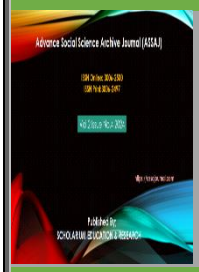

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ASSESSING THE RAINFALL VARIABILITY AND ITS EFFECTS ON FRUITS PRODUCTION IN PERIPHERAL AREAS OF QUETTA

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ABSTRACT

Background: Fruit crops are quite profitable; thus they have a big impact on growers' economies. Rain, which also satisfies crop-watering requirements, has a significant impact on fruit production and the ability to make or break fruit output. Despite being a difficult process, the cultivation of fruit crops involves a variety of elements that can affect the annual fruit yield. **Objective:** The objective of this study was to assess the impact of rainfall variability on main fruit production in the study region and to analyze the pattern of rainfall variability in Quetta. **Method:** The results of the correlational study, which is based on secondary data, were examined in SPSS (22.0), and descriptive statistics were employed to summarize the findings. The 2000-2022 data was used to calculate both the effect and the findings. The Directorate of Crop Reporting Services Agriculture Department, Balochistan Quetta, and the Meteorological Department of Quetta provided the information for this study. **Result:** The study's key findings revealed that fruit output is positively correlated with rainfall variability in Quetta, which fluctuates from time to time. The relationship between total output and cumulative rainfall in the year 2021, shows that rainfall in Quetta, District of Balochistan, is not the only source of irrigation. **Conclusion:** The production of Quetta's fruit crop showed the impact of annual unpredictability. The global fluctuation of rainfall has a significant impact on the fruit harvest.

Key Words: Rainfall Variability, temperature variation, weather variability, Fruits Production, Correlation.

1. Introduction

Agriculture as a whole greatly benefits from fruit crops, whether they are tropical or subtropical (Carvalheiro, Seymour, Veldtman, & Nicolson, 2010). Fruit crops play a significant role in growers' economies because they are so lucrative (Hearne & Easter, 1997). In the tropics, the dominant fruits are papaya, mango, guava, lemon, and mosambi, whereas, in the subtropics, they are custard apple and (B. SINGH, J. Singh, P. Bhatnagar, & Upadhyay, 2014). Fruit production is strongly influenced by rain, which also meets crop-watering needs and has the power to create or break fruit output (Pérez-Expósito, Fernández-Caramés, Fraga-Lamas, & Castedo, 2017). Despite being a complex process, the cultivation of fruit crops involves several variables that can influence the annual yield of fruits (La Pena & Hughes, 2007). The greatest dangers to agricultural output and food security are thought to be climate change and variability, particularly for places that depend on rain-fed agriculture (Cooper et al., 2008). The most crucial climatic factor for rain-fed agriculture, as well as the overall development of the socio-economic system, is rainfall (Cooper et al., 2008).

In developing nations, including Pakistan, where the fruit is also produced, the quantity and period of rainfall are of utmost importance (Ashraf & Routray, 2013). The key factor in the country's unpredictable weather spells, which are not as often as in other nations in the same region and also reflect a significant variation in its climate, was shifts in rainfall patterns (Warner & Afifi, 2014). Rainfall affects the annual production of horticulture, and between 1900 and 2000 there was an increase in rainfall that accounts for 2for 0+ in North Pakistan, +10% in Central Pakistan, and 40% in Southeast Pakistan this country is one of the nations where diverse fruit kinds are grown (Hamilton et al., 2014). These include melons, pomegranates, grapes, cherries, apricots, figs, pears, apples, plums, and plums (Erkan & Dogan, 2019). Tropical and subtropical climates are the best places to grow citrus fruits, dates, guavas, and other year-round fruits like bananas, mangoes, and dates (Mohan Jain, 2000). Rainfall during the monsoon season provides the country's standing crops with all of their water needs (Pathak, Tripathi, Jambhulkar, Bisen, & Panda, 2020). Fruits crops are greatly impacted by weather fluctuation, specifically rainfall variability (Jain, 2010). Although agriculture depends on irrigation water and an abundance of water from ice and snow, it also depends on rainfall (Rodell, Velicogna, & Famiglietti, 2009). The view on the financial impacts of climate change on global agriculture has been cautiously optimistic from the very beginning of such economic evaluations (Tol, Fankhauser, Richels, & Smith, 2000). Despite the fact that climatic changes undoubtedly have a significant impact on agricultural systems, as long as climate change is not catastrophic, individual and social adaptation can and will likely prevent any serious harm to global food security (Costello et al., 2009). Rainfall is the primary weather factor that affects crop growth,

and understanding the sequences and patterns of rainfall variability and occurrences can help in gathering particular data for agricultural planning (Yamusa, Abubakar, & Falaki, 2015).

