Demarcation of Micro Agro-Climatic Zones of Punjab, Pakistan

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https://doi.org/10.62345/jads.2025.14.1.132

Abstract

The purpose of this research was to divide Punjab into micro agro-climatic zones of homogeneous characteristics of climatic variables (temperature, precipitation, and humidity) concerning agricultural production. For the delineation of Punjab into agro-climatic zones, precipitation, temperature, and humidity regime, major crops were grown and agricultural productivity was taken into consideration. The different map layers were prepared using suitable databases and methodologies. At the end, different map layers were prepared and an agro-climate zones map was generated which reflected different agro-climatic zones. There were 4 major and 9 micro agro-climatic zones generated. Major zones were defined based on Koppen and Geiger climate classification, as well as micro-level zonation, which was based on the expert's opinion method. The highest average precipitation (1244 mm) and lowest temperature (22 OC) were seen in zone, 1cwa while the lowest precipitation (133 mm) and mean monthly highest temperature (26 OC) were observed in zone 1Bwh. The average highest concentration of humidity (64%) was recorded in zone Cfa as well as the lowest ratio (54%) was seen in the 2Bwh zone. Wheat's highest production (783 thousand metric tons), sugarcane's highest production (3745 thousand metric tons), and cotton's highest production (1066 thousand metric bales) were observed in zone 1Bwh and rice's highest production was seen in zone Cfa. The lowest crop yields were observed in the 1Cwa zone.

Keywords: Agro-climatic Zone, Crop Pattern, Productivity, Demarcation, Zonation.

Introduction

Agro-climatic classification systems distinguish the various features in different agro-climatic regions and highlight the implications for water and agriculture sectors in light of climate change (Haider & Ullah, 2021). The impact of climate change and its variability had a substantial link regarding agricultural production across the world and topographic patterns agricultural production is mainly affected by climatic variables such as precipitation, temperature, and humidity as well as the intensity and frequency of these events (Maximova et al., 2019). Future projections show that global temperature will increase by about 2.5 C up to 20250. The agro-

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Compliance with ethical standards: There are no conflicts of interest (financial or non-financial). This study did not receive any funding.

climate zone is a terrestrial part in terms of the main climate suitable for a specific range of crops and cultivated. An agro-climate zonation scheme is the standard tool for prioritizing agricultural research because it offers relevant information about the target environment (Ganaie et al., 2014). Agro-climatic classification is a technique that allows the explanation and generalization of climatic data to define climatic types in terms of basic climatic parameters (Chaudhry & Rasul, 2004). This zoning may help to adjust cropping season according to moisture, temperature, vegetation, and their combination regime. Agro-climatic zones indicate ecological conditions and agricultural potential concerning temperature or moisture conditions of the area or the region (Singh & Aggarwal, 2018).

Climate change is not just affecting the rainfall intensity but also reduces about 250mm in many parts of the country which directly affects the infrastructures linked to agriculture and crop production such as irrigation systems, canals, and water storage. Crop production in Pakistan is significantly affected due to receiving less rainfall and an increase in temperature (Imran et al., 2018). About 77% area of total cultivated and irrigated land in Punjab is irrigated with lesser amounts in other provinces. Climatic conditions have a large impact on crop production in different climatic zones (Bhatla et al., 2020). The climate of Pakistan is divided into different vast zones like humid sub-humid arid and semi-arid type but these zones show variations in climatic elements like temperature and rainfall in each zone. Pakistan depends on monsoon rainfall due to the heavy and frequent rainfall in different zones of the study area agriculture is at great risk. This extreme type of climate, the Punjab is divided into different zones of low and high crop failure and risk-free zones. The purpose of this research is to highlight the climate characteristics that are different from their neighbouring regions. The study of climate characteristics of the study area helps to assess agro-climate potential, the plants suitable for this region, the crop variety of the study area, and the ability to produce high crop yields (Chaudhry & Rasul, 2004).

Agriculture played a vital character in the economy of developing countries of South Asia and also Pakistan.it is the basic and most important part of the economy. Pakistan's agricultural production contributes 19.5 % of the gross domestic product of the country with an annual growth of 2.7% and the highest share is from Punjab. Agriculture offers working opportunities for 42.3% of the labour force. 62% percent of the rural residents depend on their livelihood in this sector. Pakistan has great diversity in its geography like natural resources, and also has many ecological and climatic regions. Climate deviation arid high desert with 5000-meter altitude in north and coastal subtropical region to the south (survey, 2016-17). According to the annual report of the State Bank of Pakistan, climate change was considered to be a huge disaster for the economy of Pakistan. It was expected that in 2020 there would be a decline of 1.5 to2.6 percent in wheat production of Pakistan which is one of the major crops of Pakistan (Sonia *et al.*, 2019)

