IMPACT OF CLIMATE CHANGE ON MAJOR VEGETABLE'S CROP PRODUCTIVITY IN PAKISTAN; A DISTRICT LEVEL ANALYSIS

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CERTIFICATE

This is to certify that this thesis entitled: **"Impact of Climate Change on Major Vegetable's Crop Productivity in Pakistan; A District Level Analysis."**. submitted by **Usman Ghani** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in MPhil Environmental Economics.

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ABSTRACT

This study investigates the impact of climate change on major vegetable crop productivity in Punjab and Sindh province of Pakistan. For evaluation, the underlying study used a production function approach using districts level time-series data for the period of 1995 to 2020. Whereas the main objectives of the underlying study are to explore whether climate change is taking place in vegetable growing districts or not. As well as to investigate the impact of climate change on vegetable productivity (Tomato, potato, and onion) in major vegetable growing districts of Sindh and Punjab. The estimated results of the fixed effect model show that climate change is affecting the yield of vegetables significantly in the selected districts of Punjab and Sindh province. However, their impact varies across the different stages of the vegetable crops. Whereas, variation in maximum temperature in the stage of maturity negatively affects the crop yield, while changes in minimum temperature in the flowering time affect the crop yield positively and significantly. This demonstrates that variation in maximum temperature by .01 percent will decline the crop yield by -14.9 percent. In addition, a 0.4 percent variation in minimum temperature in the flowering stage will increase the yield of the onion by 3.06 percent respectively. Moreover, rainfall at the time of maturity also negatively affects crop yield. This indicates that a variation in rainfall in the stage of maturity by .04 percent will lead to affect the crop yield by .07 percent respectively.

Keywords: Climate change, major vegetables, yield, rainfall, fertilizer, water, technology, production function, fixed effect.

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CHAPTER 1
INTRODUCTION

Climate change refers to changes in the atmosphere over the long run in temperature, precipitation and humidity (Lipczynska-Kochany 2018; NASA 2018). Climate change is the most significant factor that influences food production and farmer's income over time. It also explains almost 60 percent of yield variability (Ray, Gerber et al. 2015);(Matiu, Ankerst et al. 2017). Climate change effects the duration of crops growing periods, magnitude of heat and water stress, which affect the productivity of agriculture systems (Lobel et al. 2015; Lemma et al. 2016; Schauberger et al. 2017). Crop growth has affected due to the higher average temperature and climate variability affects the Physiological processes of crop productivity. Literature has investigated the effect of climate change on the productivity of major crops globally (Rosenzweig and Hillel 2015; Wang et al. 2018). Moreover, it also affects natural resources, such as land and water productivity. Whereas the availability of water is expected to decline due to the climate change but agriculture water consumption is predicted to increase by 19% in 2050 (UN- water 2013). Therefore, the impact of climate on agriculture production and natural resources will bring greater fluctuation in crop production. In addition, the food supplies and market prices that will lead to further increase food insecurity and poverty in the countries, which negatively affects the livelihoods of millions of people in the region (Cai 2014; Wang et al. 2017;(Aryal, Sapkota et al. 2020).

Furthermore, due to a lack of information about the benefits of modern technology in the agriculture production system, farmers are reluctant to invest in the climate risks reduction technology that can help to reduce climate variability. The lower part of the global agriculture sector is more vulnerable to the adverse effect of climate change because small farmers are operating under the source constraint and cannot adopt climate risk reducing technologies (Janjua, et al. 2011). However, Pakistan is among the most affected countries due to climate change and the country is ranked 8th most vulnerable in terms of being affected by climate change (Ali, Kiani et al. 2021). Being a developing country where many industries with forwarding and backward linkages depend on the growth in the agriculture sector of Pakistan. Whereas the contribution of agriculture sector to GDP is 19 percent and employed 38.5, percent of the labor force. Moreover, 65 to 70 percent of the country's population and their livelihood rely on agricultural activities (GoP 2020-21). Therefore, 90% of overall farmers in Pakistan, 7.4 million are characterize as a small farmers or poor farmers, which cannot have sufficient resources to adopt climate risk reducing technologies (Pakistan Economic Survey FY2020). In addition, the climate change not only affects the agriculture productivity but also employment in the country, which will lead to increase poverty in Pakistan.

Table 1.1: Climate Risk Index 2021: The 10 most affected countries from 2000 to 2019

CRI 2000-2019	Country	CRI Score	Fatalities	Fatalities per 100000 inhabitants	Losses in million US$ PPP	Losses per unit GDP in %	Number of events (2000-2019)
1	Puerto Rico	7.17	149.85	4.12	4149.98	3.66	24
2	Myanmar	10.00	7056.45	14.5	1512.11	0.80	57
3	Haiti	13.67	274.05	2.78	392.54	2.30	80
4	Philippines	18.17	859.35	0.93	3179.12	0.54	317
5	Mozambique	25.83	125.40	0.52	303.03	1.33	57
6	The Bahamas	27.67	5.35	1.56	426.88	3.81	13
7	Bangladesh	28.33	572.50	0.38	1860.04	0.41	185
8	Pakistan	29.00	502.45	0.30	3771.91	0.52	173
9	Thailand	29.83	137.75	0.21	7719.15	0.82	146
10	Nepal	31.33	217.15	0.82	233.06	0.39	191

Source: German watch

Agriculture productivity is measure as the ratio of agriculture output to input. Although individual products are mainly estimate by weight, which are known as crop productivity, changing products make the overall measuring of agriculture output difficult. Therefore, agriculture productivity is normally measure as the market value of the final output. As we know, several factor concern with crop productivity and the risk involving with farming. However, the four most significant factors that affect the crop yield are soil fertility, availability of water, diseases or pests as well as climate change one of these factors that influence crop productivity with the passage of time. Further, these factors can posture a significant risk to farms when they are not observe and manage properly (Omnia 2017).

In tropical and subtropical countries, the productivity of crops has been decrease due to climate change and higher temperatures. However, most of the agricultural crops have already touched the tolerance of heat and drought (Agriculture Development 2008). Whereas Pakistan is, also among those, country's which are heavily dependent on agriculture activities and holds total area under the crop 22.1 million hectares. Further, 65.8% is under the food crops, 24.2 percent under the cash crop, and 6.7 percent is under the edible oilseeds. While vegetable is the important component of agriculture sector but due to increasing pressure on food and cash crops is restricted the area for the vegetable FAO (2019).

Furthermore, Pakistan is the major producer of potatoes, onion, chilies, tomato, turnips, carrots, cauliflower, peas and gourd that possess 78 percent overall area and vegetables yield 81% of total production. Whereas, the production of potatoes is around 30.2% and 40% respectively, as well as potatoes, have the major share in the area. Follow by onion with an accessible share of 21.2% and 21.4%. Pakistan has total area of production around 0.46 million hectares and produce 8.37 million ton of vegetables including potatoes (Fruit and Vegetables statistics of Pakistan (2018-19). While out of the total production the major, producing provinces of Pakistan is Punjab and Sindh, which is the major contributors to the agricultural products. Moreover, Pakistan produces a large number of other vegetables namely garlic, mushrooms and chilly with the aim of export; reported Food and Agriculture (2019). Therefore, Environmental and natural disasters will affect the productivity of agriculture sector as well as created a considerable amount of losses to the economy of Pakistan (Hussain, Butt et al. 2020).

The basic theory, which supports environmental economics, is environmental goods. However, environmental goods have economic value and costs to economic growth. Therefore, Environmental goods contain the things like access to clean water, clean air, the survival of nature, and a universal climate. Although it is difficult to set the price for environmental goods and completely privatize due to the tragedy of the commons (James Chen, 2022). Nevertheless, if we lost the environmental goods we will pay a high cost. Moreover, misuse and destruction of environmental goods, like pollution and other types of environmental degradation can denote a kind of market failure because it creates negative externalities. Environmental economists examine the costs and benefits of particular economic strategies and try to sort out the underline issues (Rober C Kelly).

1.1 Problem statement

2 The previous studies were conducted climate variation impact on the agricultural yield in Pakistan like, Lee et al. (2012), while (Hussain and Bangash 2017) investigated the study on Impact of Climate Change on Crops' Productivity across Selected Agro-ecological Zones in Pakistan. Whereas Ahmad, Mustafa and Iqbal (2016) conducted the study on "Impact of Farm Households' Adaptations to Climate Change on Food Security: Evidence from Different Agro-

ecologies of Pakistan". Furthermore, ail et al. (2017) investigated the study on Climate Variation and Its Impact on the production of Major Food Crops: Evidence from Pakistan. According to the best of my knowledge the impact of climate change on vegetable production has rarely explore which has already discussed in the above paragraph. Therefore, the underline study will contribute in the literature by investigating the impact of climate change on major vegetable crops such as; Tomato, potato and onion. In addition, vegetable crops are more sensitive to temperature and vulnerability of climate change (Ayyogari, Sidhya et al. 2014) . Although we all know, Pakistan is the most affected country due to climate change. Through this study, we will analyze how climate change is affecting vegetable productivity in different regions of Pakistan and at the end; we will explore some policy options to improve the vegetables productivity.

1.2 Objectives

In the light of above discussion, the specific objective of the study are as below;

- To explore whether climate change is taking place in vegetable growing districts or not?
- To investigate the impact of climate change on vegetable productivity (Tomato, potato and onion) in major vegetable growing districts of Sindh and Punjab
- To estimate the economic loss of vegetable production due to climate change impacts
- To suggest effective agriculture policy measures to help the farmers in an adaptation to climate changes

1.3 Significance of the Study

The present study aims to investigate the impact of climate change on major vegetable crop's productivity. Moreover, most of the researcher has worked on the various agriculture products with the different time-period. The underlying study will highlight the issue of climate change on major vegetables crops productivity in various district of Punjab and Sindh of Pakistan. Due to agriculture based economy Pakistan one of those countries that is impulsively hits by global warming. The significance of the study is revolving around literature and policy implication. On literature side, we focus and review different research papers that highlight the same climatic scenario, how the climate affects these crops production annually is our consideration. On the bases of results, the study will be offering some important policy implication. Study will help how eradicate this issue to compress the bounce effect of major vegetables loss.

1.4 Organization of Study

Chapter 1 of this study comprises on background of study, basic definitions and key terms, problem statement, objectives and significance of the study. Whereas, Chapter 2 of the present study describes literature review of the study including climate condition of world and Pakistan as well as vegetables cropping system of Pakistan. While Chapter 3 contains on data source, descriptive statistics, regression, fixed effect model and methodology. Furthermore, in Chapter 4, included results and discussion of the underlying study, and chapter 5 included on qualitative work and Chapter 5 comprised on Conclusion and policy recommendations.

CHAPTER 2
LITERATURE REVIEW

This section reviews the previous studies, which have examined the impact of climate change on agriculture productivity. However, the previous studies proposed some theories that climate change is the most significant factor that influence the productivity of the agricultural product. Shi, Huang et al. (2020) examined the impact of climate change on agriculture yield. However, the outcome of the study shows that agricultural yield efficiency is greater in the eastern area as well as agricultural yield efficiency is large among the middle and western areas. Furthermore, (Ali, Ashfaq et al. 2017) analyzed the study on the effect of climatic variation and its impact on the production of main food crops. In addition, the result of the study shows that maximum temperature negatively affects the wheat yield, while the low temperature has some impressive results for all the crops, whereas the rainfall negatively affects the above crops except the wheat.

Ibrahim and Khalid (2021) conducted the study on basis of climate change impact on vegetable crops and the potential for adaptation. However, climate change is emerging as a major obstacle to global food security and will spread further in the coming years. Agriculture is one of the leading sectors affected by climate change. This review deals with the climatic impact on vegetable yield and quality and the critical need for adaptation. Daily average, minimum and maximum temperature fluctuations are the main effects of climate change, which adversely affects vegetable production as many physical, biochemical, and metabolic activities of plants depend on temperature. Case studies on the effects of high temperatures on the production of important vegetable crops were discuss. While An increase in CO_2 in the atmosphere can directly damage the growth of vegetable plants. Evidence suggests that higher growth rates for plants grown under high carbon dioxide concentrations may result in denser roofs with higher humidity, which favors pathogens. It is well recognize that an increase in temperature adversely affects the activity of pollinating agents and therefore reduces seed production. Climate change could potentially lead to post-harvest changes in vegetable crops that are both perceived and nutritional. Climate change may improve some quality properties, which in turn may improve some nutritional properties. However, negative effects can see in the appearance of the product. In addition, the variables of climate change can have indirect effects through the incidence of diseases and insects. The potential effects of climate change on the agricultural sector will necessitate adaptation and mitigation of the negative effects on agricultural production, especially the production and quality of vegetable crops. Improving vegetable production systems as a means of adaptation and mitigation, making better use of biodiversity, implementing biotechnology and genomic mechanisms, tolerating genetically different strains, and ultimately developing flexible vegetables for the climate. This study provides a brief summary of the state information in key areas of the impact of climate change on vegetable crops and offers key approaches to adaptation. Effective and promising methods, tools, and efforts need to be coordinated and implement for the effects of climate change. A comprehensive approach rather than a single approach needed to overcome the effects of climate change on vegetable crops.

Shi, Huang et al. (2020) analyzed the study on climate change impacts on agriculture production and crop disaster area in China. The purpose of the study was to examine the regional distinct in agriculture production in China. Whereas the study used the Slack Based Measure (SBM) model to investigate 30 provinces in China and also utilized the Dagum Gini coefficient and kernel density estimations method. Furthermore, the study utilized the agriculture input and output data of the entire nation. While the study selected the time-period from 2010 to 2017 to estimate the mean maximum and minimum values. As well as the study used several variables, like; agriculture water consumption, employees cultivated irrigated area, fixed assets, gross output value, crop disaster area, and extreme weather days. Whereas collected the data of selected study from China's yearbook from 2011 to 2018 and the local statistical yearbook of the provinces. Therefore, the outcome of the study revealed that agriculture production efficiency is greater in the eastern area as well as agriculture production efficiency is large among the middle and western areas, while variation in the Gini coefficient is more substantial between the middle and western regions. However, in china, the agriculture regional attention degree is declining and more balanced the regional distribution of agriculture aquatic resources progressively declines the national regional difference. Finally, the study recommended some suggestions for controlling of extreme weather, agricultural water supply, and water saving measure.

Brar, Kumar et al. (2020) examined the Integration of technologies under climate change for profitability in vegetable cultivation. Climate change is an inescapable situation faced by living organisms in this world. For achieving more possible yield from vegetable crops under this, serious condition of climate variation, the study discussed some practical plains, which worked as an instruction for the formers. Furthermore, many strategies are available for mitigating the harmful effect of climate variation. However, this study analyzed the mitigating strategies of climate variation on vegetables via conventional approaches. Considering the situation, the study outcome revealed that the result of conventional approaches with climate-smart adoption strategies was directly affect the vegetable yield for the increasing population in wild variations of climate scenarios.