The uplands of Balochistan are referred to as Pakistan's fruit baskets because of the region's dry environment, which is perfect for cultivating deciduous fruits (Khair, Culas, & Hafeez, 2010). The fruit-growing region of Balochistan, which is well known for producing apples, grapes, pomegranates, peaches, plums, dates, apricots, and almonds, is endowed with a temperate environment (Rana, Moeen, Shikoh, & Davies, 2021). There is a limited amount of arable land, a semi-arid environment, 200–350 mm of precipitation per year in certain areas, and a highly variable amount of 50 mm per year in others (Burney et al., 2014). The upland areas of Balochistan are blessed with a climate that is favorable for high-value fruits, including those that don't grow in other parts of the nation (Khattak & Khattak, 2014). The amount of produce generated in this province is determined by rainfall, and this province's output is reliant on rainfall (Chau, Holland, Cassells, & Tuohy, 2013). The region of Quetta is located in the province's uplands, and its typical produce includes melons, apples, pears, plums, grapes, cherries, almonds, and apricots. Consequently, Quetta is also known as Baluchistan’s fruit Garden (Khan, Shaukat, & Biotechnology, 2006).

The amount of rainfall is one of the most crucial factors that affect crop output in different ways at different stages of development (Bali & Singla, 2022). In practical terms, there hasn't been much research done on the statistical relationships between rainfall and fruit yield at sub-regional levels (Raftery, 2017). The purpose of this study is to examine the pattern of rainfall variability over a two-decade period in the Quetta district and to determine how rainfall variability affects the production of fruit crops in Quetta's outlying districts. The study will be helpful in assessing the effects of rainfall on various agri-horticultural endeavors as well as on socioeconomic technology at a regional basis.

2. Method

2.1 Research design

A research study that examines the link between two or more variables uses a correlational design. We can use data from one or two populations to create these variables. Similar to qualitative researchers, quantitative researchers often discover changes in one variable are related to other changes. This particular study also used a quantitative and correlational research methodology to examine the link between two provided variables.

2.2 Setting

The Balochistan province's capital, Quetta, served as the site of this study's outlying locations. In the Quetta region, rainfall statistics going back 20 years (2000-2022), as

well as data on the area covered by fruit crop production, were used in the study. The Quetta region has a semi-arid climate with noticeable differences in the winter and summer temperatures. Quetta's summer season lasts from May to September, when temperatures range from 24 to 26 degrees Celsius on average. The month of July becomes one of the warmest in the area when this occurs. In the region, there are two harvesting seasons: kharif and rabbi. The kharif agricultural season is when the fruits are cultivated.

2.3 Variables of study

Simply put, variables are concerned with features that change as a result of study interactions, and the strength between two variables is evaluated. The two primary types of variables are dependent and independent variables. Fruit output in Quetta District's outskirts serves as the research's dependent variable, with rainfall serving as the study's independent variable.

2.4 Data sources

To support the arguments in the literature, secondary data from various published reports are used in this study. Additional information was gathered from a variety of sources, including the Quetta Meteorological Department, the Directorate of Crop Reporting Services, and the Quetta Agriculture Department of Balochistan.

2.5 Data analysis

Data analysis was done using R.Studio, Excel and SPSS, and the outcomes are described by descriptive statistics, which display three-year moving averages, graphical correlation trends, range, maximum, and lowest values, as well as means and standard deviation. Between 2000 and 2022, the consequences of variability on the main fruits of Quetta are examined.

3. Result

3.1 Trend of temperature and precipitation

The studied region is not within the reach of the monsoon currents, much like other regions of the province. The average annual rainfall is 308.3 mm, but it is erratic and patchy. Average monthly rainfall varied from 0.3 mm in June to 68.4 mm in March. The average maximum temperature was 24.5 1C, with January experiencing the lowest temperature of −1.7 and July experiencing 35.8 1C. The trends and variability of the mean monthly precipitation and temperature data for Quetta (1719 m above mean sea level) from 2000 to 2022 are provided by the meteorological data recorded. Illustrates the Quetta precipitation anomalies for various years; the anomaly indicates the precipitation's departure from the yearly average.