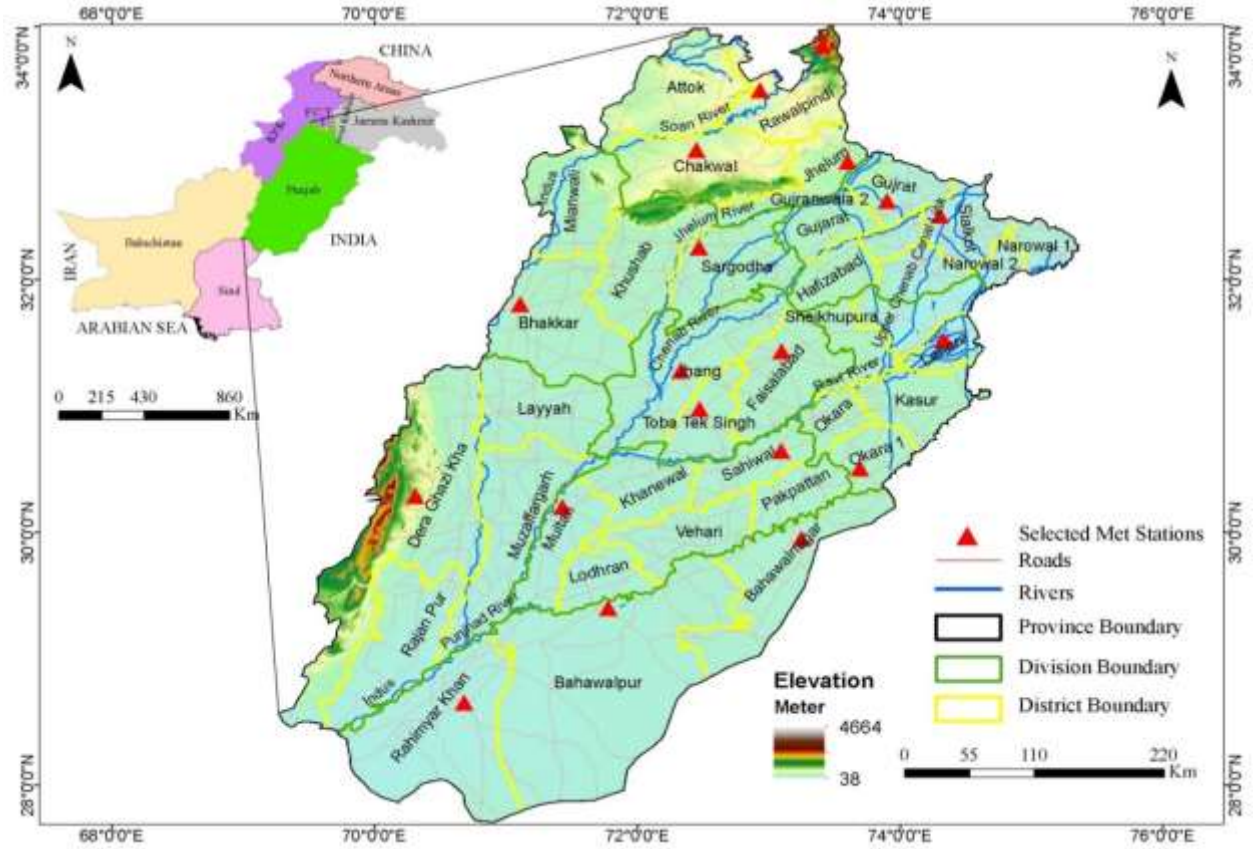
Methodology

Physiography and Climate of the Study Area

The area of Punjab mostly consists of an alluvial plain formed by the southward-flowing Indus River and its tributaries (Jhelum, Chenab, Satluj, and Ravi). The alluvial flood plain has a diversity of landforms, its active flood plains are flooded every rainy season. In 2010, 2011, 2012, 2013, and 2014 there was severe flooding. In 2010, a disastrous flood occurred in Pakistan due to monsoon rainfall in which more than 17,00population killed, and more than 20 million people were affected. There developed food insecurity of at least 7.8 million people and over US$ 16 billion in economic loss. In the 2010 flood, 0.42 million hectares of crops were affected. As a result of this flood, there was a loss of 7.5 million tons of sugarcane, 2.5 million tons of rice, 0.7 million

tons of cotton, and 0.3 million tons of maize. In 2012, 0.19 million 2013, 0.30, and 2014, 0.98 million hectares of crop area in Punjab province were affected by flood. More than 2.5 million people were affected by the floods and rainfall In September 2014, 367 people died and 129,880 houses were fully destroyed. 250,000 farmers and over 1.0 million acres of agricultural land were affected, and there was a big loss of standing food and cash crops. Punjab is situated on the margins of the monsoon climate and the temperature is generally high. Agriculture is the major source of income and occupation. Major crops are wheat and cotton. Other crops grown include rice, sugarcane, millet, corn, oilseeds, pulses, fruits, and vegetables.

Figure 1: Map of study area



Source: Author, 2019.

Acquisition of Climatic and Agricultural Data

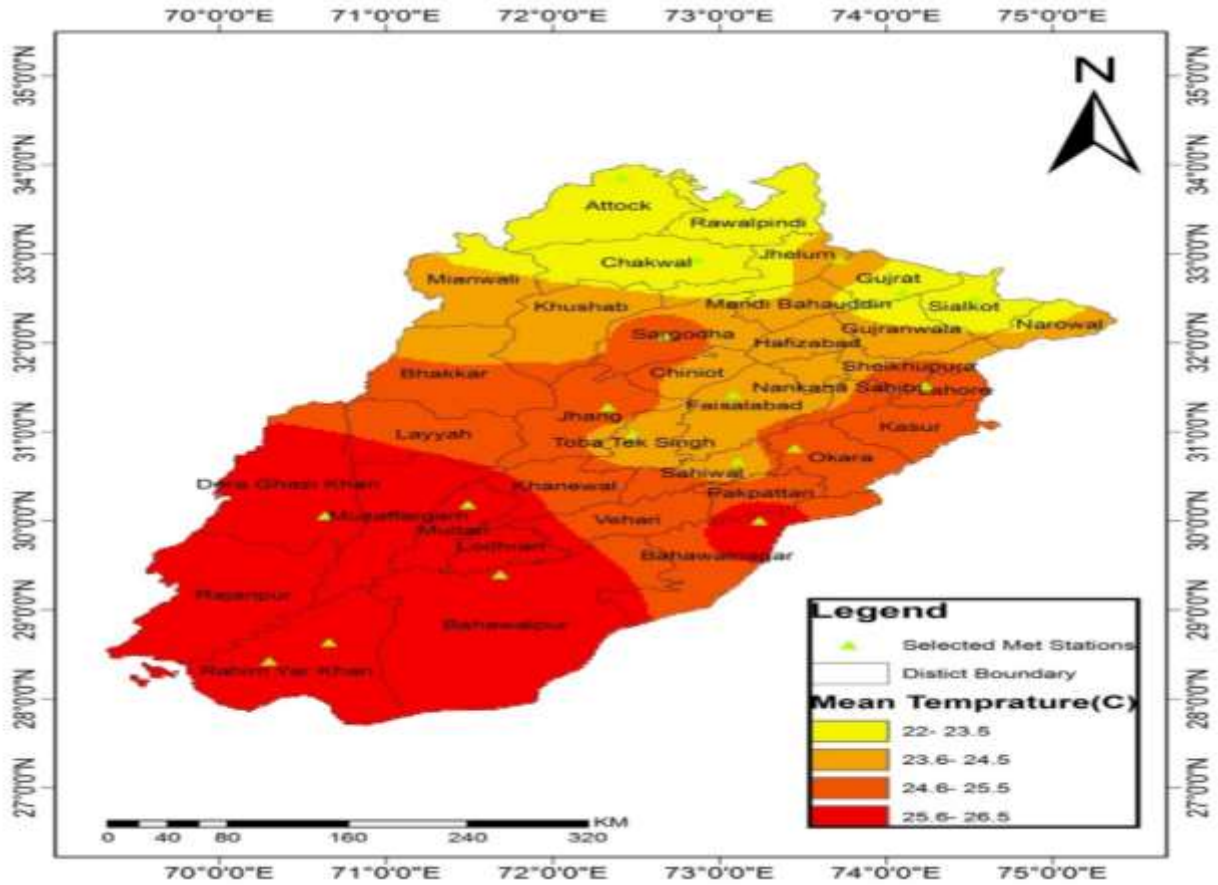
Climatic elements precipitation temperature and humidity data of 18 stations Bahawalnagar, Bahawalpur, Khanpur, Rahim Yar khan, Dera ghazi khan, Multan, Sahiwal, Okara, Toba Tek Singh, Jhang, Faisalabad, Sargodha, Lahore, Gujrat, Sialkot, Jhelum, Rawalpindi, Kamra of Punjab were collected from regional metrological head office jail road Lahore to see that which area had what kind of climate. This data was collected for last 30 years 1988-2018. Agricultural data of crops yields (wheat, cotton, rice and sugarcane) was collected from regional office of Punjab agricultural development and statistical bureau Satiyana road Faisalabad.

Data Processing and Analysis Preparation of Precipitation Temperature and Humidity

Firstly, stations were identified and a boundary map was prepared by utilizing geographic information system (GIS) 10.3.1. In descriptive statistics Climo graphs and histograms were used

to show the variation of these quantitative variables with respect to years. The precipitation temperature and humidity data was arranged and arithmetic averages were obtained. This data file is converted into CSV (MS-DOS). At the end, a database was prepared in GIS (Geographical information system) and the data file which was combining with it by exporting XY coordinates. After preparing the database spatial statistical analysis were utilizing. Interpolation method Kriging and IDW (inverse distance weighted) were applied. The data which we export was point data, this was converted into polygon by using spatial statistical tool point into polygon in Arc toolbox. Furthermore, with the help of extract by mask tool data extension was done within the Punjab boundary. At the end, the properties of final database and changed the symbology by defining the classes from classify tool and interval was given by manual method because the classes were defined according to Koppen and Geiger limits. These maps were generated which reflect the different major zones of these climatic elements.

