

ANNUAL AND SEASONAL DISTRIBUTION OF SUNSHINE IN PAKISTAN 1931-1990

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Abstract

This paper on sunshine distribution of Pakistan is based on normal data derived from various meteorological stations over the period of sixty years (1930-1990). The research analyzes the sunshine distribution in Pakistan and its advantages in harnessing the solar energy in the entire country. Sunshine brings radiant energy to the earth surface. The amount of bright sunshine is badly affected by cloudiness, humidity, air pollution, latitudinal and altitudinal location, physical relief, annual march of the sun, and length of day and night. Sunshine is also beneficial to mankind and vegetation cover. The rate of growth of plant is largely influenced by the amount of solar energy that plant receives. In long hours of summer sunshine, crops and vegetation grow rapidly and reach maturity in a short time span during a season. Some plants require short days (winter), while other needs long days (summer), but some are also indifferent to the length of daylight for flowering and photosynthesis. Excess and shortage in the degree of bright sunshine causes various diseases in plants as well as in animals. Therefore, moderate sunshine, practically, is essential for plants as well as human activities. The country receives a considerable amount of sunshine during the year as a whole. The annual average sunshine of the country is 8hr/day. January has the lowest sunshine with 6.1hr/day, and June experiences the highest sunshine of above 9hr/day. The annual sunshine of Pakistan increases from January to June and starts to decrease in August. In September there is a little rise and then there is a continuous drop till December. This variation of the sunshine in Pakistan is generally, because of its latitudinal and altitudinal extent and annual march of the sun.

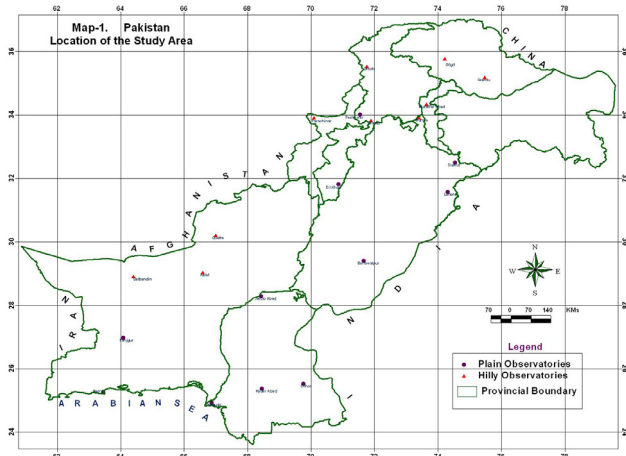
Keywords: Sunshine, summer, winter, Normal Data, vegetation cover, Photosynthesis, Growing season

1. INTRODUCTION:

Sunshine brings radiant energy to the earth surface. With special reference to climate, sunshine is expressed as the average number of hours of sunshine per month or per year, and tabulating the actual hours of sunshine, as a percentage possible duration of sunshine for the particular location indicates the relative sunshiness of climate (Russell, 1914). The sunshine of a place is the duration from sun rise to sunset. The amount of bright sunshine is badly affected by cloudiness, humidity, dustiness, latitudinal and altitudinal location, physical relief, annual march of the sun, and length of day and night.

Like other climate elements, sunshine is also beneficial to mankind and vegetation cover. The rate of growth of plant is largely influenced by the amount of solar energy that plant receives. In long hours of summer sunshine, crops and vegetation grow rapidly and reach maturity in a short growing season (Miller, 1959). Some plants require short days (winter), while other needs long days (summer), but some are also indifferent to the length of daylight for flowering and photosynthesis. The high and very low degree of bright sunshine causes various diseases in plants as well as in animal. Therefore, moderate sunshine practically, is essential for plants as well as human activities.

Pakistan extends northeast to southwest from latitude 37° N into $23 \frac{1}{2}^{\circ}$ N and longitude 60° E to 75° East. Geographical, it covers an area of 803,944 sq.km, out of which 60% in the northwest farm mountain terrain and tableland and the remaining 40% is the Indus Plain (Map-1).



