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Assessment of dependable rainfall and water availability for sustainable watershed management: A case study of Vihokhu Watershed, Dimapur, Nagaland

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Abstract
The present study evaluates dependable water availability and rainfall variability in the Vihokhu watershed, located in Kuhuboto Block of Dimapur district, Nagaland, covering a geographical area of 807 ha. The watershed receives an average annual rainfall of 1564.11 mm (2007-2021), yet much of this rainfall is lost as surface runoff due to steep slopes, jhum cultivation, deforestation and improper land management, resulting in soil erosion and reduced agricultural productivity. To support sustainable watershed management and improved crop production, weekly dependable rainfall at a 75% probability level was analyzed to determine water availability throughout all 52 weeks of the year. Results indicated that the monsoon period consistently spans from Standard Meteorological Week (SMW) 24 to SMW 42, with June-August being the wettest months (285.16 mm average rainfall), while January, February and December are the driest (18.65 mm). Although the region receives substantial annual rainfall, its uneven temporal distribution creates water-deficit weeks during the crop-growing season, necessitating supplemental irrigation. Based on the cropping pattern and water requirement analysis, an irrigation schedule was developed to bridge these deficits through water harvesting and storage structures. The study underscores the significance of dependable rainfall analysis for planning soil and water conservation interventions in hilly watersheds. The findings provide a scientific basis for improving water resource management, enhancing agricultural productivity and strengthening the socioeconomic resilience of communities within the Vihokhu watershed.

Keywords: Watershed, Rainfall, Runoff, Management, Dimapur, Nagaland

1. Introduction

Water is an essential component of human survival as well as one of the most important natural resources. It serves a variety of functions, including enhanced sanitation, health and hygiene and is therefore a necessary for quality of life. It is a production factor for industries and aids agricultural development. It is prized for its aesthetic, cultural and spiritual worth and it is a key component of the life support system that ensures the proper functioning of ecosystem services. Protecting its services in terms of utility and access to various natural and human conditions is a difficult challenge. (NITI Aayog, 2018) [6]

The practice of planning, distributing and managing the most efficient use of water resources is known as water resource management. It is a part of the management of water resources. With the growing uncertainty of global and climatic change, as well as the long-term impact of management action, the field of water resources management will have to continue to adapt to present and future issues of water allocation. It is conceivable that continuous climate change will result in situations that have never been seen before. As a result, alternative management strategies are being investigated in order to avoid future setbacks in water-based resource distribution. It's about the long-term viability of present and future water allocations. As water becomes scarce, the need of water resource management in achieving a balance between human requirements and the critical processes of water resource sustainability in the environment becomes increasingly important. Water management is the process of controlling and moving water resources in order to avoid causing harm to people and property while also maximising their effective and beneficial use. Dams and levees that are well-maintained lessen the risk of flood damage. Irrigation water management systems help farmers make the most of their limited water resources Over the last two decades, water resource management has altered dramatically. Previous management models failed to adapt to the combined pressures of increased demand and ongoing degradation of water quality, resulting in supply system failure. In fact, human management, rather than environmental or natural phenomena, can explain many of the worst cases of environmental degradation. (Zhao, M., & Boll, J., 2022) [9].

Because the world's population is rapidly increasing, it is estimated that by 2030, there will be a 40% gap between predicted demand and available water supply if current practises continue (Water Resources Group, 2015). Feeding 9 billion people by 2050 will necessitate a 60% increase in agricultural production (which consumes 70% of resources today) and a 15% increase in water withdrawal. According to estimates, 40% of the world's population lives in water-scarce areas and approximately 14% of global GDP is at risk. (Business Standard, 2018) [1].

India receives the world's second biggest quantity of rainfall, about 1150 mm per year, draining a total volume of 400 million hectare-meters, of which maximum amount of rainfall is carried away as runoff into rivers, streams, lakes and ponds. Although India has a 3700Mha-m groundwater resource, lakhs of tube wells being drilled every day to meet the growing water crisis. The water table is rapidly eroding. The need for water resources has been steadily increasing in order to maintain food security and meet the demands of the human population, agriculture and industry. Water resources now available are insufficient to fulfil the challenges of water scarcity. Water resources must be adequately developed and managed. The conservation of existing water resources, as well as the prevention of further degradation and depletion, are the most pressing concerns. To meet the demand for water and address water scarcity, one must manage groundwater and surface water effectively, prudently and inexpensively. The country's rising population should understand and adopt water saving techniques. (Central Ground Water Board, 2024).

Nagaland receives between 70-100 inches of rain per year (1800-2500 mm). The yearly rainfall in Dimapur is approximately 1200 mm. Cultivation in Nagaland is primarily rainfed and as the population grows, so do industrial and agricultural activity, necessitating an increase in water. Despite the fact that the state receives a lot of rain, a lot of water is lost as surface runoff, and there aren't enough water storage and reservoirs. Many rivers, streams and rivulets are being exploited, resulting in reduced discharges or the drying up of many rivers, streams and rivulets. Rivers, lakes and freshwater wetlands are examples of surface water resources. Groundwater resources, such as subsurface water or water contained inside aquifers, are considered good water resources. Groundwater is recharged through precipitation during the monsoon season, and canal irrigation and other types of irrigation systems also contribute to groundwater recharge. (Chakraborty *et al*., 2025) [3], (Hangshing *et al*., 2022) [4], (Singh, P. and Kumar, N., 2022) [7], (Lotha *et al*. 2024) [5].

The study of water resources management was conducted in the Vihokhu watershed under Dimapur district with the goal of improving soil and water conservation, efficient water utilisation for household, industrial and agricultural purposes and proper water harvesting practises such as water conservation structure/reservoir/storage pond to improve the socio-economic status of the area.

2. Methodology

2.1 Physical characteristics of the study area

Physical characteristics of the study area consist of location, climate, topography, soil, irrigation, drainage and ground water status.

Location

The watershed area is located under Kuhuboto block in Dimapur district. The total geographical area of watershed is 807 ha and is located at 25.90627 º N Latitude, 93.727583º E Longitude and altitude at 404.00 m. It is situated at 16 km from Dimapur.

Topography

The Dimapur district is located between 25.9089º N latitude and 93.9899º E longitude. The district's elevation varies between 160 and 450 meters above sea level. The district is bordered on the north and west by Assam, on the east by Kohima, and on the south by Assam. It has a total area of 452 sq km.

Climate

The climate is warm and temperate the average temperature is 22.6-26.8 ℃ and the annual rainfall is 1710mm.The climate zone of the Dimapur district is humid subtropical. It would be hot in the summer and cool in the winter. The area receives rain in two seasons: the South-West monsoon, which begins in the second week of June and lasts until October, and the North-East monsoon, which begins in November and lasts until January.

