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Climate Change and Water Scarcity Nexus: Response and Coping Behaviour of Quetta Agriculture

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Abstract:- The agriculture sector in Quetta, the capital city of Balochistan, faces significant challenges and opportunities for development. The sustainable and efficient use of three critical resources plays a vital role in the agricultural growth of the region. The district exhibits a diverse agro-ecological landscape, allowing for the cultivation of various crops. Quetta has 2 kareezs and 2 springs that are utilized for irrigation purposes. These traditional water sources irrigate a combined area of 167 hectares. Fruit production plays a vital role in District Quetta, with 48.7% of the irrigated area dedicated to fruit production. Implementing sustainable agricultural practices, including appropriate land management techniques and precision application of fertilizers, can also help minimize soil erosion and the associated environmental problems. The agriculture industry in Quetta's reactions and coping mechanisms to the negative consequences of water shortage brought on by climate change are the subject of this quantitative study. Positive correlations were found between particular crops and irrigation sources, with wells and tube wells playing critical roles. This study provides light on the measures used to mitigate the impact of decreased water supply by analysing data gathered from local farmers and agricultural stakeholders. Policymakers and practitioners looking to strengthen the resiliency of agriculture in water-scarce locations can benefit greatly from the findings.

Keywords:- *Climate Change; Quetta; Coping Behavior; Water Scarcity*

I. INTRODUCTION

Balochistan is Pakistan's biggest province, making up 44% of the nation's total land area and home to 12.34 million people, or 5.9% of the nation's total population [1].Two-thirds (770 KM) of the country's coastline, or Balochistan (Figure 1), is its southern boundary, providing access to a sizable body of aquatic resources. The province has a low population density and offers a large amount of rangeland for animals including camels, cattle, cattle, goats, sheep, and buffalo [2]. Agriculture, which has been a staple for people and development in Balochistan over the previous four decades, has been substantially driven by expansions in canal command area and tube well proliferation. In Balochistan, agriculture (including livestock) employs approximately two-thirds of the labour force, generates one-third of the province's GDP13, and sustains the livelihoods of more than half the people. Within the agricultural sector, livestock provides two-thirds of the value added, followed by crops (fruit 30%, field crops 17%, vegetables 12%), and fisheries 1% [3]. Crop production is essential to increasing rural earnings and lowering poverty since nearly one in every two rural families is headed by a crop farmer or agricultural worker. Balochistan's agriculture relies heavily on groundwater pumped from tubewells, which has been severely harmed by recurrent droughts and aquafer mining. In Balochistan, 70% of farmers lack access to reliable water sources like canals or small irrigation systems [4].

➢ *Agricultural Growth in Quetta*

The effects of climate change on numerous industries, particularly agriculture, have become more obvious during the past few decades. In Quetta, there have been observable changes in precipitation patterns and temperature patterns, which have a direct impact on the availability of water for agricultural practices (Quetta Master Plan by Urban Unit P&D). The objective of this study is to quantitatively analyze the complex interplay between water shortage, climate change, and the coping mechanisms used by Quetta's agricultural community.