Figure 2: Mean annual temperature

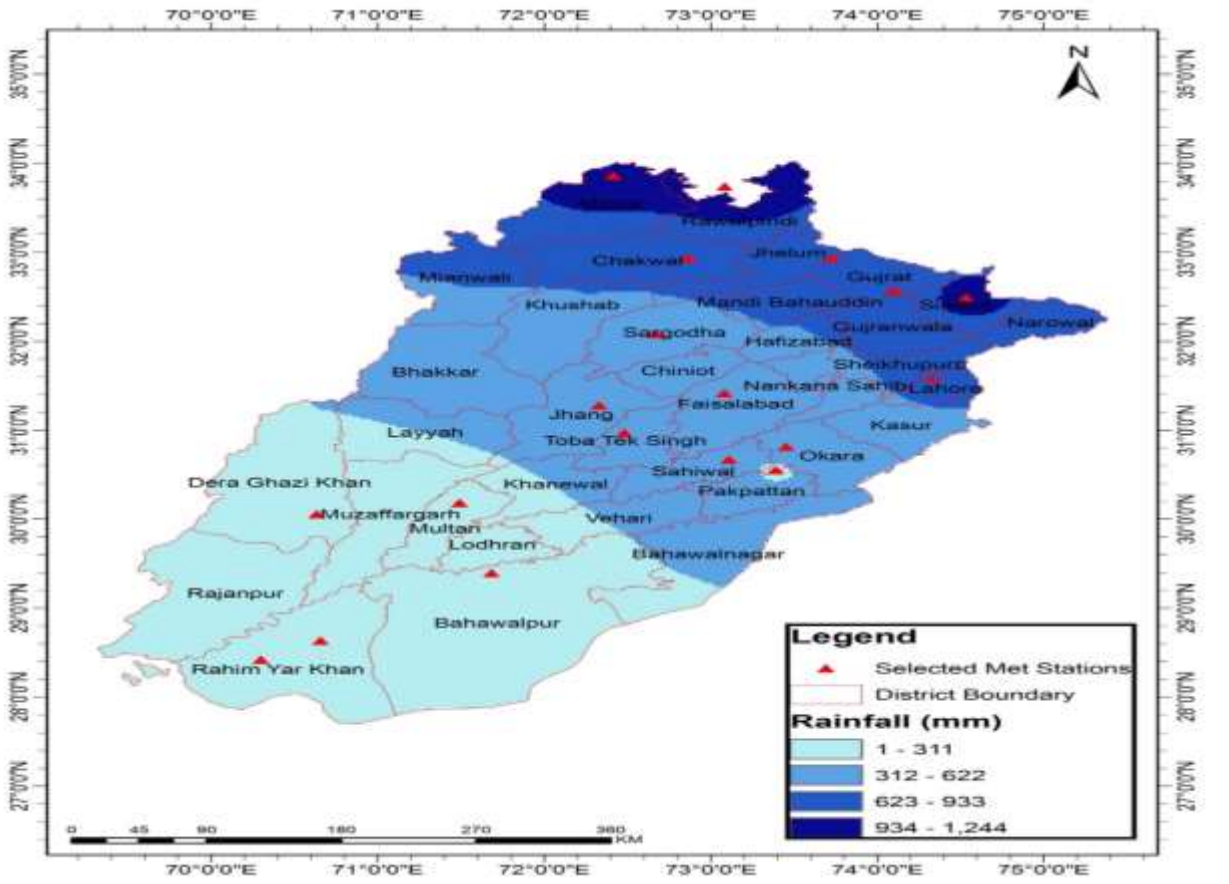


Source: Author, 2019.

Figure 2 indicates the temperature variation in different areas of Punjab. Class one limit was form 25.6-26.5^{o}C which was given manually with the help of data limits. In this class southern part of Punjab most areas were occupied. Districts of Bahawalpur, Dera Ghazi Khan, Rajanpur, Rahim Yaar Khan and Multan covered by this class. In these areas temperature ratio was kept very high. Second class was 24.6-25.5^{o}C. In this class temperature concentration was lower than class one and it covers the districts of Bahawalnagar and to the central Punjab Layyah Pakpattan, Bhakkar,

Khanewal, Vehari, Okara, Sahiwal, Sargodha and Lahore some parts. Politically divided called southern and lower areas of central Punjab, western and eastern areas were covered by this class. Next class had 2nd lowest temperature ratio in Punjab and its limits were 23.6-24.5ºC. This class covered the areas of Mianwali, Gujranwala, Faisalabad, Toba Tek Singh, Mandi Baha Uddin, Nankana Sahib and Narowal. Lowest temperature was received in this zone which was limited 22-23.5oC. This zone covered the northern areas of Punjab like Attock, Chakwal, Rawalpindi and Sialkot.

Figure 3: Mean annual rainfall



Source: Author, 2019.

Figure 3 indicates the precipitation variation in different areas of Punjab. Class one limits was form 1-311 millimeter which was given manually with the help of data limits. In this class southern side of Punjab most area were occupied like Rahim Yaar Khan, 47
Bahawalnagar, Rajanpur, Dera Ghazi Khan and ends to the central Punjab Layyah some part of Sahiwal and Pakpattan districts. These areas were receiving very low ratio of rainfall. Second class was 312 to 622 millimeters. In this class precipitation was higher than class one and it covers the districts of Bhakkar, Jhang, Toba Tek Singh, Faisalabad, Sargodha, Khushab, Okara, Sahiwal, Nankana Sahib, Kasur, and lower areas of Mandi Bahauddin. Politically divided called central Punjab is covered by this class. Next class had 2nd highest precipitation ratio in Punjab and its limit were 623 to 933 millimeters. This class covered the areas of Mianwali lower Attock northern Jhelum southern Rawalpindi Gujrat, Gujranwala, Sheikhupura, Lahore, northern Chakwal and

Mandi Baha Uddin and southern Sialkot and Narowal. Highest precipitation was received in this zone which was limited 934-1244 millimeters. This zone covered the northern Attock, Rawalpindi, Sialkot, and Narowal.