Fig 1: Location Map of Nagaland in India

Fig 2: Location Map of Dimapur in Nagaland

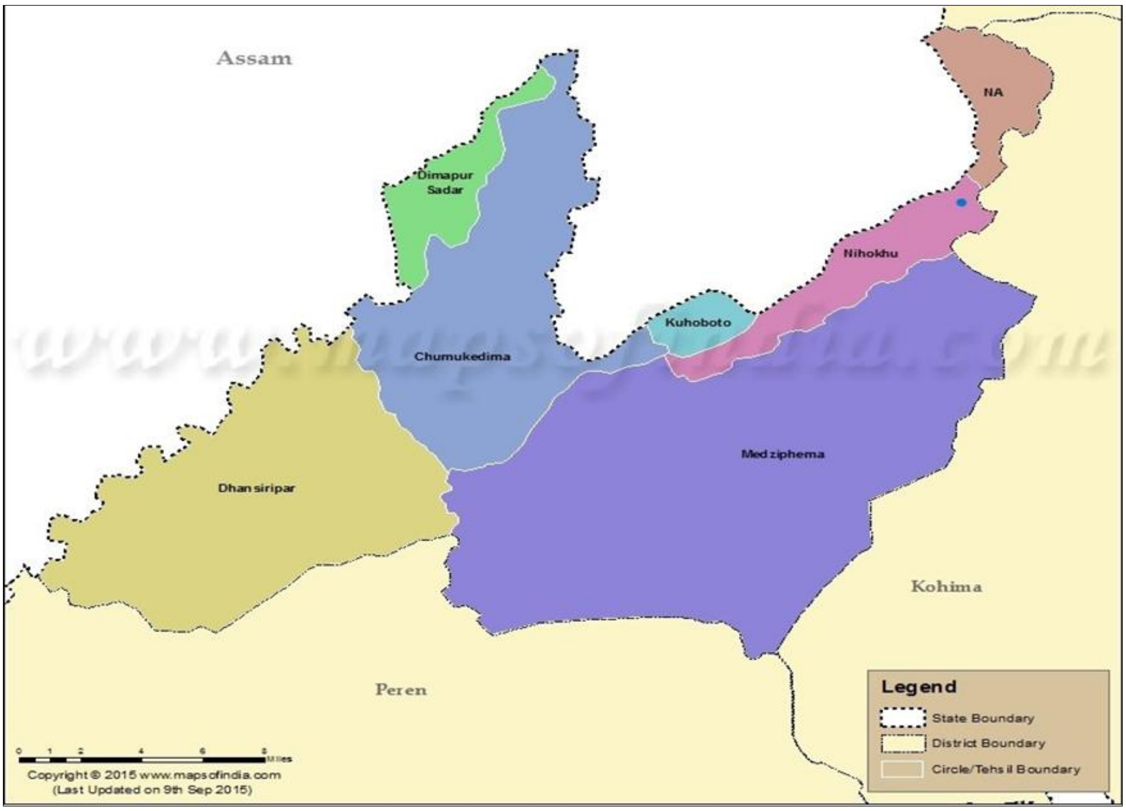

Fig 3: Vihokhu watershed in Dimapur district

Soil

In the Dimapur district, around 70% of the soil pH is below the 5.5 mark. The rapid weathering of acid parent materials (Tipam group and sandstones), undulating topography, and higher rainfall intensity cause leaching losses of exchange bases from the surface soil, resulting in the formation of acidity. Aluminum (Al) toxicity in acid soils has been identified as one of the major reasons limiting productivity, especially in soils with a pH below 5.5. Zinc (Zn) availability in soils was also found to be low at Dimapur, with up to 37.0% deficient. Soil type is loamy to sandy loam.

Forest
The district's hilly slopes are rich in natural vegetation, which is covered in evergreen tropical and subtropical forest, which is home to a diverse flora and fauna. The forests in the Dimapur district are densely forested, with palms, rattan, medicinal herbs, canes, and bamboos. Recorded forest area (RFA) in the state is 8623 sq km of which 234 sq km is reserved forest and 8389 sq. km is open forest. Total forest area in district is around 103 sq km,

Irrigation
Farmers and cultivars generally depend on monsoon rain as agricultural practice has been carried on in primitive ways. The total area in the state under irrigation is 61,153ha. The irrigation work is mostly meant to divert small hill streamlets to irrigate valleys.

Groundwater quality
The district's groundwater is generally slightly alkaline to neutral in composition. Soft water has a low electrical conductivity and a low total dissolved solid. The rest of the constituents are within the BIS's acceptable limits for drinking, agricultural, and industrial water. The district has not yet been found to be polluted by chemicals. However, in the district's valley area, the iron content in ground water exceeds the legal limit due to the shallow water bearing zone.

Groundwater resources
The GEC1997 guideline and suggestion were used to calculate the ground water resource estimation. The district is dominated by hilly terrain, for which ground water data is essentially non-existent. Hilly locations with a slope of greater than 20% were removed from the calculations because they are unsuitable for ground water recharge. Because there are no poor-quality, command/non-command zones, ground water resource computation is limited to monsoon and non-monsoon seasons. The current resource assessment approach follows GEC1997 recommendations: 1) Rainfall Infiltration Method 11) Water Level Fluctuation Method.

Ground water irrigation, recharge from ponds and tanks, check dams, and nala bunds are all considered non-rainfall sources of recharge for the district. The total yearly recharge is calculated by adding the recharging from rainfall during the pre-monsoon and post-monsoon seasons, as well as recharge from non-rainfall sources.

Drainage
The area is drained by the Zubza and Chathe rivers. The Zubza River flows from the north-east to the west of the area, while the Chathe River travels from the east to the south, eventually merging with the Dhansiri River. The two rivers serve as the district's primary source of surface water for irrigation, animal production, and drinking water.

Cropping pattern
Both Kharif and Rabi crops are grown in the Dimapur district. Paddy is the principal crop grown in the area (Rice). There are two types of farming patterns: permanent and shifting cultivation (Jhum). In the valley sections, permanent agriculture is done. On the districts hill slopes, where water for irrigation is scarce, shifting agriculture (Jhum) is practiced. Other crops planted in addition to paddy include maize, wheat, cereals, pulses, oilseeds, fruits, vegetables, and commercial crops such as sugarcane and cotton jute.