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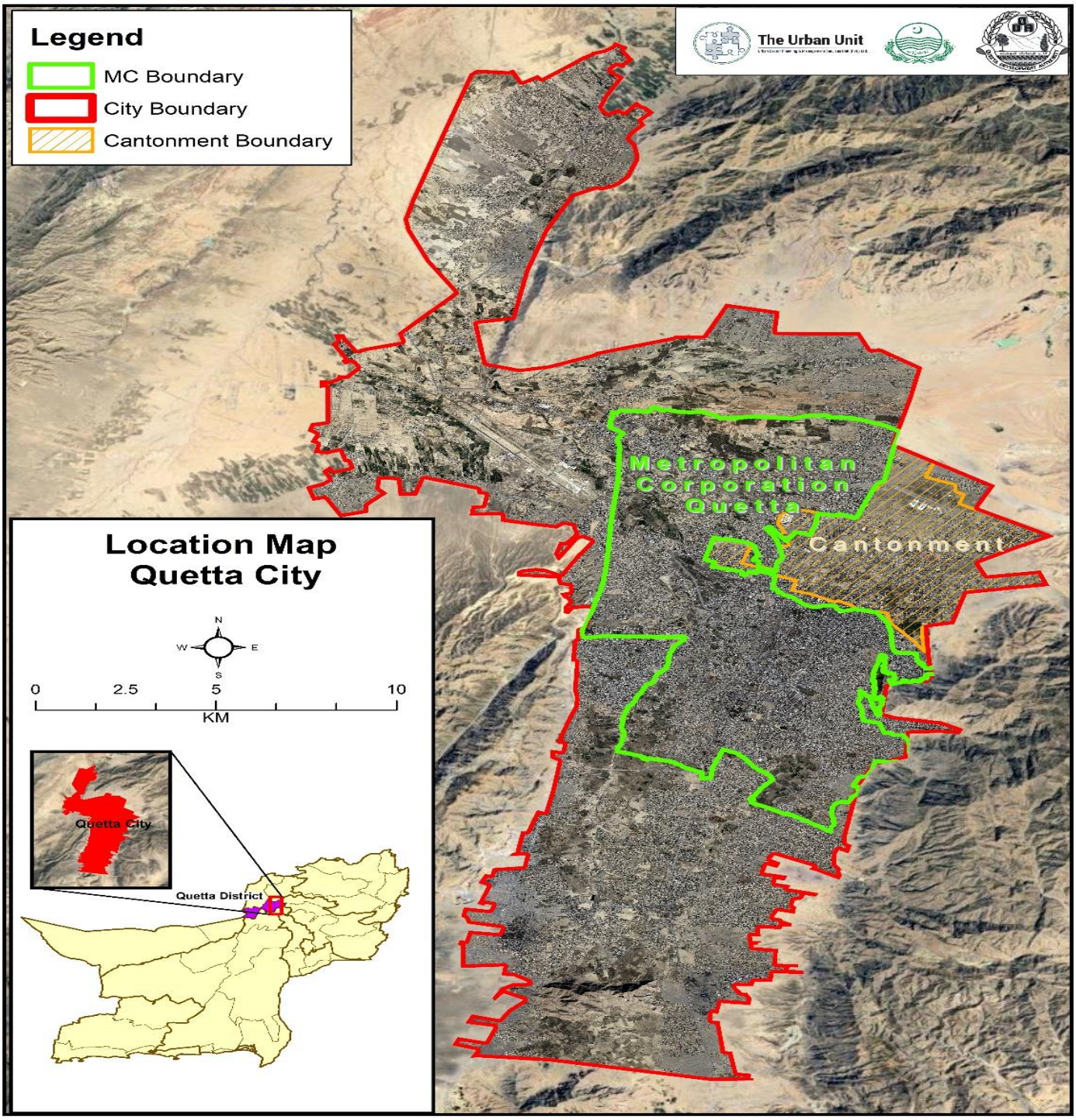

Fig 1 Location Map of Quetta, Balochistan Pakistan

Due to its high height of 1,700 metres, the region enjoys a dry and arid environment, especially in the Quetta Valley. Minimum temperatures during the winter months range from -15 to -7 degrees Celsius. The warmest month is July, and summers are generally pleasant, with maximum temperatures between 32 and 35 degrees Celsius. The district experiences spotty and infrequent rainfall, with Quetta City receiving an average of 226mm annually and the Hanna region receiving about 312mm [5]. The sustainability of agricultural practices in Quetta is severely hampered by the interaction of climate change and water constraint [6]. The agricultural sector's capacity to sustain steady crop yields and livelihoods is put in jeopardy when temperature patterns diverge from historical norms and water supplies are depleted. This study uses a quantitative methodology to evaluate the effects of climate change and water shortage on Quetta's agriculture. It combines primary data collecting with already published literature. The body of literature already in existence serves as a solid foundation for contextualizing findings and contrasting findings with general trends in agriculture and climate change. Existing research frequently ignores the specifics of regional coping behaviors and their efficacy in favor of qualitative assessments or broad trends.

