# DISTRIBUTION PATTERNS OF MEDICINAL PLANTS IN CHOLISTAN DESERT, PAKISTAN: A PHYTOGEOGRAPHICAL STUDY

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**ABSTRACT:** Medicinal plants are economically beneficial to heal various diseases and have been significant source of many important drugs. The Cholistan desert has arid type climatic conditions with scattered xerophytic vegetation which have been adopted to intensely high temperatures, humidity fluctuations and wide variety of edaphic conditions. In summer season, the temperature is extremely high but in winter season, it is mostly mild with no frost conditions. The amount of rainfall annually is greatly changing both on temporal and spatial levels. The main objective of the present study was to identify the relationship between soil and atmospheric conditions (temperature, rainfall and humidity) on the growth of medicinal plants during winter and summer seasons. Secondary data of rainfall, humidity and temperature was collected from Agriculture extension department of Bahawalpur and Meteorological department, Islamabad. The analysis carried out using quadrate method and locations were marked with Global Positioning System (GPS). The Geographical information system (GIS) software ArcGIS 10.5 used to illustrate the maps of the study area and the quadrates. In the study area, four sites on the basis of soil structure i.e. Q1, Q2, Q3 and Q4 were selected. Phytogeographical parameters of plants i.e. number (frequency), density and cover were tapped during October, 2021, February, 2022 and May, 2022. The relative frequency, relative density, and relative cover were counted to ascertain the importance value index (IVI). Based on IVI, in each quadrat the communities of medicinal plant were delimited. The highest IVI bearing medicinal plants was conceived as dominant. Correlation results of Plants with different Soil Types and Rainfall is found positive. The strongest correlation with high $R^2$ value was noted on Interdunal Sandy Soil Area (Q3) and low correlation was existed on Hard Clayey Soil Area (Q4).

**Keywords:** Medicinal Plants; Quadrates; Importance Value Index; GIS, GPS, Correlation; Cholistan Desert.

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## INTRODUCTION

The branch of science involving the geographical distribution of plants is known as Phytogeography or sometimes as geo-botany. Phytogeography is generally concerned with geographic association of plants and their distribution (Toby *et al.*, 2000; The American Heritage Dictionary, 2000; Lomolino *et al.,* 2006). Phytogeography is retrieved from Greek words, 'phyto' means plants and 'geography' means distribution (Wallace, 1878). Phytogeography delineated major features and aspects of plants distribution of individual species, the features that govern over the configuration of the whole communities and floras (Peoinado *et al.,* 2011). It is different form Phyto-sociology, which emphasize the structure of the vegetation, diversity of plants, association between soil and plant and the variations in available seasonally and temporally (Rafay *et al.,* 2015). Medicinal plants are knows as the oldest medicines that have been utilized by the humans since antiquity. The vegetation in Cholistan desert is typically found in arid areas, the xeric plant varieties which are changed to extremely high temperature, moisture variations and a varied variety of soil-bound conditions (Akbar, 1996). In Cholistan Desert, the usual plant life has characterized arid and dry climate encompassed of xeric plant species which are altered to very high regular temperature and moisture. In desert, the existence of soil humidity, salinity and characteristics of plants are based on distinctive plant species (Naz, 2011). New spatial and analytical techniques are proved highly appropriate for the functioning of resource organizational tasks. The ability of Geographical Information System (GIS) with the facilities of interpersonal data handling, the calculation of expanded set of facts and number of

variables to maintain in executing verdicts (Arvanitis *et al.,* 2000). On the other hand, Geographical Positioning System (GPS) is utilized for the determination of a geographic position of an area. GIS and Remote Sensing (RS) are valuable for spatial depiction of the region or site (Ortigosa *et al.,* 2000). Thus, the main objective of the present study was to identify the association between soil and atmospheric conditions (temperature, rainfall and humidity) on the evolution of medicinal plants during winter and summer seasons in selected areas of Cholistan Desert, Pakistan.

## MATERIAL AND METHODS

The medicinal plants distribution in Cholistan desert is focused in this research. The phytogeographic variables, frequency analysis, absolute density analysis and area coverage were estimated. In study area, the importance value index (IVI) of medicinal plants species was measured in selected sites. The months of October (2021), February (2022) and May (2022) were chosen for to assess the seasonal change in IVI accounts. The annual variation in precipitation and temperature affect plants productivity is recognized. The plant species with the maximum and minimum counts were documented the selected sites of study area. The impact of soil characteristics on the growth of medicinal plants was examined. The leading varieties of medicinal plants in the specific study sites were then noted. A Phytogeographical assessment was carried out to mapped and evaluated Cholistan desert's vegetation.

**Study area:** Cholistan desert is a part of Great Indian Thar Desert that covered an area about 26,000 sq. km (FAO, 1993). It is located in southern face of Punjab Province. Cholistan desert lies geographically between 27°42′ to 29°45′ north latitudes and 69°52′ to 75°24′ east longitudes (Baig *et al.,* 1980, Hameed *et al.,* 2011). The location of Cholistan and study area near Derawar Fort is shown in figure 1. The selected area covering about 10 kilometers and marked by varied soil conditions. Four quadrates were chosen according to the various soil patterns (Figure 2). Cholistan desert in Pakistan is characterized by its hot and sandy terrain. The rain in eastern area is 200 millimeters and in western area is 100 millimeters. The rain occurs mostly in heavy downpours during the monsoon season. In Pakistan, Cholistan desert is one of the scorching deserts where in summer temperatures soar up to 50°C and in winter it falls even below the 0°C (Ahmad, 2007; Arshad *et al.,* 2008). The average minimum temperature is 20°C and the maximum is 40°C.