Table 1: Demography of the district

Sl.no	Particulars	Total	Male	Female
1	Total geographical area	452 sq km		
2	Number of villages	97		
3	Number of households	7067		
4	Population	38648	19663	18985
5	Literacy rate	71.39%	69.28%	66.05%
6	Climate	Subtropical		
7	River	Chathe and Zubza		
8	Soil Ph	4.5-5.7		
9	Rainfall	1500-2000 mm		
10	Altitudes	140-450 m(ASL)		

Table 2: Demographic of study area

Sl.no	Particulars	Total	Male	Female
1	Total no of households	250	-	-
2	Population	1167	612	555
3	Literacy rate	75.42%	81.56%	69.32%
4	Total workers	490	255	235
5	Main worker	442	-	-
6	Marginal worker	48	38	10
7	Labour	28	23	5
8	Schedule caste	0	0	0
9	Schedule tribe	654	317	337

Agriculture infrastructure
The use of enhanced technology tools in agriculture farming is extremely limited in many areas, including the use of improved and quality seed, fertilizer, pesticides, weedicides, insecticides, tools, and machinery, all of which hinder agricultural management, quality, and productivity. Even if the districts produce various agricultural products in sufficient quantities to meet the demand for export, the farmers confront challenges due to the high cost of transportation both inside and beyond the state.

Resource constraints
The major constraints faced by the people in Dimapur district is as follow:
1. Lack of awareness of finance facilities.
2. Lack of information system, extension worker etc.
3. Improper soil and water management strategies.
4. Lack of water harvesting structure and storage.
5. Lack of knowledge on improved crop production methods.
6. Lack of farm input equipment and machinery

Planning consideration
Certain aspects of the project area's topography, climate, cropping methods, ground water supplies and quality, agricultural infrastructure and socio-economic situation must be considered for planning and overall development of the watershed.

1. Water resource development and management

Water resource management necessitates a thorough understanding of the related physical sciences and technology. The various institutional, social and political issues affecting water resource planners and managers are at least as essential, if not more so. Promoting rainwater collection on rooftops, in catchment systems and in storage ponds. Diverting Surface runoff water into water reservoirs to maintain a sufficient supply of water for off-season crop production. Promoting Vegetation covers to reduce erosion and the quantity of sediment that enters water systems by controlling storm water runoff and filtering dirty water.

2. Animal husbandry

To ensure adequate supply of food and fodder.

3. Crop production

Pumping of storage pond, ground water. as well as irrigating the field by tapping the streams to meet the crop water requirement in summer and winter. Increasing the efficiency of water use through conserving water and making greater use of proven technologies, as well as reducing overall water use.

Technical Programme in Details

The technical programmed that will be studied in the watershed include the following:

Collection of rainfall data

Rainfall data, preferably on a daily basis for 15 years, was taken and analyzed in order to assess the watershed's surface water resource potential.

1. Average weekly, monthly and annual rainfall.
2. Maximum daily, weekly and monthly rainfall.
3. Total rainfall during kharif, rabi and Zaid.
4. Estimation of rainfall at 75% level of probability for different weeks of the year.
5. Estimation of probability of rainfall by Gumbel and Weibull's distribution at different level of probability (60, 70, 75, 80).

Probability analysis of weekly rainfall data

Because rainfall is uncertain and unpredictable in nature, the very same amount of rain may not fall on the same day every year. As a result, probability research was conducted in order to get an average estimate of the amount of rainfall that will be received on a particular day or week. Below are the various plotting methods that are commonly used to predict these precipitation events.

Table 3: Plotting position relationships

Name	Source	Relationship
Hazen	Hazen (1930)	$\frac{(2m-1)}{2N}$
Weibull	Weibull (1939)	$\frac{M}{(N+1)}$
California	California	$\frac{m}{N}$

To predict the chance of rainfall over the next 15 years, including the average and maximum amounts, on a weekly, monthly and annual basis. The data were organized in descending-ascending order of magnitude, with m=1 representing the highest value and m=N representing the lowest. Weibull's plotting position equation was used to compute the plotting positions, where 'm' is the rank number and N is the number of data sets.

$$P=\frac{M}{(N+1)}\times 100$$

The probability of these events is assessed at various percentage levels, including 60, 70, 75, and 80 percent. The Central Water Commission of Indian advised that rainfall be estimated using a 75 percent level probability. As a result, the probability level for forecasting rainfall events in this study was set at 75 percent.

Crops grown in the watershed area and their water requirement

The study will consider crops planted in the watershed region during several seasons, such as Kharif, Rabi, and Zaid, as well as their sowing time, water requirements, total area of each crop grown in the watershed, crop growth period, and harvest time. On a weekly basis, the set of government-recommended crops cultivated in the watershed would be assessed for crop water requirements. It would determine whether rainfall is sufficient or insufficient to meet crop water requirements during the growing season, and whether surplus water obtained during the monsoon season may be retained and used to irrigate rabi season crops or pump ground water for irrigation.

Soil conservation structures and water storage/reservoirs

The study includes engineering structure as well as agronomical ones that need to be adopt to trap the monsoon rain through construction of water harvesting pond, terrace cutting, trenches, which is practice in the north-eastern and foothill part of India. Some conservation structure that are constructed across the stream are drop structure, check dams, boulder dams, chutes and spillways. which reduce the peak rate of runoff during monsoon season in the stream and stored the draining stream water. So that during non-monsoon season there will be available water that could be utilize for household, livestock, irrigating cultivation of crops. Apart from this the stored water in the pond and dams increases the ground water recharge, and also the conservation structure retained the soil from runoff erosion.

Analysis of data

Weibull's distribution techniques and Binnie's runoff co-efficient will be used to analyze 15 years of rainfall data and estimate streamflow with a 75 percent probability using Weibull's distribution techniques and Binnie's runoff co-efficient. Crop water requirements would be predicted, based on water resource availability data, crop grown, and watershed area. A study will also determine whether the monsoon rainfall will be insufficient or excessive for irrigating the crop and ground water recharge. Determination of total runoff, irrigation and storage.

3. Results and Discussion

The main goal of this project is to use various conservation techniques, such as mechanical and vegetative barriers, to arrest certain amount of rainwater received in the watershed. When flow rates are high and vegetation barriers can't support or reduce the flow rates to protect soil and water from erosion, mechanical measures are frequently built on mild to severe slopes. The right use of every land and water resource within a watershed is implied by watershed management or protection, which aims to maximize output while minimizing risk to natural resources.

Watersheds are commonly discovered to be harmed as a result of unplanned, improperly managed, and illogical land use activities. Poor planning, deforestation, mining, construction, industrialization, shifting cultivation, natural and man-made fires, soil erosion, water erosion, and ignorance of the local population are some of the factors that have contributed to the degradation of many watersheds.

A watershed management program's various goals include

(1) To limit harmful runoff,
(2) To control and make use of runoff for beneficial purposes,
(3) To prevent erosion and reduce the creation of sediment,
(4) To lessen flooding in the places downstream,
(5) Improve groundwater storage wherever possible, and
(6) Making proper use of the watershed's land resources to develop forest and fodder resources and safeguard the environment.

