Comparative Analysis Between Precipitation in the District of Julcan and Precipitation in the Sinsicap District of the La Libertad Region, Peru as of 2023

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Abstract

The objective of this investigation is to determine if the rain in the districts of Sinsicap and Julcán are same or different, with the purpose that any hydraulic work designed in one of the districts can be done in the other in a similar way, for which it used a comparative descriptive research design with a quantitative and retrospective approach.

The population that was used was the historical data found in the national water authority (ANA) from 1964 to 2018, and the average rainfall of both places was taken for processing.

The SPPS and Excel software were used for the exploratory analysis of the data and their normality was determined with the Shapiro-Wilk method and the Levene test to determine the equality of variances, after which the t statistic student was used for independent samples with a significance level of 95% to test the proposed hypothesis and it was determined that the rain in both places is the same.

On the other hand, the rain return periods in both districts were determined as specific objectives and then compared using the Gumbel distribution and it was concluded that they are different in both, despite the fact that the rain is the same.

A rain of 100 mm was used as a forecast for both districts; in Sinsicap there will probably be an event of this magnitude or greater in approximately 15.5 years, while in the district of Julcán it will probably occur in approximately 3 years.

Keywords: student t, research design, return period.

1. Introduction

Around the world, heavy rains hit cities, collapsing sewage systems and causing widespread flooding in streets, basements, schools, vehicles and often declaring these places emergency zones due to this natural phenomenon.

In the United States the rain reports break records, so for example in the city of Brooklyn the rain equivalent to a month reaches up to 11.5 cm, just in 3 hours, in the state of Manhattan more than 12.7 cm of rain has fallen, in Queens the rainiest day reaches up to 20 centimeters (National Weather Service of the United States, 2023).

In Peru, according to the forecasts of theNational Weather and Hydrology Service (2023), the risk of heavy rains in the mountains and jungle of Peru is high at different times of the year, many of these rains are accompanied by electrical discharges and gusts of wind with speeds close to 35 km/h and accumulated rainfall close to 40 mm/day is reached, likewise the agency issues alerts to inform that the mountains of Peru reports rains of strong intensity so it increases the concern of citizens for the fear that streams will be activated and landslides and floods will occur.

In the Region of La Libertad in the provinces of Julcán and Otuzco are the districts of Julcán and Sinsicap where rains of moderate to high intensity are reported, their rainfall stations are within the scope of the Moche basin that has an area of 2,115.00 km2, according to theStudy of Delimitation and Codification of the Hydrographic Units of Peru.

These districts are vulnerable to extreme rainfall with the consequences of flooding and material loss of many inhabitants, even more so with the phenomenon of climate change and the flood of the El Niño phenomenon, so any hydraulic work that is designed or activity that is executed in one of these places to address any rainfall event, it can be done without any problem in the other, for which the conditions and scope of the place must be similar, for this reality I pose the following problem to investigate.

What is the difference between the rainfall of the Sinsicap district and the Julcán district of the La Libertad Region?

Posing three specific problems:

What is the return period for 100 mm rainfall in the district of Julcán?

What is the return period for 100 mm rainfall in Sinsicap district?

What is the difference between the return period for a 100 mm rainfall in the Sinsicap district and the return period for a 100 mm rainfall in the Julcán district?

In the same way, the general objective was proposed:

To determine the difference between the rainfall of the district of Julcán and the district of Sinsicap of the La Libertad Region.

Likewise, their respective specific objectives were set:

To determine the return period for a rainfall of 100 mm in the district of Julcán.

To determine the return period for a rainfall of 100 mm in the district of Sinsicap.

To determine the difference between the return period for a rainfall of 100 mm in Sinsicap and the return period for a rainfall of 100 mm in the district of Julcán.