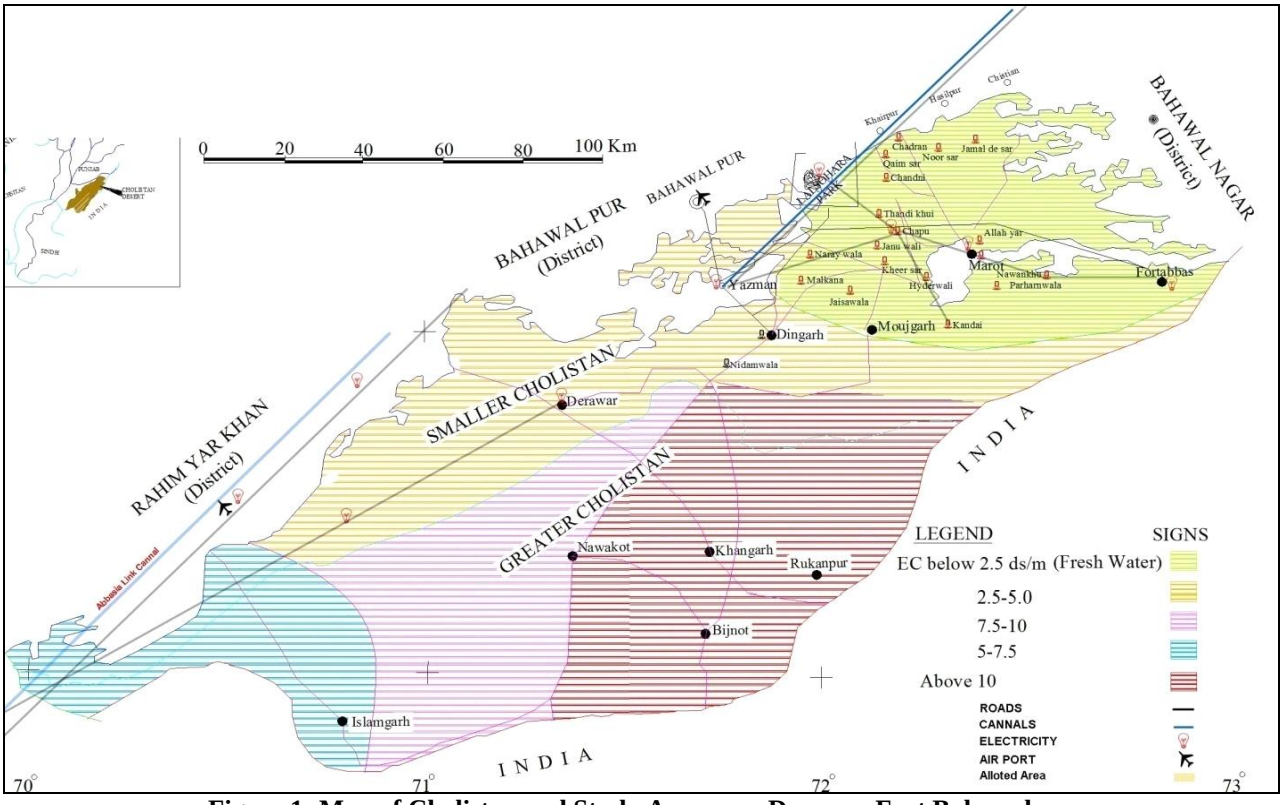


**Figure 1: Map of Cholistan and Study Area near Derawar Fort Bahawalpur**

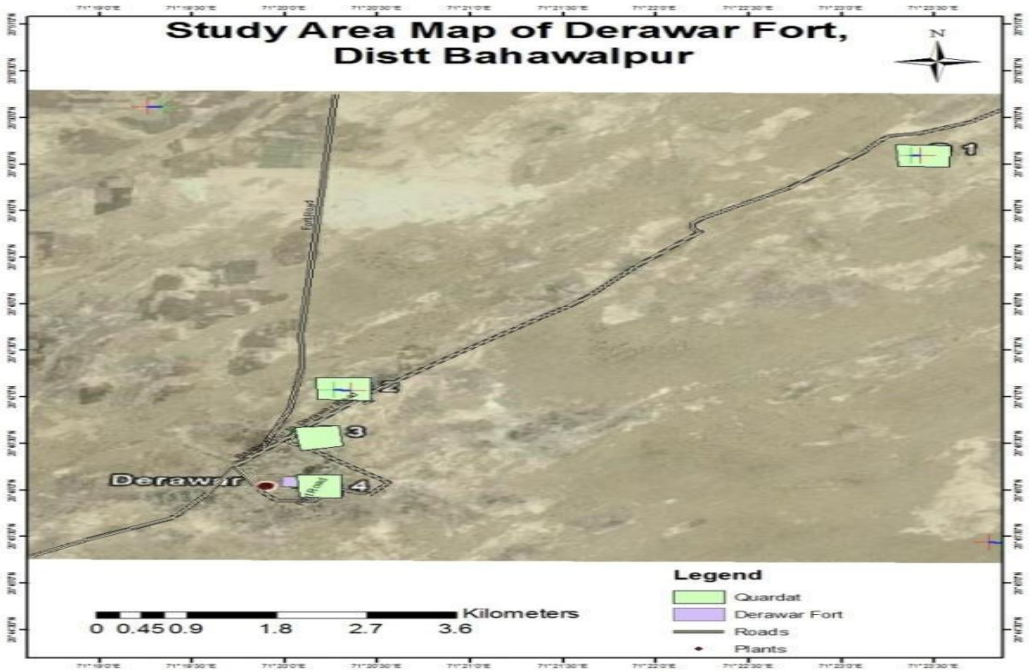


**Figure 2: Map of Study Area, Showing Quadrates, Hard Pan Soil Area (Q1), Dunal Sandy Soil Area (Q2), Interdunal Sandy Soil Area (Q3) and Hard Clayey Soil Area (Q4)**

