs Support marketing activities for local machinery providers to target the province
Agriculture Production			
Soil Management	The increased temperatures are likely to increase evapotranspiration and potentially salinity as waterlogging issues persist. Salinity management will be very important due the high levels already persisting, various solutions exist, and flushing is already practiced, but irrigation water carries with it further salts.	The management of salinity and waterlogging will be critical in the areas highlighted for cultivation. Large scale interventions to improve drainage across the province will be required. Farmers can also adapt proper soil management techniques and best practices to ensure soil health. Introduction of new leaching techniques	Promote innovative techniques of leaching - assist International service providers to bring in technical capacity if necessary Improved monitoring and information dissemination regarding salinity levels in growing areas Promote the regeneration of native species in and around growing areas

Water Management	Traditional irrigation practices not only are inefficient but also exacerbate other issues such as salinity Although irrigation from the main river is feasible in the region, variations in flows, extreme climates (floods, drought and heavy rains) will likely impact not only growing but all aspects of the value chain. Waterlogging is a severe problem in the area and needs to be effectively managed for sustained cultivation in the region	Increase storage and infrastructure to make productive use of flood/rain waters Appropriate technologies need to be identified for efficient irrigation as drip irrigation type of technologies have proven to be unpopular Intercropping with crops that can provide assistance to the waterlogging issues Reduce the impacts of sea-water intrusion Potentially shifting from water intensive onion farming	Build capacity of FMCs in technical solutions for groundwater recharge and storage like the creation of sub-surface dams, innovative solutions such as using leveraging diurnal temperature for water collection, bhungroo straw, collection of floodwaters Introduce new ways for developing efficient irrigation systems similar to 'Rainmaker utilizing local equipment' Improved water quality testing Make water monitoring equipment easily accessible and available Water salinity needs to be managed in similar ways to soil salinity Selection of alternate crops to be grown in the season to ensure higher market prices as incentive for switching Revival of traditional water management bodies

On Farm Energy	Energy availability is variable in the region and impacts on farm capacity for mechanization	Emissions per capita in the context of onion farming will be low, however the lack of availability acts a barrier to investing in new energy intensive technologies	Promotion of solar energy solutions where possible (except ground water extraction which has proven to have large negative externalities) Promote alternate energy sources, biogas, small wind turbines
Diversification	Onions are water intensive crops, prone to gluts and consequently low market prices yet farmers continue with the cultivation of onions	Encourage farmers to split available land between onion and other suitable crops to build adaptive capacity and resilience to shocks (natural and economic)	Identify ideal crops for intercropping and work with seed suppliers to expand supply in local markets supported with marketing campaigns Provide demonstration plots of appropriate planting methods
Production Infrastructure	The area is heavily prone to flooding and with soils already prone to waterlogging this can have severe impact on productivity	Basic flood protection should be considered for storage units; storage units consider humidity control due to extended dry periods and access to water	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area
Skills Base of Farmers	Farmers possess knowledge about the local environment and water management that can be insightful but there are significant capacity gaps in the skill set of farmers to effectively consider holistic ecosystem-based approaches	It is important to invest in the capacity of the local farmers in their ability to manage all the above-mentioned risks	Interventions should be designed to build capacity of farmers with mentioned climate and environmental risks.
Postproduction			
Post Harvest Management	Current harvest cycles are aligned with high temperatures increasing post harvest losses due to a lack of appropriate cold storge and/or sheds	The development of appropriate storage which can handle high temperatures and maintain humidity will build resilience	See tools and equipment