According to Carrillo, et al (2006). In his thesis NUMERICAL SIMULATION OF RAINFALL IN NORTHERN PERU he said that: extreme rains have been observed in the north of Peru, the impact of these rains on the current infrastructure in the cities is important, this due to the high vulnerability of the area. The events occur mainly in summer. Fourteen cases of extreme rainfall have therefore been selected, those recorded during the months of December and March 2001 and 2002. In this research, an evaluation of the numerical simulation of rainfall in northern Peru is carried out. Use a regional atmospheric model called RAMS (Regional Atmosphere Modeling System). It has been implemented in the northern part of Peru using the nesting technique to reduce resolution. The evaluation of the rainfall simulation is carried out by measuring the correlation between the rainfall recorded and those simulated by the RAMS model. The results show a higher correlation for the upper basin, an intermediate correlation value for the middle basin, and the lowest correlation values are observed in the lower basin. These values for the upper, intermediate and lower basins are: 0.49, 0.44 and 0.15 respectively. Although these values are apparently low, correlation values of 0.90 have appeared for the lower part of the basin, when simulating the entire extreme rainfall event. Values of 0.94 correlations were also observed in the upper part of the basin. Some explanations for the low correlation values are mentioned, as well as some measures for improvement in data acquisition systems.

Likewise, Silva (2014). In his thesis THE SEASONALITY OF THE IMPACT OF EL NIÑO ON RAINFALL IN PERU, he mentions that: rainfall in Peru is characterized by a strong seasonality, mainly in the Andean areas, where it begins in September and gradually increases until reaching maximum values in the summer months (January-March) to decrease sharply in April (PGI, 2005; Lagos et al., 2008; Silva et al., 2008). The months of May-August are months of little rainfall and in some areas there is no rainfall. On the other hand, the Peruvian coast is characterized by being very dry throughout the year, with the exception of Tumbes, which has rainfall in the summer months. However, during years El Niño rainfall can be extreme in this region, while in the Peruvian jungle it rains all year round, but always more intensely in the summer months (Woodman, 1999; Takahashi, 2004; Lagos et al., 2008; Lavado and Espinoza, 2014; Woodman & Takahashi, 2014). That is why, in this document a brief summary of the impact of sea surface temperature variability (SST) on rainfall in Peru during the beginning of the rainy season (October-December) and the peak of the rainy season (January-March) is made, according to statistics based on rainfall season data.

On the other hand, Rojas (2021). In his work, DISASTER RISK SCENARIO DUE TO THE DANGER OF INTENSE RAINS FOR REACTIVE MANAGEMENT, he states that: Peru is highly exposed to hazards of meteorological origin and to conditions of vulnerability of different origins. In this context, it is necessary to have a risk map that facilitates decision-making and actions for the benefit of the population and their livelihoods. The National Institute of Civil Defence (INDECI) includes within its organizational structure the organizational elements necessary to ensure a timely and adequate response in disaster situations that merit its intervention, in accordance with the principles of subsidiarity and gradualness. Principles that refer to the improvement of the response capacity of regional and local governments, for which the Ministry of Economy and Finance, in concert with the governing body of the National Disaster Risk Management System - SINAGERD, constitutes mechanisms to transfer resources from the Contingency Reserve in a timely manner. in order to facilitate the execution of the set of actions and measures aimed at dealing with disasters, either due to an imminent danger or due to the materialization of the risk as part of Reactive Management. In this sense, for the best decision-making and actions, a risk map on a national scale for Reactive Management is necessary, which is why this work is framed in the analysis of the hazard through seasonal forecasting and the analysis of vulnerability to intense rains, achieving the determination of a risk scenario for intense rains for the period December 2019 to February 2020. Finally, the result is a map with risk levels that determines the amount of population and livelihoods exposed during this period, thus contributing to preparedness actions.