Kumar, Chaudhary et al. (2020) conducted a study on management practices for vegetable production. Whereas climate change is the main reason for the low production of most vegetables around the world reducing the average production of vegetables. In addition, rising temperatures, and a declining availability of irrigation water, cause floods, which is the major factor of reducing crop productivity. Climate plants are able to adapt more easily to variable environmental conditions and provide opportunities to identify genes or combinations of genes that provide such flexibility. This article adapts to the climate change of vegetable production for sustainable horticulture due to effective risk management while mulching with crop residues like; plastic mulches and helping to save soil moisture. Moreover unnecessary land humidity through the torrential rains leads to creating the key issue in the cultivated area. However, the strategy required for removing the unnecessary material from cultivated are, which can enhance the crop yield.

2.1. South Asia Climatic Scenario

Aryal, Sapkota et al. (2020) investigated temperature variation and agriculture in South Asia; adaptation options in smallholder production systems. Therefore, to maintain agriculture productivity is adaption measures, to decline vulnerability, and to improve the flexibility of the agriculture sector to climate change. In addition, the purpose of the study was to analyze the views of the smallholder yield system in South Asia to adapt to climate changes and minimize the adverse effect of temperature variation on nutrition systems. Further, the study also deliberates why the farmers use some adaptation techniques if any despite the occurrence of various events in the light of the present barrier and policy system. Whereas the study is comprised of South Asian countries namely Bangladesh, Bhutan, Nepal, India, Sri Lanka, and Pakistan. Moreover, one of the key outcomes is that agriculture performance that assists weather change adaptation in agriculture exists but remained the implementation of institutional setup and technical solutions yet to boost. Thus, it is essential to observe how to bring the important institutional modification and generation of funds to invest in these improvements. Otherwise, this is also necessary to design energetic strategies' for long-term climate change adaptation in agriculture rather than little attention to agriculture technology.

Phophi, Mafongoya et al. (2020) investigated climate change perception and drivers of insect pest outbreaks in vegetable crops in the Limpopo province of South Africa. For the smallholder farmers, vegetable production is the source of income in the region. Whereas, the study stated that climate change and pests restrict vegetable production Limpopo province. Furthermore, the purpose of the study was to evaluate the farmer's attentiveness to climate change and their indicators of climatic factors that affect insect pest prevalence. While they used the multi stage cluster sampling technique to select the respondents for the study. In addition, the study used quantitative and qualitative research approaches for the data collection and employed the descriptive and bivariate analysis. However, the outcomes of the study show that more than 84% of farmers have knowledge about the climate change. Like; the pattern of late, rainfall of 24.4% and long dry spells of around 15% also pointed enlarge drought frequency as a leading indicator of 19.4% of climate variation by farmers. Moreover, the study highlighted some insect pests such as Aphids more than 22%, Bagrada hilaris at around 12.5%, and Spondoptera frugiperda is 19.4% in the selected region. Finally, the study suggested that government and farmers are need to improve the pest risk map and preparedness in controlling insect pests over climate change.

Solankey, Prakash et al. (2019) conducted the vulnerability of vegetable crops to major global climate change that will affect vegetable and other agricultural production, which will lead to affect the entire food of this universe. Moreover, variation in temperature is not a danger but an issue arising with the extreme point of temperature, which is problematic. More random rainfall and abrupt variation in high temperature spells result in lower crop yields. In the ecological and agro-economic zones, latitude and longitude changes, land degradation, extreme geographical events, low water availability, and rising sea levels and salinity make it difficult to grow traditional vegetables in certain parts of the world. In general, vegetables are more succulent (90% water) and with the sudden increase in climate change and temperature, as well as irregular rainfall at any stage of the crop growth, normal growth of flowers, Jirga's, fruits. Ordering can affect the order of the fruit. Decrease in growth, fruit ripening, and eventually yield. There is an urgent need to develop appropriate adaptation strategies for the negative effects of climate change, like; heat, cold, drought, flood, and salt pressure, to mitigate the harmful effects of climate change. Evidence of climate change through conventional and non-conventional breeding techniques, as well as the development of gene types that can withstand the stresses caused by climate change, is essential. In India, Bihar is at high risk for hydro-meteorological natural disasters, with northern Bihar being prone to extreme flooding, and southern Bihar being prone to extreme drought and heat stress due to the effects of recent climate change.

2.2. Climate change risk associated with different countries

Chepkoech, Mungai et al. (2018) considered the perceptions of the former on how climate change is important to predicting their impact, for this purpose analyzed the study effect of climate variation on African indigenous vegetable yield in Kenya. In addition, the purpose of the study is to examine the African local vegetables and how the formers understanding climatic variation and three dissimilar agro-climatic zones in Kenya. Furthermore, the study pointed out the major change in historical, seasonal, and yearly rainfall also temperature trends amongst the zone. However, the study used time series data for the period of 1984 to 2015 applied the Mann kendall and regression test, and conducted a focus group discussion also interviews were conducted from 269 formers. Moreover, the variance and least significant difference were used to check the variation in average rainfall date, while the chi-square test were used for the formers perceptions and agro-climatic zone, coefficient of variation presented as a percentage were utilized that reveal variability in the mean, yearly and seasonal precipitation among that Zones. The outcome of the study shows that the former recognize that declining rainfall due to the higher temperature while changing the pattern of rainfall and regular dry spells were increasing the numbers of droughts and floods. However, the chi-square outcomes presented a substantial association between some of these observations and Agro-climatic zones. Meteorological data gave some indication to keep up the former's observation of rainfall variation; no trend was capture in the average yearly rainfall, while substantial increases were capture in the semi humid zone. Furthermore, the study outcome suggested local and temporary official changes that could lead to falling in the negative effect of climate change.

Mohammadzadeh, Vafabakhsh et al. (2018) analyzed the assessing environmental impacts of major vegetable crop production systems of east Azerbaijan province in Iran. The study calculated the environmental effects of carrot, tomato, potato, and onion production using quantitative indices of energy efficiency, global warming potential, economic indicators, and pesticide risk. The study utilizes from 110 farmers and regulates the survey of crop production in the region. However, the outcomes of the study reveal that in terms of energy indices the onion yield system was the most energy consuming and noted the highest greenhouse gas emissions, as well as potato production was, considered higher than the other vegetables. Furthermore, the production of carrots was the best both from an environmental and economic perspective also the production of carrots was, considered the large value for economics irrigation water productivity and economic land production efficiency.

Li, Zhou et al. (2018) examined the affected of root exudate from potato onion and a fungal plant pathogen (Verticillium dahlia). Also conducted at the experimental center northeast agriculture university harbin, china (45^{o} 41'N, 126^{o} 37'E). Whereas, the study was collect some samples of onion and potato varieties and stored them at 4^{o}C before planting, the methodology of the study was according to the (Li, Zhou et al. 2018) and Ren et al (19) and collected the root exudate of potato and onion. Furthermore, the study presented that when potato and onion under sowed with the tomato that decreased substantially the verticillium wilt of tomato was. Similarly, the outcomes of the study show that the root exudate repressed the progress of V dahlia as well as repressed its amylase, pectinase, and cellulose actions.

2.3. Pakistan scenario of vegetables and climate

Malik, Mughal et al. (2018) demonstrated the impact of hydroponics is a method of growing plants using a mineral nutrient solution in water, without increasing the productivity of the soil many times compared to conventional agriculture. Pakistan's vegetable production capacity has been stagnant for decades and Pakistan forced to import. Climate change, and extreme climatic conditions, are further threatening agricultural production and therefore food security. Most national and international development agendas focus on food security through increased productivity. This, coupled with a growing population, is increasing global food demand, increasing the pressure on agricultural productivity. Technological advances through hydroponics may be a possible solution to this problem. Against this background, we adopted a global equilibrium model using the latest available GTAP dataset to estimate potential hydroponics production at the macro as well as micro levels in Pakistan. Various replicas were develop-using hydroponics to increase fruit and vegetable production and reduce import tariffs on chemicals used as inputs in this advanced technology. When the productivity of the fruit and vegetable sector increases by 25%, its welfare effects are, consider a 32% reduction in the market price of fruits and vegetables. In the factor market, unskilled labor, skilled labor, capital, and natural resource earnings will increase by 0.51, 0.85, 0.97, and 0.13% respectively. Increasing productivity through the adoption of technology will also reduce the market value of the land. The total price of fruits and vegetables in the product market will be lower in all other regions of the world. The country's exports, industrial, output and GDP quantity index will also improve. The productivity of unskilled laborers will improve which will increase the demand for unskilled laborers. Improving overall production plays a positive role in improving Pakistan's agriculture and agribusiness and balance of payments. The result is an overall positive impact on Pakistan's real GDP, sectoral exports and imports, improving trade conditions and lowering the local market prices of fruits and vegetables in Pakistan. In short, the adoption of hydroponics technology can play a positive role in economic indicators and consumer welfare in the country. Investing in hydroponics technology in Pakistan can solve the double problem of increasing vegetable production capacity and exports to reduce the trade deficit. Adoption of hydroponics technology to address food security challenges in the country by increasing productivity. Improving trade in fruits and vegetables through CPEC as a strategy to boost exports.

Khan and Tahir (2018) conducted the economic effect of climate change is a growing problem that is significant because of its broader socio-economic implications. The agricultural sector is more vulnerable to climate change, which affected by climate variation both positively and negatively. Changes in climate or rainfall can create substantial variability in crop yield. However, some biophysicists are trying to evaluate the effects of temperature on crop production by modeling the use of many crop inputs from several universal climate models. In this study, the production of crop model used as a shocker in the global computable general equilibrium economic model to assess the economic impact of climate change. However, Pakistan has two time-period of crops Rabi and Kharif, the study were selected to crop for the analysis wheat and rice. A basic situation that represents business as usual, with no climate variation created using estimates of GDP, population, factor supplies, and essential food production. A contrasting experiment has been carry out using GDP and population growth as in the baseline but with the exception of crop yield shocks from biophysical models. A comparison of the two practices shows the economic impact of climate change by 2035. However, to protect the food production, it must have a strong agricultural strategy that can play a key role in influencing its ability to adapt successfully to climate change.

Camargo and Camargo (2017) investigated the study on productivity and commercialization of the key vegetables in Brazil and the world from 1970 to 2015. Further, the study focused on the progress of yield and commercialization as well as the accessibility of garlic, onion, potato, tomato, and watermelon. Furthermore, the study comprises two different time-period from 1970 to 1990 ("the support program for production and commercialization of horticultural products"). While another 1990 to 2012 (the globalization period) and collect the information from literature 1970 to 1990. Whereas for 2001 to 2013 period use the data from food agriculture organizations and utilized the systematic survey of agriculture production from Brazilian institute of geography and statistic (IBGE 2015). Furthermore, the study also tried to represent, how the (SPFPCHP) helped in organize and modernize the production and commercialization of garlic, onion, and tomato between 1970 and 1990. However, the study also indicated the impact of (SPFPCHP) on the extension of agriculture in the core area of Brazil as well the accessibility and productivity of vegetables. Similarly, the study also represented the later period 1990-2015 globalization phase and nonstop production extension compared the growth of Brazil and world productivity of garlic, onion, potato, tomato and watermelon for the period 2001-2013.

Mahmood, Hassan et al. (2017) examined the study on profitability analysis of carrot production in different districts of Punjab Pakistan. However, the purpose of the study was to analyze the factors that affect the yield of carrots. Whereas the study used some different variables like land preparation cost, irrigation cost, labor cost, harvesting, and miscellaneous cost, while the study selected two major carrot-producing districts; Nankana sahib and Sheikhupura for the time-period 2014. Furthermore, the study sample size comprised on 140 and applied some different econometric techniques, “descriptive statistics, simple budgeting technique and log linear profit function to evaluate the impressive outcomes”. Similarly, the outcomes of the study represent that reversely associated costs with profit, while a direct relationship of price and productivity with income. In addition, the profitability analysis points out that carrot cultivation is a fruitful and valuable agricultural product in the wintertime in Punjab. Moreover, the study recommended that due to the absence of education that the farmers did not have enough information about crop management and production; however, most of the farmer is doing their carrot farming on the traditional method.

Ali, Liu et al. (2017) analyzed the study on the effect of climatic variation and its impact on the production of main food crops in the case of Pakistan. The study investigated the effect of climate change such as; maximum, and minimum temperature rainfall, relative humidity, and sunshine on the main crops of Pakistan; wheat, rice, maize as well sugarcane. Moreover, this study used secondary time series data and covered the time-period of 1989 to 2015, whereas district wise data collected from different agriculture statistics of Pakistan, while the climate data collected on a daily basis for the same period from Pakistan meteorological department. In addition, the study applied the feasible generalized least square, heteroscedasticity, and autocorrelation consistent standard error methods . Similarly, the result of the study expressed that maximum temperature negatively affects the wheat yield, while the low temperature has some impressive results for all the crops, whereas the rainfall negatively affects the above crops except the wheat. Furthermore, the study recommended that the population is going up continuously, and in the coming future country will face a huge problem with food security; the government should tackle this problem and ensure sufficient food for the coming future.

Yadav, Singh et al. (2016) analyzed the climate change impacts assessment on oilseed and pulse, vegetable crops in Varanasi India. The study used the agro technology transfer by the decision support system to evaluate the impact of climate change on the productivity of the winter season. In addition, the study used various monsoon crops like; Tomato, potato, mustard, and chickpea in the selected region. However, the purpose of the study was to examine the tendency of climate change on cash crop production. Furthermore, the result of the study shows that the productivity of the selected vegetables decreases and increases with the temperature. Whereas the productivity of several pulses such as oilseed is, enhance due to an increase in temperature. While large decrease occurs in the productivity of pigeon pea crops around 96% in the monsoon, season, and a minimum in tomato crops 4.0% in winter season. Moreover, in the productivity of mustard crop 150% after the tomato 81% during the winter season and the lowest in the pigeon pea crop 99% simulated during the monsoon season.

Malhotra (2017) examines horticultural crops and climate change. If agriculture is the primary source of greenhouse gas emissions from climate change, then agricultural crops have a significant role to play by reducing the negative impact of climate change by contributing and dealing with carbon and sink. One of the worst physical reactions to climate change is the short growth period, which leads to a significant decrease in fruit and vegetable production. This reaction will adversely affect the growth stage of the agricultural crop through the high heat and dehydration of the land. Therefore, involvement in the search for smart horticulture related to climate were felt to be an unnecessary necessity to coordinate location-specific and knowledge bases to improve productivity in such a challenging environment. Crop-based adaptation strategies needed, taking into account the nature of the crop, its level of sensitivity, and the agro-ecological region. At the same time, monitoring the carbon sink potential of different horticultural crops compared to annual field crops will further help in developing a blueprint for addressing climate change issues.