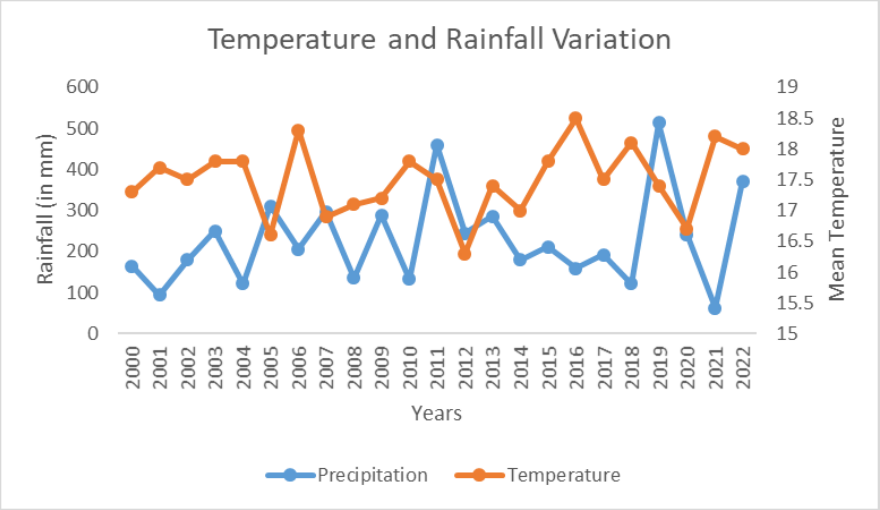

Figure 1 Mean annual temperature and rainfall

The graph clearly shows that from 2006 to 2022, the temperature rose and was warmer than usual, with the exception of 2006, 2016, 2018 and 2021, when the temperature was somewhat lower than usual. Since Quetta station's temperature data only becomes available for the years 2000 to 2022, it serves as a stand-in for the research area. The mean annual temperature reached its highest point in 2018 and its lowest point in 2012 (Figure 1). The temperature fluctuations that occur during the designated timeframe are significant enough to induce stress in agricultural plants, especially in fruit orchards, resulting in decreased growth and output. The annual precipitation total of 513.0 mm in 2019 was the highest ever recorded. In addition to represent drought period, the Standardized Precipitation Index (SPI) is a commonly used tool for estimating the length and intensity of droughts. Time-series SPI results for the various time scales for both meteorological stations are shown in Figs. 2a, b, c, and d, correspondingly.