**Material and data set:** The four locations were chosen in the desert region of Cholistan, near Fort Derawar, District Bahawalpur, to study Phytogeographic distribution of medicinal plant species in the desert area of Cholistan. These sites were consisted the following soil types;

Quadrate 1: Hard pan soil area
Quadrate 2: Dunal sandy soil area
Quadrate 3: Interdunal sandy soil area
Quadrate 4: Hard clayey soil area

The geographical location of the quadrates is shown in the table 1. It shows elevation and soil type of these medicinal plants. The geographical location was pinpointed using GPS coordinates (latitudes, longitudes and elevations) of the quadrates. GIS software, ArcGIS 10.5 employed to create study area's the accurate map. Previously, Qayum et al. (2014) applied the same methodology to study medicinal plants, and the quantity of medicinal plants in each sample quadrates were also mapped out.

**Table 1: The Geographical Locations of Quadrates.**

| Locality | Corners | Elevation | Latitude | Longitude | Soil type |
|---|---|---|---|---|---|
| Chowkiwali Pul, | A | 303 Feet | N 28˙871974 | E 71.334867 | Hard pan soil |
| eight kilometers | B | 301 Feet | N 28.872006 | E 71.335913 | area |
| north of Derawar | C | 313 Feet | N 28.871242 | E 71.334498 | |
| Fort (Q1) | D | 317 Feet | N 28.871180 | E 71.335439 | |
| Karin Wali Bath | A | 339 Feet | N 28.784370 | E 71.339158 | Dunal sandy soil |
| two km north of | B | 308 Feet | N 28.783824 | E71.339949 | area |
| Derawar Fort | C | 350 Feet | N 28.7838801 | E 71.338408 | |
| (Q2) | D | 349 Feet | N 28.783210 | E 71.339188 | |
| One kilometer | A | 347 Feet | N 28.775780 | E 71.336360 | Interdunal sandy |
| North of Derawar | B | 307 Feet | N 28.775785 | E 71.335325 | soil area |
| Fort (Q3) | C | 334 Feet | N 28.774888 | E 71.336362 | |
| | D | 343 Feet | N 28.774854 | E 71.335293 | |
| Front side of | A | 312 Feet | N 28˙ 766537 | E 71.337105 | Hard clayey soil |
| Derawar Fort (Q4) | B | 313 Feet | N 28.765636 | E 71.337278 | area |
| | C | 335 Feet | N 28.765636 | E 71.338323 | |
| | D | 303 Feet | N 28.766555 | E 71.338380 | |

**Location maps of quadrates:** Four sites were chosen in the Cholistan desert, near Derawer Fort to study the variability in soil quality. These sites included Chowkiwali Pul (Q1) with its hard pan soil, Karin Wali Bath (Q2) with dunal sandy soil, interdunal sandy soil area (Q3), and Toba, with hard clayey soil (Q4).

***Chowkiwali Pul, Hard Pan Soil Area (Q1):*** Chowkiwali Pul with hard pan soil (Q1) is located eight kilometers north of Fort Derawar in Cholistan desert. In October, 2021, a total of 32 medicinal plants were identified and noted. The location area of (Q1) in October, 2021 is shown in figure 3. During February, 2022 the counting of medicinal plants were 27 and in May, 2022, these were 29. The figure 4 showed the location area of this quadrate during February, 2022 and the figure 5 showed the location area of this quadrate during May, 2022.

