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Agricultural Losses and Adaptation Strategies under Climate Change, Water Scarcity and Floods in Kamber-Shahdadkot, Sindh

Naveed Noor
Department of Geography, Shah Abdul Latif University, Khairpur, Sindh
Email: naveed.chandio@salu.edu.pk
Noor Hussain
Department of Geography, Shah Abdul Latif University, Khairpur, Sindh
Kamal Hussain
Department of Geography, Shah Abdul Latif University, Khairpur, Sindh

Abstract
Water, soil, and temperature are the key factors for the cultivation of any crop. Climate is a main driver of maintaining agricultural sustainability overall. The globe is facing the adverse impacts of climate change, due to an upsurge in the world population, food resources are going to short supply. Pakistan is among the top three countries which is facing the issue of water scarcity. Climate change has impacted to agricultural sector in different ways in different regions. The coastal belt is facing cyclonic hits, the Riverine belt is facing floods, and the semi-arid areas are facing water scarcity, floods, and high temperatures. The footprints of the floods in the study area are very old since the formation of the Khirthar Mountain. The Water Scarcity, floods and high temperatures have badly affected the crop yield. This variation has changed the cropping pattern in the region. This review study examines, adverse effects of Climate Change on agriculture. The main findings concern the role of human adaptations in reacting the climate change, and possible regional impacts on crop yield.

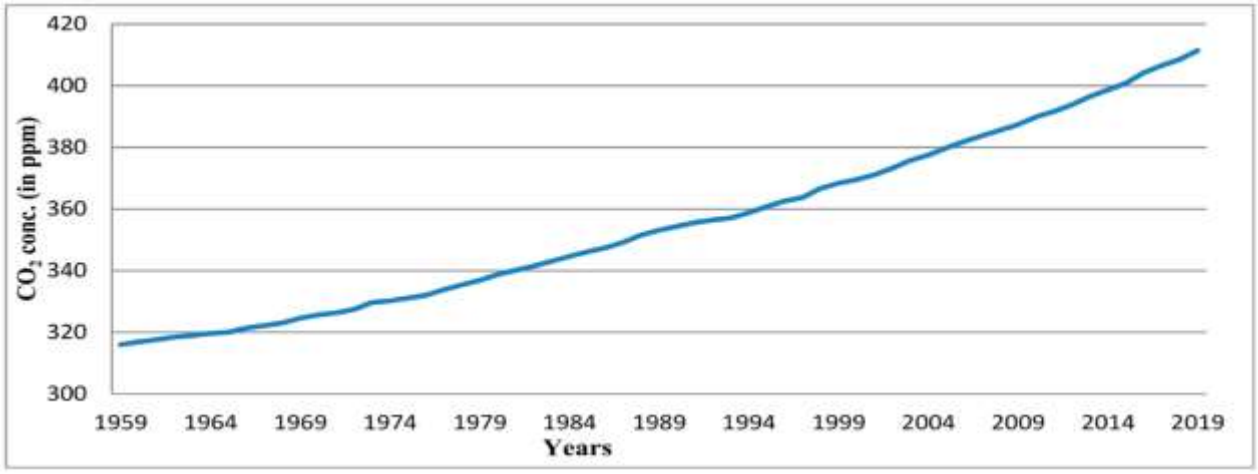
Keywords: *Climate change, Water scarcity, Agriculture,*

Introduction

Climate change is one of the biggest challenges to the world in the present times. It is defined as significant changes in the average values of meteorological elements, such as precipitation and temperature, for which averages have been computed over a long period(Charoensilp et al., 1998). The past few decades indicate that significant changes in climate at a global level were the result of enhanced human activities that altered the composition of the global atmosphere (Amon et al., 2021). The concentration of greenhouse gases such as methane (CH4), carbon dioxide (CO2), and nitrous oxide (N2O) has increased by 150%, 40% and 20%, respectively, since 1750 (Kantardjieff & Rupp, 2003). Carbon dioxide emissions account for the maximum proportion of greenhouse gases. The average global temperature has increased at an average rate of 0.15–0.2^{0}C °C per decade since 1975 (Darwin, 1995), and is expected to increase by 1.4–5.8 °C by 2021

(Arora et al., 2005). Greenhouse gas (GHG) emissions, particularly CO2 from the combustion of fossil fuels and non-CO2 GHGs such as nitrous oxide, methane, and CFCs, add to global warming. The CO2 concentration in the atmosphere had increased to 411.43 ppm in 2019 from 315.98 ppm in 1959, as shown in Figure 1 (Wei et al., 2012).