2. METHODS AND DATA

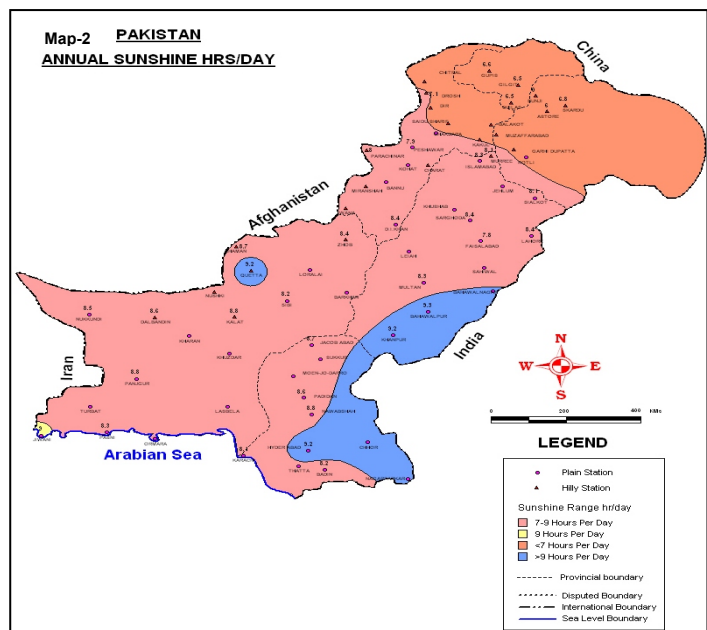
The work deals with the study of annual and seasonal distribution of sunshine in Pakistan and to identify area having maximum and minimum sunshine throughout the year. The work based on normal data of 1931-60 and 1961-90 collected from Pakistan Meteorological Center Karachi. Month of the year having maximum average sunshine is considered as summer month other wise winter. Based on the stated criteria the year has been divided into two main seasons that is summer and winter. The annual and seasonal sunshine of Pakistan has been studied taking into account Maximum sunshine areas (above 9hr/day), Moderate sunshine areas (between 7 hr/day to 9hr/day), and Minimum sunshine areas (below 7hr/day). All of the data have been demarcated on the maps in the form of isohels that clearly mentioned area of maximum and minimum hours throughout Pakistan. The sunshine of a place above 9hr/day enhances evapotranspiration, melting of snow, ice, and vegetation growth. It also causes dry weather and evapotranspiration of moisture from human skin as well as plants. Sunshine between 7 hr/day and 9hr/day is essential for plant growth and human activities, while sunshine below 7hr/day is not appreciable for crops and human body. These isohels (lines join areas of equal sunshine) are suggested as boundaries of the sunshine regions in for the present study.

3. RESULTS AND DISCUSSIONS

Pakistan is located in the sub-tropical belt, and generally, receives a considerable amount of sunshine, but due to the high mountains and the seasonal variation, monsoon wind, and western depressions, the annual sunshine varies throughout the country, as the weather remain cloudy for long term in some areas.

a. Annual sunshine

In January, the sunshine is low in Pakistan (6.1hr/day), along with the low temperature, moderate rainfall, and high humidity. Whereas, June is the highest sunshine period with 9.7hr/day, high temperature and low humidity as shown on graph-1. Sunshine increases from January to June, while it decreases in July, remaining almost constant till October. From November, it decreases till January, which is the month with the lowest sunshine. In spite of this, the annual sunshine of the country shows positive deviation from April to September, while it is below the mean condition from October to March. The highest mean monthly annual bright sunshine of Pakistan is 9.3hr/day recorded at Bahawalpur, while the lowest is 6hr/day, at Astore (Map-2 and table-1). The general distribution of sunshine in Pakistan is as follow.



3.1.1. Maximum sunshine areas

Generally, the Thal and Thar deserts, lower Sindh, Jiwani at the Makran coast and Quetta in Balochistan are the localities of maximum sunshine. The high rate of reflection of solar energy in the deserts, cloudless skies, long trajectory of prevailing winds over land at Jiwani and hot prevailing winds of the Seistan desert of Iran at Quetta may be the causes of maximum sunshine.