The implementation of conservation farming techniques to boost agriculture, controlled grazing to maintain pasture productivity, water management for irrigation and drainage, and all other kinds of erosion control measures could be regarded as components of the watershed management programme.

Watershed Management Influencing Factor

The following are the key elements that need to be studied in order to create a management programme and have a significant impact on the behaviour of the watershed:(i) The watershed's size and shape, (ii) topography (iii) The properties of soils, (iv) Rainfall (v) Land use (vi) A green covering.

The type and volume of information required to plan watershed improvement projects will be influenced by the project's nature and objectives.

The following major categories can be used to classify the data required for planning:

(1) Hydrological information,
(2) Soil and land use data, and
(3) economic and social data

For determining agricultural water needs, stream flow data, and sediment flow data, hydrological data that will indicate data about precipitation, temperature, relative humidity, evaporation, and sunshine hours are necessary parameters. Information regarding the different types of soil found in the watershed, land use data, topographic and geologic maps, and the different types of flora are all necessary for planning and management of watershed.

This chapter includes planned tactics for estimating and using precipitation, runoff resources for optimal agricultural production, followed by the results and discussion and emphasizing the approach that is transferable to other watersheds with similar conditions.

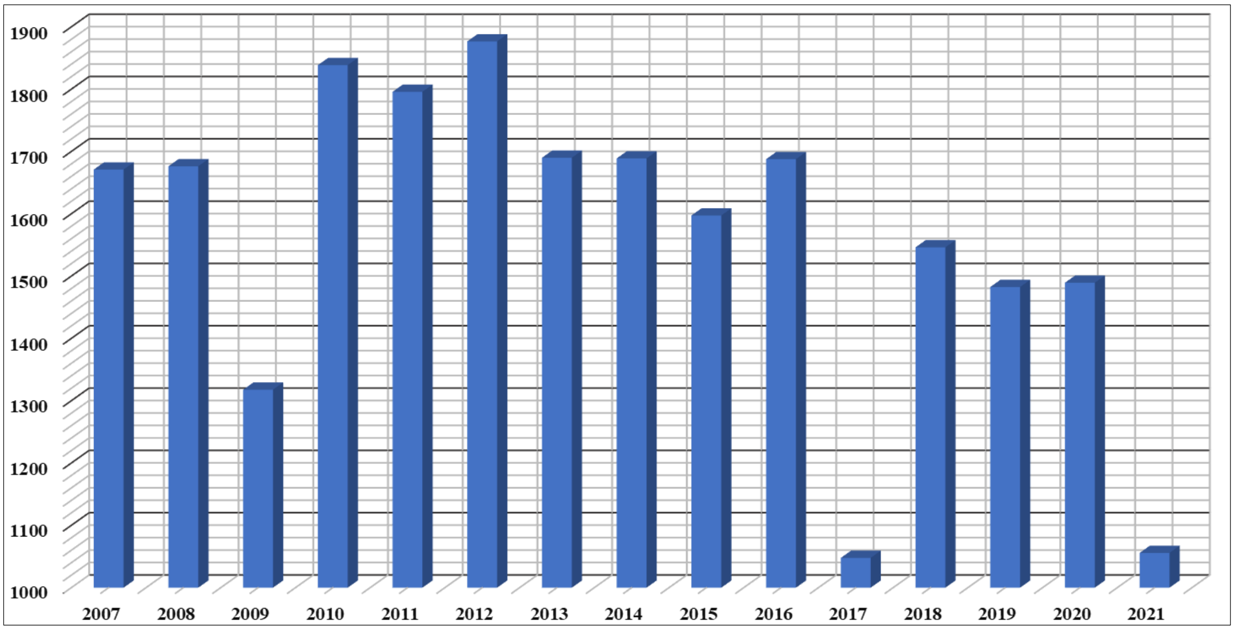

Fig 4.1: Annual rainfall at Vihokhu watershed (2007-2021), mm

3.1 Hydrological Data Analysis (Precipitation)

The following section provides a thorough examination of the watershed's precipitation and stream flow occurrences.

3.1.1 Analysis of annual rainfall data

The hydrological data for analysis were obtained from the Dimapur soil and water conservation office, which is 24 km away from the Vihokhu watershed was selected as the reference weather station of the project and its climatic data were utilized for hydrological analysis work because there was no weather station in the vicinity of the watershed.

Rainfall data for 15 years was observed, as shown in Table 3.1. It was discovered that both the pattern of rainfall and the amount of rainfall that occurred in the watershed varied. The maximum amount of precipitation was 1876.7 mm in 2012, and the least amount was 1047.8 mm in 2017.

The average annual rainfall over the years worked out to be 1564.113 mm, The fact that 10 of the 15 years of data contain more than 1500 mm of rainfall suggests that the watershed has gotten a respectable quantity of precipitation. A 75% level of probability may be viewed as a reasonable estimate when planning for the annual production of a watershed because average rainfall received across the area has little bearing on watershed project planning (rainfall is a stochastic event as opposed to a deterministic one).

Table 3.1: Annual Rainfall (mm) 2007-2021 received at Vihokhu watershed

Year	Rainfall, mm
2007	1671
2008	1676.3
2009	1317.7
2010	1838.6
2011	1795.8
2012	1876.7
2013	1690
2014	1688.9
2015	1597.3
2016	1687.7
2017	1047.8
2018	1546.2
2019	1482.5
2020	1489.4
2021	1055.8

3.1.2 Analysis of monthly rainfall data

Similar monthly rainfall information for the years 2007 through 2021 is shown in Table 3.2. The highest monthly rainfall was recorded in July 2010 at 432.4 mm, and the lowest was in December 2009 and 2014 at zero mm. January, February, march, November, and December have experienced extremely low rainfall on average over the past 15 years, with values of 17.26, 21.72, 36.5, and 16.98 mm, respectively while July has received highest rainfall on average of 312.34.