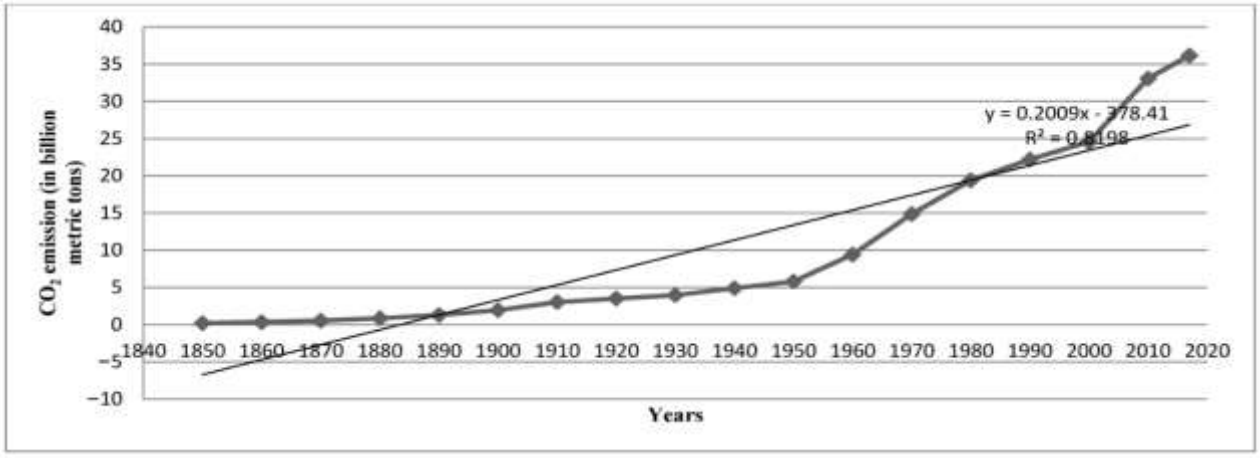
Figure 1: The increase in CO_2 concentration in the atmosphere



Source: (Wei et al., 2012).

CO2 constitutes a major proportion of greenhouse gases in the atmosphere: 65% from fossil fuels and industrial processes and 11% from forestry and other land use, followed by methane (16%), nitrous oxide (6%), and fluorinated gases (2%). Before 1750, CO2 emissions from fossil fuels were negligible, but they increased rapidly with industrialization. Figure 2 shows the increase in CO2 emissions over the years (1850–2020) (Montzka et al., 2011)

Figure 2. CO2 emission in the atmosphere over the years (1850–2020).



Source: (Montzka et al., 2011).

The world has emitted around 1.5 trillion metric tons of CO2 since 1751. However, there are regional variations in the emissions. Europe is the largest contributor of CO2, having around 514 billion metric tons of CO2 emissions, followed by Asia and the North American continent, which have recorded cumulative CO2 emissions of 457 billion metric tons each (Droubi, 2006). The USA

is the largest contributor to CO2 emissions (399 billion metric tons), and has contributed 25% of total historical emissions since 1751, followed by China (200 billion metric tons). The European Union (EU-28), a union of 28 countries that sets collaborative targets, has contributed 22% of historical emissions of CO2. Africa contributes only 3% of global cumulative CO2 emissions due to low per-capita emissions. However, countries like Brazil and India, which historically emitted less, significantly add to the total emissions in the current context (Yost, 2016). With an increased level of CO2 in the atmosphere, the fertilization of crops is increased, along with decreased energy requirements due to warming. These are certain positive impacts of climate change, whereas water resources are negatively impacted due to climate change. In the 20th century, the impact of climate change was mainly positive. Most countries benefited until 1980, after which the trend remained the same for the developed world, while the Third-World countries were negatively impacted. In the 21st century, climate change will become a severe problem, and both rich and developing countries will face negative externalities (Zhang et al., 2010).