3.1.2. Moderate sunshine areas

The region of moderate sunshine includes a part of Baluchistan, northern Punjab, KPK, Azad Jammu and Kashmir, and the northern mountainous region. The duration of bright sunshine decreases from lower Baluchistan towards central Punjab and Peshawar with 7.9hr/day. The plain areas have more bright sunshine

duration than mountainous regions, due to variation in cloudiness, fogginess, altitude and latitude of the areas (Map-2).

3.1.3. Minimum sunshine areas

Northern Areas, part of the upper KPK, Azad Jammu and Kashmir are the maximum sunshine areas, which are located at high altitude from the sea level, and are also characterized by cloudiness, fogginess, moderate rainfall (snow) particularly in winter season that cause low sunshine hours.

The sunshine distribution in Pakistan, generally, decreases from northwest to southeast due to variation in summer and winter rains, latitude and altitude, and annual march of the sun. Plain areas record more sunshine hours as compared to mountainous region, while the eastern slopes of the mountains receive more sunshine than the western slopes (Map-2).

3.2. Seasonal variation of sunshine

There is no drastic variation in the distribution of sunshine during the summer and winter seasons. On seasonal distribution maps the average sunshine duration has been placed above the observatory or station, while months having mean monthly sunshine above 9hr/day have been written to the right and months between 7 hr/day to 9hr/day or below 7hr/day to the left of the location point.

3.2.1. Winter sunshine

The maximum winter sunshine duration of Pakistan is 9.1hr/day, recorded at Hyderabad, and the lowest is 4.7hr/day at Astore (Map-3 and table-2). The winter sunshine of Pakistan has been categorized into the following regions.

3.2.1.1. Maximum sunshine areas

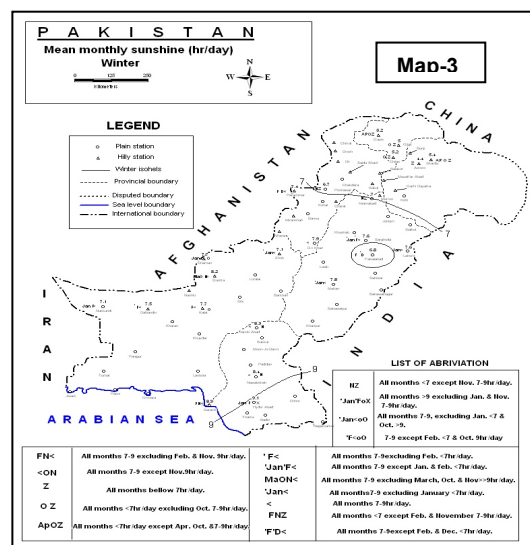
The region includes the lower Sindh, Cholistan and Thar deserts, and Jiwani in the Makran coast. The high winter sunshine is due to clear skies and its tropical location. These areas usually receive summer rains and are dry in winter. The region has sunshine duration of above 9hr/day from March to December, while in January and February, it is between 7hr/day and 9hr/day.

3.2.1.2. Moderate sunshine areas

In winter most of Balochistan, upper Sindh, southeastern Punjab and lower KPK receive moderate sunshine with average of 7hr/day to 9hr/day throughout the year, but sometime, it is below 7hr/day. The highest sunshine duration of the region is 8.9hr/day at Karachi, and decreases to 7.4hr/day at Parachinar and to 7.1hr/day at Nokkundi and Zhob. These areas are generally suitable for vegetation growth and human activities as compared to other areas of the country.

3.2.1.3. Minimum sunshine areas

The Northern Areas, Peshawar, Azad Jammu and Kashmir, and northern Punjab fall in this region. These areas are normally at high altitude with high humidity and rainfall that reduces the sunshine duration of the region. Sunshine duration is below 7hr/day in the region, while at Islamabad it is 7hr/day and fall to 4.7hr/day at Astore. The winter sunshine increases from northwest to southeast. Areas, receiving most of their rains in winter have low degree of sunshine than those that have abundant rainfall during summer. The mountain areas experience sunshine for shorter duration than the plain. The coastal belt has high sunshine duration than continental areas due to warm weather condition over Arabian sea and clear skies most of the year.



3.3. Summer sunshine

The highest summer sunshine duration is 10.4hr/day, recorded at Quetta, and the lowest is 7.6hr/day, at Karachi (Map-4 and Table-3). The sunshine of the country increases from lower Punjab towards northeast and southwest. The summer sunshine of Pakistan has been grouped into the following zones.