Energy in processing	With limited to no processing in the province current impact is low	The locations of any additional processing units being developed, and storage units need to consider the availability of water and energy	Integrate environmental risk assessment in the planning of new processing units and/or expansion of farming area Cost-benefit analysis for renewable energy sources, utilization of biogas
Packaging materials and methods	Current poor packaging practice mean rising temperatures and heavy isolated downpours can increase post harvest losses during transportation	Suitable packaging needs to be developed for increasingly high temperatures and waterproof while maintaining food safety standards	Research into most suitable packaging in conjunction with suppliers of packaging material Increase distribution and marketing activities to reach farmers in onion growing regions Develop backward linkages with retailers and provide appropriate packaging to contracted farmers Develop backward linkages in order to ensure farmers receive information regarding market requirements for improved packaging
Processing infrastructure	Sind being particularly disaster prone to floods, cyclones and heavy rains, processing infrastructure is vulnerable and can create huge losses	Ensure climate proofing of new investments in processing and storage infrastructure	Integrate environmental risk assessment in the planning of new processing and/or storage units

8 Livestock in Balochistan

8.1 Backyard Poultry

Backyard poultry rearing in Balochistan is unique compared to other livestock rearing activities but like many parts of the developing world provides the developing world. Unlike intensive poultry farming the environmental footprint of such activities is quite low, also due to the small size flocks per household. It was observed that currently most households are able to provide adequate water and feed through a combination of scavenging. However, what was observed is that there was scope for vast improvements in the management of backyard poultry in order to improve productivity and profitability form this economic activity.

The risks facing the sector are slightly impacted do face climate risks, but prudent planning and taking a climate smart approach to the development of backyard poultry can result in a more resilient sector. In rearing poultry was able to substitute the rearing of traditional livestock (i.e. sheep and goats) the potential environmental impact could be positive due the less grazing required, animal waste, water requirements and general conversion of land.

Balochistan has some extremely unique biodiversity present in the area however habitat loss and environmental degradation is increasing the incidence of human wildlife conflict. Backyard poultry without appropriate sheds and/or supervision are susceptible to predators and increase the potential for human-wildlife conflict.

Value Chain Interventions / Outcomes	**Climate Risks**	**Climate Risk Management Opportunities**	**Implementation Strategies and Potential Partners**
Inputs			
Feed and Resources	currently water availability is sufficient for the animals but development is successful and flock sizes increase acute water shortages can persist; as temperatures increase the overall water requirements are likely to rise	Since the rearing of poultry is very much tied to the wellbeing of the household, the availability of clean water at household levels will ensure availability to poultry. Ensuring availability of water in the household through rainwater harvesting, recycling etc. can indirectly benefit poultry farmers	Build capacity of women in the benefits of best rearing practices including adequate water, the impact of hot days and drought on the animals water requirement needs Develop HH level water storage infrastructure; rainwater harvesting, condensation collection (where environmentally feasible), solar desalination and introduction of filters to improve water quality

	Feed availability and conversion: Temperature extremes can create both heat and cold stress on the animal; this will impact the ability of the animals feeding and conversion of food. Increased incidences of drought and high temperatures will also reduce feed availability through drought.	Appropriate shed development can provide important shade and shelter to poultry, particularly in areas which are heavily degraded. Research and availability of appropriate feeds for the animals; although there is little investment into feed generally, if development is successful and households keep larger numbers feed availability will an important consideration Utilizing mobile sheds	Introduce mobile sheds through women entrepreneurs Develop capacity for appropriate shed development Develop small village level entrepreneurs to cultivate specifically for chicken feed
Financial	Lack of access to finance is a barrier to increased investment in backyard poultry rearing.	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Leverage MFIs in order to promote backyard poultry, be the conduits for the availability of appropriate equipment Develop financial products for flock expansion/breed shift
Production			
Reproduction and Animal Wellbeing	Decreased productivity because of increased temperatures; not only productivity of meat but off laying eggs, which is the main form of generating income from poultry rearing	Breed selection and availability can provide farmers with enhanced resilience to climate shocks particularly heat tolerance and cold tolerance n the north	Introduction of highly productive breeds Introduce mobile sheds through women entrepreneurs Develop capacity for appropriate shed development Develop small village level entrepreneurs to cultivate specifically for chicken feed