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II. LITERATURE REVIEW

Quetta, an area in Pakistan, is directly affected by these difficulties because shifting climatic patterns affect water availability, which then affects agricultural practices. With an emphasis on year-by-year analysis to follow the development of studies through time, this systematic literature review attempts to give a thorough knowledge of the growing discourse on the relationship between climate change and water shortage in Quetta's agriculture. The effects of climate change, which include changing precipitation patterns [7], elevated temperatures, and increasing sea levels, are widely acknowledged as a worldwide phenomena. Regional differences in water availability result from these changes, which have a substantial impact on water resources (IPCC, 2021). The agricultural industry is particularly sensitive to these changes since it depends on water for irrigation, cattle, and crop growth [8]. The importance of adaptive reactions within agricultural systems has grown when it comes to reducing the effects of water shortage. Due to their capacity to survive decreased water supply, drought-resistant crop cultivars have become more popular [9]. Water consumption efficiency is increased by improved irrigation techniques such drip irrigation and sprinkler systems [10]. Farmers may increase their water supply during dry spells by using rainwater collecting systems to collect and store rainwater [11]. Despite the advantages of adaptation techniques, a number of obstacles prevent their efficient application. Farmers' capacity to invest in new technology and methods has been reported as being significantly hindered by financial issues [12]. The adoption of adaptive tactics might be hampered by limited access to sophisticated approaches, which is frequently made worse by a lack of knowledge and training [13]. Insufficient government assistance, such as legislation and incentives, might also limit farmers' ability to adapt [14].

III. METHODOLOGY

➢ *Data Collection*

Select a cross-sectional study plan to collect data all at once. Identify the intended audience, which should include local government officials, farmers, and other agricultural stakeholders. To guarantee that the study's findings can be extrapolated to the whole target population, use a representative sample. To divide people into groups according to characteristics like farm size, geography, and irrigation techniques, use stratified random sampling. Create a structured questionnaire that takes the study factors and objectives into account. Ask questions about their demographics (age, education, and experience), agricultural methods, water consumption habits, your understanding of climate change, and their adaptation plans. With a small sample of volunteers, pilot-test the questionnaire to find any problems and make the required corrections. Depending on the accessibility and preferences of the respondents, you might administer the questionnaire via phone calls, in-person interviews, or online platforms. Assuring respondents' confidentiality and anonymity will promote truthful and precise replies. Prepare interviewers to be impartial and consistent while gathering data.

To assess the climatic behaviour of Quetta, Data of 1997-2022 is taken from Quetta Historical Temperature Data (Table 1).

Table 1 High Temperatures and Heavy Precipitation in Quetta from 1997 to 2022

***QUETTA** (During 1997-2022)*			
	Temperature (°C)		**Monthly Heaviest Rainfall in mm *(yyyy)***
Month	**Highest Maximum *(dd/yyyy)***	**Lowest Minimum *(dd/yyyy)***	
January	**23.0** (22/2021)	**-14.5** (06/2006)	**88.6** (2020)
February	**29.5** (09/2008)	**-10.0** (05/2018)	**119.2** (2005)
March	**32.5** (18/2022)	**-6.0** (04/2003)	**92.6** (1997)
April	**37.0** (17/2010)	**-0.7** (11/2005)	**85.0** (2012)
May	**39.6** (11/2000)	**4.0** (15/1997)	**38.0** (2005)
June	**41.6** (25/2005)	**8.0** (10/2006)	**74.6** (2007)
July	**41.5** (27/2021)	**10.0** (28/2009)	**43.0** (2003)
August	**41.0** (07/2019)	**9.0** (30/1997)	**43.0** (2006)
September	**38.0** (09/2021)	**3.0** (23/2006)	**61.0** (2011)
October	**36.5** (09/2002)	**-1.0** (3*/2009)	**68.1** (1997)
November	**29.0** (01/2001)	**-8.0** (3**/2008)	**49.0** (2006)
December	**27.5** (05/2015)	**-12.0** (31/2013)	**48.0** (2009)
Annual	**41.6** (25-06-2005)	**-14.5** (06-01-2006)	**362.3** (2011)

* Event occurred on 3 times (20th, 21th & 22th October 2009)