Water scarcity refers to a situation where the available water supply within a region is insufficient to meet the demands of its population or various sectors like agriculture, industry, and households. Scarcity occurs when the water demand exceeds the available amount during a certain period. Water scarcity is an issue in the world, but developing countries are facing it seriously because agriculture is the main source of income in developing countries. Pakistan is among the top 8th countries facing water scarcity. Water scarcity is responsible for affecting the quality and quantity of agricultural grains (Hatibu et al., 2006), as well as the availability and interest of food for consumers. Water scarcity is responsible for reducing food quantity, and less food is responsible for increasing the prices of food worldwide (Petanidou et al., 2008).

Literature review

Climate is an important factor in agricultural productivity. The fundamental role of agriculture in human welfare concerns has been expressed by many organizations and others regarding the potential effects of climate change on agricultural productivity. Interest in this matter has motivated a substantial body of research on climate change and agriculture over the past decade. Climate change is expected to affect agricultural and livestock production, hydrologic balances, input supplies and other components of agricultural systems. Water scarcity has a significant impact on agriculture globally, affecting food production and security. The agricultural sector is among the largest users of freshwater globally, accounting for 70% of water withdrawals.

The present freshwater resources are limited and cannot fulfil the global demand for conventional crop cultivation (D'Angelo et al., 2018). The discrepancy between agricultural water availability and demand for cultivation, when agricultural water demand exceeds available water resources. Water shortage denotes a multi-dimensional social deficiency of humankind; water shortage may impact whole areas, it is the susceptible and growers that suffer the severe costs. This plays a vital role in the economic development of any country, especially in an agricultural country. So, water shortage in both terms, generally from the perspectives of physical requirement and economic growth of a country (D'Odorico et al., 2018).

Research methodology:

Study Area: The district Kamber-Shahdadkot is one of the main agricultural areas, famous for paddy crop in Sindh. Once, the district was a subdivision of Larkana; it now contains seven Taluks:

Kamber, Warah, Shahdadkot, Quboseed Khan, Miro Khan, Sajawal Junejo and Nasirabad. The Khirthar Mountain is a natural boundary between Sindh and Balochistan. About 15% area of the region is mountainous. Its shape is roughly octagonal and is the hottest region after Jacobabad, Nawabshah and Larkana in Sindh; the maximum temperature is 124.8^{0}°F reported in July 2002. May, June and July are the hottest months. The study area has been facing natural calamities-turned disasters due to its geographical location. The area is under constant threat from the surface drainage effluent coming from Balochistan Plateaus and local drains (Anwar & Chandio, 2012). Geographically, the region is divided into two parts *viz*: the Kohistan tract (Western tract) and the central canal irrigation tract. The western portion of the region comprises uneven topography of hills and uplands consists of the Kohistan area. The most elevated peak, known as ***Kutay-ji-kabar*** (Dog's Grave), is 2065 meters above sea level and 300 meters from local relief. At the North of *Kutti-Ji-Kabar,* the *Darhyaro* plateaus (1800 meters above sea level) are situated with nearly a thousand acres of cultivable land. At one time, *Darhyaro* was proposed for a sanatorium (Chandio & Anwar, 2009).

To acquire the study objectives, both primary and secondary data sources were utilized. Primary data was collected through interviews and surveys from the local farmers, and secondary data from satellite images.

Primary data

To serve the objectives of the research, the sample was collected from the rural area of five talukas of the study area. These sample cities include Kamber, Shahdadkot, Mirokhan, Naseerabad, and Warah. According to the 2023 census, the total population of all these Talukas was 14 13,760. A total of 162 interviews were conducted with the owners of agricultural fields. The sample size areas were selected based on two purposes: firstly, their agricultural lands were critically affected by water scarcity, and secondly, their agricultural land was badly affected by floods in the study area.

Data was analyzed through different statistical tools, SPSS, and an Excel master sheet. Interview data was put into SPSS for the data analysis, the Excel was used for the tables and graphs for the quality of the result.