Table 3.2: Monthly rainfall received (mm) 2007-2021 at Vihokhu watershed

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2007	11.4	33.4	15.6	125.8	343.5	248.5	356.4	311	165.8	55.6	2.2	1.8
2008	18.4	24.5	31.9	72.1	160.2	285.2	292.7	379.4	211.6	142.8	25.1	32.4
2009	17.3	10.6	36.2	73	103.6	203.8	311.6	288.8	188.9	44.2	39.7	0
2010	35.6	0.2	72.6	126.2	144.4	423.5	432.4	277.3	167.8	110	38.6	10
2011	12	31	56.8	163.5	276	419.7	341.4	278	110.3	41.1	38.9	27.1
2012	18	20.3	44	135.4	287.5	365.9	368	309.6	155	108.7	44.8	19.5
2013	23.6	29.2	62.6	90.4	174.5	353.5	332.3	306.3	193.3	67.8	31.2	25.3
2014	10.4	17.3	27.3	167.1	269.7	329.1	306.5	255	142.2	110.9	53.4	0
2015	16.2	28.6	13.3	149.5	230.2	245.4	220.6	305	211.9	131.7	26.5	18.4
2016	15	23	38	109.8	140.5	269.4	391.7	222.5	262.9	84.5	93.6	36.8
2017	24.9	8.4	12.4	46.2	71.8	120.9	211.7	287.8	65.8	156.9	35.6	5.4
2018	5.5	23.9	58.5	57	138.5	162.8	348.2	319.5	248.4	118.4	45.2	20.3
2019	16.4	24.9	45.1	85.5	222	205.2	265.5	173.6	110.2	291.7	18.8	23.6
2020	20.5	10.7	18.4	69.4	176.7	258.4	246.9	242.2	137.4	254.5	41.6	12.7
2021	13.8	39.8	44	59	152.1	164.7	259.3	135.3	121.4	32.6	12.3	21.5

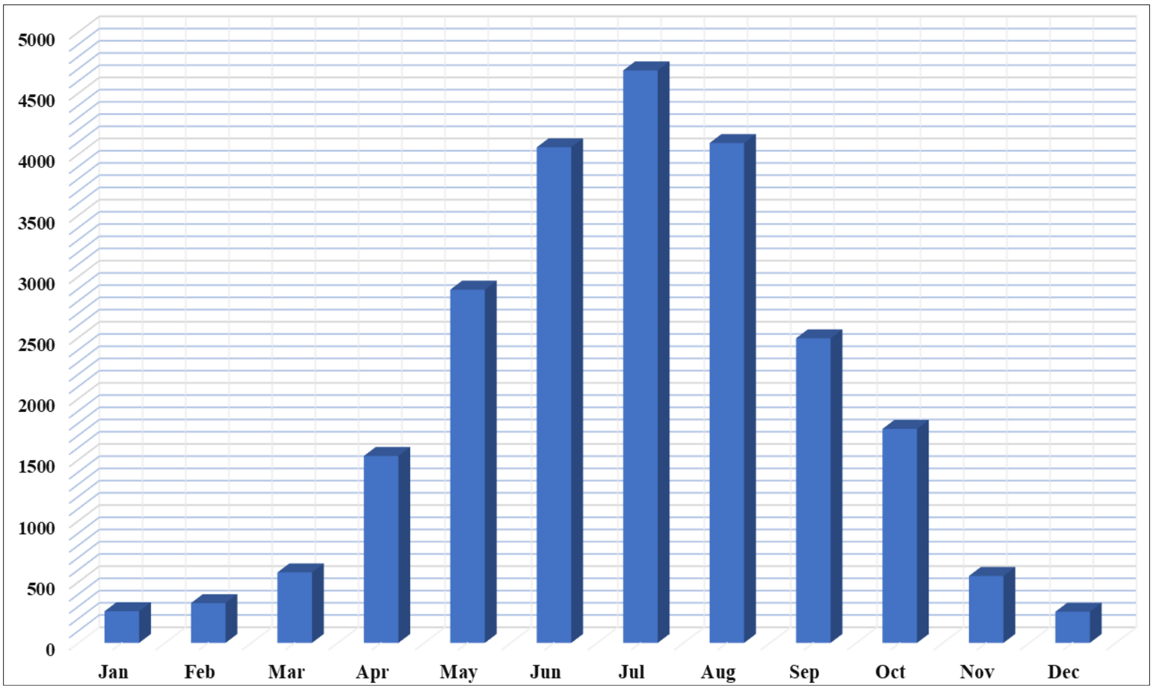

Fig 3.2: Monthly rainfall at Vihokhu Watershed (2007-2021), mm

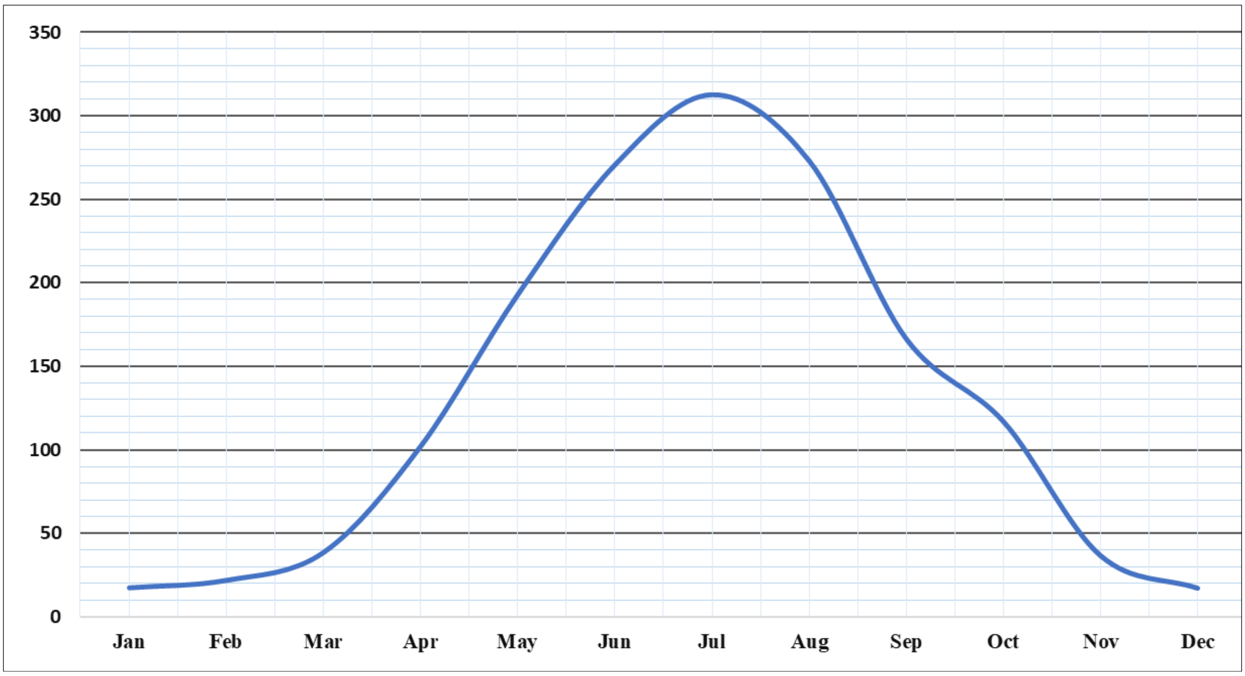

Fig 3.3: Average Monthly Rainfall at Vihokhu Watershed (2007-2021), mm

The graph Fig 3.3 shows a sudden rise and falling indicating a high degree of precipitation variability in the watershed. Fig 4.3 displays the monthly average for rainfall. Additionally generated and attached to Table 4.3 are three statistical metrics of these values, including average (X‾), standard deviation (σ), coefficient of variation (C_v), and coefficient of skewness (C_s).