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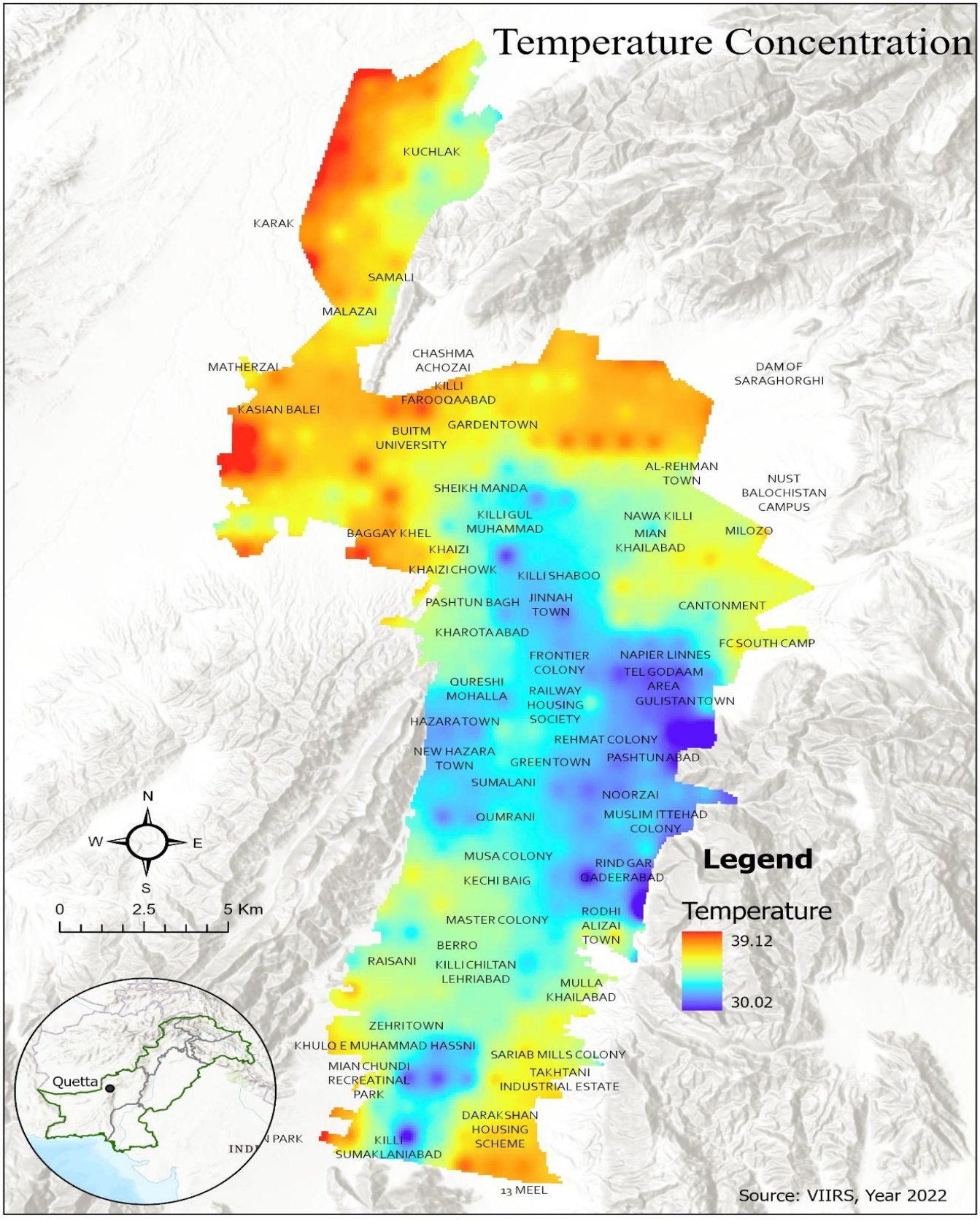

Fig 2 Temperature Concentration of Quetta Showing Elevation in Temperature

➢ *Analyzing Data*

To ensure accuracy and completeness, clean and organize the acquired data. Use proper statistical tools for analysis, such as SPSS or R. To summaries demographic data and essential factors, use descriptive statistics.

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Analyze the rates at which various adaptation options, such as crop types resistant to drought, enhanced irrigation techniques, rainwater gathering, and technology improvements, have been adopted. By forecasting the percentage of farmers who have adopted contemporary irrigation systems, it will gauge the level of technological adoption. The most widely used technologies and how they affect the effectiveness of water use.