Also Chira (2023). In his work, A BRIEF STATISTICAL ANALYSIS OF SEASONAL RAINFALL IN NORTHERN PERU. He says that the objective of his study is to understand the variability of the rainy season in northern Peru. Principal Component Analysis (PCA) was used to find regional rainfall indices. These results were compared with ENSO (El Niño-Southern Oscillation) indices, several months in advance, to find some relationship that helps to understand the physical mechanisms that control the rainy season in the region. Northern Peru is the first place to be affected by the El Niño phenomenon, and it is the region where it has the strongest impact. This phenomenon causes torrential rains and heavy floods, causing losses to the agricultural and fishing industry among others, as well as sometimes loss of human lives. It is therefore very important to know what the next rainy season will look like, for the prevention and mitigation of natural disasters, as well as for agricultural and fisheries planning. A statistical analysis (Principal Component Analysis and Correlation Analysis -CA) was performed for the rainy season in northern Peru, with several indices related to the ENSO phenomenon (Standardized Anomalies of Surface Temperature of Seawater Niño12 and Niño3 and Southern Oscillation Index). With ACP, two regional indices were found: R1 (Coast) and R2 (Mountainous Region), for the seven monitoring stations in the period 1973-1998. Data from NCEP (National Center for Environmental Prediction) and Correlation Analysis were used to calculate areas correlated with these indices, using various atmospheric and oceanographic parameters, including Seawater Surface Temperature-SST, Winds (850 hPa) and Sea Level Pressure (SLP). Finally, the CA was used to calculate the relationship between the regional index and NCEP ENSO indices. The year-on-year variations of R1 and R2 were also compared with the indices of the Niño3 and IOS regions. The results show that the R1 index for the Coast region is more predictable than the R2 index for the mountainous region. The predictability of precipitation for northern Peru is highly influenced by the occurrence of ENSO events.

Precipitation is defined as any form of moisture that, originating in clouds, reaches the earth's surface. Precipitation includes rain, snow, and other processes by which water falls to the earth's surface, such as hail and snowfall, consisting of liquid water droplets mostly with a diameter greater than 5 mm. In many countries, such as the United States, for example, it is usually classified as light, moderate or strong depending on its intensity:

Light: For fall rates up to 2.5 mm/h, Moderate: From 2.5 to 7.6 mm/h. and Strong: Above 7.6 mm/h. (Cahuana and Yugar 2009).

2. Materials and Methods

This research was carried out with the existing data in the National Water Authority (ANA) updated to 2023 of the rainfall of both districts reported from 1964 to 2018, from which the average rainfall was taken for its process.

The type of research was Basic and a comparative descriptive research design was used with a quantitative approach for the presentation of results in numerical form and a retrospective approach for using specialized data from a government entity.

SPSS statistical software and Excel were used to perform the exploratory analysis of the data, first, the rainfall intensity in mm/h was calculated and tabulated in both districts and its corresponding hyetogram was graphed:

$$\frac{P(mm)}{dias\_mes} * 1dia/24h$$

Then the normal distribution test was done for which the Shapiro-Wilk method was applied since the data were less than 50 and then the student's t to compare if there is similarity or inequality in the rainfall of both districts, both tests were carried out with a significance level of 5%.

For the Normality test, the following hypotheses were raised:

Ho: The data do not follow a normal distribution (Null hypothesis)

H1: Data follow a normal distribution (Alternative hypothesis)

The statistic of decision to accept Ho and reject H1 was the p-value (sig.), reported by the SPSS, if this value is greater than the significance level (alpha=0.05) then Ho is rejected and H1 is accepted.

To compare the rainfall of both districts, the student's t-statistic was used and the following hypotheses were proposed:

Ho: Rainfall in the districts of Julcán and Sinsicap is not equal (Null hypothesis)

H1: The rainfall in the districts of Julcán and Sinsicap is the same (Researcher's hypothesis).