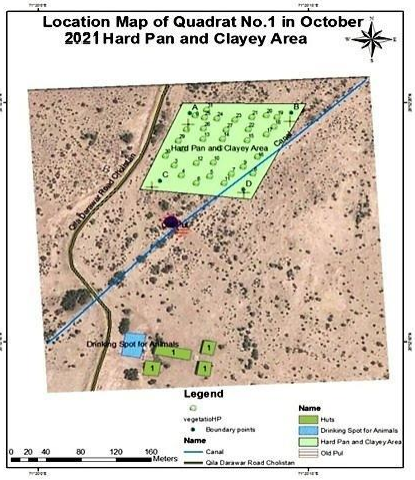


**Figure 3: Hard pan soil Area (Q1) Showing Medicinal Plants in October (2021)**

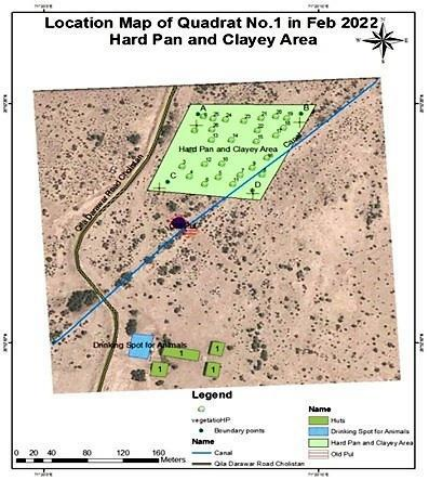


**Figure 4: Hard pan soil Area (Q1) Showing Medicinal Plants in February (2022)**


**Figure 5: Hard pan soil Area (Q1) Showing Medicinal Plants in May (2022)**

***Karin wali Bath, Dunal Sandy Soil Area (Q2):*** Karin Wali Bath with dunal sandy soil (Q2) is located two kilometers north side of the Derawar Fort in Cholistan desert. In February, 2022, a total of 16 medicinal plants were found and documented. The figure 6 showed the location area of medicinal plants at (Q2) in October, 2021. While in February, 2022 the medicinal plants were 15 and in May, 2022 these were recorded 16 in numbers. The location area of medicinal plants at (Q2) in February, 2022 is shown in figure 7 and in May, 2022 is shown in the figure 8. This soil contains no biomass and very little humidity level. It became heat up and cools rapidly. Soil temperature plays a crucial role in influencing plant growth.

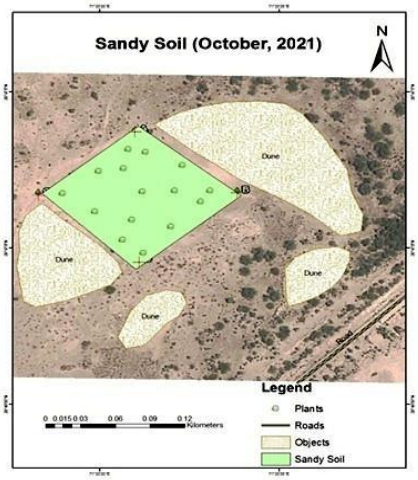


**Figure 6: Dunal Sandy soil Area (Q2) Showing Medicinal Plants in October (2021)**

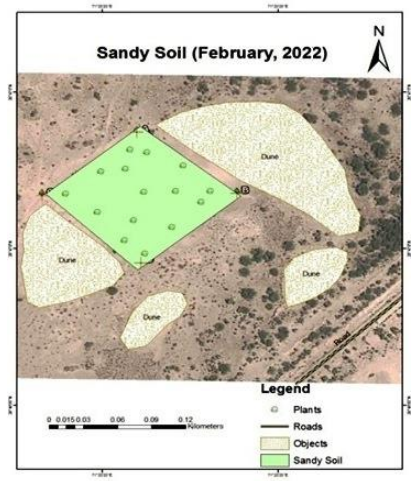


**Figure 7: Dunal Sandy soil Area (Q2) Showing Medicinal Plants in February (2022)**

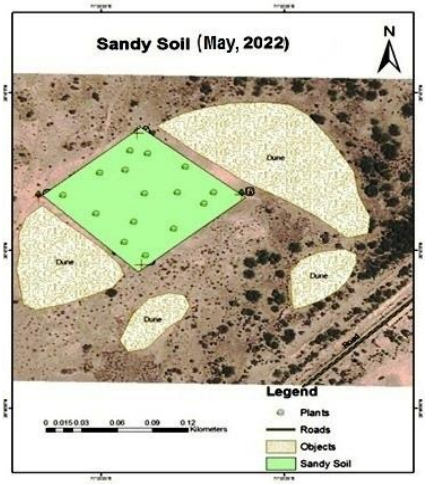


**Figure 8: Dunal Sandy soil Area (Q2) Showing Medicinal Plants in May (2022)**

***Interdunal Sandy Soil Area (Q3):*** The interdunal sandy soil area (Q3) retained a total of 24 medicinal plants in October, 2021 that were identified and documented. The figure 9 showed the location area of medicinal plants at (Q3) in October, 2021. While in February, 2022 the medicinal plants were 18 and in May, 2022 these were recorded 21 in numbers. The location area of medicinal plants at (Q3) in February, 2022 is shown in figure 10 and in May, 2022 is shown in the figure 11. Notably, in Q3, stabilized dunes dominate the area, with limited shifting sand and hard pan base.