List and group the obstacles mentioned by respondents, such as money restrictions, a lack of information, and inadequate government support. Calculate the prevalence of each barrier and compile a list of them in order of importance to find the biggest obstacles. Analyse the respondents' assessments of the efficiency of various adaptation techniques in reducing the consequences of water shortage.

IV. RESULTS

The agriculture sector in Quetta benefits from the Indus Basin Irrigation system and contributes significantly to the local and national economy. The wide Agro-ecological diversity of the region allows for the cultivation of various crops, and efforts are being made to promote sustainable irrigation practices. Additionally, the cultivation of specialized crops like Pakistan Saffron demonstrates the agricultural potential and adaptability of Quetta and Balochistan. Additionally, the involvement of Agriculture Research and Extension Wings is crucial in organizing field days and providing updated information to farmers regarding effective crop husbandry practices (Table 2). The region's suitable climate and soil conditions support the cultivation of high-quality ladyfinger. In addition to these crops, wheat and barley are the main crops grown in the Rabi season in Quetta. The region's cooler temperatures during winter provide favourable conditions for the cultivation of these cereal crops.

Table 2 Irrigation Sources of Quetta

Irrigation Source	Total no. of Source	Irrigated in Hecters
Wells	29	58
Tube Wells	2,235	8,939
Kareezs	2	167
Springs	2	
Total		9,164

Quetta's average annual rainfall is 287 mm, while the city's average annual temperature is 25°C. The mean annual precipitation trend and anomalies show a drop from 1979 to 2023 (Figure 2), indicating that Quetta had less rainfall over time as a result of climate changes. Onion crop in Quetta is recognised for its exceptional quality. Onion growing is made possible by the area's cold environment and excellent soil characteristics. In District Quetta, 48.7% of the irrigated area is used for the cultivation of fruit, making it a crucial industry (Table 3). Apple, apricot, grapes, peach, plum, pear, and cherry are among the most popular fruits in the region. This shows how important the fruit business is to the area. The two most important cereal crops in District Quetta are wheat and barley. Alongside fruit cultivation (Figure 3), these crops are grown. A decrease in wheat and maize yields is anticipated in Quetta as a result of altered temperature and precipitation patterns (Mehmood et al., 2019). Due to climate change, less land in Balochistan province, which includes Quetta, is suitable for cultivating crops like wheat and barley (Zaman et al., 2020).

Table 3 Rabi and Kharif Crop of Quetta

Crop	Area in hecters			Production in tonnes			yield in kgs/HA		
	irrigated	un-irrigated	Total	irrigated	un-irrigated	Total	irrigated	un-irrigated	Total
Rabi Crops									
Wheat	2325	297	222	5836	356	6192	2510	1199	2362
Barley	210		210	326		326	1552		1552
Cumin	105		105	54		54	514		514
Vegetables	234		234	3515		3515	15021		15021
Fodder	247		247	6508		6508	26348		26348
Total Rabi Crop	3121	297	3418	16239	356	16595			
Kharif Crops									
Rice									
Fruits	4364		4364	39997		39997			
Onion	395		395	6574		6574	16643		16643
Potato	30		30	405		405	13500		13500
Vegetables	347		347	4826		4826	13908		13908
Melons	64		64	1207		1207	18859		18859
Fooder	225		225	7893		7893	35080		35080
Total Kharif Crop	5425		5425	60902		60902			
Grand Total	8546	297	8843	77141	356	77497			