Table 3.3 Mean Monthly Rainfall (mm) received at Vihokhu Watershed (2007-2021)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17.26	21.72	38.44	101.99	192.74	270.4	312.34	272.75	166.19	116.76	36.5	16.98

Mean= 130.34, SD = 110.32, C_v = 0.85, C_s = 0.57

The high C_v percent number (0.85) suggests that the data were widely spread, which caused the $C_s$value to be less than (1.00). This has occurred because the standard deviation's value has become closer to its mean value (110.32). (130.34) Fig. 3.2 shows this fluctuation in rainfall for several months.

3.1.3 Analysis of weekly rainfall data

It is safe to irrigate the crop before they experience water stress in the soil because irrigation practices and irrigation schedules in growing crops are created with irrigation intervals ranging from a few days to almost two weeks. As a matter of practice, the majority of vegetable crops are irrigated according to time tables ideally with weekly irrigation intervals of seven days.

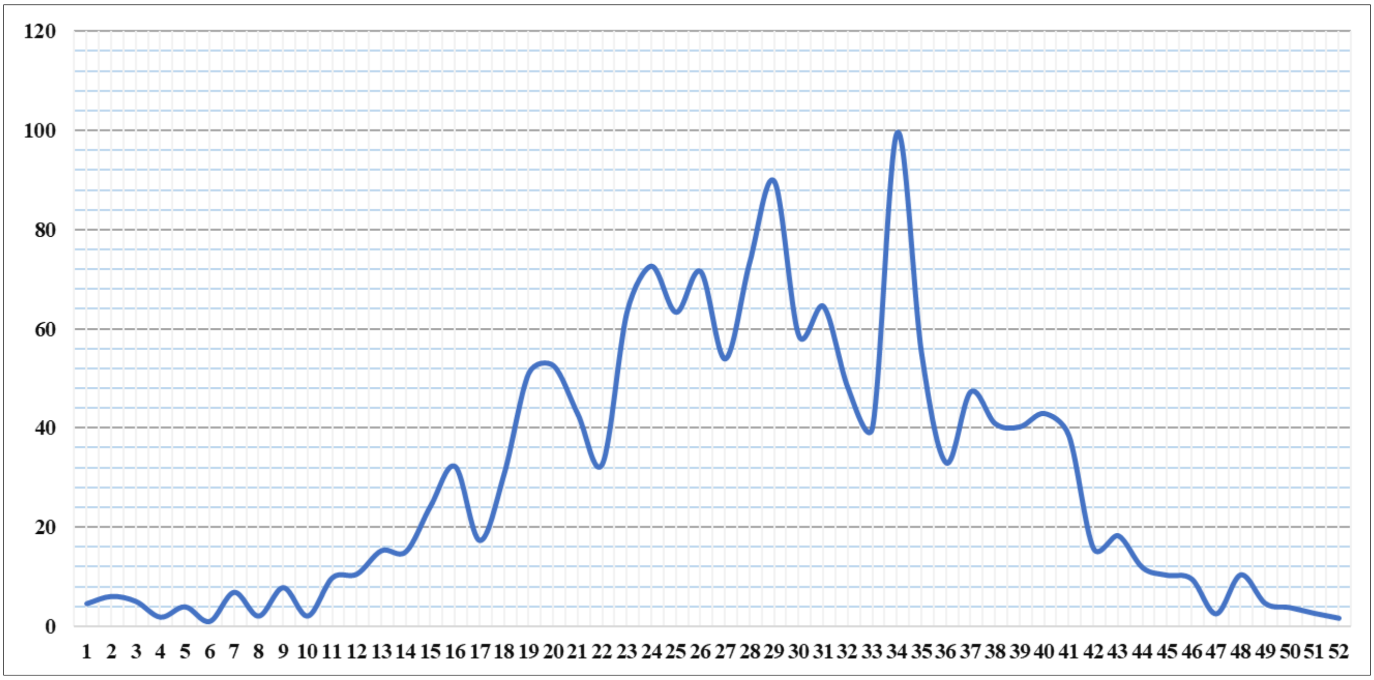

Fig 3.4: Weekly Rainfall pattern at Vihokhu Watershed (2007-2021),mm

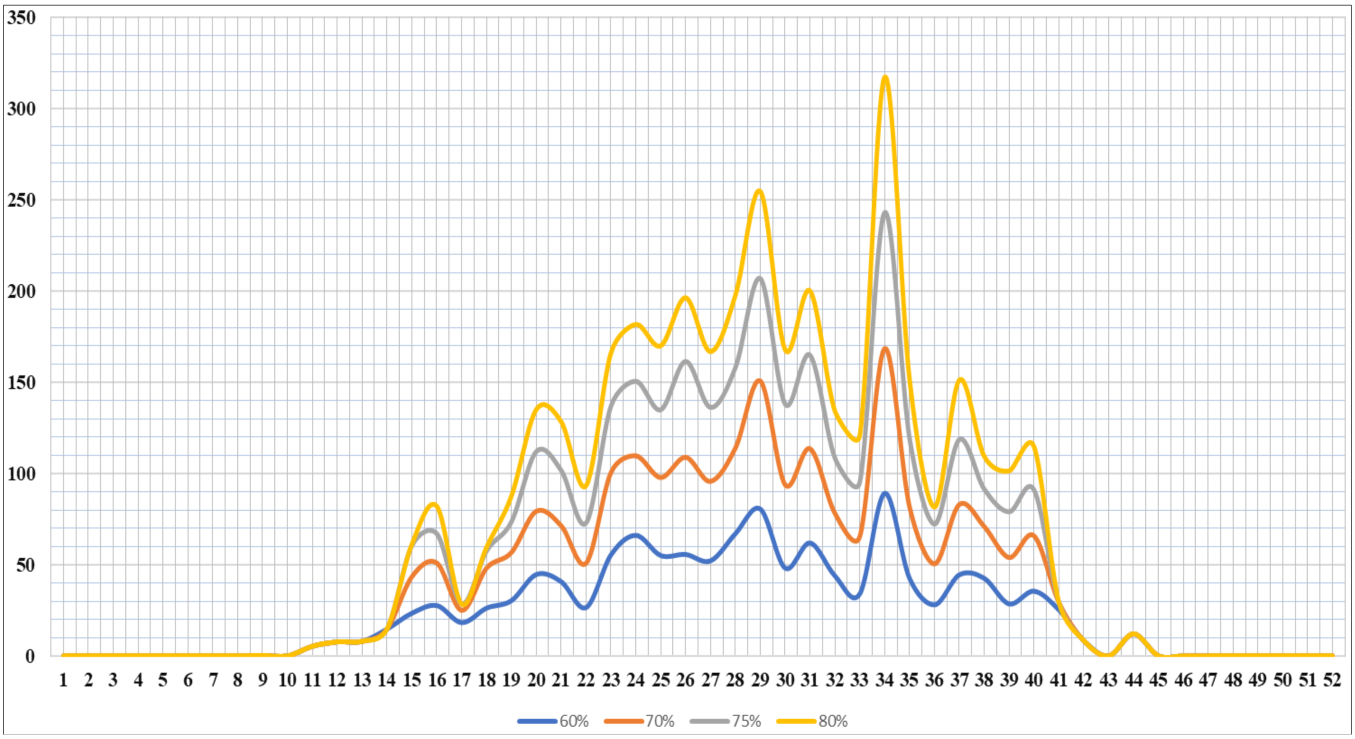

Fig 3.5: Weekly Rainfall pattern, mm at different level of probability at Vihokhu watershed (2007-2021), mm

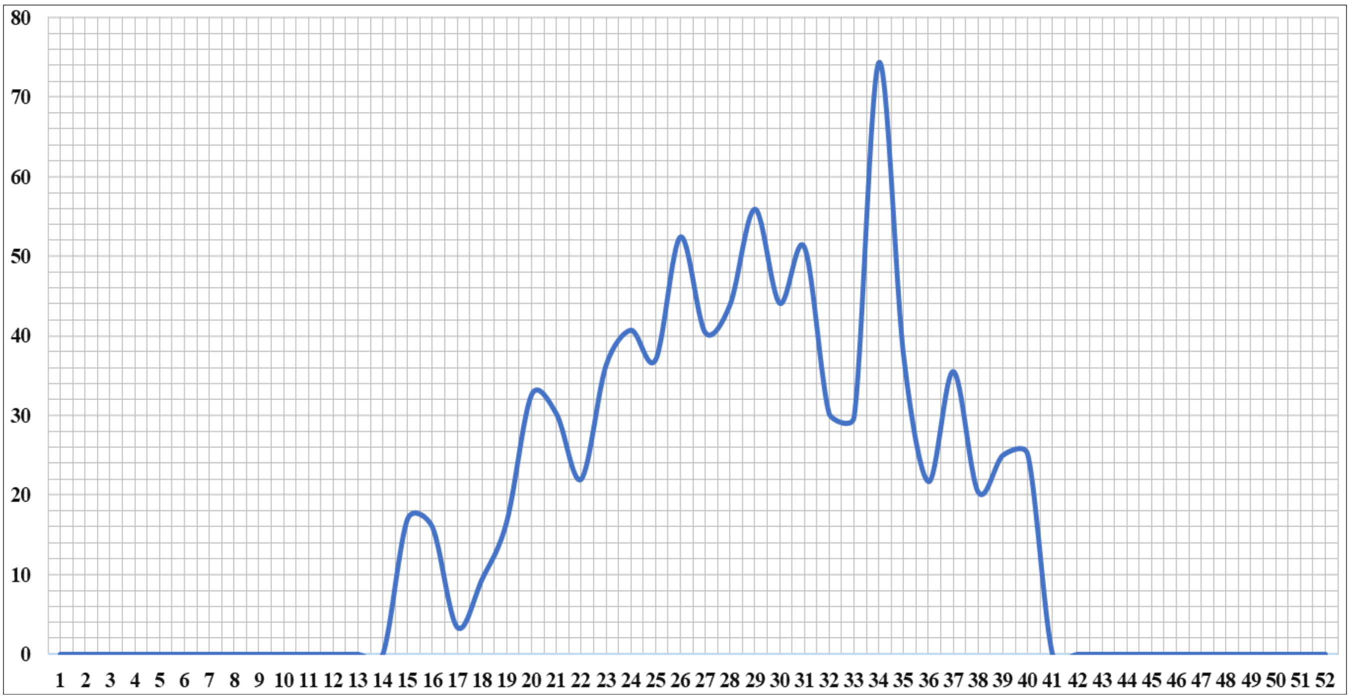

Fig 3.6: Rainfall distribution at 75% level of probability (2007-2021), mm

When rotational irrigation is used, this aids greatly in operating, regulating, and managing water flow through stream and channel systems. Based on this, a rainfall study is carried out on the basis of the seven days' worth of total rainfall that fall inside the watershed.