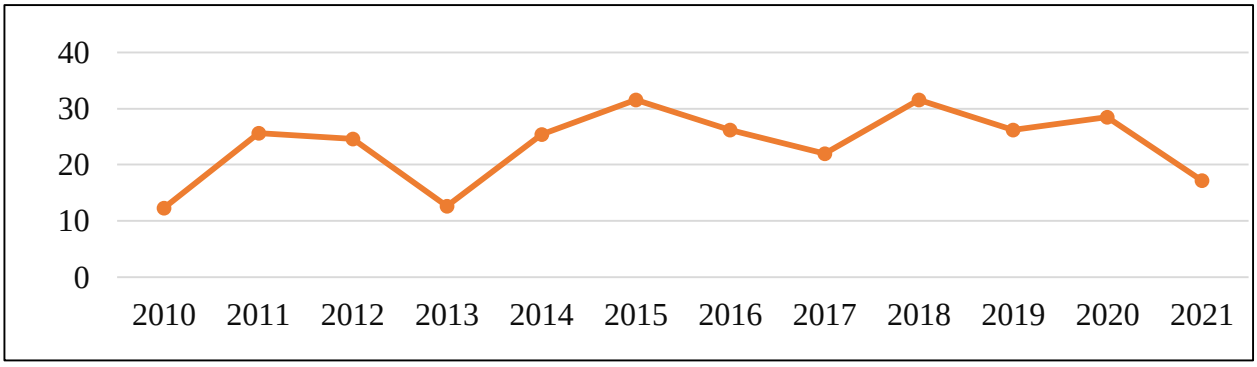
Secondary data: For the collection of secondary data, the satellite images were downloaded from the USGS. The Landsat-8 images were downloaded from USGS with 0 to 10% cloud cover. The images were analyzed through the Arch 10.3 version for the quality of results. The analyzed images show the flood-affected area. The use of ArcGIS is to collect the quality and accuracy of the results.

Secondly, data were also gained from the different websites,.ie. Irrigation, population departments, government of Sindh, and Bureau of Statistics, Government of Pakistan.

Results

The Rice Canal originates from the Indus River and flows through the Larkana district, serving as a lifeline for the local agriculture sector. The canal is a vital component of the extensive irrigation system that has been crucial to sustaining agricultural activities in the region. Figure 3 shows that the most deprived years were recorded in 2015 and 2018.

Figure 3. Water scarcity per year in the Rice canal

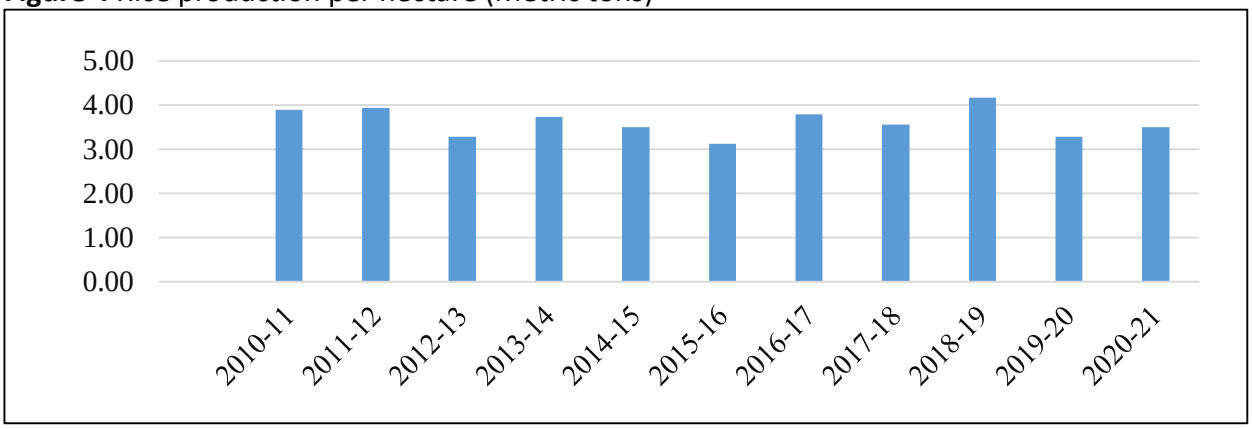


Source: (Field Survey, 2022).

The majority of the respondents were satisfied with cultivating the rice crop in 2010; they sell-out rice/paddy in markets, and also stored paddy in homes for food purposes. On the contrary, in the year 2021, growers were not satisfied with cultivating the rice crops owing to adverse impacts.

The Rice productivity per hectare has shown considerable fluctuations in the entire study period. In the cropping year 2012-13 per per-hectare production was highest (more than 4 metric tons per hectare), and in 2019-20, it was lowest with less than 3.3 metric tons per hectare.