How climate change impact vegetable growth, which is an essential constituent of human diet and the only source of nutrient, vitamins and minerals. Moreover, vegetables considered as a good compensation for the farmers because of its higher demand and price in the market. In the same scenario other crops also being effected by climate change such as global warming, seasonal monsoon along with abiotic factors. Where under these climatic fluctuating conditions accumulate crops failure, low yields, and poor quality and common problems of pests and diseases, which make the cultivation of vegetables unprofitable. As we know that many of the physiological and enzymatic actions depending on temperature, due to climatic change the impact on vegetables are also going to be severe. On the other hand, drought and salinity are consider the two immense penalties of temperature hike which directly obstructing vegetables agronomy. Which are further accountable to drought or moisture stress, flooding and salinity along with other pressures like water logging in coastal areas causing through polar ice melting as well rising sea level (Ayyogari, Sidhya et al. 2014). Is the atmospheric gas CO2 showing a vital role in the growth of vegetable crops and induces diseases and pests along with the greenhouse house effect as a major component and the main responsible factor for global warming? However, CO2 increase may enhance crop yields because of fertilizer surge; it also decays this yield to some extent too. With CH4 and CFC, the Carbon Dioxide act is an anthropogenic air pollutant, which is the main contributor to global warming. Where Nitrogen and Sulfur Dioxide are the main depletes of the Ozone layer, which further permits harmful ultraviolet rays to enter. These climatic fluctuations also influence the pests, and diseases presence, host pathogens interactions, pest, and environment distribution, time appearance their travel to new multiple places and maximum potentiality in the winter season, causing a huge blow to agronomy. Of all vegetables, potatoes are consider the riskiest of climatic change because of exact seasonal prerequisite for numerous bodily functions.

Ahmad, Siftain et al. (2014) analyzed the study on the effect of climate variation on wheat yield in Pakistan; A district-level analysis. The aim of the study was to evaluate the impact of climate variation on the output of wheat in Pakistan; therefore, the study covered all the wheat producing major districts prevailing as autonomous administrative units in 1980-81 and for which climate data existing since the early 1980s. Moreover, the study used the 19 key district level time-series data for the period of 1981 to 2010 by utilizing the production function approach. Furthermore, the study selected the 19 districts from the various provinces of Pakistan; the selection of districts was based on three different criteria; the availability of the meteorological department, the contribution of the district to the output of wheat and lastly the creation of districts before 1980-81. Whereas the independent variable of the study was wheat output per acre while several independent variables was selected for the study such as climate normal, climate variation, squares climate and area under wheat crop, fertilizer as well as time trend. However, the study used the fixed effect estimation technique and collected the data for the selected variable from various Pakistan statistical organizations and provincial development indicators from Pakistan a meteorological department Islamabad. Similarly, the outcomes of the study reveal that the output of wheat substantially affected by climate change. and its differs over the growth stages of crop as well as the production of wheat was adversely affected by increasing of long run mean temperature during the growth of crops, the output of yield decreased by 7.4 % due to the increase of mean temperature in 1^{o}C. In addition, the study suggested some policy recommendations that the climate change is not equally affected all the country the government should introduce climate policy on the bases of local region as compare to the national.

Bakri and Abou-Shleel (2013) conducted the study on economic impacts of climate change on some vegetable crops in Egypt. The purpose of the study was carry out the impact of climate change specifically on major vegetable crops like; potato, tomato and green bean and pointing out the association between climate changes and consumption gap due to the increasing population yearly by 2.7 percent. In addition, the association between climate change and water supply of the study crops. However, the study used the quantitative and qualitative analysis for the attaining the objective and utilized the published and unpublished data arranged by ministry of agriculture. Whereas the quantitative approach was use for the processing of statistical data observation and economics variables, while regression analysis and paired t-test as well as the SPSS and Minitab program were used for the outcome of the selected variables and study. Furthermore, the result of the demonstrated that the consumption gap increased due to the increasing population as well as the impact of climate scenario for the selected major vegetable crops, and change the consumption gap from 1396.6,3415.7 and 103.8 to 8658.7,21177.5 and 630.3 thousand tons per selected vegetable respectively over the period of 2025s-2100s linked with the year of 2001. Moreover, the total water supply also increased about 1450.0, 4404.2 and 413.9 Mm3 per selected vegetable. Lastly, the study recommended some mitigation strategy as the production of new type that have the capability of droughts and heat stress for the future challenges and climate scenario.

Abou-Hussein (2012) investigated the climate change and its impact on the productivity and quality of vegetable crops. Global climate change, which has described, as the most serious threat to the environment, has been the focus of debate among environmentalists and policy makers. While it has become not only an environmental, political and economic, issue but also a global one. Including agriculture is the main target. Therefore, rapid increase in CO_2 and other greenhouse gases to atmosphere is cause climate change and affect agriculture, forests, human health, biodiversity, snow cover and water to mountain ecosystems. Climate change like; temperature, solar radiation and rainfall have the potential to affect crop yields. Plants are directly affect by the increasing concentration of CO_2 in the atmosphere, as they are the first molecular link between the environment and the biological sphere. The role of CO_2 in agriculture is complex in that it can be positive in some cases; an increase in [CO_2] will increase photosynthesis and improve water use efficiency, thus increasing yields in most crops. Increase and negative in other matters. Concentration of CO_2 directly affects crop production by affecting the physiological process of photosynthesis. The effects of rising temperatures are more difficult to predict. Seed germination will likely improved for most vegetables, such as growing in regions where the daily temperature is less than 25 ° C during the growing season, assuming adequate watering. Available. Reproductive growth in many important vegetable fruit crops, like; tomatoes, peppers, beans, and sweet corn, is at high risk for periods of heat stress, and yields may decline as long as yields remain. Should not be move to colder parts of the year. In many crops, high temperatures can reduce quality parameters, like; size, soluble solids and softness. For fresh market vegetable producers, even minor defects in quality can make their crops completely unsold in some markets. More or less erratic rainfall will also reduce the production and quality of vegetables, although some crops may gain soluble solid and specific weight. Leafy vegetables and most coal crops such as broccoli, cabbage, cabbage, are generally consider cold-weather crops, so heat stress in the growing season will be detrimental to these species. It may suggested that scientists in developing countries should work on how they can mitigate and adapt to climate change in agriculture, as agriculture is a major source of income. Therefore, researchers should continue their research on developing varieties of crop plants that are naturally resistant to droughts, dehydration, heat stress and high levels of water and soil salinity, as well as certain diseases and pests. Can grow successfully if resistant. In addition, to change the planting dates of vegetable crops according to the new climatic conditions and to increase the yield from the water unit by cultivating varieties in suitable climatic zones. Thus, if the temperature is high, planting dates, productive areas and crops may need to adjust.

Anwar and McKenry (2010) examined the study of incidence and Reproduction of Meloidogyne incognita on Vegetable Crop Genotypes, whereas assessed the seventeen vegetable crop genotypes planted in the sixteen main vegetable yield production region were select in the Punjab for the 2006 to 2008 to regulate the existence of root-knot nematodes, meloidogyne spp. Moreover, the different vegetable crops were estimates like; bitter gourd, cabbage, carrot, chillies, coriander, cucumber, lettuce, mustard, okra, pea, pumpkin, radish, sponge gourd, tomato and watermelon. However, the result of the study clearly stated that in the entire Punjab M icongnita is widely distributed; Meloidogyne incognita was point out with seventeen kinds of "plant species concern to eight families, Apiaceous, Asteraceae, Brassicaceae, Cruciferae, Cucurbitaceae, Fabaceae, Malvaceae, and Solanaceae". Furthermore, the outcomes of the study acknowledge with the reported from sultanate Oman parasitizing bitter gourd, eggplant, okra, pepper, and tomato (Mani and Al-Hinai, 1996) and cabbage, carrot, cucumber, pea, pumpkin, sponge gourd, water melon, and melon (Johnson, 1998). The consequences of the study also suggested some information to scientist also recognized the possible variation crops like cauliflower, radish and mustard that may utilize to achieve the root knot nematodes by planting on field earlier planted with vulnerable host crops.

Chen, Zhang et al. (2004) conducted the study conducted the study in the Beijing region the current fertilizer practice and soil fertility of the vegetable production. Furthermore select the main vegetable yield area in the north China plain also conducted the survey from 1996 to 2000, while the study evaluated the inputs of the major nutrients nitrogen, phosphorus, and potassium (NPK) application methods and several vegetable types in the field. Whereas the unnecessary used of nitrogen and phosphorus were five time higher than the require limit for the in the case of nitrogen was very normal, particularly for the valuable crops. While the supply of potassium was not appropriate for the leafy vegetable and Urea, diammonium orthophosphate, chicken manure was the main source of nutrient for the vegetable yield in that area. However, more than 50 percent of nitrogen and 60 percent of potassium, around 90 percent of phosphorus applied created form organic manure. Furthermore the study revealed that the production of cabbage from organic and inorganic fertilizers in the open field from 300 to 900 kg N ha-1. Over 35% of the surveyed greenhouse-grown tomato crops received _ 1000 kg N ha–1 from organic and inorganic sources. Similarly, the outcome of the study indicated that for the increasing and sustainable vegetable yields should use of equal NPK fertilizer and keep up the soil quality are important for the yield.

2.4 Conceptual Framework

The Climate change impact on vegetable crops and potential for adaptation. Climate change is emerging as a major obstacle to global food security and will spread further in the coming years. Agriculture is one of the leading sectors affected by climate change (Ibrahim and Khalid 2021). This study deals with the climatic variation on vegetable yield, quality and the critical need for adaptation. Daily average, minimum and maximum temperature fluctuations are the main effect of climate change, which adversely affects vegetable production as many physical, biochemical and metabolic activities of plants depend on temperature. While an increase in CO_2 in the atmosphere can lead to affect the vegetable crop in the growth stage. Evidence suggests that higher growth rates for plants grown under high carbon dioxide concentrations may result in denser roofs with higher humidity, which favors pathogens. It is well document that an increase in temperature adversely affects the activity of pollinating agents and therefore reduces seed production.

However, negative effects can see on the appearance of the product. In addition, the variables of climate change can have indirect effects through the incidence of diseases and insects. Further, the significant effects of climatic variation on the agricultural sector will necessitate adaptation and mitigation of the negative effects on agricultural production, and especially the production and quality of vegetable crops. Improving vegetable production systems as a means of adaptation and mitigation, making better use of biodiversity, implementing biotechnology and genomic mechanisms, tolerating genetically different strains, and ultimately developing flexible vegetables for the climate.

Various replicas were developed countries using hydroponics to increase fruit and vegetable production and reduce import tariffs on chemicals used as inputs in this advanced technology. When the productivity of the fruit and vegetable sector increases by 25%, its welfare effects are considering as a 32% reduction in the market price of fruits and vegetables. In the factor market, unskilled labor, skilled labor, capital and natural resource earnings will increase by 0.51, 0.85, 0.97 and 0.13% respectively. Increasing productivity through the adoption of technology will also reduce the market value of land. The total price of fruits and vegetables in the product market will be lower in all other regions of the world. The country's exports, industrial output and GDP quantity index will also improve.

The productivity of unskilled laborers will improve which will increase the demand for unskilled laborers. Improving overall production plays a positive role in improving Pakistan's agriculture and agribusiness and balance of payments. The result is an overall positive impact on Pakistan's real GDP, sectoral exports and imports, improving trade conditions and lowering the local market prices of fruits and vegetables in Pakistan. In short, the adoption of hydroponics technology can play a positive role in economic indicators and consumer welfare in the country.

2.5. Summary

The underline study has conducted based on climate change and major vegetable crop yield in the case of Punjab and Sindh province of Pakistan. However, previous studies indicated that climate change is the most significant factor that affects the yield of agricultural products. On the other hand, climate change and vegetable crops have rarely explored in the present region. Like, Mahmood, Hassan et al. (2017) investigated the profitability analysis of carrot production in several districts of Punjab in the year . Similarly, Anwar and Mckenry conducted a study on sixteen vegetable crops yield like; carrots, chilies, coriander, cabbage, and several others, to regulate the existence of root-knot nematodes. Moreover, the present study has comprised several studies, in the case of developed, developing, as well as Asian countries. Therefore, the previous studies directed that climate change is the key issue for vegetable crop yield and many other agricultural products. Likewise, Mohammadzadeh, Vafabakhsh et al. (2018) examined the environmental impact on the major vegetable crops in the case of Azerbaijan province in Iran. Furthermore, based on previous studies' evidence, climate change is one of the key issues for vegetables and many other agricultural products.

2.6. Climatic change and its consequences

Founded on the review of the previous studies conceptual framework for the underlying study has developed on bases of above steps. Various research has empirically examined the effect of climate change on different agriculture products. These climatic changes may affect directly, indirectly or socially. In the present study, the climatic changes are categorize as, the direct effects

Morphological, Plants productivity; Food demand and cost of production is identify. Due to this adverse effect of climate, it may create lot of troubles.

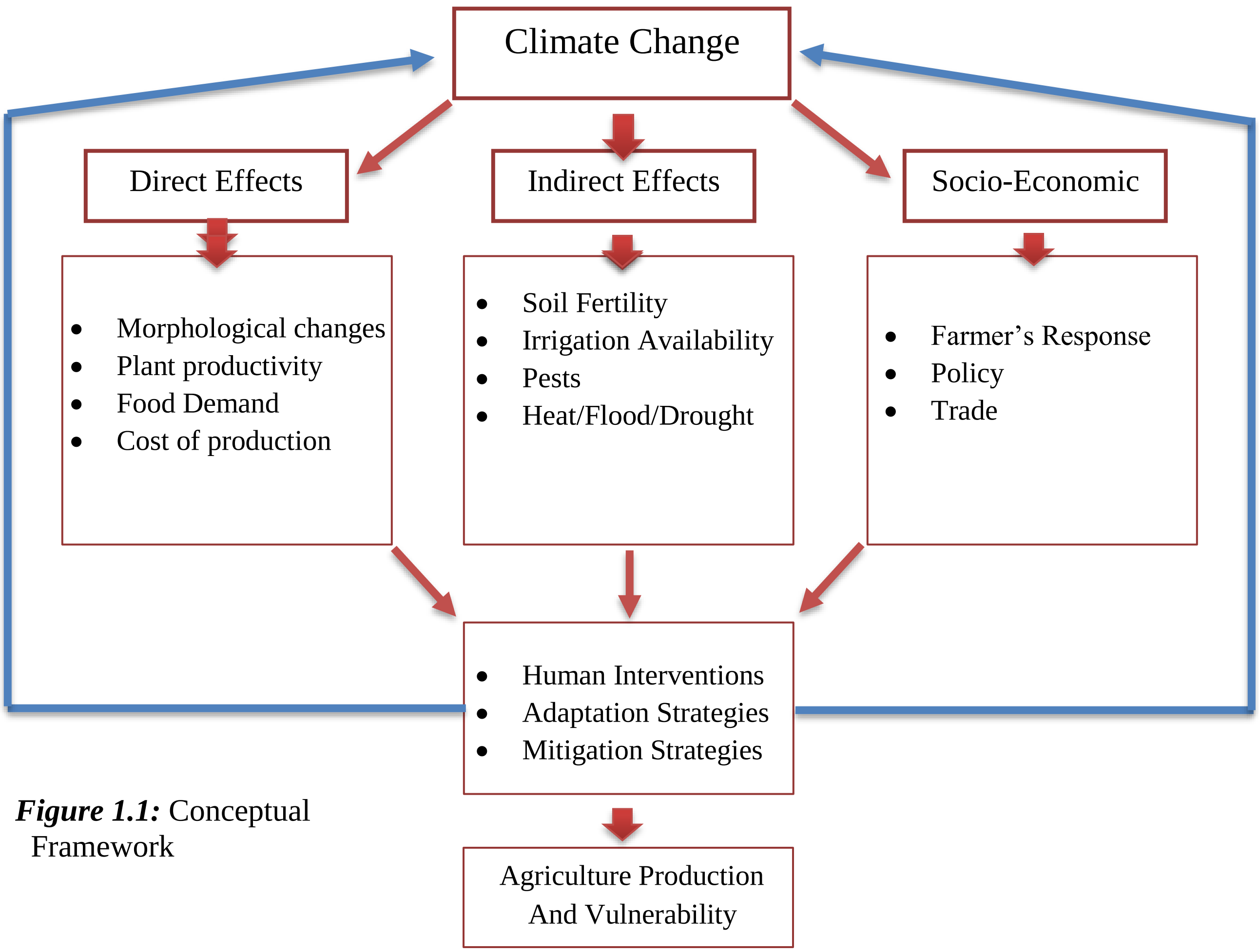

Figure 1.1: Conceptual Framework

While fulfilling the gap it required time and financial efforts. Because agriculture productivity directly affect food demand. Then it creates supply shortage in the market. Parallel to this the indirect effect of climate change negatively affect soil fertility, irrigation availability, pests and drought. The before mentioned effects of climatic changes also bring shortage in the agriculture market. After this pressure comes upon the prices. The researcher also finds out that climatic changes also effect the socio economic side of the society. Because when different crops face losses the farmers not giving proper response. Also, trade in the agriculture market not taking place. By collecting overall effect and it is conclude that these effects have direct negative impact on the production.