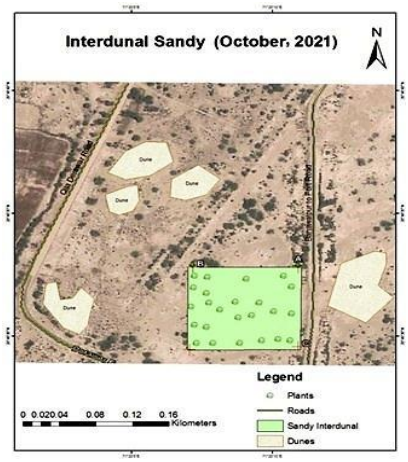


**Figure 9: Interdunal Sandy soil Area (Q3) Showing Medicinal Plants in October (2021)**

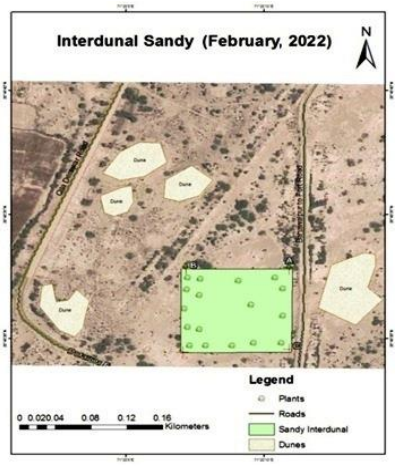


**Figure 10: Interdunal Sandy soil Area (Q3) Showing Medicinal Plants in February (2022)**

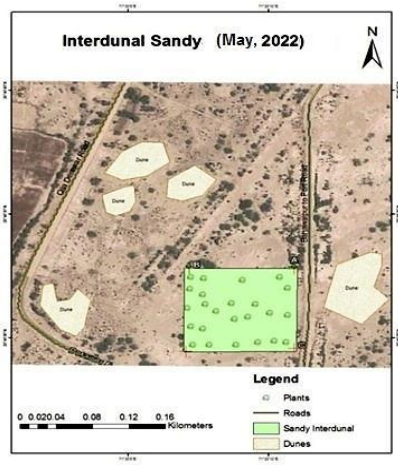


**Figure 11: Interdunal Sandy soil Area (Q3) Showing Medicinal Plants in May (2022)**

***Toba, Hard Clayey Soil Area, (Q4):*** A *'toba'* is literally referred to an old water reservoir locally, which is located in the southern front side of Fort Derawar (Q4). The soil in that area is particularly hard and clay like. A total number of 17 medicinal plants were identified and documented in October, 2021. The figure 12 showed the location area of medicinal plants at (Q4) in October, 2021. In February, 2022, 13 medicinal plants were recorded and in May, 2022, 14 were recorded in this area. The location areas of medicinal plants at (Q4) in February, 2022 and in May, 2022 are shown in figure 13 and 14.

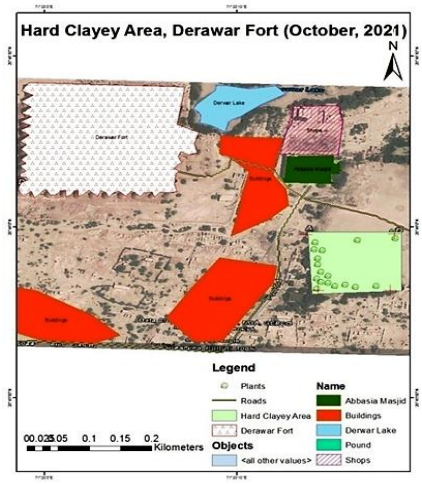


**Figure 12: Hard Clayey soil Area (Q4) Showing Medicinal Plants in October (2021)**

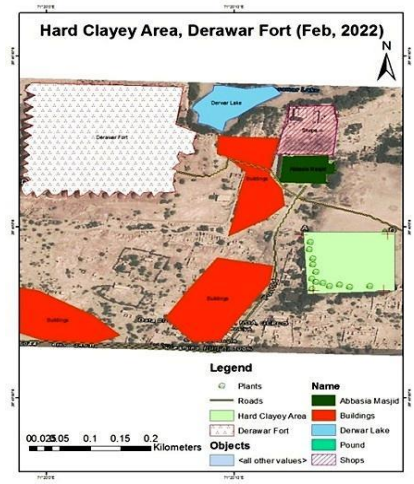


**Figure 13: Hard Clayey soil Area (Q4) Showing Medicinal Plants in February (2022)**

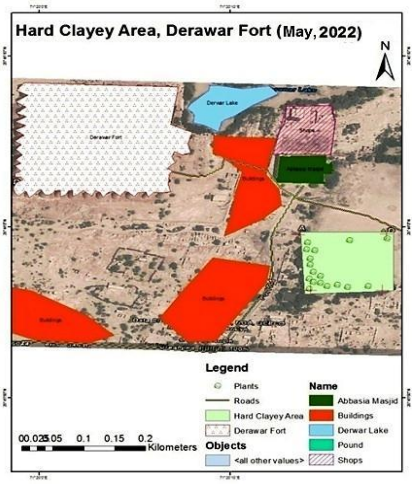


**Figure 14: Hard Clayey soil (Q4) Showing Medicinal Plants in May (2022)**

**Data sets used:** Temperature, Rainfall and humidity has a direct impact on the growth of the plants. Therefore, the data of these atmospheric elements was collected of selected years. Rainfall data from July-September, 2021,

November-January, 2021 and 2022 and February-April, 2022 were utilized. The impact of summer rainfalls on plants growth was evaluated in October, 2021, while the effects of winter plant were measured in February, 2022 and after winter, rainfall also impacted on growth of plants which was measured in May, 2022. The rainfall data was gathered from Agriculture Extension Department, Bahawalpur. The rainfall data from July-September, 2021 is shown in table 2. This table showed the rainfall pattern during monsoon at different locations of Cholistan desert lying in different tehsils/ sub-divisions of the district.

Winter rainfall also affects the growth of plants. The table 3 showed the rainfall pattern during November and December 2021 with no recorded rainfall and January, 2022 with scant rainfall. Table 4 showed the rainfall pattern during February-April, 2022 with variable amount of rainfall.

The data of temperature was collected for the year 2021 and 2022 to evaluate its impacts on the medicinal plants growth. Average Temperature during the years of 2021 and 2022 in Cholistan is shown in table 5.

The data of humidity was collected for the year 2021 and 2022 to assess its effect on the growth of meditational plants. The table 6 showed the humidity percentage during the year 2021 and 2022 in Cholistan.