Figure 4 Rice production per hectare (Metric tons)



Source: (Field Survey, 2022)

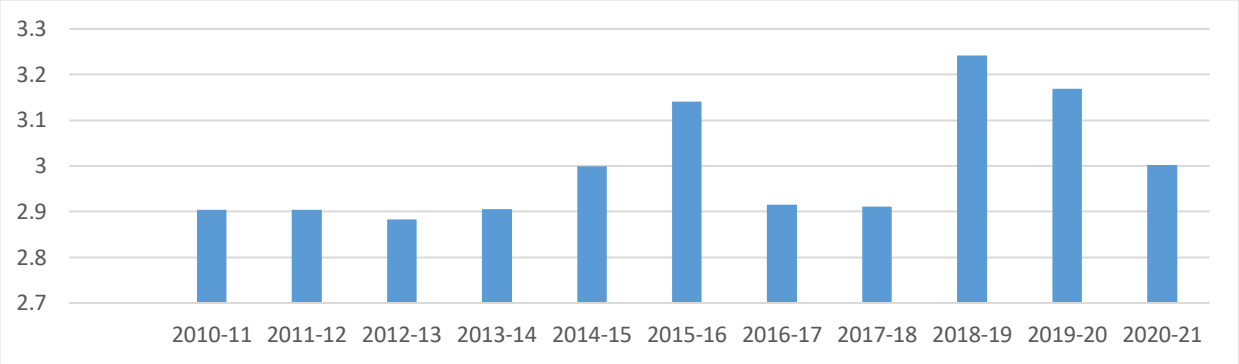
District Kamber Shahdakot is the 7th largest district of Sindh province, where the wheat crop is being cultivated (District Irrigation Department 2021).

Wheat is a staple crop with great importance in the agricultural landscape of many regions, including the research area. Wheat is a primary source of food for the local population. It is a dietary staple, and its cultivation ensures a consistent food supply for the people of the area.

During the research, 90% of growers were satisfied with cultivating the wheat crop; they sold out wheat crops in markets, and some farmers stored wheat for food purposes in their homes. However, in 2021, most growers were not satisfied with the wheat crop due to water scarcity.

This graph shows that the Wheat Production per hectare has altered, with the year 2010-11 being the highest production, and the year 2020-21 being the lowest production year of the Wheat crop.

Figure 5 Wheat Production per hectare (MetricTon)



Source: (Field Survey, 2022).

The cropping pattern has undergone significant changes since 2010. Farmers cultivate less water-consuming crops and provide better yields.

Farmers have started cultivating drought-resistant crops like watermelon in areas with low rainfall. These crops require less water and can survive even during water scarcity. Change has also occurred in the cropping pattern in the study area. In 2010, only 0.6% of the farmers cultivated watermelon, which increased to 2.4%. Wheat was cultivated by 47.5% of respondents in 2010, which decreased to 37%. Similarly, rice cultivators decreased from 51.2% in 2010 to 43.5% in 2021. There was no barren land in 2010, but 12% of the respondents answered that their agricultural land remained uncultivated/barren due to water scarcity.

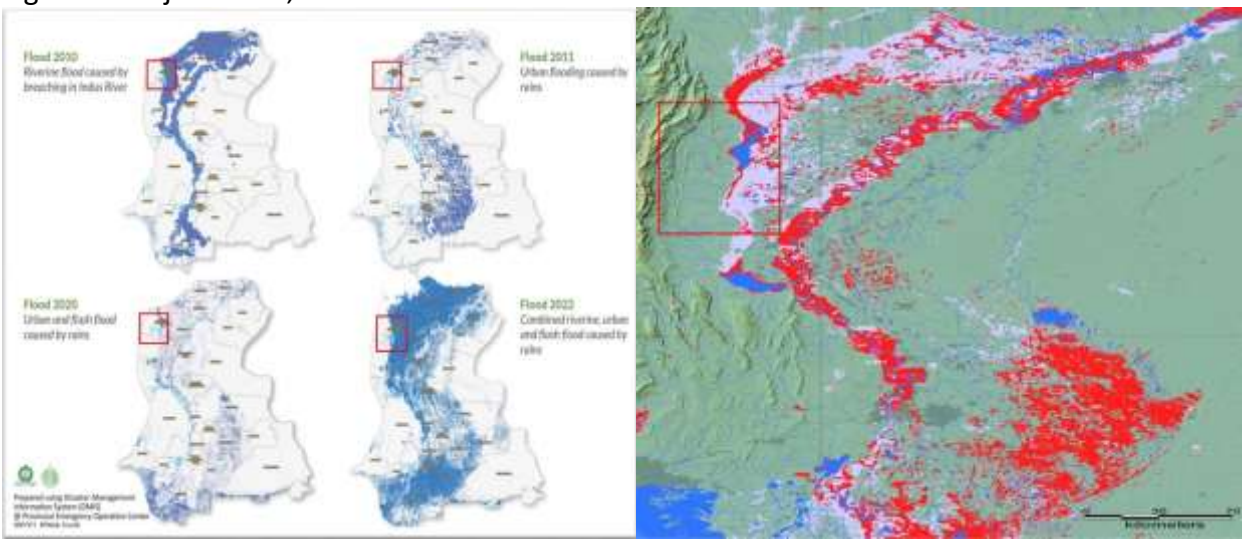
Table 1, Change in cropping pattern (2010_ 2021).