Figure 4: Mean annual Humidity

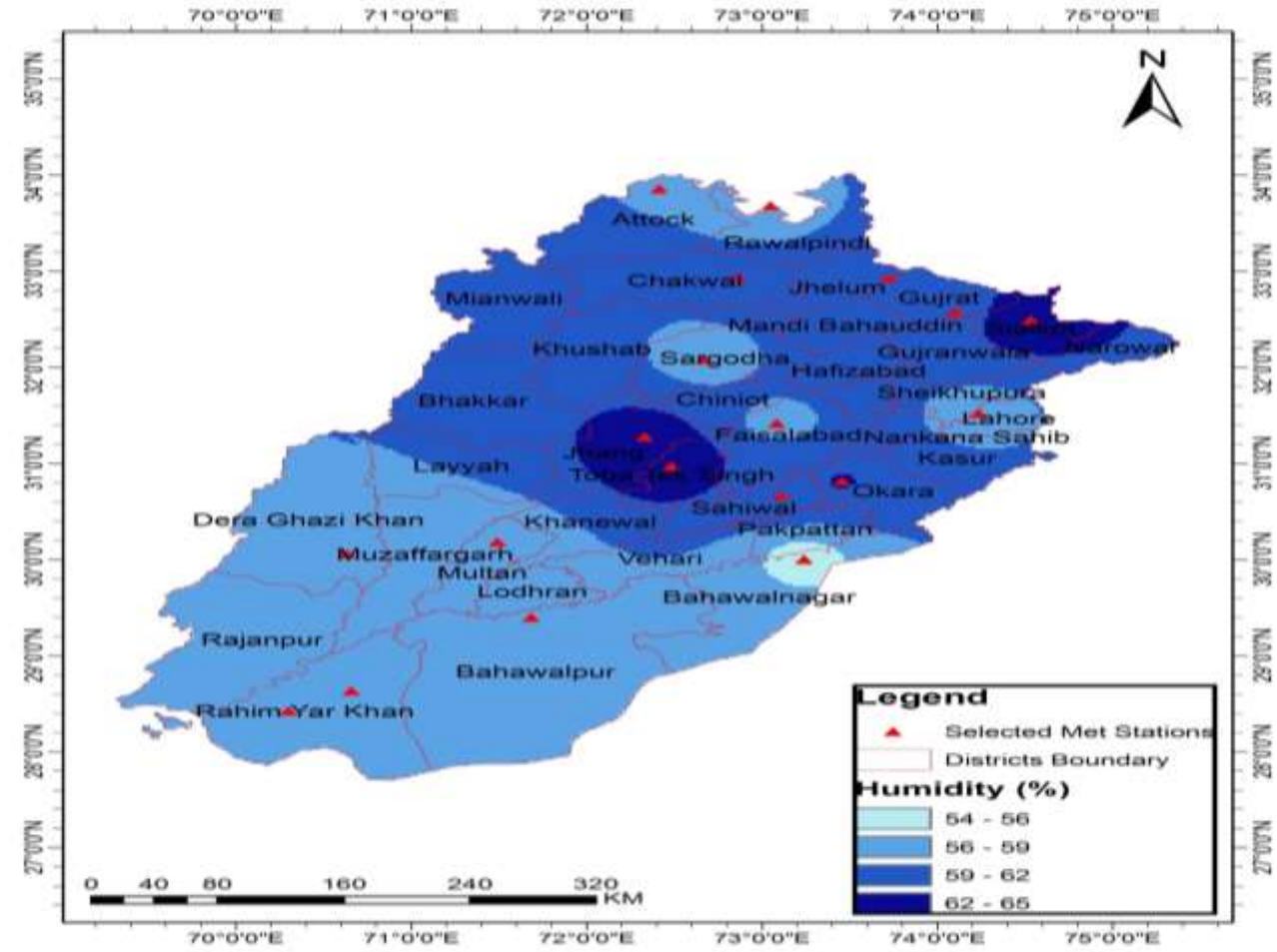


Figure 4 shown the humidity spatial variations in different areas of Punjab. Humidity was the key element of Punjab climate and it was also varied spatially and temporally as precipitation and temperature. Class one limit was forming 54-56 percent which was given manually with the help of data limits. In this class Punjab most area was occupied just one district Bahawalnagar. In this area humidity ratio was receiving very low. Second class was 57 to 59 percent. In this class humidity percentage was higher than class one and it covers the districts of Rahim Yaar Khan, Rajanpur, Dera Ghazi Khan, Bahawalpur and to the central Punjab Layyah Pakpattan, Bhakkar, Multan, Khanewal, Vehari, Faisalabad, Sargodha, Lahore and Sheikhupura some parts. Politically divided called southern and lower areas of central Punjab were covered by this class. Next class had 2nd highest humidity ratio in Punjab and its limit were 60 to 62 percent. This class covered the area of Mianwali, Attock, Jhelum southern Rawalpindi, Gujrat, Gujranwala, Chakwal and Mandi Baha Uddin, Nankana Sahib, Faisalabad, Okara, Sahiwal, Qasur and Narowal. Highest humidity was received in this zone which was limited 63-65 percent. This zone covered the northern Jhang, Toba Tek Singh and Sialkot.

Preparation of Crops Production Maps

Different maps needed to delineate the Punjab into micro agro climatic zones. These zones were prepared by using appropriate methods for each as presented below. Crop production maps were generating in Arc GIS 10.3.1. In Microsoft excel area wise mean was calculated by using this formula.

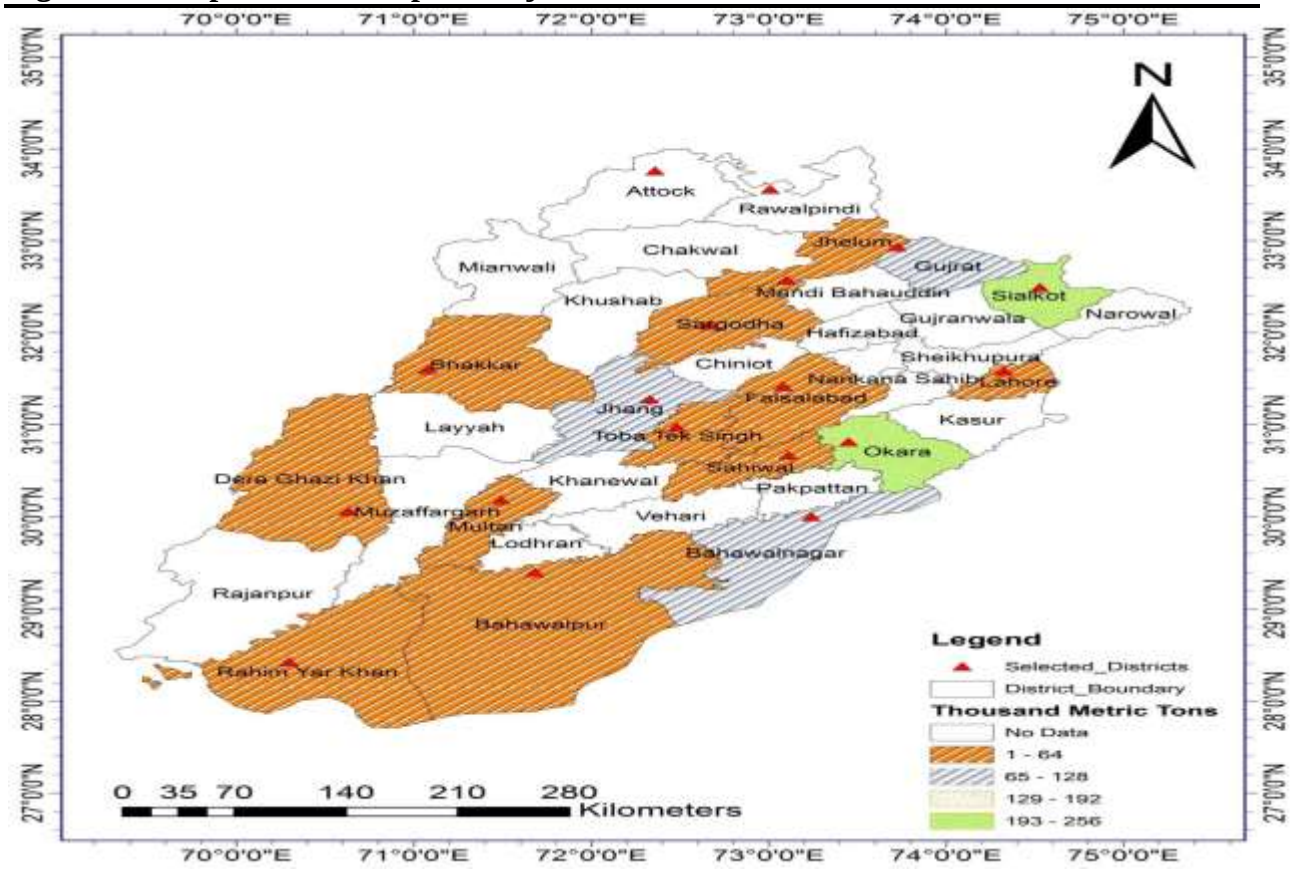
$$\bar{x} = (\Sigma x_i) / n$$

- $\bar{x}$ "just stand for the average/mean"
- Σ "means "submission"
- x_i "all of the x-values"