	Climate extremes of drought and flooding can impact. Drought issues are dealt with in feed availability but floods also have the potential to disrupt what is meant to be extra security for emergency situations; standing water can also impact the spread of disease and overall health of the animal	Developing flood proof sheds, or designing poultry sheds considering the potential of floods	Introduce raised sheds Community level diversions can not only help store additional water but protect animal sheds.
Human-Wildlife Conflict	natural habitat and prey availability is decreasing across Balochistan as a consequence of degradation and habitat loss. This households in risk of being targeted by predators, not only creating potentials for human losses but also human wildlife conflict and retaliatory killings of important species	Appropriate shed development and awareness regarding protective measures that can be taken to keep livestock safe can help reduce losses	Develop capacity for appropriate shed development Introduce poultry-insurance mechanisms
Post-Production			
Energy in Processing	Lack of processing and/or cold storage; the increasing temperatures will make the necessity of cold storage important particularly for slaughtered animals	In an energy insecure region there will be hurdles for cold storage at a small scale, but the use of aggregators and/or processors to develop cold storage can help ensure consistent supply from a region but also provide farmers a buffer in terms of maintaining stocks	Develop aggregators in the region with incentive to invest in cold storage
Transport and Logistics	Lack of appropriate transportation during incidences can increase mortality rates of animals; stress also will cause animals to lose weight and can spread disease before slaughter	Building awareness amongst aggregators about the benefits of ensuring healthy animals are transported and impact on mortality rates needs to be raised Policy level development on the safe transportation and movement of animals should be developed and enforced by traffic police	Policy level research on optimal number of animals in locally available transport Developing linkages with larger processors who require healthy animals at facilities

	Lack of market; the sustainability of investing in backyard poultry is going to be determined by the demand and price received for the product. There will be little investment in climate smart solutions if those rearing the animals are not receiving benefit of premium prices	By developing an identity of quality 'desi' chicken from Balochistan farmers may be able to ask demand higher prices while the middlemen are still able to maintain their margins	A nationwide marketing campaign promoting Balochistan backyard poultry

8.2 Goats and Sheep

The analysis of potential impacts on goats and sheep in Balochistan will be conducted together due to the similarities in the three types of production systems, i.e. sedentary, transhumant and nomadic. In all three production systems there is a dependence on the availability of grazing grounds; these can be communal with more controlled access and maintenance or completely open pasture lands that are part of historical routes. These routes follow seasonality and as summers are extended it is likely that livestock owners will be required to adapt their migratory routes, keeping another eye on precipitation and water availability. Although there is not significant evidence as of yet but in the long term the increasing temperatures can impact reproductive cycles.

S #	Winter Quarter	Summer Quarter	Tribes/Groups
1)	Sibi lowlands	Chaman, Western Toba kakari range and several areas in Afghanistan	Pashtun
2)	Sulaiman range	Central Toba Kakari Range	Pashtun
3)	Harnai, Sibi district	Central Toba Kakari, Ziarat and Loralai	Pashtun
4)	Zhob district	Killa Saifullah, Pishin and Afghanistan	Pashtun
5)	Suleiman ranges	Loralai, Killa Saifullah.	Pashtun

North – South Migratory Routes of Nomads & Transhumant

S #	Summer Quarter	Winter Quarter	Tribe/Groups
1)	Nushki	Kacchi plains	Peerkani and M. Hasni
2)	Mangochar, Khad Kucha & D. Goran	Kacchi Plains	Langhav, Zehri,Shahwani Mengel
3)	Isplinji and Johan	Kacchi plains	Zehri, Bangulzai & Kolloi
4)	Johan and Narmuk	Kacchi plains	Kolloi, Zehri
5)	Dasht	Kacchi plains	Satakzai, Kurd, Bangulzai and Peerkani

6)	Kanak	Kacchi plains	Raessani

East-West migratory routes of nomads and transhumant

Balochistan has some extremely unique biodiversity present in the area however habitat loss and environmental degradation is increasing the incidence of human wildlife conflict. Backyard poultry without appropriate sheds and/or supervision are susceptible to predators and increase the potential for human-wildlife conflict. The migratory routes place domestic livestock near wild ruminants and that can also increase the incidence of zoonotic diseases within a herd.