CHAPTER 3
DATA AND METHODOLOGY

This chapter explain about data collection procedure and methodological framework employed to achieve the specific objective of this study. We collected time series data at the districts level over input and output quantities and climatic variables such maximum temperature, minimum temperature and rainfall for the crop duration period. In order to explore the impact of climatic variables on vegetable productivity we employed the production function approach. Since, we are dealing with time series panel data from 1995-2020 for a number of districts producing more than 10% of total production. Hence, we employed Hausman test to decide whether to use Fixed or Random Effect Model.

Estimating the effect of climate change on short-term crops with a cropping period of only three months can be challenging because climate change is a long-term phenomenon that occurs over decades or even centuries. However, there are some ways to conceptually explain and justify how we can estimate the effect of climate change on these crops. To estimate the effect of climate change on short-term crops is to look at the historical climate data for the region and compare it with the current climate data. By analyzing temperature, precipitation, and other relevant climate variables, we can identify trends and patterns that suggest a changing climate. For example, if the historical climate data indicates that the region typically experiences mild temperatures during the cropping period, but the current climate data shows a significant increase in temperature, we can infer that the crops may be impacted.

Another way to estimate the effect of climate change on short-term crops is to use modeling techniques to project future climate scenarios. By simulating different climate scenarios, we can estimate how changes in temperature, precipitation, and other variables might impact crop yields.

These models can also help us identify potential adaptation strategies, such as using different crop varieties that are better suited to the changing climate or implementing irrigation systems to compensate for reduced precipitation.

3.1 Data

The data and methodology, which is, follows by the present study to evaluate the impacts of climate change on major vegetable crops productivity in selected districts of Punjab and Sindh province. However, for this purpose, the study used the production function approach by employing time-series data for the period 1995-96 to 2019-20 but for the provinces of Sindh the data was available only from 2000-01 to 2019-20. The District wise data of each crop collected from Crop Reporting Services Punjab (1995-96 to 2019-20), Punjab development statistics, Sindh development statistics and Ministry of national food and research.

3.2 Targeted Area

The targeted area for underline study is selected 18 major vegetable districts from Punjab and Sindh, the selection of districts based on two criteria: availability of metrological data (rainfall, temperature, and humidity). Secondly, selected those districts, which are contributing more than 10% to overall production of Tomato, potato, and onion as compare to other districts of the province (CRS Punjab, MNFS&R, Punjab and Sindh Development Statistics). In addition, the temperature data of each districts is use from different meteorological departments of Pakistan.

3.2.1 Graphical representation of temperature for each districts.

Fig: 4.1**.** The below figure shows that the maximum temperature of Multan district for the months of April, May and June. However, the temporary fluctuation of temperature is taking place but not over the longs term. Moreover, look at that point where the variation in temperature suddenly start from 41 to 37°C and then suddenly increase from 37 to 44°C this is the climate change. For all three months of crop period variations is taking place in the specific point and time. Through these, variation in the, stage, sowing, vegetation and maturity affects the crop. Which leads to affect the yield of vegetable in that year.

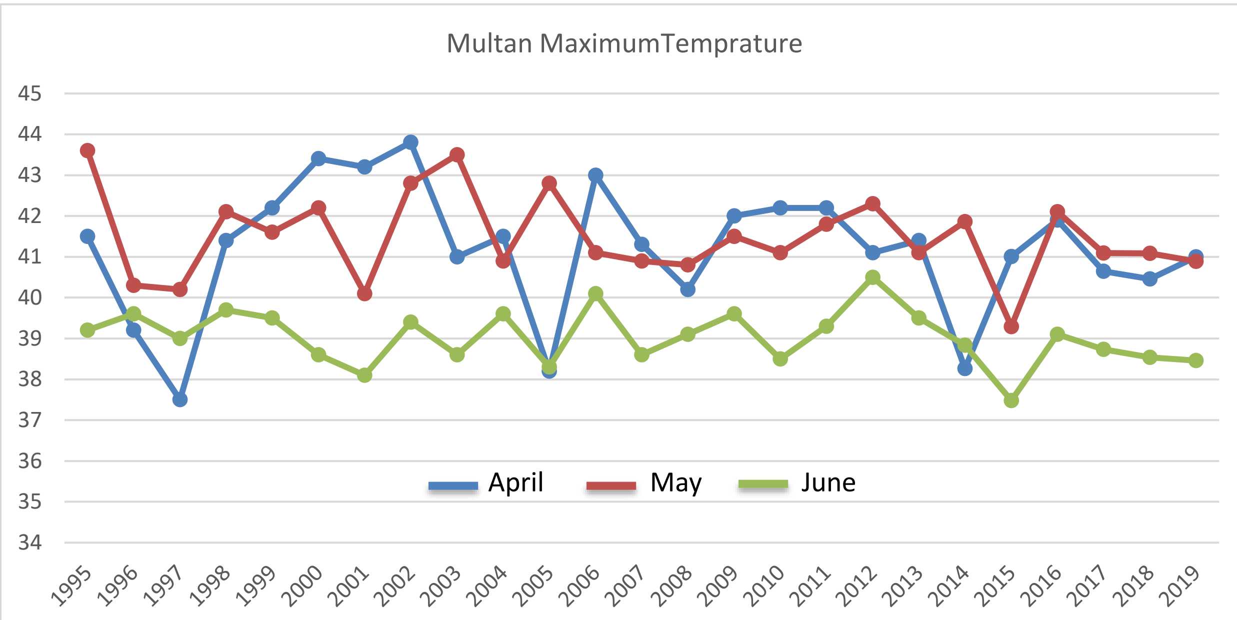

Figure 4.1: Maximum temperature of Multan district

Fig; 4.2: The given figure represent that the maximum temperature of Kasur district for the months of October, November and December. However, there is a variation, which indicate that climate change is taking place in all the three stage of crop. Moreover, in the month of December there is more variation it means abrupt changes is taking place as compare to other two months. While these are the point which productivity of vegetable effected by suddenly fluctuation in temperature.

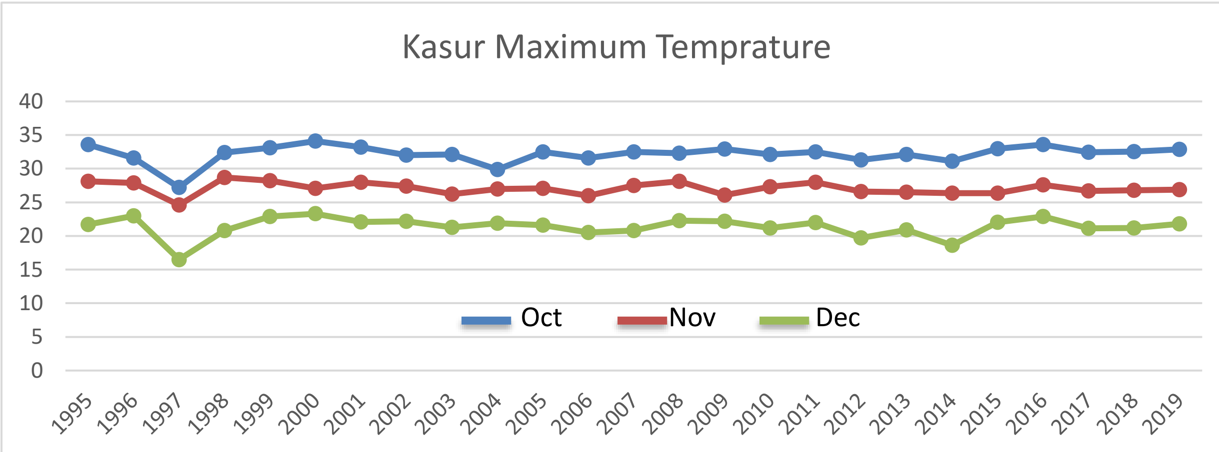

Figure 4.2: Maximum temperature of Kasur district

Fig; 4.3: The figure represent the maximum temperature of Sheikhupura district for the months of April, May and June. However, in the maximum temperature huge variation is taking place in the stage of vegetation. Similarly, look at that point where the temperature suddenly increase from 30 to 35°C this is a huge fluctuation. While, variation in maximum temperature in the stage of sowing and maturity are also taking place in that district, that indicates significant effect on the yield of vegetables crops.

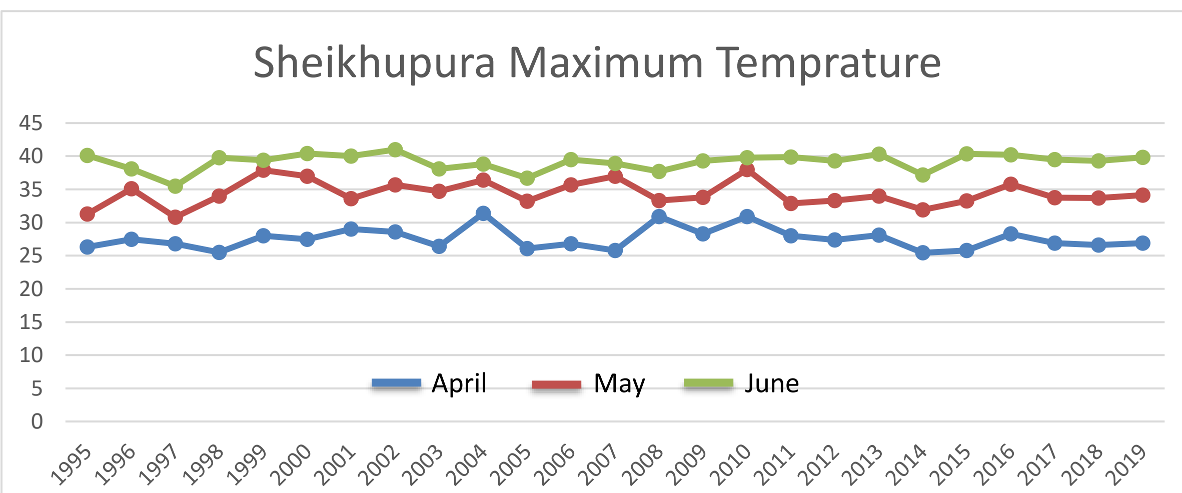

Figure 4.3: Maximum temperature of Sheikhupura district

Figure 4.4: representing the temperature of three different months for Nawabshah district, which is located in Sindh province of Pakistan. However, the fluctuation of temperature is taking place in all the three months, but in the month of May the variation of temperature is suddenly decrease which is the huge variation in temperature in vegetative stage of crop. While in the stage of vegetation, the variation of temperature is baldy, hit the yield of crop in the selected district. This is climate change.

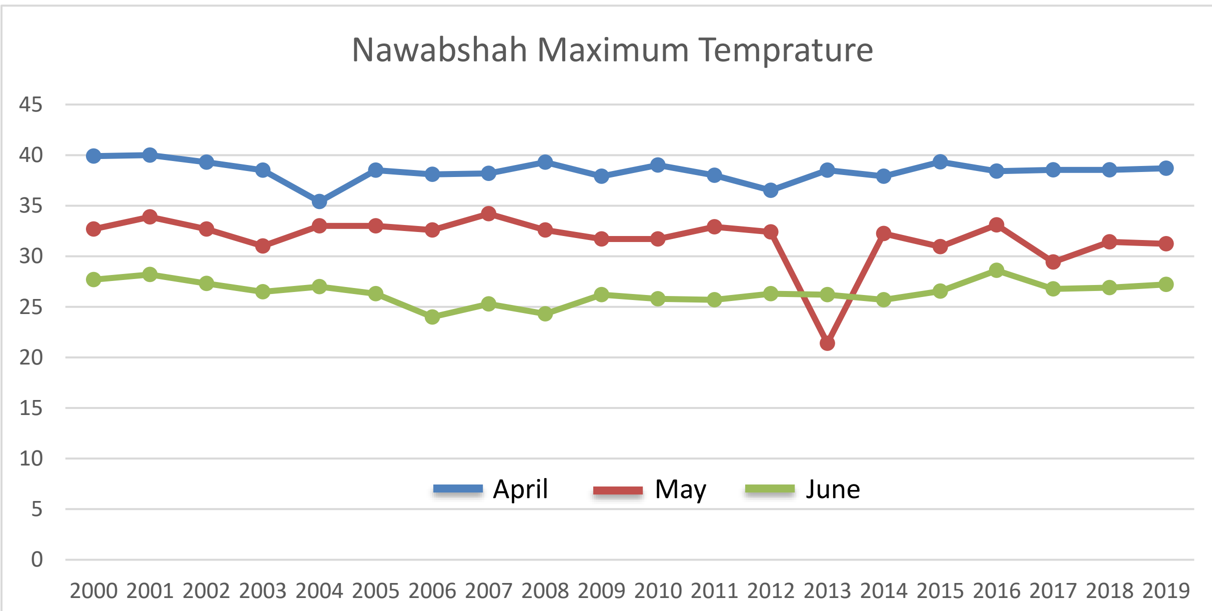

Figure 4.4: Maximum temperature of Nawabshah district

Figure 4.5: is the representation of maximum temperature in Thatta district, which is the main district for tomatoes crop. Whereas in the below figure shows the three maximum temperature for the different months, April, May and June which are consider the critical months for tomatoes crops. Although that three different temperature are taking place in the three different months in which the highest temperature is existing in the May month as compare to the two other months. While the variation of temperature in the vegetative stage of crop is taking place through this variation, the productivity of crop is badly affect by this minor change.

