

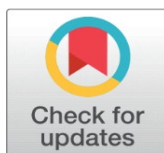
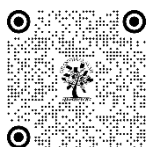
ANALYSING RAINFALL FOR EFFECTIVE CROP PLANNING AND WATER MANAGEMENT IN GARIYABAND DISTRICT OF CHHATTISGARH PLAIN

Asha Kiran Minj¹, Dr. Sanddep Sahu², Dr. Praveen Kumar Yadaw³, Dr. Lekhraj Sahu⁴

^{1,2} Department of Geography, ISBM University, Gariyaband, Chhattisgarh, India

³ Department of Engineering, Kalinga University, Gariyaband, Chhattisgarh, India

⁴ Department of Geography, CIT Science and Commerce College, Abhanpur, Chhattisgarh, India



DOI

[10.29121/shodhkosh.v5.i6.2024.3744](https://doi.org/10.29121/shodhkosh.v5.i6.2024.3744)

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Copyright: © 2024 The Author(s). This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

With the license CC-BY, authors retain the copyright, allowing anyone to download, reuse, re-print, modify, distribute, and/or copy their contribution. The work must be properly attributed to its author.

ABSTRACT

The volume and distribution of rainfall have a major impact on agricultural output. Rainfall statistics on a weekly, monthly, and seasonal basis are very useful for agricultural planning. With an emphasis on weekly, seasonal, and yearly rainfall, this study assesses the patterns of rainfall distribution in Gariyaband, Chhattisgarh, during a ten-year period (2011–2023). With an average of 104.6022 mm, the research shows that the 29th week of the monsoon season had the most rainfall, reaching 313.803 mm. According to monthly rainfall statistics, August had the most average rainfall of 299.1059 mm and November had the lowest, at 0.003628 mm. The highest amount of rainfall recorded in the Kharif season was 1437.004 mm, or 90.20% of the yearly average. With an average of 969.2082 mm, the monsoon season saw the most rainfall, while the winter season saw the least at 15.3071 mm. Runoff causes significant loss of rainfall, but it may be caught by employing in-situ or ex-situ water harvesting systems to be used in the summer, during Rabi and Kharif. In the rainy season, this water may also be used for irrigation that saves lives during dry spells, especially those that last one or two weeks and negatively impact standing Kharif crops. The variation in annual rainfall from the mean was -25.4% to +24.64%. The Gariyaband region's crop planning and the creation of water and soil conservation infrastructure can benefit from the knowledge gained from this rainfall research.

Keywords: Rainfall Analysis, Water Management, Environmental Quality, and Agriculture in India



1. INTRODUCTION

India's economy continues to be based mostly on its rain-fed agriculture. Limited irrigation availability and extremely changeable agroclimatic conditions frequently impede planning for agricultural expansion in rainfed agro-ecosystems. Growing demand puts a great deal of strain on finite natural resources, endangering ecological equilibrium and making a detailed study of rainfall necessary for efficient resource management. India's water and agriculture industries are among the most susceptible to the effects of climate change, since erratic rainfall leads to natural disasters like droughts and floods. For the purpose of maintaining food security, increasing agricultural productivity, stopping land degradation, and promoting biodiversity and environmental quality, rainfall analysis is essential.

Covering 13.51 million hectares, Chhattisgarh is situated between latitudes 17°46' to 24°5' North and longitudes 80°15' to 84°24' East. The state has a subtropical climate, with the southwest monsoon providing 85% of the state's rainfall from June to September and the northeast providing the remaining 15% in the summer and winter. There are around 65 rainy days and 1200–1400 mm of rainfall on average each year (Bhuarya, 2015). For many years, rice has

been the main crop grown in the area. Seasonal droughts commonly impact rainfed farming, even in the face of plentiful rainfall, particularly in September and October when crops are in vital growth phases (Pali AK et al., 2012). Droughts are mostly caused by unpredictable rainfall patterns that result in uncertain agricultural production.

In light of the current situation, thorough studies of rainfall data are crucial. Rainfall magnitude is essential for the hydrological design of soil and water conservation structures, such as contour trenches, contour bunds, spillways of water harvesting structures, and check dams. Consecutive days of rainfall analysis are critical for the design of agricultural land drainage systems.