Although grazing is more widespread during the summers, the winter months show a worrying trend of a high dependence on a few grazing pastures, i.e. Kacchi plain, Suleiman Range and Sibi. This means many groups/tribes from different ethnic backgrounds are utilizing a common resource; the lack of effective management regimes has created issues related to rangeland degradation through overgrazing and fuelwood extraction. Issues related to climate change are exacerbating these issues and placing the farmers and their animals at further risk.

Value Chain Interventions / Outcomes	**Climate Risks**	**Climate Risk Management Opportunities**	**Implementation Strategies and Potential Partners**
Inputs			
Feed and Resources	As temperatures increase the overall water requirements are likely to rise for both goats and sheep and the dependence on naturally available water sources may place them at risk	Best management practices regarding sheep and goat rearing including water management Introduction of water storage techniques for sedentary farmers Rangeland management Improved information availability regarding climate trends	Build capacity of women in the benefits of best rearing practices including adequate water, the impact of hot days and drought on the animals water requirement needs Develop HH level water storage infrastructure; rainwater harvesting, condensation collection (where environmentally feasible), solar desalination and introduction of filters to improve water quality

	Feed availability and conversion: Temperature extremes can create both heat and cold stress on the animal; this will impact the ability of the animals feeding and conversion of food. Increased incidences of drought and high temperatures will also reduce feed availability. Rangeland degradation and the resilience of the rangelands will be extremely important due to current feedings practices	Appropriate shed development can provide important shade and shelter to livestock Research and availability of appropriate feeds for the animals; research into most nutritious locally available fodder in conjunction with crop cycles Rangeland management and regeneration	Development of Rangeland Management Action Plan and associated policy instruments Build capacity for shed development Communal Shelter Development along migratory routes with processors
Financial	Lack of finance is a barrier to the adoption of new techniques or investing in building the resilience against climate shocks	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop livestock insurance products to protect against drought, floods and wildlife predation Develop financial products for breed shift Develop products for investment in fodder production
Production			
Reproduction and Animal Wellbeing	Limited access to information and knowledge of best practices is a barrier; this impacts general management practices which will help build the resilience of the animals to climate change	Introduce best management practices	Build capacity for best management practices Identify innovative communication channels targeting migratory pathways Establishment of markets and backward linkages will ensure that pastoralists will have better accesses to market requirements
	Decreased productivity as a consequence of increased temperatures with yields already low per animal the increased temperatures and climate extremes will likely further reduce productivity	Rangelanad management Development of alternate fodder, particularly tied into cycles associated with drought Improvements in water and feed management Introduce livestock fattening at the farm level	Build capacity for best management practices Development of Rangeland Management Action Plan and associated policy instruments Build capacity for shed development Communal Shelter Development along migratory routes with processors

			Work with seed companies to promote agriculture based on alternate fodder options (low delta crops needs to be considered)
	Climate extremes of drought and flooding can negatively impact mortality. Animals that depend on following migratory routes tied to climate patterns will face difficulties if the timing of the routes are not adjusted with real time climate data and early warning systems particularly in the mountainous north	Developing flood proof sheds, or designing poultry sheds considering the potential of floods Development of early warning systems Improved information availability regarding weather Development of financial products around insurance	Introduce raised covered sheds along flood plains as emergency stations Community level diversions and channelling of floodwater can help store additional water, replenish grazelands but also make water available for livestock during drought seasons
	Disease transmission and susceptibility increases as various stresses are placed on the animals (heat, standing water, water stress); Balochistan also faces the issues of zoonotic diseases due to the the population of wild ruminants	Rangeland management Improved veterinary services	Development of Rangeland Management Action plan and relevant policy Utilize vaccine manufacturers to extend reach and market products to pastoralists
Human-Wildlife Conflict	Human-Wildlife Conflict; natural habitat and prey availability is decreasing across Balochistan as a consequence of degradation and habitat loss. This households in risk of being targeted by predators, not only creating potentials for human losses but also human wildlife conflict and retaliatory killings of important species	Appropriate shed development and awareness regarding protective measures that can be taken to keep livestock safe can help reduce losses	Develop capacity for appropriate shed development Introduce livestock-insurance mechanisms
Post-Production			