N "means the number of years by whom we take average"

This excel sheet was in the format of CSV (MS-DOS) because this format was just accepted by GIS. A district boundary map of Punjab shape file was prepared as a base map. After acquiring the base map CSV file data was export in shape file and thematic mapping were utilize to show the variations of production in different districts of Punjab.

Figure 5: Rice production map of Punjab



Source: Author, 2019.

Figure 5 indicates the rice production in the selected districts of Punjab. Data was classified in four major classes while 1st class is just shown no data districts. Data was divided into four classes just because of that climatic data was divided into four major classes which was determined by Koppen and Geiger. In 1 to 64 thousand metric tons district Rahim Yaar Khan with mean production of 28 thousand metric tons, Bahawalpur 12, Dera Ghazi Khan 51, Multan 15, Toba Tek Singh 40,

Faisalabad 37, Sahiwal 39, Bhakkar 2, Sargodha 56, Lahore 54 and Jhelum 2 thousand metric tons production which were the lowest production districts of rice in Punjab. 65 to 28 class Gujarat rice production was 66, Jhang 103 and Bahawalnagar had 82 thousand metric tons rice production. Next one class was 129 to 192 thousand metric tons. In this class there was no district found. At the end highest production class limit was 193 to 256. In this class district Okara and Sialkot were included with the highest rice production of 200 and 255 thousand metric tons. These two districts were having the mean highest production in last thirty years.

Figure 6: Sugarcane production map of Punjab

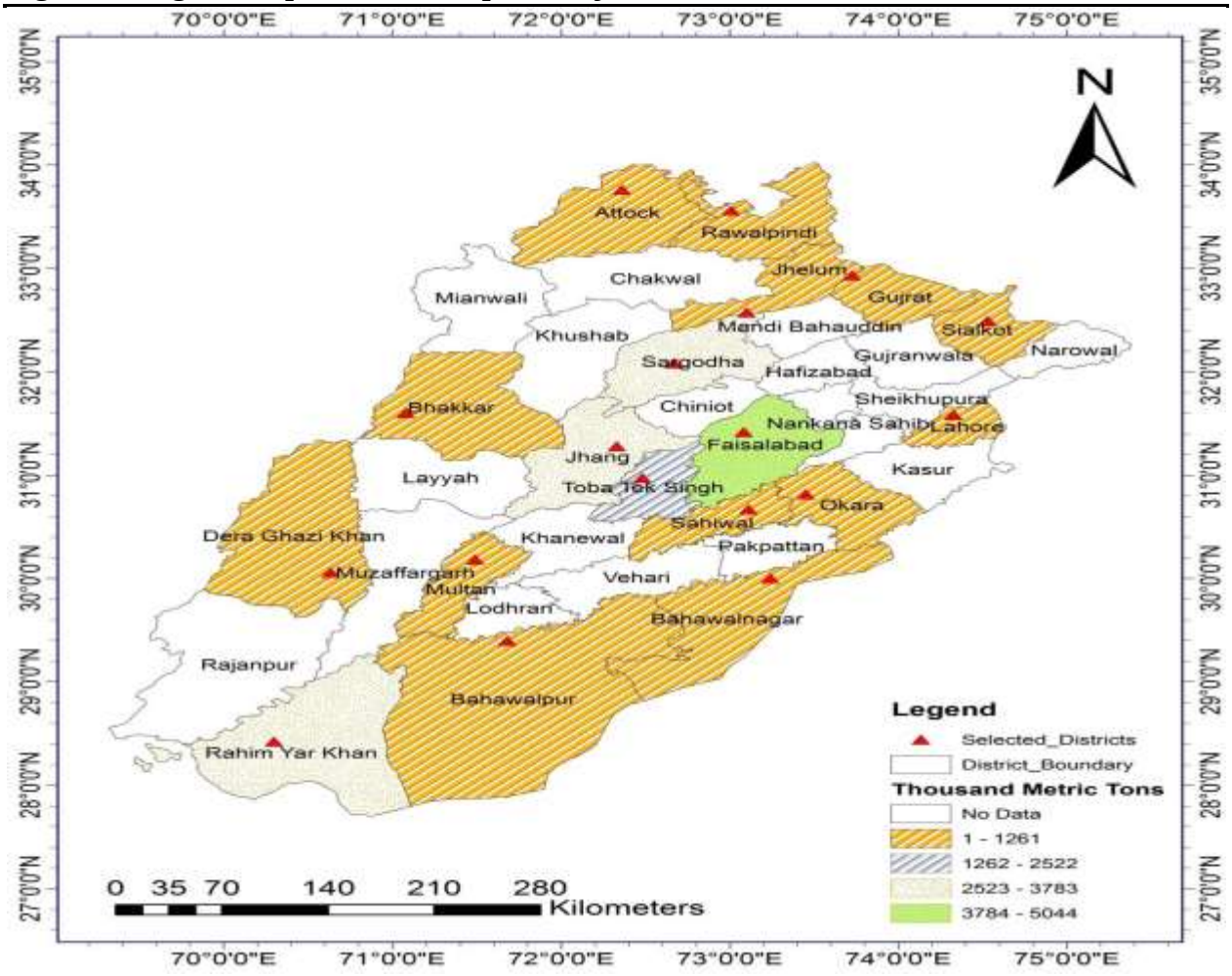
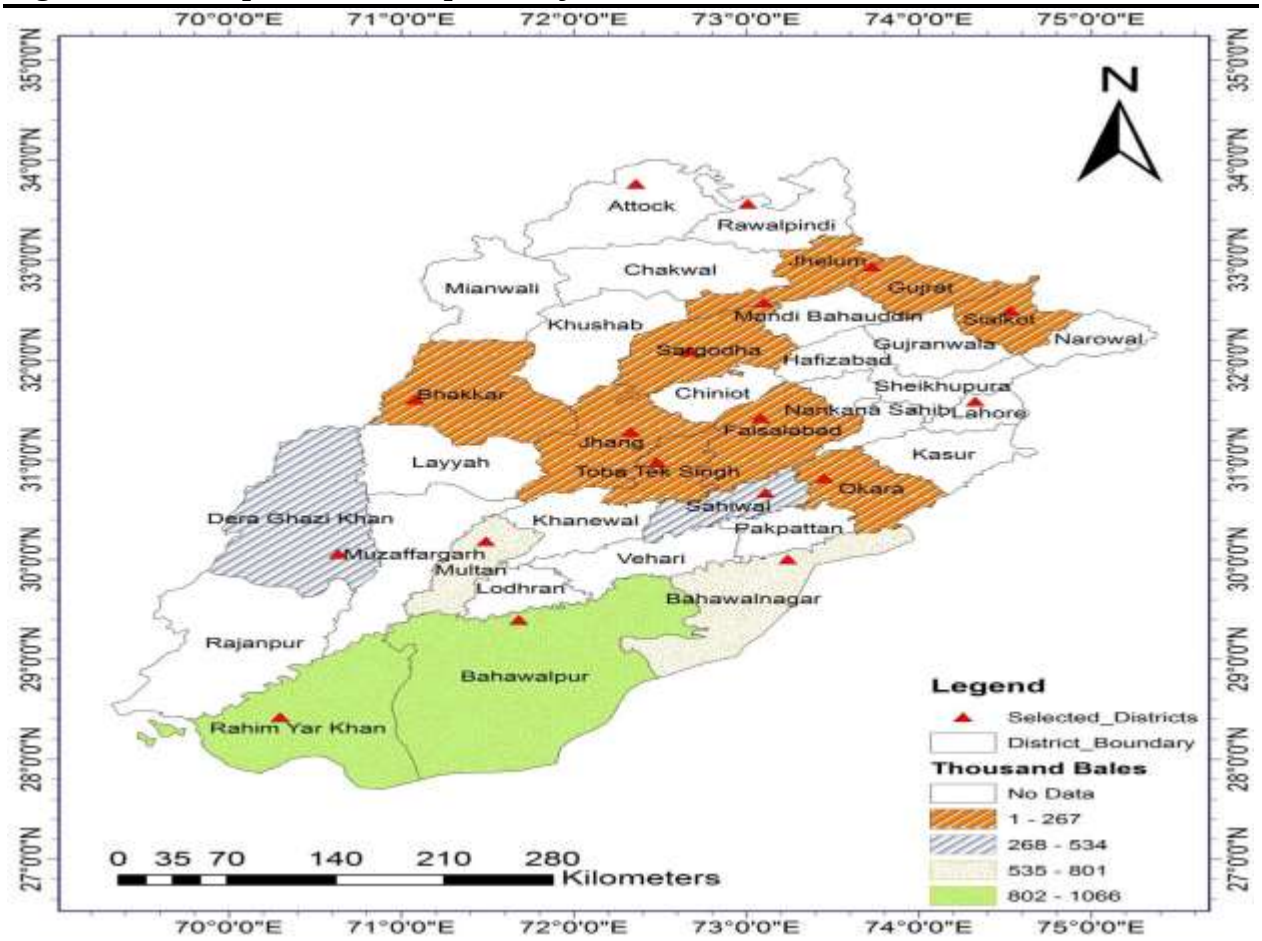