A previous investigation by Veeraputhiran et al. (2003) and Manorama K et al. (2007) has shown that examining past rainfall data can lead to increased agricultural yield. According to Vaidya et al. (2008), Pali AK et al. (2012), Bhuarya (2015), Sinha BL et al. (2019), and Sinha BL (2020), designing cropping patterns and water management methods can benefit greatly from the analysis of weekly rainfall data.

India's agriculture, primarily rain-fed, remains the backbone of the country's economy. Planning for agricultural development in rainfed agro-ecosystems is often complicated by limited irrigation access and highly variable agroclimatic conditions. Increasing demand places significant stress on limited natural resources, threatening ecological balance and necessitating a thorough study of rainfall for effective resource management. Agriculture and water sectors in India are among the most vulnerable to climate change impacts, with rainfall variability causing hydrological issues like floods and droughts. Analyzing rainfall is crucial for sustainable food security, enhancing land productivity, preventing land degradation, and improving biodiversity and environmental quality.

Chhattisgarh, located between latitudes 17°46' to 24°5' North and longitudes 80°15' to 84°24' East, covers 13.51 million hectares. The state has a subtropical climate, receiving 85% of its rainfall from the southwest monsoon between June and September, and the remaining 15% from the northeast during the summer and winter seasons. The average annual rainfall is 1200-1400 mm, with about 65 wet days (Bhuarya, 2015). Traditionally, rice has been the staple crop for local inhabitants. Despite abundant rainfall, seasonal droughts frequently affect rainfed farming, especially in September and October when crops are in critical growth stages (Pali AK et al., 2012). Unpredictable rainfall patterns leading to unstable agricultural yields are a primary cause of droughts.

Given current conditions, detailed analyses of rainfall data are essential. Consecutive days of rainfall analysis are crucial for designing agricultural land drainage systems, while rainfall magnitude is vital for the hydrological design of soil and water conservation structures, such as contour trenches, contour bunds, spillways of water harvesting structures, and check dams.

Past studies, including those by Veeraputhiran et al. (2003) and Manorama K et al. (2007), have demonstrated that analyzing historical rainfall data can improve agricultural production. Vaidya et al. (2008), Pali AK et al. (2012), Bhuarya (2015), Sinha BL et al. (2019), and Sinha BL (2020) have suggested that studying weekly rainfall data is particularly useful for planning cropping patterns and water management strategies.

2. BACKGROUND OF GARIYABAND DISTRICT

Gariyaband, located in the Chhattisgarh plains, is situated between latitudes 20°57'46" N and 20°17'36" N and longitudes 82°53'05" E and 81°53'05" E, at an elevation of 340 meters above mean sea level (MSL). The district was formed on January 1, 2012, from the Raipur district, with its headquarters 90 kilometers south of Raipur. It is bordered by Raipur to the north, Dhamtari to the west, and the state of Odisha to the east. The total geographical area of Gariyaband is 582,286 hectares, with a gross cropped area of 157,872 hectares and a net cropped area of approximately 136,110 hectares as of 2023-22. The Kharif cropping area was 136,103 hectares.

3. MATERIALS AND METHODS

Gariyaband is located amid Chhattisgarh plains region. This district is located between latitudes N 20°57'46" and 20°17'36" and longitudes E 82°53'05" and 81°53'05" at an elevation of 340 m above MSL. It was formed on January 1, 2012, from the Raipur district, and its headquarters are 90 kilometers south of Raipur. This district is delimited to the north by Raipur, to the west by Dhamtari, and to the east by Orissa State [2]. The overall gross cropped area in the Gariyaband district (in the year 2020-23) was anticipated to be 157872 ha, while the net cropped area in the district is roughly 136110 ha. The district has a total geographical area of 582286 ha. The district's Kharif area was 136103 hectares [3].



Figure 1: Gariyaband geographical Map

The Gariyaband District Collect orate was the source of the majority of the data for the Gariyaband district. Daily rainfall statistics were provided for the ten-year period by the Department of Land Records Gariyaband District (2011-2023).

A rainfall characteristics analysis included determining statistical parameters such as maximum, minimum, mean, standard deviation and coefficient of variation, skewness, (Table 1) and percentage deviation of weekly, monthly, seasonal, and annual rainfall values using a computer programmer in MS Excel. By taking into account the largest and lowest amounts of rainfall throughout each particular week, month, season, and year, the maximum and minimum values of rainfall were calculated.