Energy in Processing	Lack of processing and/or cold storage; the increasing temperatures will make the necessity of cold storage important particularly for slaughtered animals	In an energy insecure region there will be hurdles for cold storage at a small scale, but the use of aggregators and/or processors to develop cold storage can help ensure consistent supply from a region but also provide farmers a buffer in terms of maintaining stocks	Develop backward linkages with processors in order to develop aggregators in the region with incentive to invest in cold storage;
Transport and Logistics	Lack of appropriate transportation during incidences can increase mortality rates of animals; stress also will cause animals to lose weight and can spread disease before slaughter	Building awareness amongst aggregators about the benefits of ensuring healthy animals are transported and impact on mortality rates needs to be raised Policy level development on the safe transportation and movement of animals should be developed and enforced by traffic police	Policy level research on optimal number of animals in locally available transport Developing linkages with larger processors who require healthy animals at facilities

9 Livestock in Sindh

9.1 Cattle

Cattle plays an important role in the rural households economy and food security as evident by the 18.1 million heads of cattle and buffalo reared for milk. The milk is not only consumed domestically but also provides invaluable income while the sale of animals can provide respite during crop failures or emergency situations. The performance of the sector is not hampered by the availability of animals but rather the productivity; besides farmers facing risks, the fact that livestock is a large contributor to global greenhouse gas emissions also must be considered.

The risks faced by the dairy and livestock sectors are varied based on the production system; this is a consequence of large variations in the capacity, and production techniques adopted by the different actors in the value chain. Rural subsistence farmers rely to a certain extent upon open grazing with limited availability to consistently supply milk and meat; the per capita emissions may be low but the sheer numbers of animals means this group does contribute to the overall emissions from the sector. This group probably also represents that with the least adaptive capacity, both in terms of knowledge and resources.

Rural market-oriented producers can produce surplus milk and have relatively more productive animals. Grazing still plays a part but milk producing animals will receive supplementary feed. The remaining producers have significantly higher capacity to adapt to climate risks and are already aware of best practices. There is still significant improvements that can be made in productivity to reduce emissions per litre/kg, but due to higher capacity these actors are well placed to make investments in adaptation strategies.

Value Chain Interventions / Outcomes	Climate Risks	Climate Risk Management Opportunities	Implementation Strategies and Potential Partners
Inputs			
Feed and Resources	Water Availability ; as temperatures increase the overall water requirements will increase for cattle, particularly important for pregnant and lactating cows. Saline water is a problem in the area and that can impact the health of the animal	Best management practices for cattle management Introduction of water storage techniques for farmers Improved water stations for cattle Improved information availability regarding climate trends	Build capacity of women in the benefits of best rearing practices including adequate water, the impact of hot days and drought on the animals water requirement needs Develop HH level water storage infrastructure; rainwater harvesting, condensation collection (where environmentally feasible), solar desalination and introduction of filters to improve water quality