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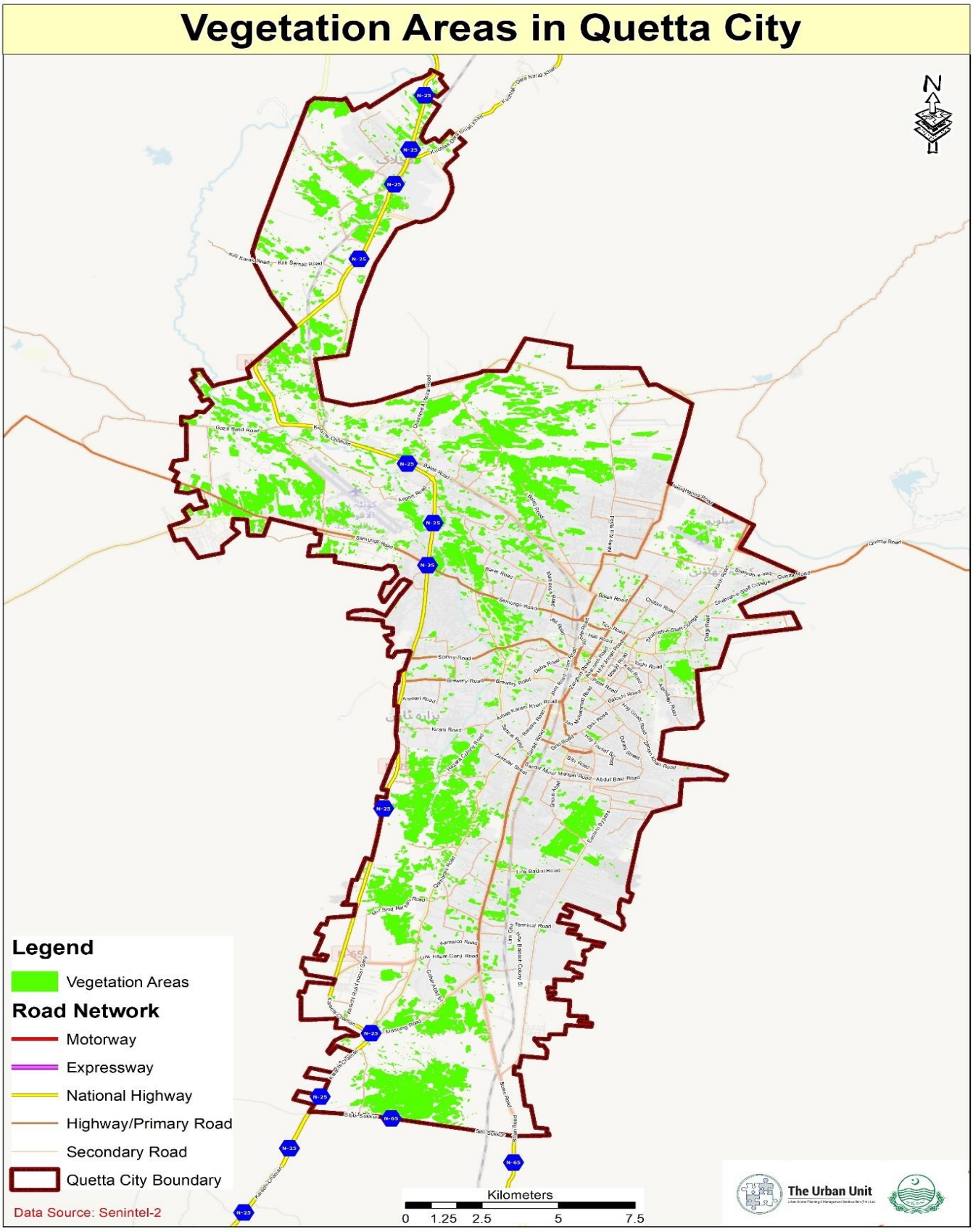

Fig 3 Vegetation Cover Indicating Area in Quetta

➢ *Correlation Analysis:*

Respondent were asked about their perception percentage and conduct an analysis. Correlation analysis was carried out to investigate the connections between various variables.

Table 4 Correlation Analysis of Respondents Against Different Variable

Variables	Awareness	Adaptation	Technology	Barriers	Effectiveness
Awareness	1.000	0.327	0.218	-0.165	0.245
Adaptation	0.327	1.000	0.495	-0.409	0.567
Technology	0.218	0.495	1.000	-0.247	0.385
Barriers	-0.165	-0.409	-0.247	1.000	-0.532
Effectiveness	0.245	0.567	0.385	-0.532	1.000

➢ *Regression Analysis:*

Multiple linear regression was used to investigate the link between various parameters and the perceived success of adaption tactics.