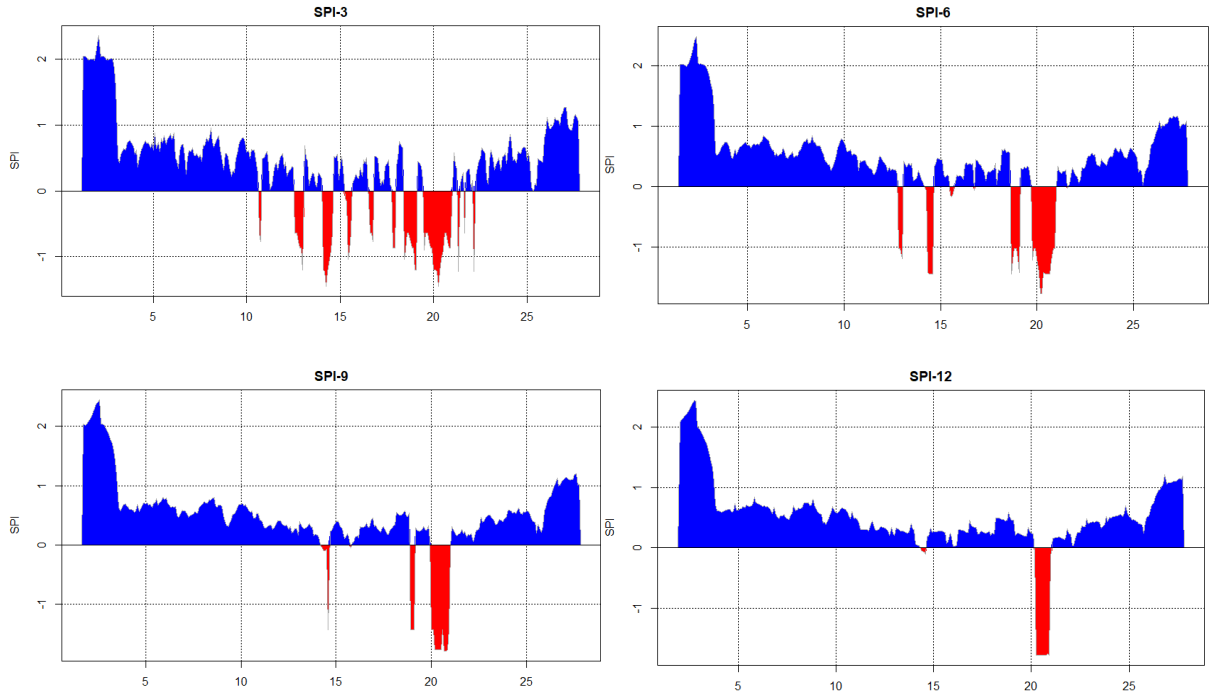

Figure 2 Drought period in Quetta station at multiple time steps

Monthly precipitation data is used for Quetta station to compute SPI for several periods (i.e. 3-month, 6-month, 9-month, and 12-month). A thorough description of the SPI calculation may be obtained. In the research area, the winter drought is represented by the 3-month SPI during the rainy season. In the research area, the 12-month SPI depicts the drought status during all dry and wet seasons combined, whereas the 6-month SPI measures the precipitation deficit during the karif cropping season. Taking into account the four extreme cases of SPI-3, SPI-6, SPI-9, and SPI-12, Figs. 2a, b, c, and d demonstrate that, in the case of SPI-3, two and three severe drought occurrences (-2 o SPI o -1.5) were seen at Quetta station, respectively, but only one extreme drought event (SPI≤-2) happened at the station. However, throughout the recorded period, the quantity of severe drought episodes climbed to three in the vicinity of the station when the time scale was extended from three to twelve months. The inter-seasonal variations in the precipitation data surrounding the select station may be the cause of the comparatively greater frequency of exceptional and severe droughts in the cases of SPI 3 and SPI 12. A notable precipitation shortfall, or drought, was noted in some of the year.

3.2 Proportionate variation in the study area's major fruits' production

Variations in precipitation and fruit output in Quetta may be closely correlated, as precipitation plays a significant role in determining agricultural results. Quetta is particularly susceptible to changes in precipitation patterns because to its semi-arid

setting. Fruit crops require a significant amount of equally distributed rainfall in order to grow and develop. Insufficient rainfall can cause plants to undergo water stress, which can lead to decreased production and quality. Variations in fruit production can have an impact on the quantity and size of the harvest due to changes in precipitation patterns. Quetta's semi-arid climate makes it susceptible to droughts, which may have a detrimental effect on fruit production. Prolonged dry spells can result in a water deficit, which can damage irrigation systems and reduce total agricultural productivity. Irrigation techniques are crucial for fruit growth in Quetta because of the region's dry climate. To make up for any shortages in precipitation caused by natural processes, farmers may rely significantly on irrigation systems.

The graph demonstrates a notable impact in 2000, a year with high levels of rainfall and apple production. reduced the following year as well. Nonetheless, there was a discernible variation in precipitation during the ensuing ten years, but there was no significant shift in apple yield. Both indicators showed a decline in 2012 and an increase in 2013 subsequent to that year. 2019 is the year with the most rainfall and production during the previous 20 years. There hasn't been any discernible association during the past two years. However, it is important to note that 2022 was a flood year, which had a detrimental impact on apple production.

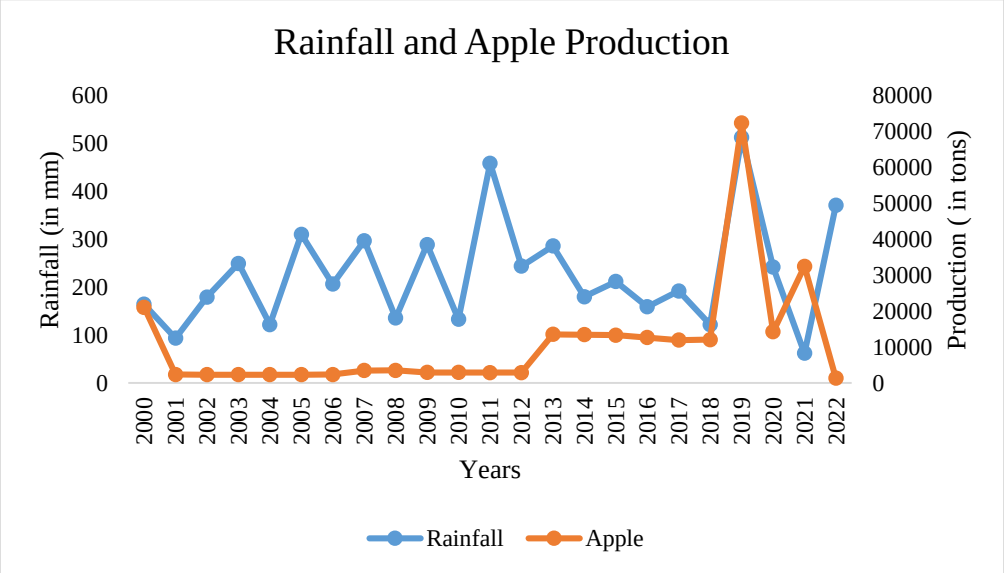

Figure 3 Rainfall and apple production

In the Quetta District, the amount and timing of rainfall have a major impact on apricot output. For the best yields, there must be enough rainfall during the flowering and fruit-setting stages. Water stress brought on by insufficient or unexpected rainfall might impact fruit size and yield as a whole. In order to lessen the effects of erratic rainfall on apricot orchards, farmers frequently rely on irrigation techniques.