Data for the Gariyaband district were primarily sourced from the Gariyaband District Collectorate. The Department of Land Records provided daily rainfall statistics for the ten-year period (2011-2023). Rainfall characteristics analysis involved determining statistical parameters such as maximum, minimum, mean, standard deviation, coefficient of variation, skewness (Table-1), and percentage deviation of weekly, monthly, seasonal, and annual rainfall values using a computer program in MS Excel. Maximum and minimum rainfall values were calculated by considering the highest and lowest amounts of rainfall for each specific week, month, season, and year.

4. RESULT AND DISCUSSION

The characteristics of regional rainfall were assessed using quantitative metrics such as maximum, minimum, mean, standard deviation, coefficient of variation, skewness, and percentage deviation of weekly, monthly, seasonal, and annual rainfall values. The following are the outcomes of these quantitative measures:

Weekly Rainfall Distribution Pattern

The assessment of weekly rainfall data over ten years (2011-2023) demonstrates significant fluctuations in rainfall during Standard Meteorological Weeks (SMW) across the years. The SMW weeks spanning from the 22nd to the 44th were identified as monsoon weeks, during which there was a higher concentration of rainfall. The weekly rainfall distribution clearly shows that 90.20 % of the rainfall occurs from the 22nd to the 44th SMW. The statistics indicate that the maximum average rainfall of 104.6022 mm, accounting for 10.22193% of the total monsoon rainfall, was recorded in the 29th SMW, while the lowest value of 0 mm was recorded in the 44th SMW, as shown in Table 1.

Table 1: Weekly rainfall parameters over Gariyaband (2011-2023)

SMW	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
22	9.300685	51.30131	0.008517	16.4022	176.6016	1.709329
23	16.00773	57.5074	0.007505	19.80027	123.6064	1.204316
24	36.50792	96.00303	0.00756	26.00545	71.30193	1.002621
25	69.10381	184.4037	4.603598	56.70884	82.10979	0.702477
26	30.80841	64.80375	7.102314	22.50257	73.3	0.904677
27	37.60902	86.40005	4.400228	28.70053	76.30726	0.307789
28	57.60302	112.8094	15.20858	32.00792	55.50853	0.49566
29	104.6022	313.803	19.00722	106.4061	101.7006	1.302672
30	65.50686	166.001	26.00603	44.80534	68.50943	1.005548
31	78.60022	284.3096	2.800742	92.40728	117.6034	1.108111

32	78.10869	155.0039	22.6064	37.40029	47.90297	0.009653
33	50.90402	133.8088	13.20162	37.60405	73.80042	1.105293
34	35.60188	69.00136	1.604272	25.00902	70.30869	0.2054
35	101.7028	240.5095	38.00025	75.70703	74.40437	1.604971
36	70.90298	198.0024	0.009222	64.70895	91.20859	0.102971
37	48.60005	123.0071	0.008486	38.70902	79.70561	0.906914
38	64.80468	127.2019	2.60672	40.0027	61.70771	0.19181
39	16.40718	61.20196	0.005702	22.60849	137.4019	1.900003
40	28.20101	76.80985	0.009933	30.90381	109.5061	0.906019
41	12.10907	36.20199	0.008613	14.40691	118.6058	1.500567
42	7.00907	64.20234	0.008348	20.20689	289.1064	1.008472
43	3.304183	22.60389	0.002187	7.30954	223.206	1.301221
44	0.006651	0.000569	0.004478	0.00944	0.003648	0.001277

Pattern of Weekly Rainfall Distribution

The highest weekly rainfall recorded during the 44th Standard Meteorological Week (SMW) was 0.006651 mm, while the 29th SMW saw 313.803 mm. The 28th SMW had 15.20585 mm of minimum rainfall, but many SMWs (the 22nd-24th; 36th, 37th, and 39th-44th) had 0.00 mm (Table 1). Weekly rainfall readings varied from 0.00944 to 106.4061 in terms of standard deviation (SD) and from 55.5% to 289.1% in terms of coefficient of variation (CV). According to Pali AK et al. (2012), a larger SD combined with a smaller CV denotes more reliability in rainfall patterns. This implies a regular and even pattern of precipitation throughout specific weeks. The study does, however, also show notable fluctuation in rainfall measurements, suggesting that the region's distribution of rainfall is incredibly erratic.