The total water required for irrigation of the crop each week was adjusted from the weekly rainfall available at a probability level of 75% on the field because the amount of irrigation water needed for the crop each week depends on the amount of rainfall, especially during the kharif season.

Since our project defined the monsoon season as lasting from June to October, or from Week No. 24 to 42, planning was done based on the amount of rainfall that was available for irrigation, drainage, and storage**.** The estimated weekly rainfalls from 2007 to 2021 are displayed in Table 4.4 at different levels of probability, including 60, 70, 75, and 80. A graph was created using these probabilities and is shown in Figure 3.5.

Table 3.4: Weekly rainfall pattern at different level of probability, mm (2007-2021)

Week No	60%	70%	75%	80%
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0.3	0	0	0
10	0	0	0	0
11	5.3	0	0	0
12	7.7	0	0	0
13	8	0	0	0
14	14.8	0	0	0
15	23.5	20	17	0.8
16	27.7	23.3	16	15
17	18.3	6.7	3.4	0
18	26.3	21.9	9.4	2
19	30.4	26.4	16.7	14.2
20	44.8	34.6	32.6	23.1
21	40.8	30.6	30.2	26.7
22	26.6	24.3	22	20.5
23	55.6	45.1	36.3	29.2
24	66.3	43.5	40.7	31.2
25	55.2	42.7	37	35.1
26	55.8	53.2	52.4	34.9
27	52.3	43.5	40.4	30.6
28	67.2	46.9	43.9	39.7
29	80.8	70.1	55.9	47.8
30	48.3	45.6	44.1	29.8
31	62.1	51.6	51.1	35.2
32	44	34.2	30.2	25.7
33	34.2	31.4	29.8	25.6
34	89.4	79.3	74.3	74.2
35	42.6	39	37.4	32.4
36	28.1	22.4	21.7	9.4
37	44.6	38.5	35.5	32.6
38	42.7	28.3	20.4	18
39	28.6	25.4	25	22.4
40	35.6	30.3	25.1	23.7
41	25.4	4	0	0
42	8.4	0	0	0
43	0	0	0	0
44	12.1	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
48	0	0	0	0
49	0	0	0	0
50	0	0	0	0
51	0	0	0	0
52	0	0	0	0