Maintaining a consistent apricot output in the area requires constant observation of and adjustment to shifting patterns of precipitation. The years 2000, 2007, 2019, and 2020 represent the direct relationship between rainfall and apricot production. Like apple production, peach production is also negatively affected by rainfall in 2021 and 2022.

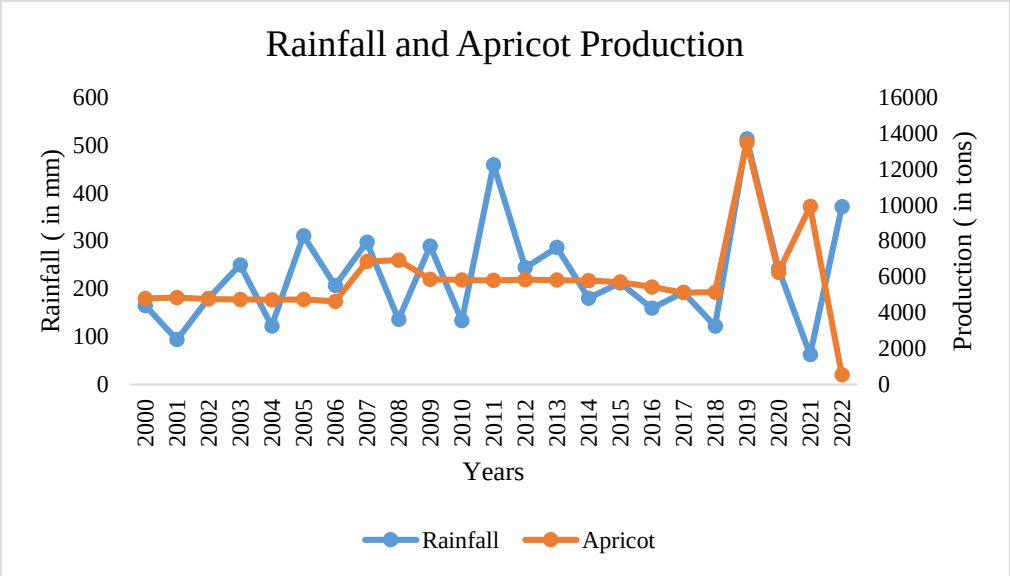

Figure 4 Rainfall and apricot production

In the Quetta District, rainfall and grape yield have a critical link that is essential to the viability of agriculture. Grapes, like many other fruit crops, are highly dependent on regular, uniform rainfall throughout the growing season. Water stress at critical junctures brought on by insufficient precipitation can impact grape quality as well as yield. However, excessive rain can postpone grape ripening and raise the chance of disease. Farmers frequently need to make use of efficient irrigation techniques to supplement natural rainfall. For the Quetta District to experience reliable and abundant grape production, it is imperative to keep an eye on precipitation trends and put adaptation measures into place. Grapes are the major fruit of Quetta. The graph shows significant relationships in the years 2000, 2002, 2004, 2006, 2007, 2009, 2012, 2013, 2019, and 2020. The rainfall in 2021 and 2022 has an adverse effect on grape production due to flooding.