For the calculation of the return periods of the most intense rains in both districts, the Gumbel distribution was used, to see if the data follow this distribution, the Weibull probability criterion was applied, which consisted of ordering the precipitation in descending order and assigning correlative numbers from one to the total of the data by applying the following equation:

$$P(x) = \frac{m}{N+1} * 100$$

where P(x) is the probability that the event will be exceeded or equaled, m is the assigned correlative number, and N is the total of the data. The probability of return of rainfall was calculated by the equation:

$$P(mm) = Ppro * (1 + Cv * (0.78 * y - 0.45))$$

Where:

Ppro = average precipitation of precipitation (mm)

Cv = coefficient of variation of rainfall data

y = Gumbel distribution aid factor

The aid factor was calculated by Gumbel's distribution equation:

$$y = -ln(-(\ln(1 - P(x))))$$

To obtain the tabulated results and their respective graphs, Excel was used. The return period Tr (years) was found with the inverse of the probability P(x) calculated in each rainfall event using the following formula:

$$Tr = \frac{100}{P(x)}$$

The data obtained were then graphed to obtain the corresponding curves and forecast the probability of rainfall in the near future in graphical form.

3. Results

General Objective: To determine the difference between the precipitation of the district of Julcán and the precipitation of the district of Sinsicap of the La Libertad Region

STATEMENT OF THE GENERAL HYPOTHESIS:

Ho: The precipitation of Sinsicap City and the precipitation of Julcan City are the same.

H1: The precipitation of the city of Sinsicap and the precipitation of the city of Julcán are different.

TEST STATISTIC: t-student

Significance Level: 5%. If the p-value < 0.05, we reject the Ho and accept the H1

EXPLORATORY ANALYSIS OF THE DATA FOR THE GENERAL OBJECTIVE:

Table 1. Precipitation data

MONTH	P(mm) SYNSICAP	P(mm) JULCAN
Jan	59.19	131.10
feb	96.93	162.08
sea	117.69	205.92
Apr	48.19	118.57
May	10.05	43.80
jun	2.23	12.94
jul	0.49	7.37
Aug	1.67	13.61
set	4.20	42.51
oct	16.08	86.41
nov	12.08	63.84
Dec	19.83	93.69

Table 2. Rainfall Intensity Data

MONTH	SINSICAPI(mm/h)	JULCANI(mm/h)
Jan	0.08	0.18
feb	0.14	0.24
sea	0.16	0.29
Apr	0.06	0.16
May	0.01	0.06
jun	0.00	0.02
jul	0.00	0.01
Aug	0.00	0.02
set	0.01	0.06
oct	0.02	0.12
nov	0.02	0.09
Dec	0.03	0.13

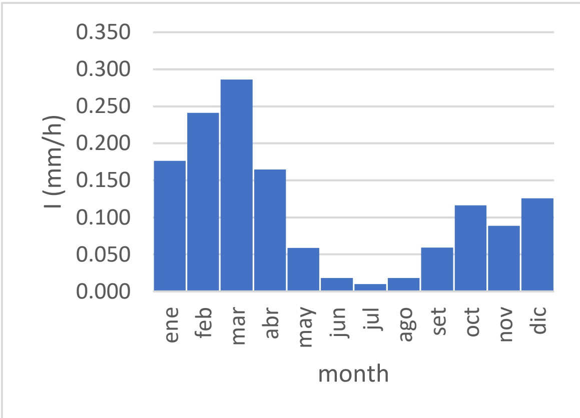

Fig 1. Average Intensity of Sinsicap

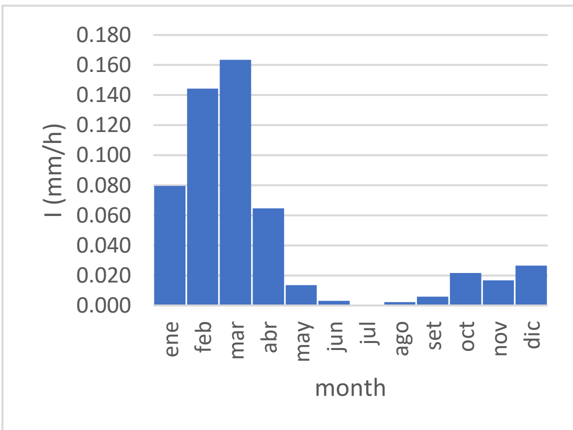

Fig. 2. Julcán average intensity

Table 3. Normality test for data

	F	Sig.	t	gl	Sig. (bilateral)
Se asumen varianzas iguales	2,708	,114	-2,291	22	,032
No se asumen varianzas iguales			-2,291	18,522	,034

Using the SPSS statistical software, the following was obtained.