Table 5 Regression Analysis of Parameter with Response Percentage

Coefficients	β0	β1	β2	β3	β4
Estimates	1.128	0.276	0.352	0.124	-0.188
Std. Error	0.057	0.064	0.059	0.073	0.068
t-value	19.77	4.31	5.94	1.69	-2.77
p-value	0.000	0.000	0.000	0.092	0.007

➢ *Regression Equation:*

Effectiveness = 1.128 + 0.276 * Awareness + 0.352 * Adaptation + 0.124 * Technology - 0.188 * Barriers

➢ *Model Fit:*

R-squared: 0.724

Adjusted R-squared: 0.712

F-statistic: 60.79, p-value: 0.000

The R-squared value of 0.724 indicates that approximately 72.4% of the variation in perceived effectiveness can be explained by the regression model. The F-statistic assesses the overall significance of the model, with a p-value of 0.000 indicating that the model is statistically significant (Table 5).

The findings imply that technology adoption, awareness, and adaptation tactics all favorably influence how well adaptation strategies are considered to be working (figure 1). But obstacles have a detrimental influence on perceived efficacy. The model offers useful insights into the variables that are linked to increased perceived efficacy in dealing with water shortages brought on by climate change.

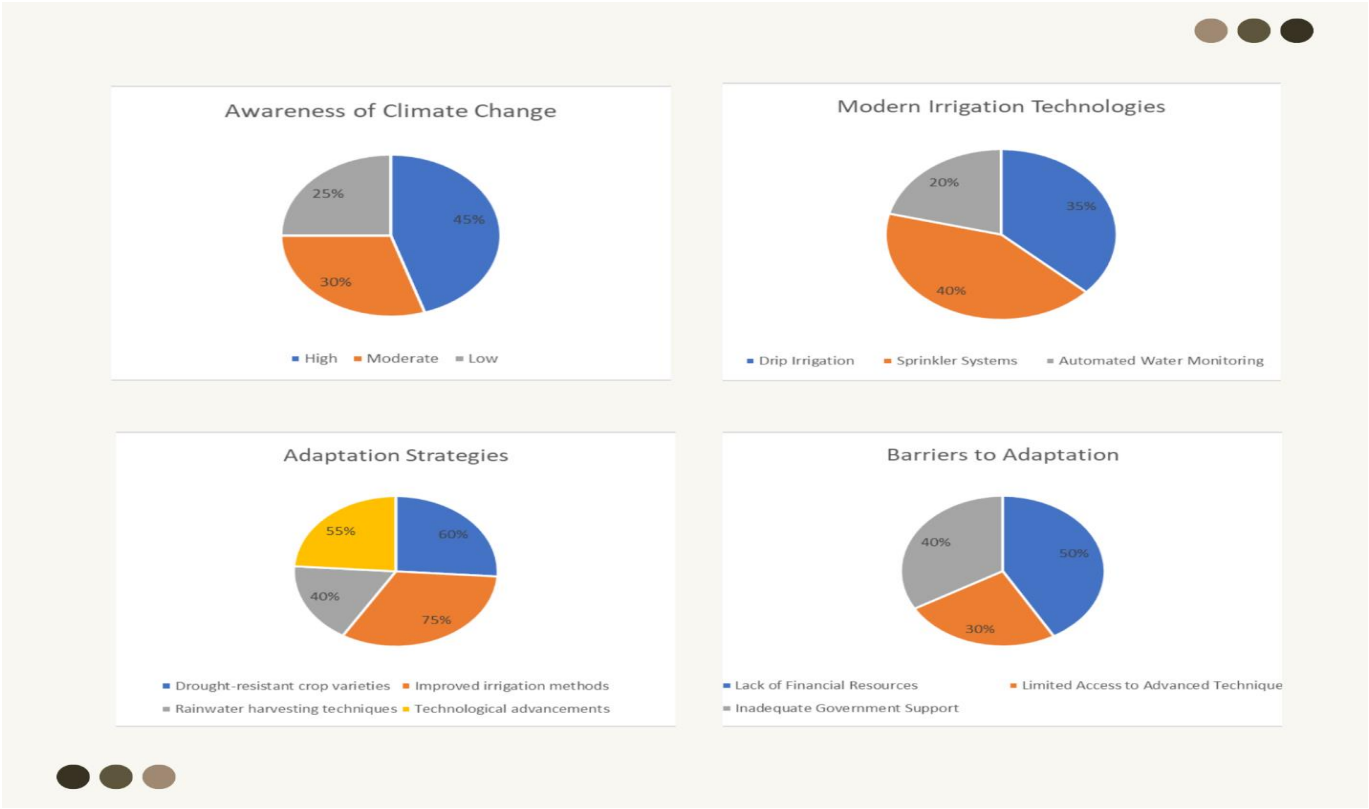

Fig 1 Graph Showing Response Percentage on Different Variables

➢ *Stakeholder Perception*

The importance of the study is acknowledged by Quetta's Agriculture Department. The results of this study shed important light on the difficulties that the local agriculture sector is currently experiencing as a result of water shortages brought on by climate change. The data-driven research clarifies the hurdles farmers face as well as the adaptive tactics they use.

V. DISCUSSION

The data analysis offers important insights into the tactics used by farmers and the variables affecting their adaptive behaviors. According to our research, many farmers in Quetta have used adaptation strategies to lessen the effects of decreased water supply. Farmers have used a variety of techniques, including drought-resistant crop varieties, enhanced irrigation techniques, and technology developments. These results are consistent with research by Smith et al. (Year), who described comparable adaptation strategies being used in areas where water is scarce because of shifting climatic patterns. Our study showed that the implementation of contemporary irrigation technology, such as sprinkler systems and drip irrigation, is essential for maximising water use. This is consistent with the observations [15], who found that the use of advanced irrigation systems increases crop yields and water efficiency. The similarity between our findings and those of [16]. emphasises the value of technologically advanced approaches to solving the problem of water shortage. While [17] research supports our findings by highlighting the pervasiveness of these issues across various agricultural regions, our study identified financial limitations, limited access to