Value	**2010**		**2021**	
	Respondent	**Percent**	**Respondent**	**Percent**
Watermelon	1	**0.6**	4	2.4
Wheat	77	**47.5**	60	37
Vegetables	1	**0.6**	8	4.8
Rice	83	**51.2**	70	43.5
Barren Land	0	**0**	20	12
Total	**162**	**100**	**162**	**100**

Source: (Field Survey, 2022)

As another part of the results is secondary data analysis, for this goal, the satellite images of the study period were digitalized for the quality of results.

Figure 6. Major floods, and flood water covered area.



Source: https://floodobservatory.colorado.edu/Events/4966/2020Pakistan4966.html

The above maps show the floods in the study area from 2010 to 2022; the region was under floodwater. Despite this, the growers were unable to cultivate the crop of another season owing to the floodwater availability on their agricultural land. The study area is located near the Eastern slope of the Khairthar Mountain; therefore, 12 rainwater rivulets are flowing from the uplands. So the river floods and rainwater rivulets are major causes of the floods.

Conclusions

Climate change and Water scarcity can have a significant impact on agricultural production, as plants need sufficient water to grow and thrive. Lack of water can reduce yields, stunt growth, and even lead to crop failure. In areas where water scarcity is a chronic problem, farmers may have to rely on irrigation systems and rainwater harvesting to increase the volume of water supplies.

Climate change and water scarcity also lead to soil degradation as it dries out and compacts, making it difficult for plants to grow. In the research area, soil degradation is also an issue faced by the farmers, farmers, policy-makers, and stockholders may take a range of actions, no new irrigation techniques are still introduced in the region, using water-saving techniques such as *drip irrigation*, *using drought-tolerant crops,* and improving *water management practices*. The construction of dams (water reservoirs) is a source to increase water availability and helps ensure a stable water supply for agricultural production, and water reservoirs may help the water table. The construction of water reservoirs is also suggested in the recommendations section of this study.

The impact of water scarcity on agriculture in research areas has wide-ranging economic and social consequences. This led to a decline in economic activity in rural areas and an increase in migration to cities in search of employment and better living conditions. Conflicts over water resources can also occur as different groups compete for access to limited water supplies, as mentioned in the findings.

Finally, the issue of climate change and water scarcity its impacts on agriculture in the research area requires careful management and planning to mitigate its impact.

Another major cause of the degradation of agriculture is floods; the unregulated water from the River and Khairthar Mountain is a cause of degradation of this sector. Unfortunately, no management for both types of water is observed. Therefore, a huge volume of water is going to waste. However, with effective management and conservation practices, it is possible to reduce the impact of water scarcity and flood intensity to protect the agriculture.

Recommendations:

The study area is a Flood-Prone Zone (FPZ) where river and rainwater rivulets are the major causes of floods and destruction.

It is recommended that the Flood Protective Bund (FPB) be stronger to protect the agricultural fields from the adverse effects of the rainwater rivulets of Khirthar.

It is also recommended that a water reservoir (Dam) be constructed before entering the agricultural lands.

A few Natural waterways (Western Nara) are available to cross the water of flood by the RBOD, MNV Drain and the Harridan Drain to the Arabian Sea, so this is recommended that, for the protection of agricultural lands, River floodwater may drain out through these natural waterways.

The study area is facing an acute water shortage (excluding flooding years), so this is recommended that new techniques of irrigation, like *Drip Irrigation* Systems (DIS), *Drought-Tolerant Crops* (DTC), and *Water Management Practices* (WMP), be introduced.

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