Figure 6 shows the Sugarcane production in the selected districts of Punjab. Data was also classified in four major classes same like earlier maps while 1st class was just shown no data districts. Data was divided into four classes just because of that climatic data was divided into four major classes which was determined by Koppen and Geiger. In 1 to 1261 thousand metric tons district Bhakkar with mean production of 762 thousand metric tons, Bahawalpur 663, Dera Ghazi Khan 153, Multan 145, Toba Tek Singh 40, Faisalabad 37, Sahiwal 619, Bahawalnagar have 1037, Okara 1072, Lahore 40, Jhelum 9, Sialkot 128, Gujrat 315, Rawalpindi 1 and Attock having 7 thousand metric tons production which were the lowest production districts of sugarcane in Punjab. 1262 to 2522 class just one district Toba Tek Singh include with 1991 thousand metric tons

sugarcane production. Next one class was 2523 to 3783 thousand metric tons. In this class district Sargodha 2851, Jhang 3305 and Rahim Yaar Khan 3745 having thousand metric tons production were including. At the end highest sugarcane production class limit was 3784 to 5044 thousand metric tons. Only one district Faisalabad was having the mean highest production of 5042 thousand metric tons in last thirty years.

Figure 7: Cotton production map of Punjab

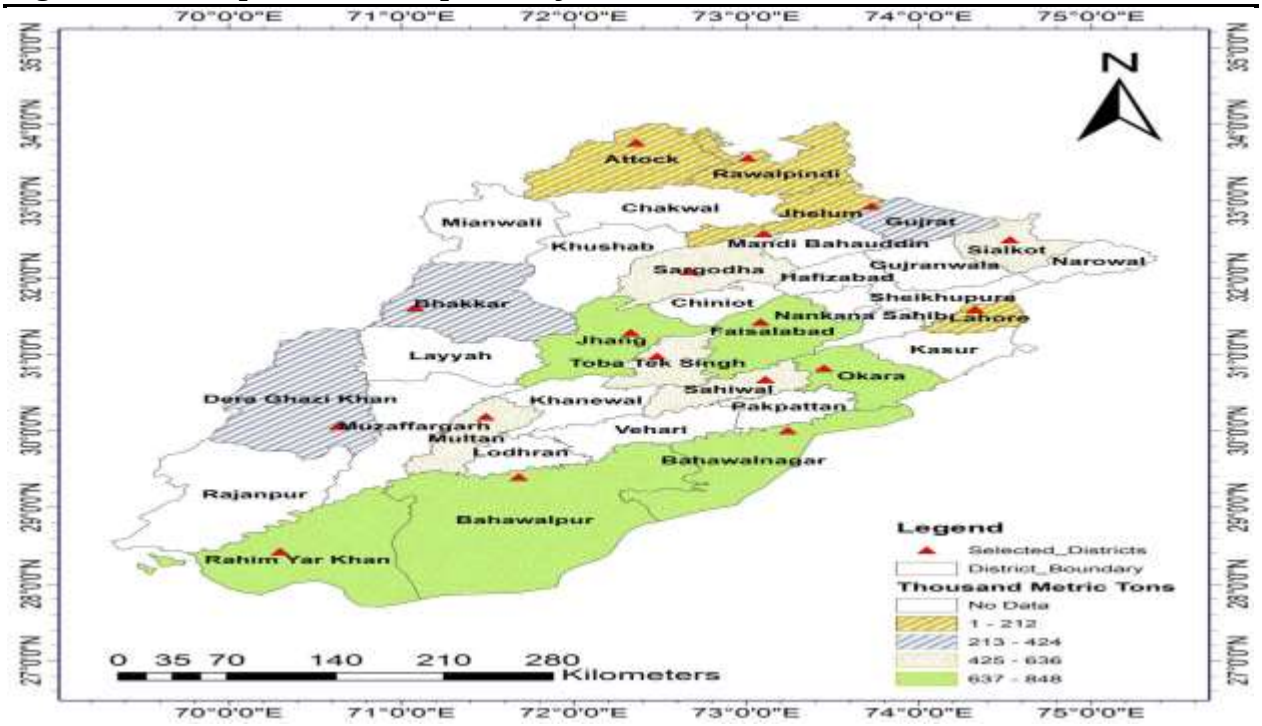


Source: Author, 2019.