	Feed availability and conversion: Temperature extremes can create heat stress on the animal; this will impact the ability of the animals feeding and conversion of food. Increased incidences of drought and high temperatures will also reduce feed availability, this applies not only to rangelands but cultivated stands of fodder	Appropriate shed development can provide important shade and shelter to livestock Research and availability of appropriate feeds for the animals; research into most nutritious locally available fodder in conjunction with crop cycles Rangeland management and regeneration	Development of Rangeland Management Action Plan and associated policy instruments Build capacity for shed development Development of alternate fodder market
Financial	Lack of finance is a barrier to the adoption of new techniques or investing in building the resilience against climate shocks	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop livestock insurance products to protect against drought, floods Develop financial products for breed shift Develop products for investment in fodder production
Production			
Reproduction and Animal Wellbeing	Limited access to information and knowledge of best practices is a barrier; this impacts general management practices which will help build the resilience of the animals to climate change	Introduce best management practices	Build capacity for best management practices Identify innovative communication channels targeting migratory pathways Establishment of markets and backward linkages will ensure that pastoralists will have better access to market requirements
	Decreased productivity as a consequence of increased temperatures with yields already low per animal the increased temperatures and climate extremes will likely further reduce productivity; dairy production can be severely reduced through high	Rangeland management Development of alternate fodder, particularly tied into cycles associated with drought Improvements in water and feed management Introduce livestock fattening at the farm	Build capacity for best management practices Development of Rangeland Management Action Plan and associated policy instruments Build capacity for shed development

	temperatures	level	Work with seed companies to promote agriculture based on alternate fodder options (low delta crops needs to be considered)
	Climate extremes of drought and flooding can negatively impact mortality rates amongst animals	Developing flood proof/raised sheds considering the potential of floods Development of early warning systems Improved information availability regarding weather Development of financial products around insurance	Introduce raised covered sheds along flood plains as emergency stations Community level diversions and channelling of floodwater can help store additional water, replenish grazelands but also make water available for livestock during drought seasons; needs to be supported through ground water management policies
	Disease transmission and susceptibility increases as various stresses are placed on the animals (heat, standing water, water stress)	Rangeland management Improved veterinary services	Development of Rangeland Management Action plan and relevant policy Utilize vaccine manufacturers to extend reach and market products to livestock farmers.
Post-Production			
Energy in Processing	Lack of processing and/or cold storage; the increasing temperatures will make the necessity of cold storage important particularly for slaughtered animals and dairy products	In an energy insecure region there will be hurdles for cold storage at a small scale, but the use of aggregators and/or processors to develop cold storage can help ensure consistent supply from a region but also provide farmers a buffer in terms of maintaining stocks	Develop backward linkages with processors in order to develop aggregators in the region with incentive to invest in cold storage; Cost-benefit analysis of renewable energy powered cold storage
Transport and Logistics	Lack of appropriate transportation during incidences can increase mortality rates of animals; stress also will cause animals to loose weight and can spread disease before slaughter	Building awareness amongst aggregators about the benefits of ensuring healthy animals are transported and impact on mortality rates needs to be raised Policy level development on the safe transportation and movement of animals should be developed and enforced by traffic	Policy level research on optimal number of animals in locally available transport Developing linkages with larger processors who require healthy animals at facilities

		police	

9.2 Goats

In Sindh the market system around goat and goat products is very traditional at the production stage; animals are predominately allowed to free graze as large flocks constantly move to find good grazing lands. At most locations access is unrestricted but certain areas have introduced the concept of grazing rights. 40% of those involved in goat herding are agro-pastoralists and rangeland based, while an additional 13% used a mixed system. It is important to note that most farmers provide unrestricted supply of water; goat herding is a way of life and significant importance is placed on the health of their animals.

Goat farmers in Sind will have to be aware of the changing precipitation patterns. A significance dependence on grazing lands leaves the entire flock particularly prone to exogenous climate shocks. Developing affordable alternate fodder can provide respite in emergency situations and improve the overall health of the animal. There needs to be significant awareness and disaster preparedness in the region which is prone to floods; animals are not only at risk from the physical forces of the floods themselves but the aftereffects where the natural topography results in large tracts of standing water. Migratory paths will have to be adapted as precipitation patterns change. The incidences of heat waves and drought will also be of particular concern for herders and appropriate adaptation strategies need to be in place to minimize losses during such times.