From Table 3.4, it can be shown that, with a 60% chance, the weeks of 1-10 and 43 -52 do not see any rainfall, but at 70%, 75%, and 80% probability, there is no rain for 26 weeks out of the year, from weeks 1 -14 and 41 - 52

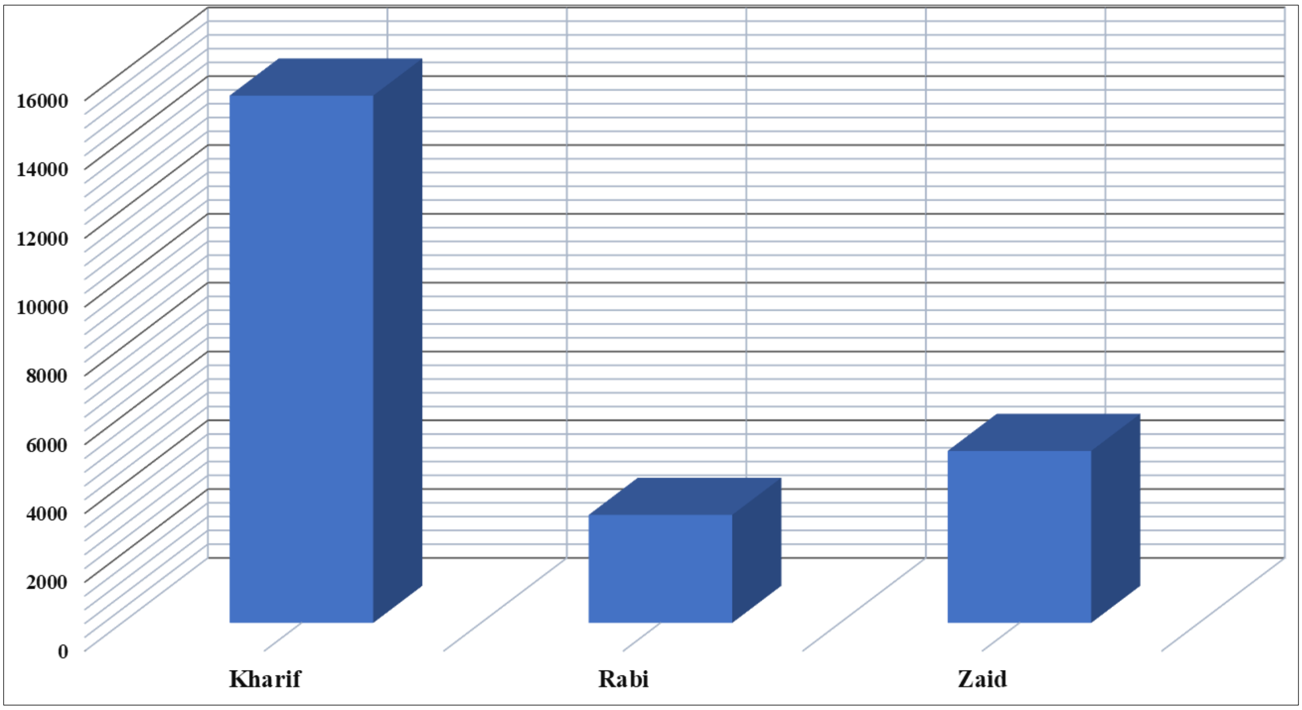

Fig 3.7: Seasonal Rainfall Pattern at Vihokhu Watershed (2007-2021), mm

respectively depending on the probability. This time frame might be considered the driest time of the year. And Week No. 19 - 40 witnessed more than 50 mm of rain, making it the wettest week of the year. since A real kharif season is when all rainfall is sufficient to meet the crop's whole water requirement. This is because kharif crop planning is dependent on the amount of rainwater anticipated to be available in the watershed. Only 26 weeks of the year can deliver enough precipitation to the crop in a year, according to this notion and the projected availability of rainfall at a probability level of 75%. A clearer graph is drawn and presented in Fig. 4.6 because it is in our best interests to estimate the expected amount of rainfall at a probability level of 75% as always recommended by the Central Water Commission, Govt of India. It can be seen that the rainfall pattern exhibits a complete curve path with regular rising and falling limbs at various probability levels. The remaining weeks of the kharif season must be carefully considered, especially when crop water needs are taken into account, as Week No. 20-37 experienced rainfall ranges from 30-70 mm at 75 % probability.

3.1.4 Analysis of seasonal rainfall data

The entire calendar year has been divided into the three seasons of kharif, rabi, and Zaid. The cumulative season rainfall for the previous 15 years was shown in Fig. 3.7. The kharif season (weeks 24 - 42) saw the highest rainfall total of 701.2 mm, followed by the Zaid season (weeks 10-23), which saw a total rainfall of 147.3 mm, while the rabi season saw no rainfall at all (week 43 - 9). This was computed using the water that would be accessible with a 75% probability.

Conclusion

The present study assessed dependable water availability and rainfall variability in the Vihokhu watershed of Dimapur district, Nagaland, with the objective of supporting sustainable watershed management and improving agricultural productivity. The watershed, covering 807 ha, receives an average annual rainfall of 1564.11 mm; however, due to the steep and undulating terrain, a significant portion of this rainfall is lost as surface runoff, resulting in soil erosion and reduced crop productivity. Effective management of this rainfall is therefore critical for improving agricultural outcomes in the region. Analysis of long-term rainfall data (2007-2021) revealed that the monsoon period consistently occurs between Standard Meteorological Week (SMW) 24 and SMW 42, during which more than half of the annual rainfall is received. The driest period occurs during January, February, and December, with an average rainfall of only 18.65 mm, while June, July and August are the wettest months, receiving an average of 285.16 mm. Based on the rainfall distribution and cropping pattern, weekly dependable rainfall at a 75% probability level was used to estimate water availability for crop growth throughout all 52 weeks of the year. The results show that although the watershed receives sufficient rainfall annually, its temporal distribution and the region's physiographic constraints (steep slopes, high runoff velocity, jhum cultivation practices and poor land management) limit the amount of water that can be effectively used for crop production. The dependable rainfall analysis confirmed the need for supplemental irrigation during specific weeks of the crop-growing season, especially during water-deficit periods within the kharif season. Consequently, water harvesting structures and improved soil-water conservation measures are essential to enhance water retention, reduce runoff losses and meet crop water requirements reliably. Overall, the study demonstrates that systematic assessment of weekly dependable rainfall is an effective approach for planning irrigation schedules and designing water storage interventions in hilly watersheds. The findings provide a scientific basis for implementing soil and water conservation technologies, which can support sustainable agriculture, reduce land degradation and improve the socioeconomic conditions of the Vihokhu watershed community.

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