Figure 7 shows the cotton production in the selected districts of Punjab. In the beginning of classes no data class was highlighted which reveals the no data districts. Data were divided into four classes just because of that climatic data was divided into four major classes which is determined by Koppen and Geiger. In 1 to 267 thousand metric tons district Bhakkar with mean production of 28 thousand bales, Toba Tek Singh 130, Faisalabad 107, Jhelum 1, Sialkot 1, Gujrat 3 and Sargodha having 21 thousand bales productions which were the lowest production district of cotton in Punjab. 268 to 534 class just two district Sahiwal and Dera Ghazi Khan include with 308 and 330 thousand bales cotton production. Next one class was 535 to 801 thousand bales. In this class district Bahawalnagar 770 and Multan having 716 thousand bales productions were including. At the end highest sugarcane production class limit was 802 to 1066 thousand bales. Only two districts

Bahawalpur and Rahim Yaar Khan were having the mean highest production of 1049 and 1066 thousand bales in last thirty years.

Figure 8: Wheat production map of Punjab



Source: Author, 2019.

Figure 8 indicates the wheat production in the selected districts of Punjab. Data was also classified in four major classes same like earlier maps while 1st class in this last map of agricultural productions were just shown no data districts. Data was divided into four classes just because of that climatic data was also divided into four major classes which were determined by Koppen and Geiger. In 1 to 212 thousand metric tons production of wheat districts were Jhelum 90, Rawalpindi 173, Attock 210 and Lahore having 197 thousand metric tons production which were the lowest production district of wheat in Punjab. 213 to 424 class three districts, Dera Ghazi Khan Bhakkar and Gujrat include with 390, 326 and 250 thousand metric tons wheat production. Next one class was 425 to 636 thousand metric tons. In this class district Multan, Sahiwal, Toba Tek Singh, Sargodha and Sialkot were including which having 496, 472, 431, 487 and 467 thousand metric tons production. At the end highest sugarcane production class limit was 637 to 848 thousand metric tons. In this class districts Bahawalpur and Rahim Yaar Khan, Bahawalnagar, Okara, Faisalabad and Jhang were having the mean highest production of 678, 783, 670, 739 and 848 thousand metric tons in last thirty years.

Preparation of Agro-Climate Zones Map

The different map layers were prepared and boundaries of different zones were defined on the base of Koppen and Geiger classification. The agro-climate zones map described the main purpose of this research. In this map different agro climatic zones were shown and their characteristics were described in earlier tables. The major zones were described according to Koppen and Geiger limits

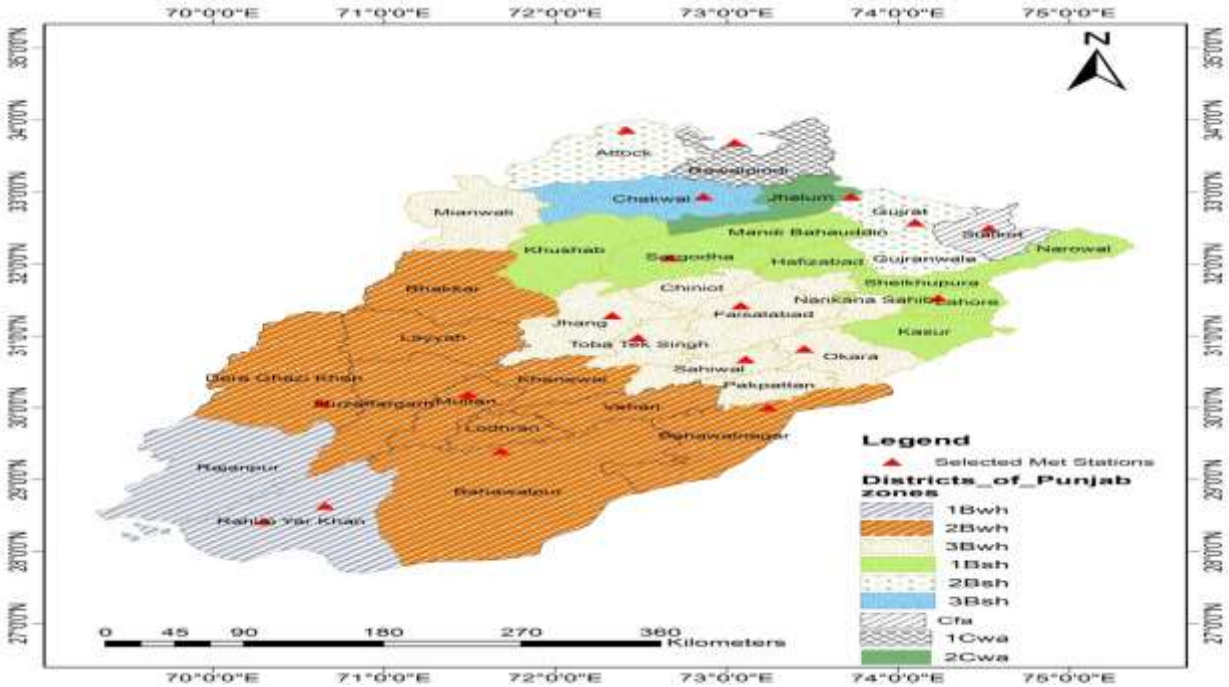
of temperature precipitation and their absolute location. Furthermore, multiple layers were collectively studied and micro level demarcation of agro-climatic zones were described on the base of expert opinion method which was applied earlier in many developed countries researches.

Results and Discussion

Table 1: Characteristics of micro agro-climatic zones of Punjab, Pakistan

Zones	Area(km^2)	Mean Rainfall (mm)	Temp(°C)			Humidity (%)	Productivity Thousand Metric Tons			
			Max	Mini	Mean		Rice	Wheat	Sugarcane	Cotton
1Bwh	24199	133	34.2	18.5	26	57.36	28	783	3745	1066
2Bwh	83534	212	32.7	18.4	25.55	56.54	40	582	500	716
3Bwh	39662	398	31.9	17.04	24.55	61.9	84	632	2406	161
1Bsh	29340	583	31.5	17.9	24.7	57.6	55	342	1446	11
2Bsh	13672	892	30.2	15.7	22.9	60.1	33	230	161	2
3Bsh	6524	646	28.9	15.4	22.15	59.18	-	-	-	-
Cfa	3016	1025	29.4	16.7	23.05	64.09	255	467	128	1
1cwa	5286	1244	28.8	14.9	21.85	57.8	0	173	1	0
2cwa	3587	885	30.6	17	23.8	60.3	2	90	9	1

Figure 9: Agro-climatic zone map of Punjab



Source: Author 2019.

Zone 1Bwh covered the districts of Rajanpur and Rahim Yar Khan in which average annual rainfall was just 133 millimeters, mean maximum and minimum temperature 34.2°C, 18.5 °C respectively. Average monthly temperature was 26°C and mean humidity is 57.36%. This zone had highest

mean temperature and lowest mean rainfall. the agricultural production, in this zones rice 28 wheat 783 sugarcane 3745 thousand metric tons as well as cotton production was 1066 thousand bales.

Zone 2Bwh zone was covered the districts of Dera Ghazi Khan, Multan, Khanewal, Bahawalpur, Bahawalnagar, Vehari, Lodharan, Layyah and Bhakkar in which average annual rainfall is 212 millimeters, mean maximum and minimum temperature 32.7 ºC and 18.4 ºC. Average monthly temperature were 25.55 ºC and mean humidity is 56.54%. This zone had second highest mean temperature and lowest mean rainfall. It was seen that crop yields in area were not bad. In this zone rice 40 wheat 582 sugarcane 500 thousand metric tons and cotton was produce 716 thousand bales annually. This zone was having second highest cotton production in Punjab.