Value Chain Interventions / Outcomes	**Climate Risks**	**Climate Risk Management Opportunities**	**Implementation Strategies and Potential Partners**
Inputs			
Feed and Resources	Water Availability ; as temperatures increase the overall water requirements are likely to rise for goats and the dependence on naturally available water sources may place them at risk even if farmers do their best to make water available	Best management practices goat rearing including water management Introduction of water storage techniques for farmers Improved information availability regarding climate trends	Build capacity of women in the benefits of best rearing practices including adequate water, the impact of hot days and drought on the animals water requirement needs Develop HH level water storage infrastructure; rainwater harvesting, condensation collection (where environmentally feasible), solar desalination and introduction of filters to improve water quality

	Feed availability and conversion: Temperature extremes can create heat stress on the animal; this will impact the ability of the animals feeding and conversion of food. Increased incidences of drought and high temperatures will also reduce feed availability. Rangeland degradation and the resilience of the rangelands will be extremely important due to current feedings practices	Appropriate shed development can provide important shade and shelter to livestock Research and availability of appropriate feeds for the animals; research into most nutritious locally available fodder in conjunction with crop cycles Rangeland management and regeneration	Development of Rangeland Management Action Plan and associated policy instruments Build capacity for shed development Development of alternate fodder market
Financial	Lack of finance is a barrier to the adoption of new techniques or investing in building the resilience against climate shocks	Financial services need to be more available across the province; the ability to access traditional financial services is limited and alternate channels, micro-finance, insurance schemes and government banks need to be leveraged	Develop livestock insurance products to protect against drought, floods and wildlife predation Develop financial products for breed shift Develop products for investment in fodder production
Production			
Reproduction and Animal Wellbeing	Limited access to information and knowledge of best practices is a barrier; this impacts general management practices which will help build the resilience of the animals to climate change	Introduce best management practices	Build capacity for best management practices Identify innovative communication channels targeting migratory pathways Establishment of markets and backward linkages will ensure that pastoralists will have better access to market requirements

	Decreased productivity as a consequence of increased temperatures with yields already low per animal the increased temperatures and climate extremes will likely further reduce productivity	Rangeland management Development of alternate fodder, particularly tied into cycles associated with drought Improvements in water and feed management Introduce livestock fattening at the farm level	Build capacity for best management practices Development of Rangeland Management Action Plan and associated policy instruments Build capacity for shed development Communal Shelter Development along migratory routes with processors Work with seed companies to promote agriculture based on alternate fodder options (low delta crops needs to be considered)
	Climate extremes of drought and flooding can negatively impact mortality. Animals that depend on following migratory routes tied to climate patterns will face difficulties if the timing of the routes are not adjusted with real time climate data and early warning systems particularly in the mountainous north	Developing flood proof sheds, or designing poultry sheds considering the potential of floods Development of early warning systems Improved information availability regarding weather Development of financial products around insurance	Introduce raised covered sheds along flood plains as emergency stations Community level diversions and channelling of floodwater can help store additional water, replenish grazelands but also make water available for livestock during drought seasons; needs to be supported through ground water management policies
	Disease transmission and susceptibility increases as various stresses are placed on the animals (heat, standing water, water stress)	Rangeland management Improved veterinary services	Development of Rangeland Management Action plan and relevant policy Utilize vaccine manufacturers to extend reach and market products to livestock farmers
Post-Production			

Energy in Processing	Lack of processing and/or cold storage; the increasing temperatures will make the necessity of cold storage important particularly for slaughtered animals	In an energy insecure region there will be hurdles for cold storage at a small scale, but the use of aggregators and/or processors to develop cold storage can help ensure consistent supply from a region but also provide farmers a buffer in terms of maintaining stocks	Develop backward linkages with processors in order to develop aggregators in the region with incentive to invest in cold storage;
Transport and Logistics	Lack of appropriate transportation during incidences can increase mortality rates of animals; stress also will cause animals to lose weight and can spread disease before slaughter	Building awareness amongst aggregators about the benefits of ensuring healthy animals are transported and impact on mortality rates needs to be raised Policy level development on the safe transportation and movement of animals should be developed and enforced by traffic police	Policy level research on optimal number of animals in locally available transport Developing linkages with larger processors who require healthy animals at facilities

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