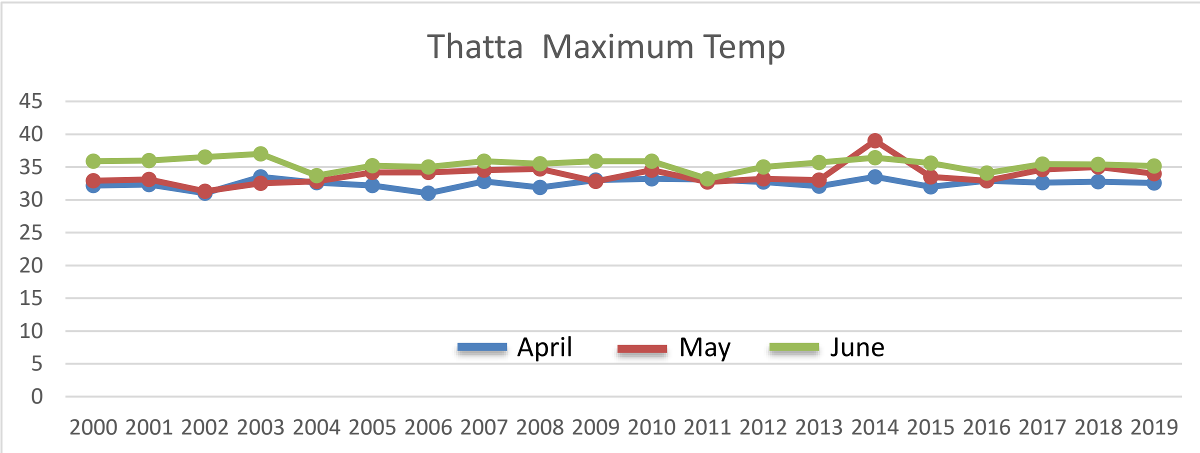

***Figure 4.5**:* Maximum temperature of Thatta district**.**

The given figure 4.6: display the results of Naushehro Feroz district of Sindh province and their three different maximum temperature for the months of Oct, Nov and Dec. However, the temperature of these three months are temporary changing with the same direction but over the long term. While in the month of Oct and Nov, the variation in temperature is take placed which is the sowing and vegetative stage of vegetable in these stage the productivity of crop is effect through this minor change.

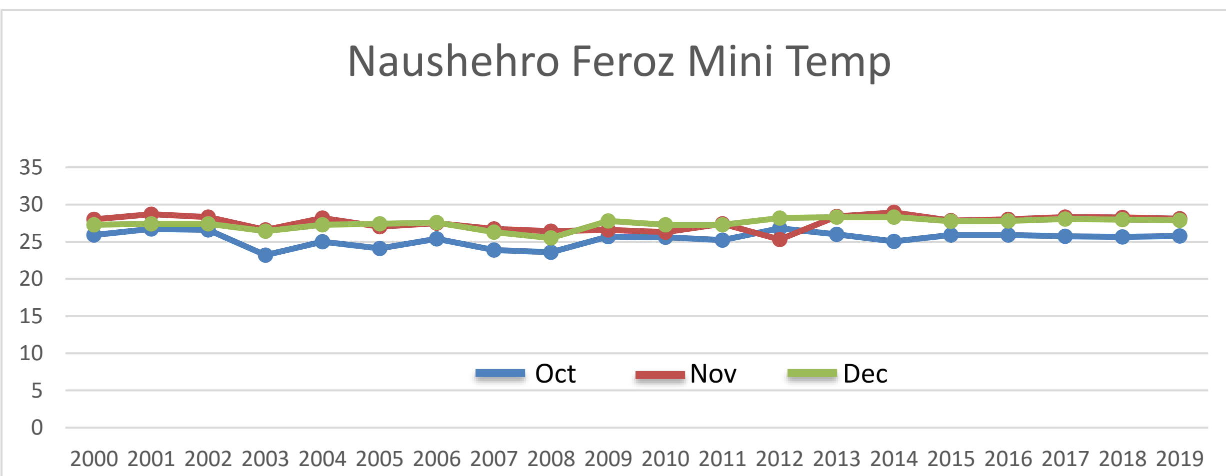

***Figure 4.6**:* Maximum temperature of Naushehro Feroz district.

The figure 4.7: represents the minimum temperature of Multan district for the three months of April, May and June, which are the lowest temperature of that district. Moreover, the minimum temperature of Multan district has increased with the huge portion. Whereas variation in the sowing stage is effect, the productivity of crop negatively, while variation in the stage of vegetative effect the productivity of crop is positively.

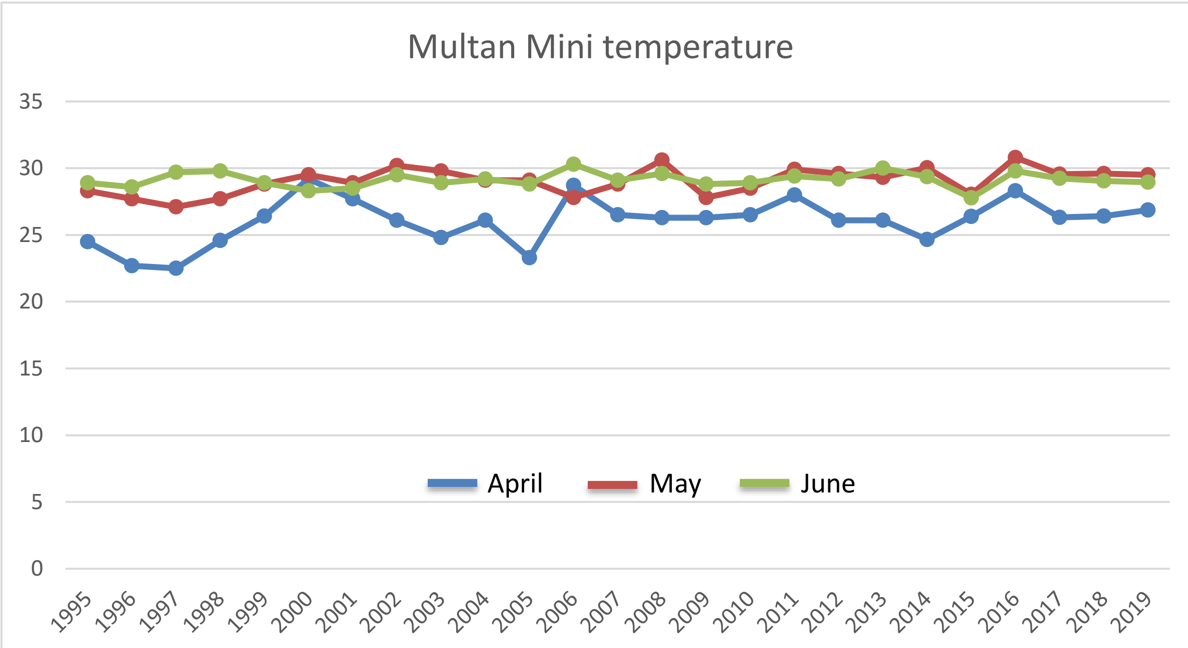

Figure 4.7: Minimum temperature of Multan district

Figure 4.8: is the finding of Kasur district and the minimum temperature of October, November and month, which gives information about the huge variation in temperature, is taking place in the certain years for the temporary basis. While variation in the planting stage of crop is harmful for the productivity of crop. However, variation in the stage of vegetation is effect the productivity of crop positively. While variation in temperature in the all stage of crop is taking place with the huge amount.

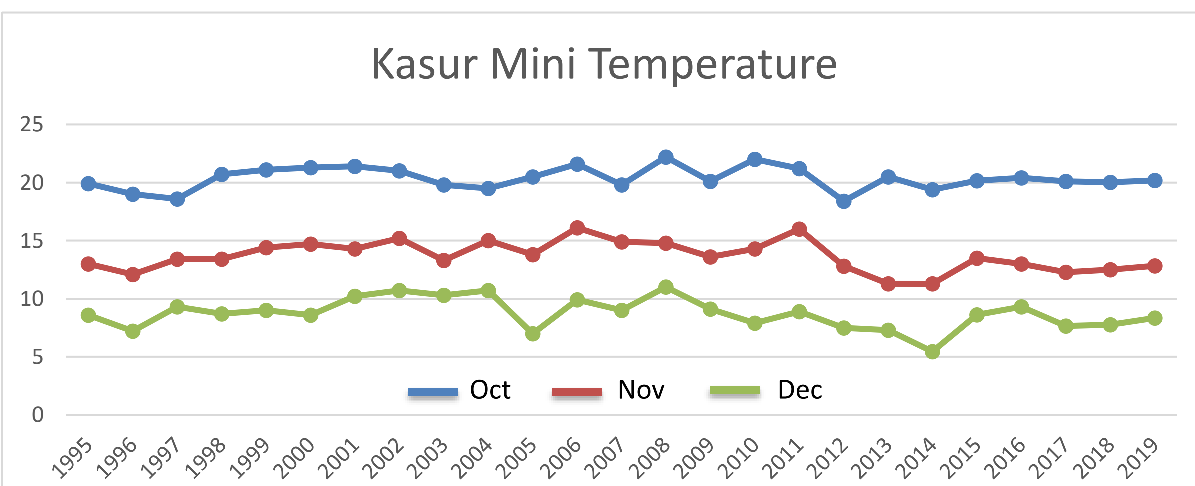

Figure 4.8: Minimum temperature of Kasur district

Figure 4.9: Is the key findings of minimum temperature in Sheikhupura district for the month of April, May and June, Which gives us information about the variability, is occurring in the selected district in the some years. However, in these three months the large number of variation is occur , however through these huge variation of temperature effect the yield of crop negatively. Moreover look at the starting point of all the minimum temperature line the below figure.

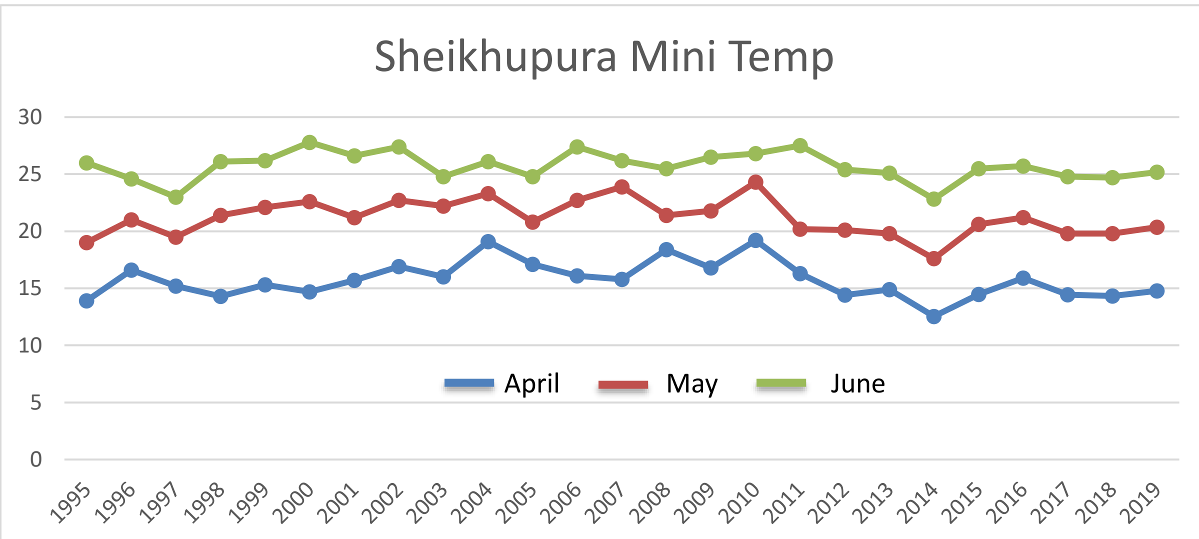

Figure 4.9*:* Minimum temperature of Sheikhupura district

The below minimum temperature figure 4.10: Is indicating for Nawabshah district and for the month of April, May and June, which is, consider as a coldest months of the year. However, with the passage of time the minimum temperature of selected district is increasing and decreasing with the huge amount over the short term but not over the long term. Nevertheless, this temporary variation is harmful for the crop. While in the stage of vegetation, the variation in temperature is effect the productivity of crop positively where in the stage of planting and maturity effect the crop yield negatively.

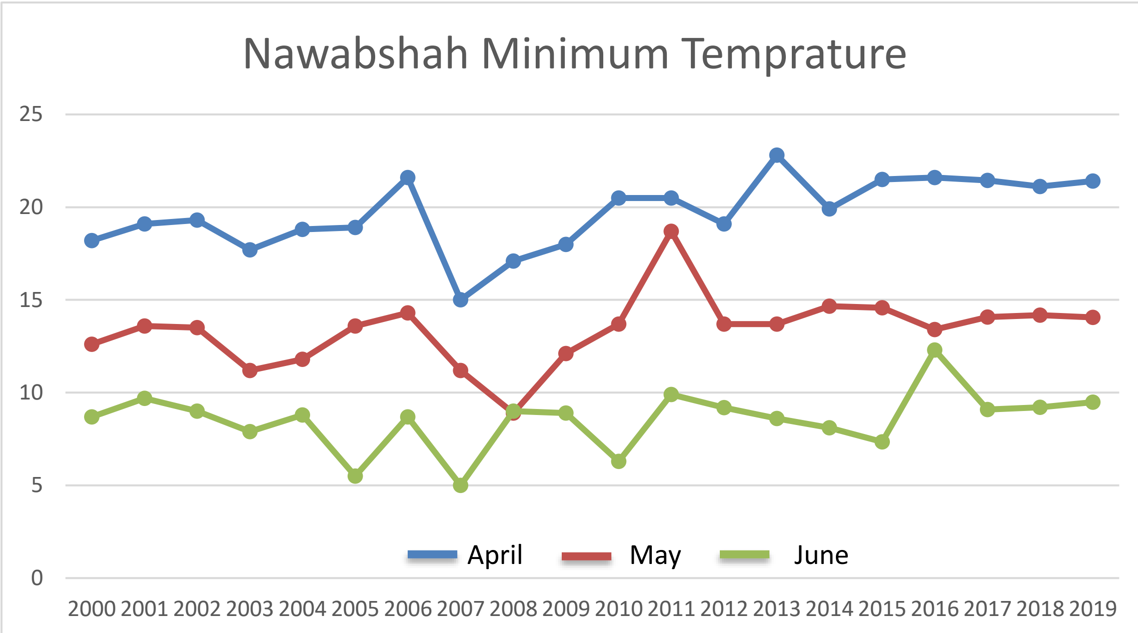

Figure 4.10: Minimum temperature of Nawabshah district

The figure 4.11: Is the representation of Naushehro Feroz district and the Minimum temperature of sowing to till maturity, for the selected district. Whereas, among these selected years the minimum temperature is fluctuating with the certain point and time. While variation is taking place in the three stage of crop such as; sowing stage, vegetative and maturity stage. However, variation in the stage of sowing is effect the productivity of crop negatively, while variation in the stage of vegetation is effect the productivity of crop positively.