Pattern of Monthly Rainfall Distribution

In the Gariyaband area, June to October accounts for more than 95% of the yearly rainfall, according to a review of monthly rainfall (Table 2). With an average rainfall of 299.1059 mm in August and 300.2083 mm in July, respectively, August is the wettest month.

Table 2: Monthly Rainfall Characteristics (2011-2023)

Month	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
January	9.703029	83.80972	0.003774	26.10855	271.0076	1.104361
February	5.706104	37.00847	0.001551	12.7023	222.2055	1.403995
March	11.50905	66.00582	0.009183	21.30409	186.3042	1.604238
April	7.601287	51.3039	0.008319	16.10595	210.7038	1.402508
May	11.90095	71.20594	0.009455	22.10437	185.8032	1.309047
June	150.5055	241.5056	40.00548	58.5048	38.90319	0.206738
July	300.2083	559.6034	176.0042	134.8026	45.10632	1.00369
August	299.1059	596.1037	157.6013	149.1073	49.70847	1.107976
September	219.702	378.0092	91.40587	82.40393	37.50616	-0.19312
October	50.60577	97.20132	0.004669	39.40924	77.90738	-0.59933
November	0.003628	2.84E-05	0.002991	0.009933	0.008469	0.001994
December	2.90951	29.60499	0.008415	9.409948	316.2074	0.906161

Pattern of Monthly Rainfall Distribution

It is evident that there is a considerable likelihood of substantial rainfall from June to October. Ten years of data analysis show that, with 300.00 mm and 0.00 mm of average monthly rainfall, respectively, August and November had the largest and lowest amounts. Rainfall varies and is reliable, as seen by the high standard deviation of 149.1073 mm in August and the low standard deviation of 0 mm in November. The region's erratic rainfall pattern is highlighted by November, which is the driest month with an average rainfall of 0.003628 mm (Table 2).

Distribution Pattern of Seasonal Rainfall

The highest rainfall quantities for the pre-monsoon, monsoon, post-monsoon, and winter seasons are 137.2098 mm, 1538.101 mm, 97.20896 mm, and 83.80613 mm, respectively, according to the climatic seasons. With an average rainfall of 969.2082 mm, the monsoon season records the most amount, while the winter season has the lowest amount, 15.3071 mm. Runoff from this downpour loses a lot of its water, which can be collected with in-situ or ex-situ

water harvesting systems. Then, throughout the summer, Kharif, and Rabi seasons, this water may be utilized to irrigate crops. It can also be used to provide vital irrigation during one- to two-week dry periods in the rainy season, which can damage standing Kharif crops.

Reliability in rainfall patterns is indicated by the monsoon season's coefficient of variation, standard deviation, and skewness, which are 24.00857%, 232.7041 mm, and 1.709449, respectively. Higher coefficients in the winter, summer, and post-monsoon seasons imply erratic rainfall patterns, but lower coefficients during the monsoon season indicate steady rainfall. The average pre-monsoon rainfall of 31.0022 mm is helpful in preparing the soil.

Distribution of Rainfall During the Cropping Season

The quantitative measures of the rainfall data, including maximum, minimum, mean, standard deviation, coefficient of variation, skewness, and percentage deviation, are shown in Table 3 during the cropping season. With a coefficient of variation of 27.60887% and a standard deviation of 239.5026 mm, the average rainfall during the Kharif season (July-October) accounts for 81.3132% of the annual rainfall. This indicates consistent rainfall. A large portion of this rainfall evaporates as runoff, which the seasons of Zaid, Rabi, and Kharif may store and utilize. In addition to providing vital irrigation during dry spells during the rainy season, this stored water can help lessen the effects on standing Kharif crops. During the Kharif season, the highest and lowest amounts of rainfall were 1437.004 mm and 601.807 mm, respectively. Reliance on irrigation or preexisting soil moisture is required because of the less predictable rainfall during the Rabi season, as indicated by the larger coefficient of variation.

Distribution Pattern for the Year

The general variability and trends in the region's rainfall are indicated by the distribution patterns of annual rainfall. Significant variations in yearly rainfall are revealed by the data analysis for Gariyaband, highlighting the necessity of efficient water management and conservation measures to promote agricultural planning and sustainability in this area.