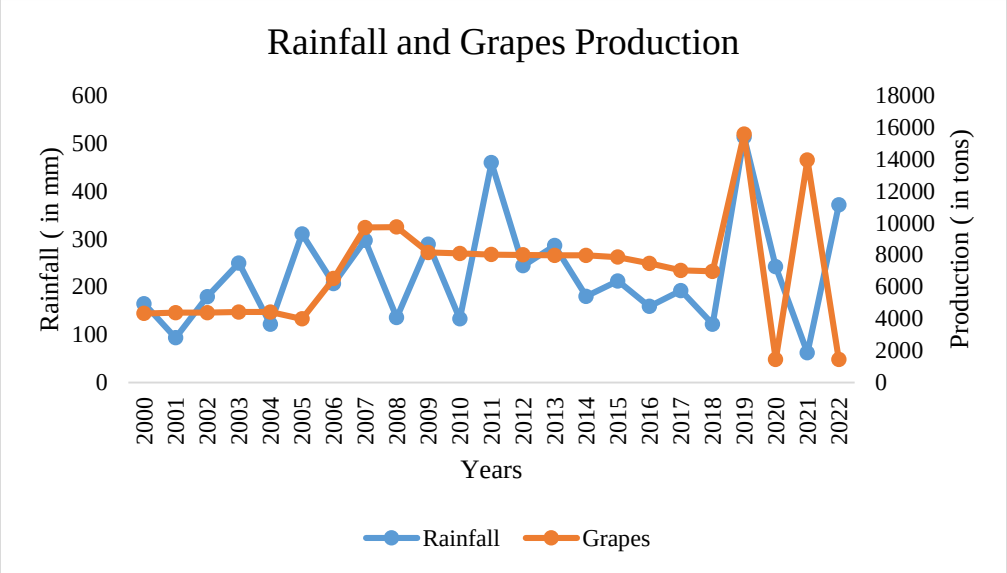

Figure 5 Rainfall and grapes production

Figure 6 demonstrates the relationship between pomegranate productivity and rainfall in the Quetta District. For pomegranate trees to grow and develop, they require a sufficient and evenly distributed amount of rainfall, which affects fruit quality and productivity. Inadequate rainfall might cause water stress at crucial growth phases, which could affect productivity as a whole. On the other hand, problems like root rot and poor fruit quality might result from too much rainfall. Sustaining a reliable and prosperous pomegranate harvest probably depends on efficient water management techniques, such as irrigation techniques. To maximize pomegranate production in the Quetta District, it is important to continuously evaluate rainfall patterns and adaption techniques. Pomegranate cultivation is another one of Quetta's notable products. Except 2019 and 2021, the data examined for this study do not indicate a significant correlation between production and rainfall. Apart from that, it was discovered that, in contrast to other fruit production, pomegranate output grew in 2022.

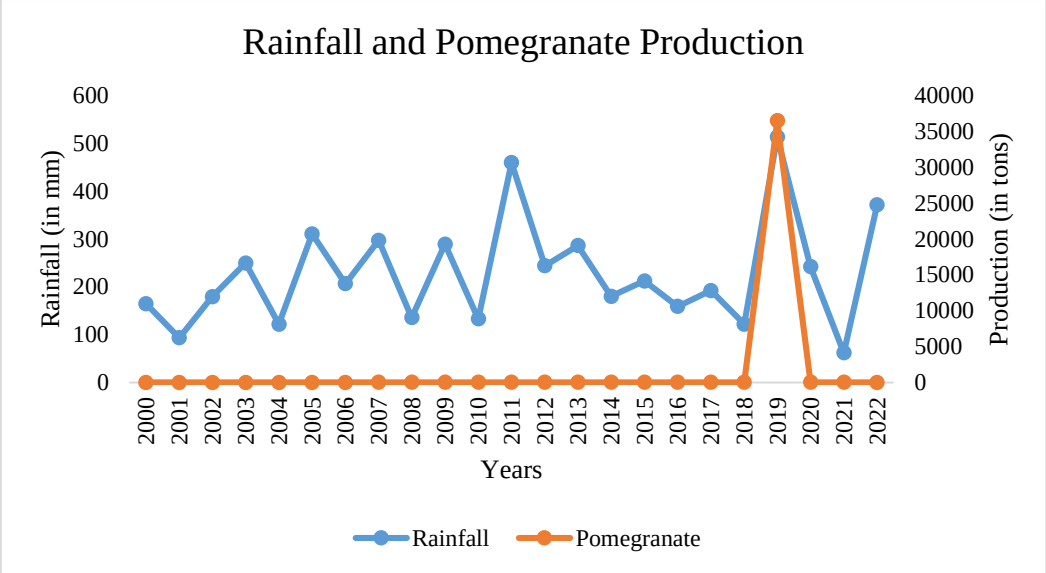

Figure 6 Rainfall and pomegranate production

In the Quetta District, rainfall and peach output interact significantly. Rainfall that falls on peach trees in a well-timed and dispersed manner is essential, especially during the flowering and fruit-setting seasons. Water stress brought on by insufficient rainfall can impact peach harvests in terms of both quantity and quality. On the other hand, an abundance of precipitation can cause the soil to become soggy, endangering the wellbeing of the roots and the total yield. Farmers frequently use effective irrigation techniques to augment deficient natural rainfall. In the Quetta District, tracking patterns of precipitation is crucial to maximizing peach yield and guaranteeing a steady crop. The graph represents variations in the quantity of rainfall and peach yield. The following years demonstrate a positive link between two variables: 2000, 2007, 2011, 2020, and 2019. The last two years have had the same negative effect as other fruit productions.