3.3.1. Maximum sunshine areas

Most of the Baluchistan province, Islamabad, central and lower Sindh constitutes a region of maximum sunshine. This region has longer sunshine duration, because of low rainfall from monsoon lows. It is characterized by sunshine duration of above 9hr/day throughout the year. There are also isolated patches where it is between 7hr/day and 9hr/day. The duration of the sunshine decreases from Quetta towards north and south.

3.3.2. Moderate sunshine areas

The areas of maximum sunshine have been mentioned above. The rest of the country has bright sunshine between 7hr/day to 9hr/day. The highest sunshine hours of the region have been recorded in Punjab and upper Sindh (above 8.9hr/day) that decreases to 8hr/day at Parachinar in the north and 7.6hr/day at Karachi in the south. Areas of moderate sunshine have rainfall from monsoon lows.

3.3.3. Minimum sunshine areas

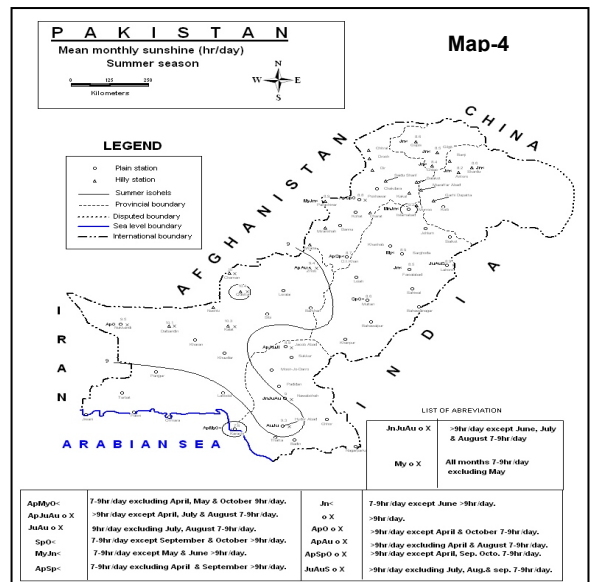
No where in Pakistan, the sunshine duration is below 7hr/day in summer season, however, high humidity, clouds and sea fogs sometime brings the coastal belt into the minimum sunshine period.

4. JANUARY ISOHEL

The highest sunshine in January is 8.7hr/day, recorded at Karachi, with 8.6hr/day in December and 9.3hr/day in February. The lowest is 2hr/day at Astore, with 2.9hr/day in February and 3hr/day in December. The isohels of 7hr/day divides Pakistan into two regions, the southern part of the country has sunshine between 7hr/day and 9hr/day, while in the rest of Pakistan, it is 9hr/day. The sunshine increases from northeast to southwest in January, while in December and February, it is from northwest to southeast. The plain and coastal areas have more sunshine duration as compared to the high altitude region in the northwest. Another specific factor of sunshine variation is the annual march of the sun. On 22nd of December, the sun is shining vertically over tropic of capricorn in the southern hemisphere and much of the areas of northern hemisphere receive tangential rays, which cover large space and provide low solar energy. Winter months also enjoy western depression with warm frontal rains, clouds, fogs, mist and high humidity and as a result, most of the solar energy is absorbed in atmosphere or reflected back to space.

5. APRIL ISOHEL

The highest sunshine period recorded has been as April is 9.8hr/day at Karachi, while the lowest is 6hr/day recorded at Astore. The highest sunshine in of May and April has been recorded at Hyderabad and the lowest is at Astore, Chilas and Gilgit. The Northern Areas, Azad Jammu and Kashmir, Malakand division, and northern mountainous region have sunshine duration below 7hr/day, while it is above 9hr/day in central Sindh, Cholistan and Thar deserts. The rest of Pakistan has a duration between 7hr/day to 9hr/day. The sunshine period in Pakistan, in March, April and May, generally, increases from northwest to southeast. Another determinant of this variable condition is the annual march of the sun. On 23rd March the sun is overhead at equator and both hemispheres have equal solar radiation and then it moves towards south for the tropic of cancer. It is why that sunshine increases from March to May.