Table 4. Student's parametric t test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
LUGAR	Estadístico	gl	Sig.	Estadístico	gl	Sig.
Julcán	,143	12	,200*	,938	12	,471
Sinsicap	,291	12	,006	,789	12	,007

EXPLORATORY ANALYSIS OF DATA FOR SPECIFIC OBJECTIVES:

Specific Objectives:

- To determine the difference between the return period of any precipitation in Sinsicap and the return period of any precipitation in the district of Julcán.
- To determine the return period for a rainfall of 100 mm in the district of Julcán.
- To determine the return period for a rainfall of 100 mm in the district of Sinsicap.

Table 5. Return Period Data using Gumbel Distribution for Sinsicap

MES	SINSICAP P(mm)	P(x)%	Tr(años)	y	P(mm)
ene	59.19	1	100.00	4.600	157.23
feb	96.93	5	20.00	2.970	106.65
mar	117.69	10	10.00	2.250	84.32
abr	48.19	20	5.00	1.500	61.03
may	10.05	30	3.33	1.031	46.47
jun	2.23	50	2.00	0.367	25.86
jul	0.49	70	1.43	-0.186	8.72
ago	1.67	75	1.33	-0.327	4.35
set	4.2	78	1.28	-0.415	1.61
oct	16.08	79	1.27	-0.445	0.67
nov	12.08	79.5	1.26	-0.460	0.20
dic	19.83				
Prom	32.39				
d.st	39.78				
Cv	1.23				

Table 6. Return Period Data Using Gumbel Distribution for Julcán

MES	JULCAN P(mm)	P(x)%	Tr(años)	y	P(mm)
ene	131.1	1	100.00	4.600	280.38
feb	162.08	5	20.00	2.970	199.93
mar	205.92	10	10.00	2.250	164.41
abr	118.57	20	5.00	1.500	127.37
may	43.8	30	3.33	1.031	104.23
jun	12.94	50	2.00	0.367	71.44
jul	7.37	70	1.43	-0.186	44.19
ago	13.61	75	1.33	-0.327	37.23
set	42.51	78	1.28	-0.415	32.87
oct	86.41	79	1.27	-0.445	31.38
nov	63.84	79.5	1.26	-0.460	30.62
dic	93.69				
Prom	**81.82**				
d.st	**63.27**				
Cv	**0.77**				

Table 7. Data from Return periods for rainfall using Gumbel distribution for Sinsicap.

MONTH	SINSICAPP(mm)	m	P(x)	Tr	P(mm)
Jan	59.19	1	7.69	13.00	117.69
feb	96.93	2	15.38	6.50	96.93
sea	117.69	3	23.08	4.33	59.19
Apr	48.19	4	30.77	3.25	48.19
May	10.05	5	38.46	2.60	19.83
jun	2.23	6	46.15	2.17	16.08
jul	0.49	7	53.85	1.86	12.08
Aug	1.67	8	61.54	1.63	10.05
set	4.2	9	69.23	1.44	4.20
oct	16.08	10	76.92	1.30	2.23
nov	12.08	11	84.62	1.18	1.67
Dec	19.83	12	92.31	1.08	0.49

Table 8. Data from Return periods for rainfall using Gumbel distribution for Julcán.