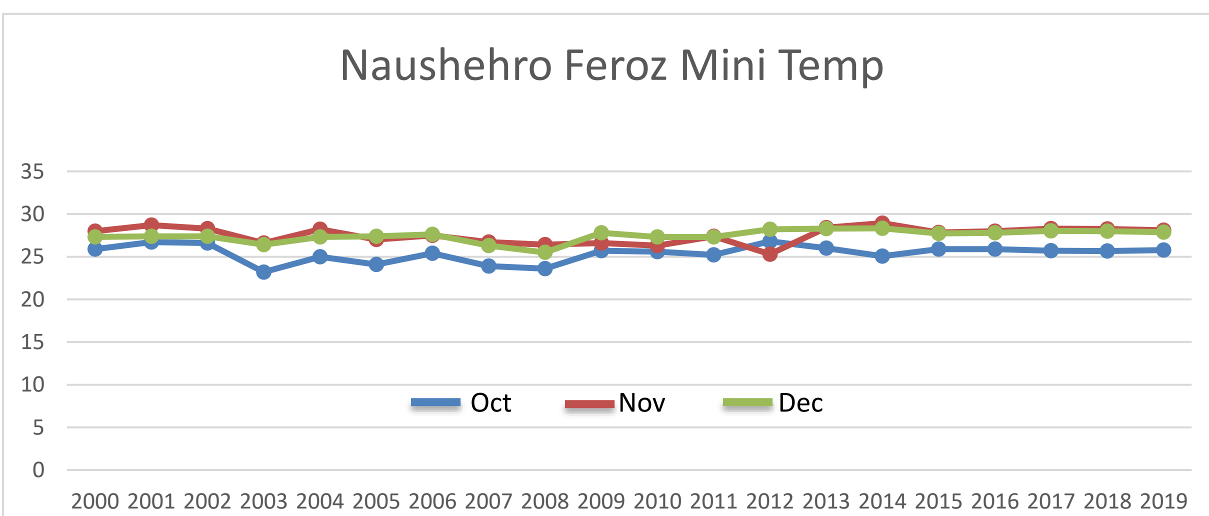

Figure 4.11*:* Minimum temperature of Naushehro Feroz district

Figure: 12. Is the finding of minimum temperature in April, May and June month for Thatta district, which is the main tomato-growing district in Sindh Province. However, the minimum temperature is fluctuating with the big change in particular years for the short time period. While variation is taking place in the three stage of crop but in the stage of maturity, there is huge variation in temperature, which badly effect the productivity of crop in the mention district.

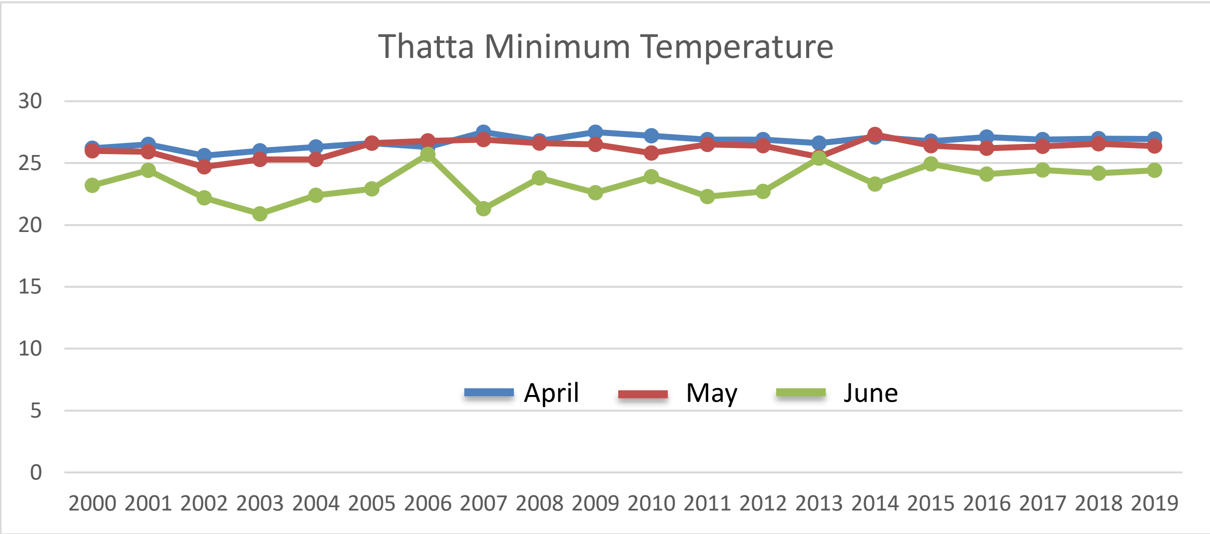

Figure 4.12*:* Minimum temperature of Thatta district

Table 4.10: Average temperature for 10 years.

10 Years	**Average temperature**
1995	41.4
1996	39.7
1997	38.9
1998	41.0
1999	41.1
2000	41.4
2001	40.4
2002	42

2003	41.0
2004	40.6

Table 4.11: Average temperature for 15 years.

15 Years	Average temperature
2005	39.7
2006	41.4
2007	40.2
2008	40.0
2009	41.0
2010	40.6
2011	41.1
2012	41.3
2013	40.6
2014	39.6
2015	39.2
2016	41.0
2017	40.1
2018	40.0
2019	40.1

3.2.2 Variable Description:

Climate change and vegetable crops has rarely explore in the case of underline country, Mahmood, Hassan et al. (2017) analyzed carrot production in the several districts of Punjab province. On the other hand, (Anwar and McKenry 2010) conducted the study on vegetable crop and selected sixteen vegetable yield and root-noot nematodes in Punjab province. As consider the above description the data for under lying study we employed major vegetables crops data, district wise of Punjab and Sindh province. The variables, which is use in the study, are major vegetable crops yields, like tomato, potato, and onion. Along with explanatory variables such as Fertilizer, water withdrawal, and two different temperature ranges is used (maximum and minimum temperatures) for the period of plantation, vegetation and maturity stage. Moreover average precipitation and technology also used as an independent variables. Further detailed are given below in the table.

Table 3.1: Detail of selected major Vegetables crop and districts

Province	Major Vegetables	Selected Districts
Punjab	Onion	Multan, Lodhran, Bhawalpur, khanewal
	Tomato	Sheikhupura, Khushab, Muzaffargarh
	Potato	Kasur, Okara, Sahiwal
Sindh	Onion	Nawabshah, Sanghar, Mirpurkhas
	Tomato	Thatta, Badin, Mirpurkhas
	Potato	Khairpur, N. Feroze

Source: Crop Reporting Services Punjab; MNFS&R; Punjab and Sindh development Statistics

3.2.3 Crop calendar for each vegetable

The below table 3.2 show the crop calendar for each vegetable in which highlighted the growing months of crops. In addition, we have not included month's dummies in the model. Rather we included actually rainfall and temperature during the flowering and harvesting stages. Rather, we have included province dummies, which represent will difference in the production of Punjab and Sindh. However, we have not included the district dummies because we believe that the environment in the districts of Punjab is almost the same and the environment is almost the same in the districts of Sindh. Conversely, we have included a provenance dummy because the climates of Punjab and Sindh are quite different.

Table 3.2 Crop growing Time Period

Vegetable	Crop calendar of vegetables										
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Onion				■	■	■						
Potato										■	■	■
Tomato				■	■	■						

Source**:** Agriculture Marketing Information Service (AMIS)

The following table briefly discusses different variables such as major vegetable crops utilized by this specific study.

3.3 Methodology

The previous studies employee different approaches to explore the impact of climate change on agricultures productivity and their methodological approaches can be divide into three different categories i.e. Production function approach(Ahmad, Siftain et al. 2014), Ricardian approach by (Huong, Shun and Fahad 2018), and simulation models (Dua et al. 2013). Therefore, due to empirical evidence support the production function approach is the more preferable to calculate the impact of climate change on agriculture productivity(Ahmad, Siftain et al. 2014).we measure the climate change in term of maximum, minimum temperature and average rainfall. Therefore, the general form of the production function is our case is defined as below:

$$Yt_i = f\,(Fert_{ti}, Wat_{ti}, Maxt_{ti1}, Maxt_{ti2}, Maxt_{ti3}, Mint_{ti1}, Mint_{ti2}, Mint_{ti3}\; Rnfl_{ti1}, Rnfl_{ti2}, Rnfl_{ti3}, Tech_{ti})$$

(3.1)

Table 3.3 Variable Description

Variables	Variables Descriptions	Measurement
Yt_i	Yield	Tonnes
$Fert_{ti}$	Fertilizer	Kg/ha
Wat_{ti}	Water withdrawal	Cubic meter
Maxt	Temperature	Maximum and minimum ℃
$Rnfl_{ti1}$	Rainfall	Millimeter
$Tech_{ti}$	Technology	Agriculture Machinery/ Tractor/harvesting

Yt_i represents the yield in t-*th* period of *i-th* crop. Whereas, independent variable of the study is $Fert_{ti}$, which shows fertilizer in t-th period of i-th crop, and wat_{ti}, represents water withdrawal in t-th period of i-th crop. While $maxt_{ti1}$ represents maximum temperature in the t-th year for i-th crop in the planting stage, and $maxt_{ti2}$, indicates maximum temperature in t-th year for i-th crop in the vegetation stage, $maxt_{ti3}$, represent maximum temperature in t-th year for i-th crop in the stage of maturity. Thereby, $mint_{ti1}$, $mint_{ti2}$, and $mint_{ti3}$ represent minimum temperature in t-th year for i-th crop in the sowing stage, minimum temperature in t-th year for i-th crop in the stage of vegetation and minimum temperature in t-th year for i-th crop in the maturity stage. In addition, three rainfall is also used $Rnfl_{ti1}$, $Rnfl_{ti2}$, $Rnfl_{ti3}$, which represents average rainfall in the t-th year of i-th crop for sowing stage of crop, average rainfall in t-th year for i-th crop in the vegetation stage as well as average rainfall in t-th year for i-th crop in the stage of maturity. While $tech_{ti}$, is represents technology in t-th year for i-th crop.

It should be noted that t=1995……...2020; i=1….3. Where 1 stands for onion, 2 stands for potato and 3 for tomato.

$$Yt = \beta_0 + \beta_1 fert_{ti} + \beta_2 Wat_{ti} + \beta_3 Maxt_{ti1} + \beta_4 Maxt_{ti2} + \beta_5 Maxt_{ti3} + \beta_6 Mint_{ti1} + \beta_7 Mint_{ti2} + \beta_8 Mint_{ti3} + \beta_9 Rnfl_{ti1} + \beta_{10} Rnfl_{ti2} + \beta_{11} Rnfl_{ti3} + \beta_{12} Tech_{ti} + ut \quad \textbf{(3.2)}$$

The above equation is the specific form of production function in which β0 represent the intercept of the equation. Where β_1 is the coefficient for fertilizer, β_2 represents coefficient for water, β_3, β_4 and β_5 represent coefficients of three maximum temperatures one for each vegetable. Along with this β6, β_7 and β_8 are the coefficients for three minimum temperature one for each vegetable and β_9, β_{10} and β_{11} represents the coefficients of rainfall for three vegetable. While β_{12} represent the coefficient of technology.

3.4 Fixed Effect Model

To estimate the climatic impact on major vegetable crops the under lying study consider the fixed effect model for data in which the dependent variable yield of major vegetables crops is linearly depend on a set of independent variables fertilizer, water withdrawal, min and max temperature, rainfall and Technology.

Let suppose Yt_i considered is dependent variable, which is the total yield of major vegetables crops. For that, a set of predictor variables that consistently vary over time which are represented by Xt_i. In the underlying study we have, different predictor variable, which is far mansion, which are varying over time. However, the best approach to follow is through a fixed effect model.

Fixed effect model is a panel data estimations technique that let one to compensate for unobserved time-invariant individual traits, which can be connect with the observed independent variables. Hence, the individual specific effect is correlated with the explanatory variables. Whereas, random effect model is a statistical model in which some of the parameters (effects) that define systematic components of the model exhibit some form of random variation. Thus, the individual unobserved heterogeneity is uncorrelated with the independent variables. We are using fixed effect model in this research as it allows to control invariant omitted variables of all the times.

CHAPTER 4
RESULT AND DISCUSSION

This chapter presents the descriptive statistics and empirical results; also, it gives some graphical representation of some climate change related variables.

As we know that global temperature has increasing day by day, and the rainfall has occasionally dropped and converted more unreliable. It considers the idea of how climatic variables performed along with trends throughout the vegetable growing season in different designated districts of Punjab and Sindh. For this purpose, we regressed 26 years of data for Punjab and 20 years for Sindh on rainfall and the time trend of temperature. Where the overall time trend of temperature and rainfall are attain through a fixed effects model. The estimated results are below in the Tables.

The Below table 4.1 highlights the result of descriptive statistics for onion crop of Punjab and Sindh districts. However, in the case of Onion for given districts, the mean yield is about 11.6 tonne per hectare with the standard deviation of 8.4. While the minimum value of 0.01 is took place in the district Mirpurkhas, during the period of 2015 and 16. Due to higher cost of production, the formers were not planting the crop of onion in that year. Therefore the minimum value of onion crop decline near to zero (Hussain and Bangash 2017). As for independent variables the mean fertilizer by 289.44 with standard deviation 148.68. Whereas the mean water withdrawal per hectare is by 2333.69 cubic meter is noted. While two different mean temperature of maximum and minimum are, variating at different stage of crop yield, April maxi temperature with their mean value is representing by 39.85 and May mean value with the 37.85 as well as June mean value noted in the table is 34.54. Furthermore, the minimum temperature of April, May and June with the mean value 23.87, 23.40, and 23.40 display in the below table. However, Rainfall of the three months are completely different story, rainfall follows a volatile pattern through all stage of the crop production process as is evident form the large values for deviation from mean.

Table 4.1: Descriptive Statistics for Onion.