**Table 2: Rainfall in Cholistan Area during Monsoon**

| Stations | Rainfall in millimeter | | |
|---|---|---|---|
| | July, 2021 | August, 2021 | September, 2021 |
| Bahawalpur | 0 | 34.2 | 38 |
| Ahmadpur East | 0 | 64 | 79 |
| Hasilpur | 21 | 70 | 35 |
| Khairpur Tamewali | 13 | 70 | 108 |
| Yazman | 10.5 | 94 | 78 |
| Mean Rainfall | 8.8 | 66.44 | 67.6 |

**Table 3: Rainfall in Cholistan Area during winter.**

| Stations | Rainfall in millimeter | | |
|---|---|---|---|
| | November, 2021 | December, 2021 | January, 2022 |
| Bahawalpur | 0 | 0 | 5 |
| Ahmadpur East | 0 | 0 | 0 |
| Hasilpur | 0 | 0 | 3 |
| Khairpur Tamewali | 0 | 0 | 17 |
| Yazman | 0 | 0 | 2 |
| Mean Rainfall | 0 | 0 | 5.4 |

**Table 4: Rainfall in Cholistan Area after winter**

| Stations | Rainfall in millimeter | | |
|---|---|---|---|
| | February, 2022 | March, 2022 | April, 2022 |
| Bahawalpur | 40 | 10 | 19 |
| Ahmadpur East | 43 | 39 | 31 |
| Hasilpur | 38 | 37 | 23 |
| Khairpur Tamewali | 39 | 21 | 17 |
| Yazman | 35 | 23 | 10 |
| Mean Rainfall | 39 | 26 | 20 |

**Table 5: Recorded Average Temperature during the years of 2021 & 2022 in Cholistan**

| Sr.no. | Months | Average Temperature in $^0$C, 2021 | Average Temperature in $^0$C, 2022 |
|---|---|---|---|
| 1 | January | 11.34 | 10.22 |
| 2 | February | 15.3 | 13.98 |
| 3 | March | 21.29 | 20.39 |
| 4 | April | 26.33 | 26.02 |
| 5 | May | 32.70 | 33.70 |
| 6 | June | 35.16 | 36.01 |
| 7 | July | 33.71 | 34.33 |
| 8 | August | 32.38 | 33.21 |
| 9 | September | 29.42 | 30.01 |
| 10 | October | 26.44 | 27.03 |
| 11 | November | 21.75 | 20.09 |
| 12 | December | 13.87 | 13.76 |

**Table 6: Humidity Percentage during the Year 2021 & 2022 in Cholistan**

| Sr.no | Months | Humidity in %, 2021 | Humidity in %, 2022 |
|---|---|---|---|
| 1 | January | 60.84 | 58.99 |
| 2 | February | 67.5 | 65.07 |
| 3 | March | 70.12 | 69.11 |
| 4 | April | 69.17 | 68.12 |
| 5 | May | 75.5 | 74.21 |
| 6 | June | 78.01 | 76.03 |
| 7 | July | 77.78 | 75.12 |
| 8 | August | 77.00 | 75.08 |
| 9 | September | 80.1 | 79.12 |
| 10 | October | 78.42 | 77.87 |
| 11 | November | 74.96 | 75.88 |
| 12 | December | 70.00 | 68.67 |

## RESULTS AND DISCUSSION

The numbers of medicinal plants were correlated with rainfall and temperature. The seasonal factors that effect on the growth of medicinal plants were rainfall and temperature.

**Mean seasonal rainfall**: The mean rainfall after October, 2021, February, 2022 and May, 2022 affect the four quadrates. Table 7 showed the mean rainfall during after monsoon, 2021, winter and spring, 2022. The Correlation is fined between soil type and rainfall. Correlation of plants with different soil types and rainfall is shown in table 8. The positive correlation found between soil types of different selected locations and rainfall on plants. The strongest correlation existed on interdunal sandy soil area with a correlation value of ($R^2$) 0.99.

**Table 7: Mean Rainfall of different Months**

| Months | Mean Rainfall (mm) | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|---|
| After monsoon October, 2021 | 47.61 | 32 | 16 | 24 | 17 |
| After winter February, 2022 | 1.8 | 27 | 15 | 18 | 13 |
| After spring May, 2022 | 28.33 | 29 | 16 | 21 | 14 |

**Table 8: Correlation of Plants with different Soil Types and Rainfall**

| Locations | Correlation Value ($R^2$) |
|---|---|
| Hard Pan soil Area (Q1) | 0.97 |
| Dunal Sandy Soil Area (Q2) | 0.90 |
| Interdunal Sandy Soil Area (Q3) | 0.99 |
| Hard Clayey Soil Area (Q4) | 0.93 |

**Effect of temperature:** The temperature affects the medicinal plants in different soil. The Temperature and Plant distribution in different Soil is shown in table 9. The correlation is found between plants at different location and temperature. The table 10 showed the Correlation between Plants at different Locations and Temperature. The noted vegetation in Cholistan desert is typically belong to arid climate consisting mainly xerophytes that have an adjustment in enormously rising temperatures, less humidity and diverse soil-bound circumstances (Arshad *et al.*, 2002).

There was no strong correlation exist between number of plants and temperature in different months except in Q2 which showed good correlation between temperature and plants with a correlation value ($R^2$) of 0.93. The surveyed site was indicated as dunal where the effect of temperature is high on plants species because this type of sand soil cannot hold water for longer period and temperature has significant effect to maintain or reduce soil moisture. The correlation between number of plants and average temperature is shown in figure 15. Although, in Bahawalpur region, the diurnal rage of temperature is decreased due to various human-induced activities in pre-monsoon and increased in Monsoon and post-Monsoon (Haider *et al.*, 2021). Yet it is certified that vegetation's ecological factors has a significant association with environmental conditions like precipitation, slope, altitude, and temperature (Haq and Badshah, 2021).