Zone 3Bwh zone was covered the districts Okara, Sahiwal, Pakpattan, Toba Tek Singh, Jhang, Faisalabad, Mianwali, Chiniot and Nankana Sahib in which average annual rainfall was 398 millimeters, mean maximum and minimum temperature 31.9 ºC and 17.04 ºC. Average monthly temperature is 24.55 ºC and mean humidity is 61.9%. It was seen that crop yields in area were not bad. In this zone rice 84 wheat 632 sugarcane 2406 thousand metric tons and cotton was produce 161 thousand bales annually. This zone was having second highest rice, wheat, sugarcane and cotton production in Punjab.

Zone 1Bsh zone was covered the districts of Kasur, Lahore, Narowal, Sheikhupura, Hafizabad, Mandi Bahauddin, Sargodha and Khushab in which average annual rainfall was 583 millimeters, mean maximum and minimum temperature 31.5 ºC and 17.9 ºC. Average monthly temperatures were 24.7 ºC and mean humidity is 57.6%. It was seen that crop yield in area was not bad. In this zone rice 55 wheat 342 sugarcane 1446 thousand metric tons and cotton was produce 11 thousand bales annually. In this zone climatic conditions were moderate comparatively other Bwh zones. This zone is having third highest rice and sugarcane production in Punjab.

Zone 2Bsh zone was include the districts of Gujranwala, Gujrat and Attock in which average annual rainfall was 892 millimeters, mean maximum and minimum temperature 30.2 ºC and 15.7 ºC. Average monthly temperatures were 22.9 ºC and mean humidity was 60.1%. In this zone rice 33 wheat 230 sugarcane 161 thousand metric tons and cotton was produce 2 thousand bales annually. In this zone climatic conditions were moderate comparatively other 1Bsh zones. In this zone crop yields were comparatively low as earlier zones of Punjab.

Zone 3Bsh zone just one district Chakwal was included in which average annual rainfall is 646 millimeters, mean maximum and minimum temperature 28.9 ºC and 15.4 ºC. Average monthly temperatures are 22.15 ºC and mean humidity is 59.18%. In this zone, there was no agricultural data from authentic source but productions of all four crops were very low.

Zone Cfa zone was including the district Sialkot in which average annual rainfall is 1025 millimeters and that is the 2nd highest ratio, mean maximum and minimum temperature 29.4 ºC and 16.7 ºC. Average monthly temperatures are 23.05 ºC and mean humidity is 64.09%. In this zone rice 255 wheat 467 sugarcane 128 thousand metric tons and cotton is produce 1 thousand bales annually. In this zone climatic conditions were moderate comparatively other Bsh zones. In this zone rice having the highest production and other crop yields are comparatively low as Bwh zones of Punjab.

Zone 1Cwa zone was include the district Rawalpindi in which average annual rainfall was 1244 millimeters and that had the highest ratio, mean maximum and minimum temperature 28.8 ºC and 14.9 ºC. Average monthly temperatures are 21.85 ºC and mean humidity is 57.8%. In this zone rice zero wheat 173 sugarcane 1 thousand metric tons and cotton was produce zero thousand bales annually. In this zone climatic conditions were moderate comparatively all other zones. In this zone crop yields were lowest point in Punjab.

Zone 2Cwa zone just one district Jhelum was included in which average annual rainfall was 885 millimeters and that had been the highest ratio, mean maximum and minimum temperature 30.6 ^{o}C and 17 ^{o}C. Average monthly temperatures are 23.8 ^{o}C and mean humidity is 60.3%. In this zone rice 2 wheat 90 sugarcane 9 thousand metric tons and 90 cotton is produce 1 thousand bales annually. In this zone climatic conditions were comparatively similar to the 1Cwa but rice, sugarcane and cotton production was little bit increased. In this zone crop yields were 2nd lowest point low of Punjab.

Conclusion

Highest average precipitation was seen in Rawalpindi (1244 mm) and Kamra (1066 mm) while lowest precipitation was received in Rahim Yaar Khan (133 mm). As far as the mean monthly temperature concern, mean monthly hottest temperature was recorded in Bahawalpur, Dera Ghazi Khan, Rahim Yaar Khan and Multan which was 26 ^{o}C as well as lowest temperature was observed in Rawalpindi (22 ^{o}C) while mean highest concentration of humidity was recorded in Sialkot (64%) and the lowest ratio was seen in Bahawalpur (54%). Wheat highest production was seen in Jhang (848 thousand metric tons) and Bahawalnagar (764 thousand metric tons) and the lowest production was observed in Jhelum (90 thousand metric tons). Bahawalpur and Rahim Yaar Khan produce highest cotton yields (1049, 1066 thousand bales) while Rawalpindi, Jhelum, Attock had zero production. Rice production was high in the district of Sialkot that was 255 thousand metric tons as well as lowest rice production district was Rawalpindi with zero production. Jhang and Rahim Yar Khan had been highest producing districts of Sugarcane with the 3305 and 3745 thousand metric tons and lowest production was recorded in Rawalpindi with 1 thousand metric tons production.

Results of the study show that precipitation varies both spatially and temporarily throughout the Punjab. The areas with the highest precipitation were northern part of Punjab in which Sialkot, Jhelum, Rawalpindi, Attock, Gujrat districts were included (Figure 3). The southern part of Punjab received the less precipitation as compared to central and northern areas. The districts of Bahawalnagar, Bahawalpur, Dera Ghazi Khan, Rahim Yaar Khan and Multan respectively. Temperature situation of the Punjab were completely opposite to the precipitation conditions. Southern areas which had been receiving low rainfall were suffering highest temperature. Third major climatic element was humidity which had significance role of micro level climate and crop yields. Humidity had same trend as precipitation. The areas having highest temperature also suffering in lowest humidity ratio as well as the central area of Punjab (Pakpattan, Okara, Faisalabad, Khushaab and surrounding districts) which had moderate ratio of temperature, precipitation and also humidity (Figure 2).

Agricultural production spatially and temporally varies with these climatic elements. Every crop had required different kind of climatic environment for their growth and production. Rice was the one of the major crop of Punjab and it requires more water as compared to other crops while lowest precipitation were seen in the southern districts (Bahawalpur, Multan, Dera Ghazi Khan, Rahim Yaar Khan etc.) of Punjab. Highest production were seen in Sialkot and Okara districts were the precipitation ratio was high and temperature was moderate.in central areas of Punjab climatic conditions were moderate that's why these areas rice yields were also moderate.

Sugarcane was also varied spatially to those areas where climatic conditions were fulfills to their growing requirement. Sargodha, Faisalabad and Jhang were leading for the highest production throughout the Punjab as well as the northern and southern areas of Punjab where precipitation and temperature high or low were suffering from lowest production.

In agricultural sector cotton was the most important cash crop of Pakistan as well as Punjab. Cotton had also required specific climatic conditions as others. In Northern areas of Attock, Rawalpindi, Jhelum, Sialkot and Lahore had been suffering from lowest yields while Faisalabad, Bahawalnagar, Bahawalpur, Multan and their surrounding areas had been the highest productive. Wheat was the last crop which include in this study.it was the single crop which had been sowing in all over the Punjab but its production was also had spatial variations. Wheat production was high in the areas of Bahawalnagar, Bahawalpur, Jhang and Faisalabad districts. As moving to upward the production was decreasing. It was concluded that these all four crops production were mostly high in central and southern areas as well as northern areas were suffering in lowest agricultural productions.

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