Variables	Mean	Std.Dev	Maxi	Mini
	Onion			
Yield (tonnes)	11.6	8.40	66.6	0.01
Fertilizer (Kg/Ha)	289.4	148.7	954	8
Water withdrawal (cubic meter)	2333.7	1542.8	5455.9	897.1
April Max (°C)	39.9	2.4	44.5	33.3
May Max. (°C)	37.9	5.03	43.7	21.4
June Max (°C)	34.6	6.2	41	24
April Mini (°C)	23.9	3.07	29.2	15
May Mini (°C)	23.4	7.05	30.8	8.9
June Mini (°C)	21.7	9.3	30.3	5
April Rainfall (mm)	6.7	14.1	117	0
May Rainfall(mm)	17.6	25.4	106.4	0
June Rainfall(mm)	28.8	35.3	138.9	0
Technology	12.0	6.8	25	1

Table 4.2 shows the result of descriptive statistics for Potatoes crop of Punjab and Sindh districts. However in the case of Potatoes for given districts, the mean yield is about 24.95 tonne per hectare with the standard deviation of 20.9. While minimum value 7.0 took place in the Naushehro Feroz district due to the abrupt variation in temperature during the period of 2004, 05 and 07, 09, which affected the crop, yield. Similarly, in the stage, sowing and maturity crop need maximum temperature around 15-25 °C in the stage sowing, whereas 30-32 °C in the stage of maturity are required respectively reported by (BBK). As for Explanatory variables the mean fertilizer by 214.13 with standard deviation 112.74. Whereas the mean water withdrawal per hectare is by 2251.02 cubic meter is represent in the below table. While two different temperature maximum and minimum is changing during the crop sowing to till maturity time and mean value is 37.34, 33.61, and 28.65 with the standard deviation 5.69, 7.82 and 9.23. Furthermore, the minimum

temperature of Oct, Nov and Dec decreases with their mean value 21.77, 17.94, and 14.55 and the standard deviation 2.93, 7.18 as well as 9.58 respectively shows in the above table. However, Rainfall of the three months, rainfall follows increasing pattern through all stage of the crop production process, as is evident form the large values for deviation from mean.

Table 4.2: Descriptive Statistics for Potatoes

Variables	Mean	Std.Dev	Maxi	Mini
Yield (tonnes)	24.95	20.9	90.6	7.0
Fertilizer (Kg/Ha)	214.1	112.7	740	76
Water withdrawal(cubic meter)	2251.0	1517.9	5455.9	897.1
Oct Max (°C)	37.3	5.7	47.8	27.2
Nov Max (°C)	33.6	7.8	45.7	24.6
Dec Max (°C)	28.7	9.2	43.4	16.1
Oct Mini (°C)	21.8	2.9	26.8	16.4
Nov Mini (°C)	17.9	7.1	28.9	9.2
Dec Mini (°C)	14.6	9.6	28.3	3.1
Oct Rainfall (mm)	7.3	17.4	106	0
Nov Rainfall (mm)	8.6	15.7	77.9	0
Dec Rainfall (mm)	22.3	48.9	301.5	0
Technology	12.1	6.9	25	1

Table 4.3 shows the result of descriptive statistics for Tomatoes crop of Punjab and Sindh districts. However in the case of Tomatoes for given districts, the mean yield is about 10.93 tonne per hectare with the standard deviation of 3.59.While maximum value 24.10 represent for the period of 2019-20 Sheikhupura district which is the highest producing district in that years. In contrast minimum value 1.13 is represents the district Mirpurkhas during the year of 2002. Where the crop badly hit by the disease root-knot nematodes. However, root-knot nematodes attack variety of plant that can become serious pests. Root-knot nematode microscopic roundworms live in plant roots and damage the plants by feeding on root cells with their needle. Moreover incidence of root-knot nematode was recorded in that district 39.6% (Jiskani, Pathan et al. 2009). As for Independent variables the mean fertilizer by 171.28 with standard deviation 159.89. Whereas the mean water

withdrawal per hectare is by 2544.96 cubic meter is in the table. While two different temperature maximum and minimum is increasing during the crop sowing vegetation and maturity time and mean, value is 30.36, 34.50, and 37.83 with the standard deviation 3.08, 1.93 and 2.60. Furthermore, the minimum temperature of April, May and June is increasing with their mean value 19.86, 22.54, and 24.21 and the standard deviation 6.04, 3.10 as well as 1.85 Respectively shows in the below table. However, Rainfall of the three months, rainfall follows increasing pattern through all stage of the crop production process, as is evident form the large values for deviation from mean. Moreover, the technology mean value is by 11.88 with their standard deviation 6.74 about.

Table 2.3: Descriptive statistics for Tomatoes

Variables	Mean	Std.Dev	Maxi	Mini
Yield (tonnes)	10.93	3.59	24.10	1.13
Fertilizer (Kg/Ha)	171.28	159.89	954	12
Water Withdrawal (cubic meter)	2544.96	1590.57	5455.95	897.15
April Max (°C)	30.36	3.08	35.1	24.3
May Max (°C)	34.50	1.93	39.7	29.2
June Max (°C)	37.83	2.60	43.8	33.2
April Mini (°C)	19.86	6.04	27.5	11.7
May Mini (°C)	22.54	3.10	27.3	16.8
June Mini (°C)	24.21	1.85	29.2	20.7
April Rainfall (mm)	48.20	60.82	336	0
May Rainfall (mm)	28.02	46.41	287.3	0
June Rainfall (mm)	13.03	20.05	117	0
Technology	11.88	6.74	25	1

The Below 4.4 table indicate the regression and log linear model results of Onion crop for Punjab and Sindh districts, which represent some positive and negative relation with the yield. The underlying study used both model but we explained the results of log linear model because it is more convenient to explain. Whereas the nutrient content of fertilizer NPK (Nitrogen, Phosphorus and potassium) has negatively related with the yield of onion, implying that 0.2 percent increases in fertilizer use will decrease the yield of onion by -0.19 percent but the coefficient is not significant. Although, it is alarming that fertilizer has negative sign and it might be that farmer are using more fertilizer than the recommended level. The maximum temperature for the month of June is negative and significant at 1% level. This demonstrate that when maximum Temperature in June increases by 0.01 percent then yield of onion is decrease by -14.9 percent.

In contrast to maximum temperature, the minimum temperature of May has positive and significant impact on the yield of onion. It observed when the minimum temperature in the month of May increases by 0.04 percent that will lead to increase yield by 3.06 percent respectively. The month June is assume to hottest month in Pakistan and minimum temperature is 24°C, which is below the range of the crop requirement. Hence, again breeder need to focus on the onion seed, which can survive at the lower temperature at the flowering stage. Such innovation may help to offset the impact of climate change on onion crop.

While rainfall in June month negatively related with the crop yield, implying that when rainfall in June increases by .04 percent that will lead to decrease the yield by .07 percent. The coefficient of fertilizer, water, April maximum temperature, May maximum temperature and April minimum as well as April and May rainfall are insignificant in our model. Further the technology show negative relation but significant means the new varieties of crops are not introduce yet.

Table 4.4: Regression Results of Onion

Variable	Coefficients OLS	Coefficients of log linear model
Fertilizer NPK (Kg/Ha)	3.7 ^{NS} (0.5)	-197.7 ^{NS} (0.4)
Water withdrawal (cubic meter/Ha)	-1.3^{NS} (0.3)	0329.9^{NS} (0.5)
Province D	-16.02^{NS} (13.43)	6267.3*** (0.001)

April Max (°C)	1366.6^{**} (0.01)	4280.9^{NS} (0.27)
May Max (°C)	-35.1^{NS} (0.9)	-195.8^{NS} (0.92)
June Max (°C)	90.8^{NS} (0.8)	-14926.9^{***} (0.00)
April Mini (°C)	-930.91^{**} (0.07)	-2117.6^{NS} (0.36)
May Mini (°C)	863.09^{**} (0.08)	3060.95^{**} (0.04)
June Mini (°C)	-1119.0^{**} (0.06)	-1413.6^{NS} (0.18)
Aprli Rainfall (mm)	21.60^{NS} (0.6)	5.70^{NS} (0.48)
May Rainfall (mm)	33.8^{NS} (0.27)	2.59^{NS} (0.59)
June Rainfall (mm)	-34.7^{NS} (0.12)	-7.41^{**} (0.04)
Technology	-332.3^{***} (0.003)	-495.34^{***} (0.001)
Constant	-119.25^{NS} (0.65)	36995.8^{**} (0.06)

*** indicated significant at 1%; ** indicated significant at 5%; * indicated significant at 10%

The below 4.5 table indicate the regression and log linear results of Potato crop for Punjab and Sindh districts, which represent some positive and negative relation with the yield. However, this study describe the result of log linear model, which is much better. While the water withdrawal indicating negative but significant relation with the yield of potato, this imply that the former's are over use the irrigation water, this show that when .07 increases irrigation water that will negatively effects the yield of potato -.42 percent. Moreover, the maximum temperature in the sowing month is negatively related and significant as well, this shows that .07 percent variation lead to decrease the productivity of potato crop that -2.82 percent, this is the sowing stage of potato is badly effect by variation of temperature. However, the maximum temperature 30 and 32°C is more than the recommended level, in the sowing stage the crop require 20-25°C reported by times agriculture (2021). In addition, the maximum temperature of November month is show negative relation with yield and significant as well, this demonstrate that the November month is the vegetative stage of selected crop in that stage variation in temperature also effect the yield of potato crop. This show that .01 percent increase in temperature lead to decrease the productivity -4.04 percent respectively. Furthermore, October and November minimum temperature indicating positive and significant relation with the yield. These indicate that .02 percent variation in minimum temperature in the stage of sowing and vegetative will positively effects the yield of potatoes by 1.9 and 1.2 percent respectively. Furthermore, the variables fertilizer, temperature of December maximum, minimum and all three months rainfall are insignificant as well as technology in our model. However, the October, November rainfall show negative relation while the rainfall of December indicate positive relation.

Table 4.5: The regression result of potato crop

Variables	Coefficients of OLS	Coefficients of Log linear model
Fertilizer NPK (Kg/Ha)	-13.31^{NS} (0.34)	22.02^{NS} (0.84)
Water withdrawal (cubic meter/Ha)	-1.76^{NS} (0.59)	-421.98^{**} (0.07)
Province D	29736^{NS} (0.24)	-95.40^{NS} (0.85)
Oct Max (°C)	-3227.6^{**} (0.002)	-2829.51^{***} (0.007)
Nov Max (°C)	-4010.82^{***} (0.001)	-4041.25^{***} (0.00)
Dec Max (°C)	831.49^{NS} (0.42)	445.64^{NS} (0.49)
Oct Mini (°C)	1737.33^{NS} (0.26)	1933.37^{**} (0.02)
Nov Mini (°C)	3374.94^{***} (0.01)	1209.23^{**} (0.02)
Dec Mini (°C)	1919.32^{NS} 0.17)	241.03^{NS} (0.35)
Oct Rainfall (mm)	-37.85^{NS} (0.70)	$-.881^{NS}$ (0.75)
Nov Rainfall (mm)	-108.13^{NS} (0.36)	-3.4084^{NS} (0.26)
Dec Rainfall (mm)	58.81^{**} (0.09)	$.8470^{NS}$ (0.34)

Technology	401.53** (0.08)	30.53^{NS} (0.57)
Constant	112635.9** (0.02)	18910.4*** (0.00)

*** indicated significant at 1% ** indicated significant at 5% * indicated significant at 10%

The below table 4.6 Display the regression and the log linear results of Tomatoes crop for Punjab and Sindh districts. Whereas the present study used both model but the result of log linear is more convenient to discuss. While the estimated results represent some positive and negative relation with the yield of tomato crop. Although the water withdrawal is indicating negative and significant relation with the yield of Tomatoes. This indicated that the former's are over used the irrigation water, implying that .07 percent more use of irrigation water will decreases the yield of Tomatoes by -.33 percent. Moreover, the maximum temperature of April month is demonstrated negative and significant relation with the tomatoes yield. This shows that .06 variation in the sowing stage of crop will lead to decline the yield of tomatoes by -1.14 percent. Similarly, the maximum and temperature of sowing, stage is around 26, 27 to 30°C that is more than the recommended level. However, in that stage the required temperature should be 20, and below the 25°C (Chishti, Hussain et al. 2019). While the maximum temperature of June month display positive and significant relation. This indicate that in the stage of maturity variation in temperature is positively effects the yield of tomatoes. Implying that .04 percent, variation in temperature in the stage of maturity will effect positively the yield of tomatoes by .19 percent respectively. However, some variables like, fertilizer, temperature of May maximum, all minimum and all three months rainfall are insignificant in our model, which mention in the above table.

Table 4.6: The regression result of Tomato crop

Variables	Coefficients Ols	Coefficients of Log linear model
Fertilizer NPK (Kg/Ha)	-.8825^{NS} (0.56)	-3.65^{NS} (0.9)

Water withdrawal (cubic meter/Ha)	-1.11*** (0.005)	-339.42** (0.007)
Province D	-3462.8** (0.04)	-86.87NS (0.6)
April Max (°C)	-364.8** (0.06)	-1142.98* (0.06)
May Max (°C)	-81.18NS (0.63)	-54.86NS (0.93)
June Max (°C)	122.46NS (0.60)	196.52 (0.84)
April Mini (°C)	-283.98NS (0.30)	-65.65NS (0.89)
May Mini (°C)	251.37NS (0.40)	406.36NS (0.5)
June Mini (°C)	281.33NS (0.15)	798.74NS (0.14)
April Rainfall (mm)	-4.14NS (0.30)	-.238NS (0.60)
May Rainfall (mm)	1.56NS (0.78)	.309NS (0.63)
June Rainfall (mm)	17.96NS (0.14)	2.03NS (0.63)
Technology	20.59NS (0.50)	-23.08NS (0.43)
Constant	17899.0*** (0.01)	6206.3** (0.05)

*** indicated significant at 1% ** indicated significant at 5% * indicated significant at 10%

The below 4.7 table show the results of fixed effect model for Onion crop of Punjab and Sindh districts, which show some positive and negative relation with the dependent variable yield. Whereas, both values are in the table but we explain the value of log linear model which more appropriate value for discussion. However, the maximum temperature of April month is show positive relation with the yield and significant at 5%. This show that 0.07 percent variation in the temperature effects the yield of crop positively by 7.97 percent. While maximum temperature in the stage of maturity effects the crop yield negatively and significant at 1%, this indicate that 0.01 percent variation in the stage of maturity negatively effects the yield by -14.96 percent respectively which is mention in the below table. Moreover, the minimum temperature variation in the stage of vegetative is positively and significantly, effects crop yield. This indicate that .05 percent change in temperature increases the yield of crop by 2.72 percent respectively. While variation in temperature in the stage of maturity effects the yield of crop significantly. This show that .01 percent variation in temperature negatively effects the yield by -0.23 percent. Furthermore, variability in rainfall in the stage of maturity also effect the crop yield negatively. Implying that .04 percent, changes in rainfall effect the crop by -0.007 percent, which is mention in the table. Further the technology show negative relation but significant means the new varieties of crops are not introduce yet. Nevertheless, there are some insignificant variables such as fertilizer, water, May maximum temperature, April minimum temperature as well as two rainfall, these are insignificant in our model.

Table 4.7: Estimation result of fixed effect model for Onion Crop.