**Table 9: The Temperature and Plant distribution in different Soils**

| Months | Mean Temperature ($C^o$) | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|---|
| October, 2021 | 26.44 | 32 | 16 | 24 | 17 |
| February, 2022 | 13.98 | 27 | 15 | 18 | 13 |
| May, 2022 | 33.70 | 29 | 16 | 21 | 14 |

**Table 10: The Correlation between Plants at different Locations and Temperature**

| Locations | Correlation (R2) |
|---|---|
| Hard Pan soil Area (Q1) | 0.53 |
| Dunal Sandy Soil Area (Q2) | 0.93 |
| Interdunal Sandy Soil Area (Q3) | 0.68 |
| Hard Clayey Soil Area (Q4) | 0.38 |

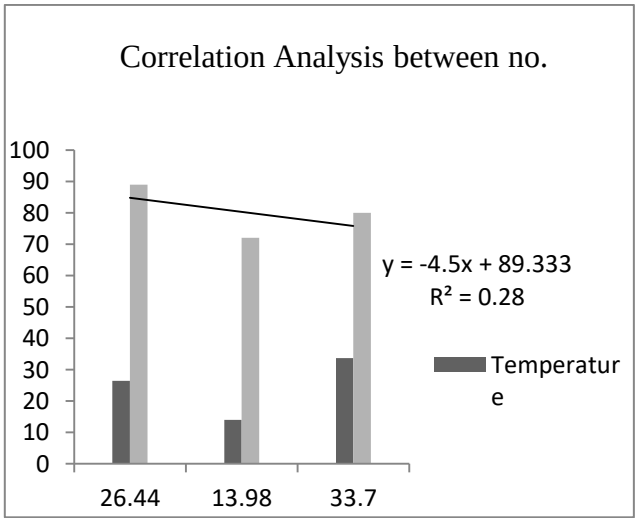


**Figure 15: Showing Correlation between no. of Plants and Average Temperature**

**Overall results:** The overall seasonal effects, soil structure and locality on the growth of medicinal plants are shown in table 11. Rainfall, as seasonal feature, has a significant impact on the number of medicinal plants. It is measured that in October, after monsoon, the highest number of plants existed. While in February, the number of medicinal plants was lowest. This is because of reduced winter rainfall which led to the change (Table 11).

**Table 11: Overall Seasonal Effects, Soil Structure and Locality on the Growth of Medicinal Plants**

| Locality | Climatic Factors | During Season Records | | Soil Structure | No. of Medicinal plants | Results |
|---|---|---|---|---|---|---|
| **October, 2021** | | | | | | |
| Q1 | Temperature | Jul | 33.71 $^0$C | Hard Pan & Clayey Soil Area | 32 | This type of soil could sustain water for long period; due to this quality more plants were present. |
| | | Aug | 32.38 $^0$C | | | |
| | | Sep | 29.42 $^0$C | | | |
| | Rainfall | Jul | 8.8 mm | | | |
| | | Aug | 66.4 mm | | | |
| | | Sep | 67.6 mm | | | |
| Q2 | Temperature | Jul | 33.71 $^0$C | Dunal Sandy Soil Area | 16 | Dominated by moving sand and particularly stabilized dunes. This soil did not contain water for long period. |
| | | Aug | 32.38 $^0$C | | | |
| | | Sep | 29.42 $^0$C | | | |
| | Rainfall | Jul | 8.8 mm | | | |
| | | Aug | 66.7 mm | | | |
| | | Sep | 67.6 mm | | | |
| Q3 | Temperature | Jul | 33.71 $^0$C | Interdunal Sandy Soil Area | 24 | Dominated by stabilized dunes which have a little area of moving sand and hard pan. |
| | | Aug | 32.38 $^0$C | | | |
| | | Sep | 29.42 $^0$C | | | |
| | Rainfall | Jul | 8.8 mm | | | |
| | | Aug | 66.7 mm | | | |
| | | Sep | 67.6 mm | | | |
| Q4 | Temperature | Jul | 33.71 $^0$C | Hard Clayey Soil Area | 17 | Very compact, hard and clayey. The area was deep, relative to the surrounding vicinity. |
| | | Aug | 32.38 $^0$C | | | |
| | | Sep | 29.42 $^0$C | | | |
| | Rainfall | Jul | 8.8 mm | | | |
| | | Aug | 66.7 mm | | | |
| | | Sep | 67.6 mm | | | |
| **February, 2022** | | | | | | |
| Q1 | Temperature | Nov | 21.75 $^0$C | Hard Pan & Clayey Area | 27 | |
| | | Dec | 13.87 $^0$C | | | |
| | | Jan | 10.22 $^0$C | | | |
| | Rainfall | Nov | 0 mm | | | |
| | | Dec | 0 mm | | | |
| | | Jan | 5.4 mm | | | |
| Q2 | Temperature | Nov | 21.75 $^0$C | Dunal Sandy Soil Area | 15 | |
| | | Dec | 13.87 $^0$C | | | |
| | | Jan | 10.22 $^0$C | | | |
| | Rainfall | Nov | 0 mm | | | |
| | | Dec | 0 mm | | | |
| | | Jan | 5.4 mm | | | |
| Q3 | Temperature | Nov | 21.75 $^0$C | Interdunal Sandy Soil Area | 17 | |
| | | Dec | 13.87 $^0$C | | | |
| | | Jan | 10.22 $^0$C | | | |
| | Rainfall | Nov | 0 mm | | | |
| | | Dec | 0 mm | | | |
| | | Jan | 5.4 mm | | | |