Pattern of Monthly Rainfall Distribution It is evident that there is a considerable likelihood of substantial rainfall from June to October. Ten years of data analysis show that, with 300.00 mm and 0.00 mm of average monthly rainfall, respectively, August and November had the largest and lowest amounts. Rainfall varies and is reliable, as seen by the high standard deviation of 149.1073 mm in August and the low standard deviation of 0.009933 mm in November. The region's erratic rainfall pattern is highlighted by November, which is the driest month with an average rainfall of 0.003628 mm (Table 2).

Distribution Pattern of Seasonal Rainfall

The highest rainfall quantities for the pre-monsoon, monsoon, Post-monsoon, and winter seasons are 137.2098 mm, 1538.101 mm, 97.20896 mm, and 83.80613 mm, respectively, according to the climatic seasons.

With an average rainfall of 969.2082 mm, the monsoon season records the most amount, while the winter season has the lowest amount, 15.3071 mm. Runoff from this downpour loses a lot of its water, which can be collected with in situ or ex-situ water harvesting systems. Then, throughout the summer, Kharif, and Rabi seasons, this water may be utilized to irrigate crops. It can also be used to provide vital irrigation during one- to two-week dry periods in the rainy season, which can damage standing Kharif crops.

Reliability in rainfall patterns is indicated by the monsoon season's coefficient of variation, standard deviation, and skewness, which are 24.00857%, 232.67041 mm, and 1.709449, respectively. Higher coefficients in the winter, summer, and post-monsoon seasons imply erratic rainfall patterns, but lower coefficients during the monsoon season indicate steady rainfall.

The average pre-monsoon rainfall of 30.0022 mm is helpful in preparing the soil. **Distribution of Rainfall During the Cropping Season** The quantitative measures of the rainfall data, including maximum, minimum, mean, standard deviation, coefficient of variation, skewness, and percentage deviation, are shown in Table 3 during the cropping season. With a coefficient of variation of 27.60887% and a standard deviation of 239.5026 mm, the average rainfall during the Kharif season (July-October) accounts for 81.3132% of the annual rainfall. This indicates consistent rainfall. A large portion of this rainfall evaporates as runoff, which the seasons of Zaid, Rabi, and Kharif may store and utilize. In addition to providing vital irrigation during dry spells during the rainy season, this stored water can help lessen the effects on standing Kharif crops. During the Kharif season, the highest and lowest amounts of rainfall were 1437.004

mm and 239.5026 mm, respectively. Reliance on irrigation or preexisting soil moisture is required because of the less predictable rainfall during the Rabi season, as indicated by the larger coefficient of variation.

Table 3: Seasonally and yearly rainfall characteristics (2011-2023)

Season	Mean (mm)	Max. (mm)	Min. (mm)	SD (mm)	CV (%)	Skewness
Climatic season						
Pre-Monsoon	31.0022	137.2098	0.0055	47.4051	152.8088	1.709449
Monsoon	969.2082	1538.101	708.2088	232.7041	24.00857	1.703959
Post Monsoon	53.60403	97.20896	0.007888	36.20978	67.60588	-0.39917
Winter	15.3071	83.80613	0.002514	27.9007	181.8012	2.000504
Cropping Season						
Zaid	181.507	354.6068	40.00586	82.40497	45.40238	0.507635
Kharif	869.408	1437.004	601.807	239.5026	27.60887	1.505976
Rabi	18.30331	83.80632	0.000169	27.70864	151.1094	1.701116
Annual						
Yearly	1069.208	1593.108	795.1025	242.4002	22.60707	1.209166

Trends in Annual Rainfall

Figure 2 shows that the percentage departure from the mean annual rainfall varied between -25.4% and +24.64% during the course of the experiment. The Twelve -year period from 2011 to 2023 did not exhibit a continuous pattern in annual rainfall; nonetheless, the years 2013 to 2019 shown a falling tendency in average annual rainfall, while the years 2011, 2012, and 2023 demonstrated an increasing trend.



Fig 2: Year wise total annual rainfall distribution & percentage deviation

5. CONCLUSION

Several important insights are revealed by the examination of the Gariyaband district's rainfall data. The monsoon season's 29th Standard Meteorological Week (SMW) saw the greatest average weekly rainfall of 313.803 mm, or 32.370% of the season's total rainfall. On the other hand, the 44th SMW had the lowest average weekly rainfall, with 0.000569 mm.