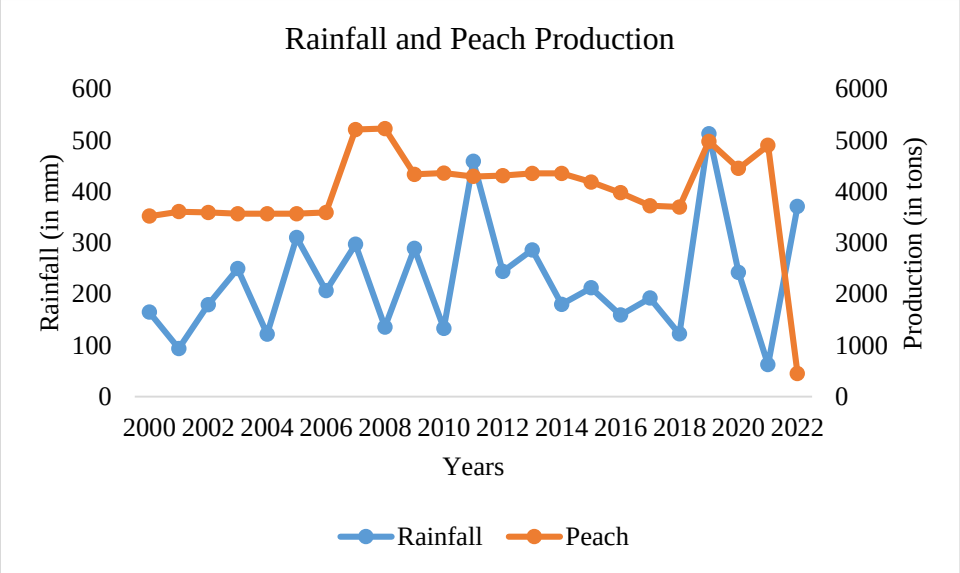

Figure 7 Rainfall and peach production

A vast range of fruits are produced in the Quetta District, and these fruits are essential to the agricultural economy of the area. In the region, a wide variety of fruits are grown, including apples, apricots, pomegranates, peaches, along with grapes. Fruit crop productivity is influenced by several factors, such as soil quality and climate, including temperature and precipitation patterns. Quetta's semi-arid environment makes it difficult for farmers to manage water supplies efficiently. Fruit orchard sustainability is largely dependent on irrigation techniques, both conventional and new. A further way to lessen the effects of water constraint is to plant resilient and drought-resistant fruit cultivars. In the Sira Gurgai area, apricots and apples are collected, while in Chasma Achozai, apples, and peaches are harvested. In the Kechi Baig region of Saryab, grapes are harvested. Miaan Ghundi is where apples are harvested. Union Council Kotowal harvests apples, peaches, plums, and apricots. Apricot, and apple Achtar Abad Shadezai, west of Quetta, close to Qambarani Road, is the harvesting location for peaches, and grapes. Quetta's Shareef Abad Kamalo Qambrani Road is where grapes are harvested.