Variables	**Coefficients**	**Coefficients of Log linear model**
Fertilizer NPK (Kg/Ha)	-6.47^{NS} (0.3)	-334.97^{NS} (0.20)
Water withdrawal (cubic meter/Ha)	-.9735^{NS} (0.48)	398.73^{NS} (0.52)
April Max (°C)	1393.2** (0.04)	7975.22** (0.08)
May Max (°C)	-38.63^{NS} (0.9)	-860.86^{NS} (0.67)
June Max (°C)	608.0^{NS} (0.42)	-14960.17*** (0.00)
April Mini (°C)	-1088.7** (0.07)	-3732.37^{NS} (0.14)
May Mini (°C)	1097.71** (0.03)	2720.36** (0.05)
June Mini (°C)	-416.52 ^{NS} (0.5)	-1667.23* (0.13)
April Rainfall (mm)	5.49^{NS} (0.12)	6.98^{NS} (0.39)
May Rainfall (mm)	34·21 ^{NS} (0.24)	2.12^{NS} (0.65)
June Rainfall (mm)	-20.56^{NS}	-7.52**

	(0.35)	(0.04)
Technology	-260.49** (0.02)	-377.12** (0.01)

Prob: 0.00 *** indicated significant at 1% ** indicated significant at 5% * indicated significant at 10%

The given 4.8 table represent the results of fixed effect for Potato crop of Punjab and Sindh districts, which represent some positive and negative relation with the yield of crop. Whereas the nutrient content of fertilizer NPK (Nitrogen, Phosphorus and potassium) is show negative and significant relation with the yield of potato, its means the over use of fertilizer decrease the productivity of potato crop in the selected districts. While the water withdrawal also indicate negative and significant relation with the yield of potato, its means the former's are over use the irrigation water.04percent over use of water decline the productivity -0.48 percent, which is mention in the given table. Moreover, the maximum temperature of October month is positively related and significant as well at 5% level. This show that .01 percent change in temperature will positively effects the yield by 0.03 percent. Furthermore, December maximum temperature also indicate negative and significant relation with the crop yield. While rainfall in the stage of sowing is represent show positive and significant relation with the dependent variable, this indicate that minor variation in rainfall will increases the yield of crop by 0.02 percent respectively. Whereas, rainfall in the process of vegetative show negative and significant relation. This demonstrate that .01 percent variability in rainfall effects the crop yield negatively by -0.04 percent, which is mention in the above table. Although, the technology is also positively contribute to the crop yield, imply that small change in technology will increases the yield of tomatoes by .02 percent. Furthermore, the maximum temperature of November month and all three minimum temperature as well as December rainfall these are insignificant variables in our model.

Table 4.8: Estimation result of fixed effect model for Potato Crop

Variables	Coefficients	Coefficients of Log linear model
Fertilizer NPK (Kg/Ha)	-29.03** (0.008)	-166.05NS (0.10)
Water withdrawal (cubic meter/Ha)	-3.59** (0.04)	-531.74*** (0.00)
Oct Max (°C)	696.91NS (0.26)	1037.10 (0.13)
Nov Max (°C)	-138.0NS (0.84)	-224.99NS (0.75)
Dec Max (°C)	-433.32NS (0.44)	-619.89NS (0.12)
Oct Mini (°C)	-235.02NS (0.77)	860.29** (0.08)
Nov Mini (°C)	961.26NS (0.21)	280.29NS (0.40)
Dec Mini (mm)	68.88 NS (0.93)	23.27NS (0.88)
Oct Rainfall (mm)	66.31NS (0.20)	2.76NS (0.10)
Nov Rainfall (mm)	-118.35** (0.06)	-4.15** (0.02)
Dec Rainfall (mm)	15.18NS (0.42)	0.61NS (0.90)
Technology	908.33*** (0.00)	170.10*** (0.00)

Prob: 0.00 *** indicated significant at 1% ** indicated significant at 5% *indicated significant at 10%

The table 4.9 show the results of fixed effect model, of the Tomatoes crop for Punjab and Sindh districts, which represent some positive and negative relation with the dependent variable yield. However, in the study, we used both model but the coefficients of log linear model is more appropriate for explanation. Whereas the water withdrawal indicating negative and significant relation with the dependent variable yield. This indicated that .01 percent over uses of irrigation water would lead to decrease the yield of crop by -.22 percent. While the maximum temperature in the time of sowing is also negative and significant, represent that show that variation in temperature in the time of sowing will lead to decline the yield of crop by -.04 percent this is the critical time for selected crop. Moreover, minimum temperature in the time of vegetation is beneficial for crop yield. This shows that in the time of vegetation variation in the minimum temperature by .01 percent will lead to enhance the crop yield by .02 percent respectively. While rainfall in the time of vegetation is also not harmful for crop yield, this indicates that little variation in rainfall in the stage of vegetative is increases the crop yield by .002 percent, which is mention in the above table. Thereby the nutrient contents of fertilizer (NPK) two maximum, minimum temperature and two rainfall , technology these are insignificant in our model, the detail are in the above table.

Table 4.9: Estimation result of fixed effect model for Tomato Crop

Variables	Coefficients	Coefficients of Log linear
Fertilizer NPK (Kg/Ha)	-.552^{NS} (0.81)	.3868^{NS} (0.16)
Water withdrawal (cubic meter/Ha)	-.492^{Ns} (0.19)	-0711^{NS} (0.12)
April Max (°C)	-305.45^{NS} (0.10)	-502.78** (0.04)
May Max (°C)	-134.19^{NS} (0.42)	-35.59^{NS} (0.10)
June Max (°C)	127.96^{NS} (0.56)	-8.62^{NS} (0.66)
April Mini (°C)	47.57^{NS} (0.94)	2.28^{NS} (0.93)
May Mini (°C)	47.57^{NS} (0.94)	21.33^{NS} (0.51)
June Mini (°C)	172.45^{NS} (0.56)	27.06^{NS} (0.44)
April Rainfall (mm)	12.66^{NS} (0.94)	9.83^{NS} (0.65)
May Rainfall (mm)	-2.65^{NS} (0.49)	-.2447^{NS} (0.58)
June Rainfall (mm)	15.99^{NS} (0.15)	2.31** (0.07)
Technology	1.34^{NS} (0.96)	-2.21^{NS} (0.56)

Prob: 0.002 *** indicated significant at 1% ** indicated significant at 5% * indicated significant at 10%

CHAPTER 5
QUALITATIVE WORK.

In the qualitative part of the study conducted online interviews from agricultural and environmental experts, on effect of climate change on vegetables production in Pakistan. However, climate change is a global problem every country in the world is facing this issue but some countries has worst impact including Pakistan because of unavailability of resources. Pakistan is the country whose 76% of the population is rely on this agriculture sector but severe implications of climate change is impacting this sector adversely. Which means that people who are connect with this sector their income and living standard will be affect, so thinking of new strategies and methods to mitigate the impact of climatic variation is very important to save Pakistan for future consequences.

5.1 interview Questions

- How would you characterize climate change in the present-day context?
- Does it have any effect on agricultural productivity in over-all?
- According to my study, production of crop has increased over time but the productivity isn't up to the mark.
- To what extent climatic changes could be the reason for this downfall
- At what stage of vegetable production, climate change adversely affect the overall yield.
- What possible strategies and measures can we adopt to mitigate the effect of climatic variations on agricultural productivity?

5.2 Discussion with Experts

In view of experts, many factors have an impact on climate change. if we talk about the condition of Pakistan the hap hazard towards industrialization means we haven't planned anything for industrialization but we jumped to it from agriculture sector because of which we have destroyed our trees, farms and now one tree is providing oxygen to 20 people which in an alarming situation. In opinion of experts, climatic conditions directly related to the environment of any place and we cannot control it artificially except using different fertilizers to improve the quality of crops and use different technology to enhance the yield productivity. Many countries in west have adopted new technology in order to deal with climate change BT technology is an example, which was adopted by the west countries.

According to experts, the major problem in agriculture sector of Pakistan is that farmer is unaware about the climatic conditions. Along with this how to tackle the new problems we are facing with the change in environment. Therefore, to improve the quality of crops we should give skills and knowledge to the farmers as because of this change, new pests are generating and we have no appropriate pesticides to protect the crops. And our farmer don't know how to use the new technology either that is why Pakistan has not adopted the new technology which means that they were unable to cope with the problem like universe did.

One of our experts suggested that as good environment has an impact on human mood. if their environment and surroundings are going to be appropriate they will be productive and active, same is the case with crops if the climatic conditions in which they are growing is going to be appropriate then they will grow and their production will increase over the time.

In the view of experts, specific climatic temperature is important at every stage of production to get the better quality of crops and increase the yield productivity. As there are some stages of production like germination and vegetation are the initial ones. According to experts if we are facing problems in these stages, we can tackle with them somehow by doing germination again or by using different techniques like animals and pesticides to solve the problem. However, the worst impact of climate change is on the stage of reproduction as we cannot do anything in that stage so experts say we should be aware about the future severity of climate and go for the crops, which can give productivity in severe climatic conditions.

One of the expert suggested that back in 1980 there were severe climatic conditions, which affected our crops badly. Vegetables primary production for Pakistan is 7.07 million tons. Therefore, agriculture is extremely vulnerable to climate change, particularly in Pakistan, due to the country's arid and semi-arid climate. A rise in temperature could have a greater impact on arid and semi-arid areas than on humid places. A number of climate variables, including rainfall patterns, rising temperatures, and higher CO_2, are affecting vegetable production in Pakistan.

The agricultural industry provided 53 percent of Pakistan's GDP in 1949-50, but this plummeted to 31 percent in 1980-81 and 21.4 percent in 2012-13. During 2010-11, the agriculture sector grew by 1.2 percent. The flood of July-August 2010 flooded the most fertile and productive part of 17 million acres of cultivated land. This fertile and productive region of the country can be referred to as the "food and economic basket" of the country. The affected region accounts for 16% of the country's agricultural land. This region of the country known for its crop cultivation, including vegetables, fruit farming, and fodder crops. The total loss to agriculture was estimated to be Rs. 429 billion. Punjab suffered the greatest crop cultivation losses (661 637 hectares), followed by Sindh (357 372 hectares), KPK (191 020 hectares). According to experts, Pakistan loses $5.2 billion every year because of environmental degradation.

CHAPTER 6
CONCLUSION AND POLICY RECOMMENDATIONS

The outcome of the study shows that climate change is affecting the yield of vegetables significantly in the selected districts of Punjab and Sindh province. However, their impact varies across the different stages of the vegetable crop. Whereas, variation in maximum temperature in the stage of maturity negatively affects the crop yield, while changes in minimum temperature in the flowering time affect the crop yield positively and significantly. This demonstrates that a variation in maximum temperature by .01 percent will decline the crop yield by -14.9 percent. In addition, a 0.4 percent variation in minimum temperature in the flowering stage will increase the yield of the onion by 3.06 percent respectively. Moreover, rainfall at the time of maturity is also negatively significant and affects crop yield. This indicates that a variation in rainfall in the stage of maturity by .04 percent will lead to affect the crop yield by .07 percent respectively.

Climate change is not only one factor that affects the vegetable crop, but also many other factors that affect the vegetable crop namely irrigation water. However, overuse of irrigation water also affects the potato crop yield negatively. This shows that a .07 percent increase in irrigation water will decline the yield of potatoes by -0.42 percent. Moreover, variation in the maximum temperature in the stage of sowing and vegetative is negatively affected the crop yield. This indicated that a .07 variation in temperature would effects the crop yield by -2.82 percent respectively. While the minimum temperature at the time of sowing and flowering is a positive effect on crop yield. This demonstrates that a .02 percent variation in both stages will affect positively the crop yield by 1.9 and 1.2 percent.

On the other hand, for some vegetable crops like tomatoes, the variation in maximum temperature in the stage of maturity is positively affected. This indicates that in the stage of maturity.04 percent variation in temperature positively affects the yield of tomatoes by 0.19 percent. Whereas, .06

variation in maximum temperature in the stage of sowing negatively and significantly affects the tomatoes yield by -1.14 percent respectively.

Policy Recommendation

Pakistan is one of the countries that have the worst impacts of climate change and in the future, if we will ignore them further consequences will be more serious so the following are the policy recommendations in order to mitigate the impact of climate change. The Pakistan Environmental Protection Act, 1997 requires that no person may import hazardous substances of which chemical activity is toxic, explosive, flammable, corrosive, radioactive, cause directly or in combination with other matters, an adverse environmental effect.

- Pakistan should adopt a climate-smart agriculture concept as one of the key solutions. Climate-smart agriculture is an approach to farming that aims to sustainably increase agricultural productivity and income, while also building resilience to climate change and reducing greenhouse gas emissions. The approach recognizes that agriculture is both a contributor to climate change and one of the sectors most affected by its impacts. Therefore, it seeks to mitigate greenhouse gas emissions, adapt to climate change, and improve food security, while also promoting sustainable land management, biodiversity conservation, and ecosystem services.
- Climate-smart agriculture stimulates the assimilation of agriculture expansion and climate receptiveness to accomplish food security and growth targets under the shifting weather and rising food requirements.
- Various studies suggested some policy recommendations that climate change is not equally affected overall countries with the same scenario but different regions have different climate

situations. The government should introduce climate policy on the bases of local regions as compared to the national.

A several types of technologies that can introduce to mitigate the adverse effect of climate change. Here are a few examples:

Renewable Energy Technologies: The deployment of renewable energy technologies such as solar, wind, and hydropower can reduce greenhouse gas emissions and help to mitigate climate change. Renewable energy sources can replace fossil fuels, which are a major contributor to greenhouse gas emissions. Carbon Capture and Storage (CCS): CCS is a technology that captures carbon dioxide emissions from industrial processes and stores them underground. This technology can reduce greenhouse gas emissions from industrial processes and mitigate the impact of climate change.

Electric Vehicles: The use of electric vehicles can reduce greenhouse gas emissions from the transportation sector and mitigate the impact of climate change.

Climate Information and Early Warning Systems: The development and deployment of climate information and early warning systems can help to mitigate the impact of climate change by enabling communities to prepare for extreme weather events, such as floods, droughts, and storms. These are just a few examples of new technologies that can introduce to mitigate the adverse effects of climate change. It is important to note that the deployment of these technologies should accompanied by policies and strategies that support their adoption and implementation.

- The farmers need more attention to the knowledge of soil, first should test the land and then use water and fertilizer according to crop and land requirements because overuse of water and fertilizer also negatively affect the crop.

- The government should introduce a new variety of crops, which have the capability of high-temperature tolerance.
- Furthermore, some studies recommended that the population is going up continuously, and in the coming future country will face huge problems with food security and food production; the government should tackle this problem and ensure sufficient food for the coming future.
  - Modification of cropping patterns with respect to climatic conditions Pakistan is facing should be focused on
  - The vegetable crop needs more attention and needs proper research on the crops first then on the land and climatic condition of the specific region then crops should be cultivated in the regions where the land and the climatic condition are suitable for them.
  - Lastly, the different studies recommended some mitigation strategies as the production of new types that have the capability of droughts and heat stress for future challenges and climate scenarios.

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