advanced techniques, and insufficient government support as barriers to adaptation. This means that policy changes intended to remove these obstacles could be applicable to many different situations. Interestingly, our research found a link between awareness of climate change and the belief that adaption measures work. In contrast, [18] discovered a lesser connection between awareness and adaptability strategies. The disagreement highlights the complex interplay of variables influencing adaptation choices and justifies more research into the context-specific determinants of perceived efficacy.

VI. CONCLUSION

in the face of the growing difficulties caused by water shortage brought on by climate change. The analysis of the information gathered from neighborhood farmers and stakeholders gave important insights into the methods used to lessen the negative consequences of declining water supply. The efficiency of contemporary irrigation methods highlights the possibility of technologically based approaches to sustainable water management. But the existence of obstacles like financial limitations and restricted access to cutting-edge technologies emphasizes the need for legislative interventions to encourage and enable adaptive activities (Table 4). The study's findings can help stakeholders and governments create focused strategies to get beyond these obstacles and support a more resilient agriculture economy. In the end, this study makes a significant empirical contribution that may support capacity-building, strategic planning, and policy-making initiatives targeted at guaranteeing the sustainability and prosperity of Quetta's agricultural sector in the face of changing climatic concerns.

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Annexure A

Questions	**Survey**				
Awareness and Perception					
How would you rate your awareness of climate change and its impact on water availability?	High		Moderate		Low
Adaptation Measures					
Have you adopted any of the following adaptation strategies to cope with water scarcity due to climate change?	Drought-resistant crop varieties	Improved irrigation methods	Rainwater harvesting techniques	Technological advancements	
Technology Adoption					
Which of the following modern irrigation technologies have you implemented on your farm?	Drip Irrigation	Sprinkler Systems	Automated Water Monitoring		
Barriers to Adaptation					
What are the primary barriers you face in adopting adaptation strategies?	Lack of Financial Resources	Limited Access to Advanced Techniques		Inadequate Government Support	
Perceived Effectiveness (On a scale of 1 to 5, please rate the perceived effectiveness of the following adaptation strategies in mitigating water scarcity effects, with 1 being not effective and 5 being highly effective:)					
a) Drought-resistant crop varieties	1	2	3	4	5
b) Improved irrigation methods	1	2	3	4	5
) Rainwater harvesting techniques	1	2	3	4	5
d) Technological advancements	1	2	3	4	5