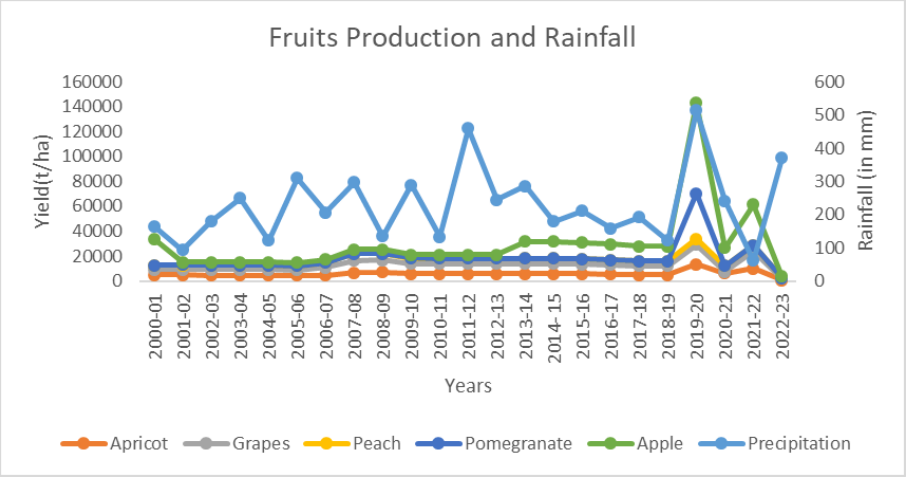

Figure 8 **Fruits production and rainfall**

4.Discussion

This study revealed that the study area is extremely vulnerable to rainfall fluctuation, which is consistent with the findings of (B. SINGH, J. Singh, P. Bhatnagar, & V. J. M. Upadhyay, 2014). Quetta has seen very quick changes as a result of the study's findings that the pattern of rainfall is changing quickly. The two decades' worth of data (gathered from the Quetta Meteorological Department) were examined to determine Quetta's rainfall trends. It was discovered that Quetta's rainfall is rising and occasionally falling, mirroring the scenario in India. A moving average was used to describe the data and display the rainfall pattern. According to the information, Quetta experienced a drought throughout these two decades, which had the effect of reducing rainfall (Figure 2). Furthermore, it was dropped all over Pakistan. The timing of the rain in Quetta is quite unpredictable (Ali et al., 2021). These modifications in rainfall patterns are seen throughout the nation as a result of climate change. There are significant variations in the amount of precipitation (Rainfall) in Quetta as a result of the impact of climate change on rainfall variability (Salma, Rehman, & Shah, 2012). Many fruits, including as apples, apricots, pomegranates, peaches, and grapes, are cultivated in the area. A number of variables, including soil quality, temperature, and precipitation patterns, affect how effectively fruit crops grow. In the Quetta District, apricot output is highly influenced by the amount and timing of rainfall (Figure 4). Like many other fruit crops, grapes depend heavily on regular, consistent rainfall during the growing season. Grape output and quality can be affected by water stress throughout critical stages caused by insufficient rainfall (Figure 5). Overall, the findings showed that Quetta's fruit output is not only reliant on rainfall. Floods, however, that are caused by rainfall, negatively impact production. The farmers are not solely reliant on rainfall because the district is steep and naturally experiences little rainfall.

The patterns of rainfall in Quetta are variable, it was discovered after analyzing the final data from the previous two decades. which are also led in the province of Balochistan. For pomegranate trees to grow and develop, they require a sufficient and evenly distributed amount of rainfall, which affects fruit quality and productivity. Inadequate rainfall might cause water stress at crucial growth phases, which could affect productivity as a whole (Figure 6). The second goal of this study involved analyzing the correlation between rainfall variability and fruit yield. The nature of the rainfall variability on fruit output is clarified by this purpose. The Directorate of Crop Reporting Services Agriculture Department, Balochistan Quetta provided the information for the past 20 years' worth of fruit output. This information was associated with the Quetta Rainfall (Belhadj, Arezki, & Gauquelin). The study discovered that while rainfall is not the only factor influencing fruit yield, it is also crucial. The findings indicate that fruit output decreases in years with the least amount of rainfall. Low productivity is a result of the erratic rains (Hailua, Manjureb, & Aymutc, 2015).

According to the findings of this study, rainfall fluctuation affects fruit yield. Rainfall that is both timely and evenly distributed is essential for peach trees, especially during the flowering and fruit-setting phases. The impact of variable rainfall on the yield of fruits has already been noted by the scientist. Three distinct time periods the Pre-Drought, Drought, and Post-Drought Periods with varying amounts of rainfall and fruit output were separated by these two decades, yet all three displayed a positive correlation with one another. The farmers in the Quetta district tried a variety of methods to counteract the effects of decreasing productivity, such as increasing the acreage in order to balance the effect. A study conducted in Nepal also demonstrates how rainfall affects production (Lal, 2011). In the Quetta District, a stable and successful fruit sector is sustained via ongoing weather monitoring, climate adaptation, and the application of contemporary agricultural techniques. The prosperity of fruit cultivation benefits the region's whole agricultural environment in addition to sustaining local livelihoods.

Limitation

The production of Quetta's fruit crop, which is extremely susceptible to rainfall variability worldwide, was a reflection of the influence of annual variability. The following study has certain limitations because it solely examines the impact of rainfall on Quetta's fruit production and ignores other variables that may have a significant impact on fruit production, due to a shortage of time, this analysis is only based on Quetta and the secondary data used is unreliable (Ashraf et al., 2021).

conclusion

Pakistan's shifting climate is primarily due to significant changes in rainfall patterns. In Quetta, the annual rainfall varies greatly. The volume of rain can change at times. This

isn't just happening in Pakistan, Balochistan, or Quetta; it's happening all around the world. All around the world, rainfall is varying in distribution. In these two decades, there was a significant disparity in the amount of rainfall; Quetta typically received less than 200mm. Somehow, > 200mm were received in 2007, 2012, and 2013. 300mm of rain fell in 2008 already. While 1995, 2003, 2006, and 2009 saw more than 300 mm of rain, respectively. The year with the most precipitation, 2011, saw more than 400 million inches. The Quetta fruit crop's yield demonstrated the impact of annual variations. Everywhere in the world, the fruit crop is extremely susceptible to variations in rainfall. According to the study, there is a decline in fruit production during droughts, and a rise in production occurs once they end. As a result, the study concluded that rainfall affects the production of fruit crops. Rainfall can have a positive or negative impact on production, however, this study's analysis of rainfall variability revealed a favorable correlation between important Quetta-area fruit crops such as apples, grapes, apricots, plums, pears, peaches, pomegranates and chard. It illustrates how important rainfall is to Quetta's fruit production, just like it is to other agricultural inputs.

Declarations

Author Contributions: The Nadia Shahzada and Asma Khan Kakar wrote the article. Nadeem Ahmed helped in data collection, and Sumra Sajida Tufail supervised and oversaw all of the research.

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Conflicts of Interest: The authors state that they have no conflicts of interest.

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