MONTH	JULCANP(mm)	m	P(x)	Tr	P(mm)
Jan	131.1	1	7.69	13.00	205.92
feb	162.08	2	15.38	6.50	162.08
sea	205.92	3	23.08	4.33	131.10
Apr	118.57	4	30.77	3.25	118.57
May	43.8	5	38.46	2.60	93.69
jun	12.94	6	46.15	2.17	86.41
jul	7.37	7	53.85	1.86	63.84
Aug	13.61	8	61.54	1.63	43.80
set	42.51	9	69.23	1.44	42.51
oct	86.41	10	76.92	1.30	13.61
nov	63.84	11	84.62	1.18	12.94
Dec	93.69	12	92.31	1.08	7.37

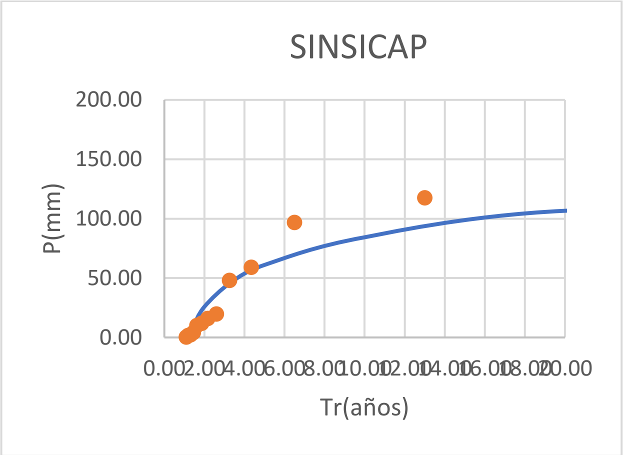

Figure 3. Precipitation vs Return Period Synsicap

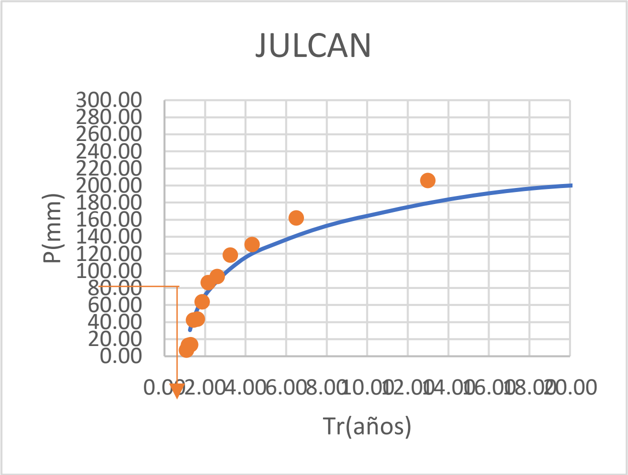

Figure 4. Precipitation vs Return Period Julcán

4. Discussion and Conclusions

For the exploratory analysis of the precipitation data of the districts of Sinsicap and Julcán, data from the National Water Assembly (ANA) reported from 1964 to 2018 was used, from which the average of the months of each year was taken for processing, as shown in table 1.

Table 2. shows the intensity of rainfall in mm/h, calculated through the data reported in table No. 1. and the respective Hyetograms for each district were graphed as shown in Fig. 1. and Fig. 2.

After observing the data in Table 3 and given that the sample is less than 50, Shapiro-Wilk was used for the normality test and it is observed that the Julcán variable has a Normal distribution since the p-value is $0.471 > 0.05$ (α), on the other hand the Sinsicap variable does not present a normal distribution because its p-value $0.007 < 0.05$ (α), therefore, Student's parametric t-test was used for independent samples.

The Student's t-test for independent samples compares the means of two groups and assumes that the variances are homogeneous.

To determine this homogeneity of variances, the parametric test statistic Levene's Test was applied, the p-value is $0.114 > 0.05$ for this test, and we conclude that the variances in both groups are homogeneous.

In Student's t for independent and homogeneous data, the p-value is $0.032 < 0.05$, therefore, we accept the Ho and reject the H1.

Therefore, we can say with a probability of 95% that the precipitation in Sinsicap is equal to the precipitation in Julcán.

To find the return period of both districts we use the Gumbel distribution and see if the precipitation data follow this trend, which is verified in the graphs Fig. 3 and Fig. 4 of probable precipitation versus return period and in both a precipitation of 100 mm was taken as a reference and we see that the return periods are different for both precipitations despite the fact that the rainfall in both districts are the same.

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