6. JUNE ISOHELLS

The maximum sunshine duration in June is 12.1hr/day at Islamabad, while the minimum is 7.7hr/day recorded at Karachi. The isohels indicate that the coastal areas, southern KPK, and central Sindh, have June sunshine duration between 7hr/day to 9hr/day, while in the rest of the country; it is more than 9hr/day. In June, the sunshine of the country increases from northeast to southwest, due to summer rainfall variation. On 22nd June, the sun shines at horse latitude in northern hemisphere (tropic of cancer), and most of the areas close to tropical region have more sunshine as compared to highland.

7. SEPTEMBER ISOHELLS

September remains under the influence of the monsoon condition, with occasional downpour, while October and November are comparatively dry, and the sunshine duration varies from September to November. In September, the highest sunshine duration is 10hr/day at Nokkundi, Dalbandin, and Kalat, while the lowest is 7hr/day at Karachi. The coastal areas of Pakistan have low sunshine (September) 7hr/day due to marine climates. The northern part of the country records sunshine duration below 7hr/day, while the southern part has duration of above 9hr/day.

The isohels also show that the sunshine in September, generally, increases from northeast to southwest. On 23rd September, the sun is at zenith at equator and both the hemispheres receive tangential solar radiation, which cover large space and provide low solar energy and then leave for tropic of Capricorn. Resultantly, the sunshine hours decrease from September to November.

8. CONCLUSION

- Pakistan receives a considerable amount of sunshine throughout the year and has opportunity to control the shortage of power energy using advance technology for the utilization of the solar energy.
- January has a lowest sunshine with 6.1hr/day with short winter days.
- June is a highest sunshine of above 9hr/day having long summer days.
- The annual sunshine of Pakistan increases from January to June then decreases in August with little increases in September and then again decreases till December. This variation of the sunshine in Pakistan, is generally, because of its latitudinal and altitudinal extent and annual march of the sun.
- The plain areas of the country have long sunshine period and decreases as we move towards north of the country.
- The coastal belt usually, records high sunshine period as compared to the rest of the country and more suitable for solar energy plants.
- The sunshine duration of the country generally, increases from northwest to southeast. This variation normally, is due to temperature and cloudiness variation, altitudinal, and latitudinal extent of the country and the annual march of the sun.

9. ACKNOWLEDGMENT

I offer my deep sense of gratitude to my supervisor, Dr. Mahmood-ul-Hasan, Associate Professor, Institute of Geography, University of Peshawar, for his valuable guidance, constructive criticism and critical review and painstaking efforts to get this research work completed. I am also thankful to Prof. Dr. Amir Nawaz Khan, Chairman, and to Prof. Dr. Amir Khan, Institute of Geography, University of Peshawar for providing all necessary research facilities during the course of work. I am also indebted to Mrs. Berjis Talat, Chairperson, and to Dr. Ihsanullah, Associate Professor, Department of Geography, University of Karachi, and to Jamil Ahmad Khan, Meteorologist and Professor for teaching of how to construct and study weather maps and climographs during my Masterate Degree, and to Late Muhammad Ashafaq Khan, Professor and Chairman, Department of Geography Urdu Science College Karachi, for their help and encouragement. We are also indebted to Prof. Dr Tahir Sarwar, Water Management Department Agriculture University Peshawar for providing evapo-transpiration and sunshine data of Pakistan. Thanks are owing to Nadeem Faisal,

Assistant Meteorologist, Pakistan Meteorological Department Karachi, for providing weather data and stupendous cooperation.