| | | | | | |
|---|---|---|---|---|---|
| | Temperature | Nov | 21.75 $^0$C | Hard Clayey Soil Area | |
| | | Dec | 13.87 $^0$C | | |
| Q4 | | Jan | 10.22 $^0$C | | 13 |
| | Rainfall | Nov | 0 mm | | |
| | | Dec | 0 mm | | |
| | | Jan | 5.4 mm | | |
| **May, 2022** | | | | | |
| | Temperature | Feb | 13.98$^0$C | Hard Pan & Clayey Area | |
| | | Mar | 20.39$^0$C | | |
| Q1 | | April | 26.02$^0$C | | 29 |
| | Rainfall | Feb | 39 mm | | |
| | | Mar | 26 mm | | |
| | | April | 20 mm | | |
| | Temperature | Feb | 13.98$^0$C | Dunal Sandy Soil Area | |
| | | Mar | 20.39 $^0$C | | |
| Q2 | | April | 26.02$^0$C | | 16 |
| | Rainfall | Feb | 39 mm | | |
| | | Mar | 26 mm | | |
| | | April | 20 mm | | |
| | Temperature | Feb | 13.98$^0$C | Interdunal Sandy Soil Area | |
| | | Mar | 20.39$^0$C | | |
| Q3 | | April | 20.02 $^0$C | | 21 |
| | Rainfall | Feb | 39 mm | | |
| | | Mar | 26 mm | | |
| | | April | 20 mm | | |
| | Temperature | Feb | 13.98$^0$C | Hard Clayey Soil Area | |
| | | Mar | 20.39$^0$C | | |
| Q4 | | April | 26.02$^0$C | | 14 |
| | Rainfall | Feb | 39 mm | | |
| | | Mar | 26 mm | | |
| | | April | 20 mm | | |

Akbar and Arshad (1996) reported that degradation of vegetation in Cholistan rangelands was primarily caused by a combination of factors, including harsh climatic conditions, overgrazing, and mistreatment by the local residents. In October, after monsoon, the highest number of plants existed. In February, the number of medicinal plants was lowest. Both seasons rely on rainfall for moisture, which typically occurs during the monsoon season from July to September and, to a lesser extent, during the winter and spring months from January to February. Rasheed *et al.* (2022) had undertaken a research in Cholistan desert by adopting quadrat quantitative ecological techniques to find the plant species using multivariate statistical analysis (Monte Carlo techniques) i.e. Indicator Species Analysis, Cluster Analysis, and Canonical Correspondence analysis. A total 49 plant species belonged to 25 communities were documented. Conclusion showed that the soil moisture and overgrazing were among the vital environmental determinants of the vegetation structure and plant communities' formation. In previous studies it is found that soil moisture is one of the key elements that has a direct impact on the usual physiologic process and ultimately determines the species' composition and their pattern of distribution (Bi *et al.*, 2018; Nazakat *et al.*, 2020; Abdullah *et al.*, 2021). So on the basis of findings, in communities experiencing distinct dry periods, rainfall is considered the primary factor influencing the timing of flowering onset, causing variations in its commencement. There is scarcity of the published research on the uses of flora in Cholistan desert, indicating a significant knowledge gap in this area. It has been noted that combination of local people's unawareness and excessive exploitation of flora has contributed to the degradation of this area (Arshad, *et al.*, 2007; Hameed *et al.*, 2011). The findings proposed that such natural ecosystems can be utilized as grazing lands; thus, highlighting the need for education and conservation efforts for the betterment of this area.

The average annual rainfall in Cholistan is varied between 100-250 mm (Arshad *et al.,* 2006). Results showed that the rainfall during the months of February, March and April affected the plants and it increased during May. Correlation of Plants with different Soil Types and Rainfall is positive. The strongest correlation was existed on Interdunal Sandy Soil Area (Q3) and low correlation was existed on Hard Clayey Soil Area (Q4). Correlation of other two quadrates exists between these two quadrates correlation. The change in temperature has not any significant effect on the growth of plants. There was no strong correlation exist between number of plants and temperature in different months. Only Karin Wali Bath, Dunal Sandy Soil Area (Q2) has shown good correlation between temperature and plants growth. This shows that plant with different soil type and rainfall had strongly correlated with each other than that of temperature and plant location. It is manifested that Cholistan desert experiences highly variable and unreliable rainfall patterns, both temporally and spatially.

**Conclusion:** The rainfall had great influences on medicinal plants growth rate. The number of plants in Cholistan desert was highest in October due to rainfall received during after monsoon, in February, minimum because of least rainfall during winter. Rainfall after winter affected the plants growth and it slightly increased during May. The seasonal fluctuations in temperature did not affect widely on the growth rate of plants. The leading dominant medicinal plants remained same during all seasons in hard pan area soil and hard clayey area soil, while in sandy soil area soil and interdunal soil area the leading dominant plant species were changed during all seasons. The implementation of spatial techniques GPS and GIS portrayed and visualized the distribution of plants in different Quadrates on seasonal scale effectively and precisely.

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