Based on a monthly rainfall analysis, July has the highest average rainfall of 300.2083 mm, followed by August with 299.1059 mm. With zero millimeters of rain on average, November is the driest month.

Seasonally, 90.64 % of the annual average rainfall occurs during the monsoon period, which has the maximum average rainfall of 969.20 mm. There is a lot of rainfall throughout the Kharif season as well an average of 869.408 mm. Although runoff usually loses a large amount of this rainfall, it can be preserved by using in-situ or ex-situ water harvesting systems. You may use this water that has been conserved to irrigate crops in the summer, during Rabi and Kharif. Additionally, it can supply vital irrigation during brief dry spells of one or two weeks during the rainy season, which would otherwise negatively impact standing Kharif crops.

With an average of 1069.208 mm, the annual rainfall in the Gariyaband area ranges from 795.1025 mm to 1593.108 mm overall. The information emphasizes how crucial it is to have efficient water management plans in order to lessen the negative effects of erratic rainfall patterns on the area's agricultural sector.

ACKNOWLEDGEMENT

None.

CONFLICT OF INTEREST

None.

REFERENCES

- Agriculture Contingency plan for District – Gariyaband, ICAR; c2014.
<http://www.nicraicar.in/nicrarevised/images/statewiseplans/Chhattisgarh/CHH23-Gariyaband-30.08.2014.pdf>.
- District Survey Report – Gariyaband (Chhattisgarh), Directorate of geology & mining, mineral resource department, Government of Chhattisgarh; c2019, p. 17-18.
- District socio-economic data brochure, District Planning and Statistics, Gariyaband; c2021, p. 34B.
- Bhuarya, Shiv Kumar. Agro climatic analysis of Chhattisgarh state with respect to sustainable crop production. M.Sc. Thesis, Indira Gandhi Krishi Vishwavidhyalaya, Raipur. 2015;5-26:30-42.
- Chaudharay JL. Analysis of rainfall for strategic crop planning under rainfed rice-based cropping system in CG Ann. Agri. Res. New Series. 2015;3(2):184-190.
- Manorama K, Ravichandran G, Joseph TA. Rainfall analysis and crop planning for the Nigeria. Journal of Agrometeorology. 2007;9(2):209-215.
- Pali AK, Thakur H, Khalkho D. Rainfall analysis-based rice crop planning in Durg district of Chhattisgarh. Indian Journal of Soil Conservation. 2016;44(1):30-36.
- Singh PK. Rainfall variability and crop planning in Sabour region of Bihar. Journal of Agrometeorology. 2005 Dec 1;7(2):284-90.
- Shriwastav PC, Shriwastav SK. Climatic variability and its influence on water availability over Eastern Himalayan belt of Arunachal Pradesh. Journal of Soil and Water Conservation. 2014;10(1):3-9.
- Sinha BL, Sahu RK, Pradhan MK. Evaluation of Rainfall Distribution pattern for agricultural planning in Mungeli District of Chhattisgarh Plain. International Journal of Current Microbiology and Applied Sciences. 2019;8(3):2255-2263.
- Sinha BL. Study on Rainfall Distribution Pattern for Agricultural Planning in Bhatapara Region of Chhattisgarh Plain. International Journal of Chemical Studies. 2020;8(6):3002-3006.
- Solanki NS, Singh AK. Rainfall analysis for crop planning in the humid southern plains of Rajasthan, Journal of Water Management. 2009;17:12-15.
- Vaidya VB, Karande BI, Pandey V, Lunagar MM, AM Shekh. Rainfall probability analysis for crop planning in Gujarat state. Journal of Agro meteorology. 2008;10(1):183-185.
- Veeraputhiran R, Karthikeyan R, Geethalakshmi V, Sundersingh SD, Balasubramanian TN. Crop Planning Climate atlas Pub by AE Publications Coimbatore; c2003, p. 1-45.
- Sinha BL. Analysis of Rainfall Data for Drought Investigation at Mungeli of Chhattisgarh Plain. Int. J. Curr. Microbiol. App. Sci. 2019;8(3):2255-63.
- Sinha BL, Singh A. Embodying a Preparedness to Die: Why Bishops of Western Rajasthan Rise in Defence of the Blackbuck and the Chin Kara?. Sociological Bulletin. 2020 Apr;69(1):34-50.