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Graph-1: Pakistan
Mean monthly sunshine (hr/day), temperature(°C), humidity (%) & rainfall (cm) 1931-90

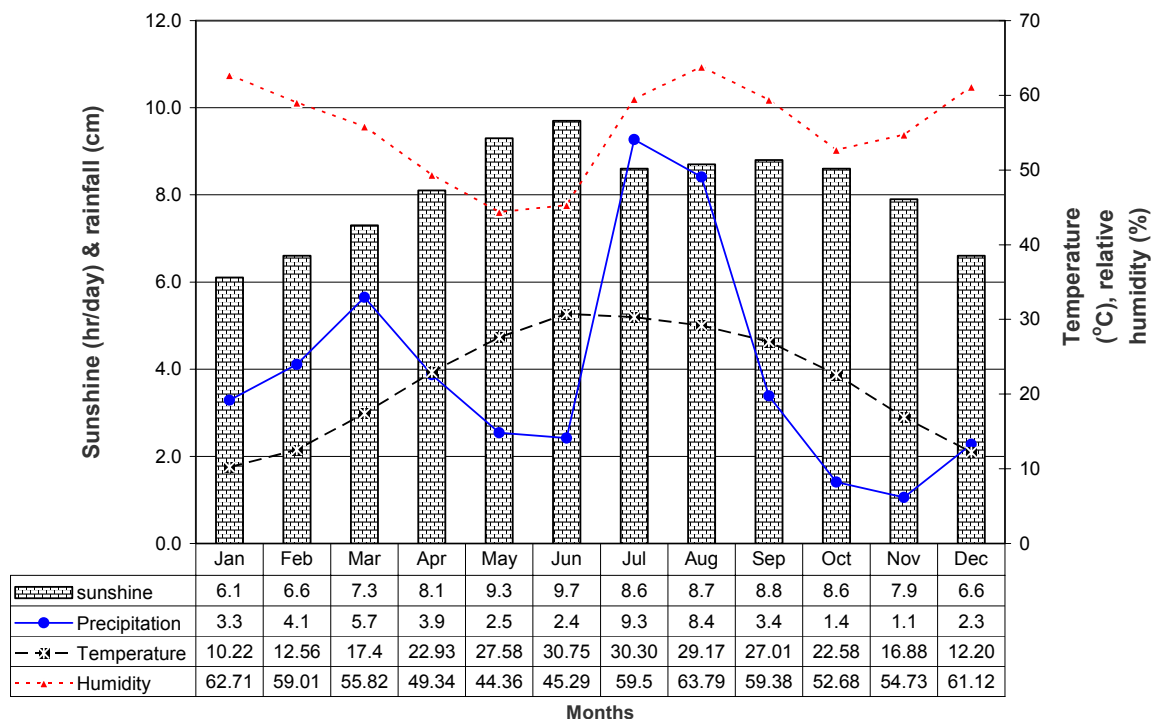


Table-1: Mean monthly annual sunshine hr/day 1980-90

Station.N.	Annual	Station.N.	Annual	Station.N.	Annual	Station.N.	Annual
Astore	6	D.I.Khan	8.4	Lahore	8.4	Nawabshah	8.8
Chilas	6.5	Parachinar	8	Multan	8.3	Sargodha	8.4
Gilgit	6.5	Peshawar	7.9	Hyderabad	9.2	Chaman	8.7
Gupis	6.6	Faisalabad	7.8	Jacobabad	8.7		
Skardu	6.8	Islamabad	8.3	Karachi	8.1		

Table-2: Mean monthly winter sunshine hr/day 1980-90

Station.N.	Winter	Station.N.	Winter	Station.N.	Winter	Station.N.	Winter
Astore	4.4	D.I.Khan	7.9	Lahore	7.6	Nawabshah	8.4
Chilas	5.2	Parachinar	7.4	Multan	7.8	Sargodha	7.6
Gilgit	5.0	Peshawar	6.7	Hyderabad	9.1	Chaman	7.7
Gupis	5.2	Faisalabad	6.8	Jacobabad	8.3		
Skardu	5.4	Islamabad	7.0	Karachi	8.9		

Table-3: Mean monthly summer sunshine hr/day 1980-90

Station.N.	Summer	Station.N.	Summer	Station.N.	Summer	Station.N.	Summer
Astore	8.2	D.I.Khan	8.7	Lahore	8.9	Nawabshah	9.0
Chilas	8.4	Parachinar	8.9	Multan	8.6	Sargodha	8.9
Gilgit	8.5	Peshawar	8.8	Hyderabad	9.3	Chaman	10.0
Gupis	8.6	Faisalabad	8.5	Jacobabad	8.9		
Skardu	8.6	Islamabad	9.2	Karachi	7.6		

Source: Pakistan Meteorological Department, Karachi.