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Rainfall Index as a Measure of Change of Rainfall

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Abstract – An attempt has been made to develop a measure of change of rainfall in a region from one situation to another situation in general and from one period to another period in particular. This article has been prepared to describe this measure along with its numerical application in the context of change of rainfall in Assam from the period 2009 - 2011 to the period 2020 - 2022.

Keywords: Rainfall, Measure of Change, Rainfall Index, Change in Assam.

1.INTRODUCTION

Rainfall is one of the most important factors that determine the climate of a region. It changes continuously over time and its change occurs basically due to two types of causes namely

1. Assignable Cause (that contains not only a single one cause but many causes that are imposed and accordingly are controllable)
2. Chance Cause (that contains the cause which occurs accidently and accordingly is not controllable)

and the change can be regarded as significant if & only if it occurs due to both the causes and as insignificant if & only if it occurs due to chance cause only [8].

There is necessity of testing/examining the significance of change whose methods are available in standard literature of statistics [1] which can help to know whether the change occurs due to both the causes or due to the chance cause only since the need of initiating step(s) of precaution and/or remedial measure arises when the change occurs due to assignable cause (or causes). Testing of significance is necessary but not sufficient since it cannot measure the amount of change.

There had been several studies on rainfall in India and abroad on various aspects like identifying the significance of its change, its trend/tendency, its variation, its confidence interval (also natural interval), forecasting on it etc. [2 – 4 , 6 – 8 , 10 – 30]. However, it is also essential to know the degree or amount of change of rainfall in a region over time. Attempt has here been made on developing a measure of change of rainfall in a region from one situation to another situation in general and from one period of time to another period of time in particular. This article has been prepared for describing this measure along with its numerical application in the context of change of rainfall in Assam from the period 2009 – 2011 to the period 2020 – 2022.The philosophy/concept behind the geometric mean due to Pythagoras [5 , 9] has been used as the basis of the measure developed here.

In a region, rainfall may not occur and usually does not occur every day. On the other hand, rainfall is more likely to occur in a month in general and most likely to occur in a month belonging to rainy season as the trend/tendency of rainfall indicates [4 , 8 , 10 – 14 , 2 , 25]. Moreover, the overall change of monthly rainfall over years can be regarded and is usually regarded as its behavioral change over years. Accordingly,

attempt has been made on developing measure of overall change of rainfall over years on the basis of monthly rainfall.

2. RAINFALL INDEX

Suppose

$$R_1 , R_2 , \ldots\ldots , R_{12}$$

are the amounts of rainfall occurred in the 12 months numbered as

$$1 , 2 , \ldots\ldots , 12$$

respectively.

Then each of them changes over years and hence they form a group of variables.

Suppose

$$R_{1b} , R_{2b} , \ldots\ldots , R_{12b}$$

are the values of the respective variables in the situation (say year) 'b'

as well as

$$R_{1c} , R_{2c} , \ldots\ldots , R_{12c}$$

are the values of the respective variables in the situation (say year) 'c'.

Suppose the values of the variables $R_1 , R_2 , \ldots\ldots , R_{12}$ in the situation 'c' are respectively

$$p_1 , p_2 , \ldots\ldots , p_{12}$$

times (i.e. multiples or relative changes or change relatives) of the respective values of the variables in the situation 'b'.

This means,

$$R_{1c} = p_1 R_{1b} , R_{1c} = p_2 R_{2b} , \ldots\ldots , R_{12c} = p_{12} R_{12b}$$

or equivalently

$$p_1 = \frac{R_{1c}}{R_{1b}} , p_2 = \frac{R_{2c}}{R_{2b}} , \ldots\ldots , p_{12} = \frac{R_{12c}}{R_{12b}}$$

which implies

$$(p_1 R_{1b}).(p_2 R_{2b}). \ldots\ldots .(p_{12} R_{12b}) = R_{1c} . R_{2c} . \ldots\ldots . R_{12c}$$

Now, if p is the overall multiple (or equivalently overall relative change or change relative) which makes the values in the in the situation 'b' to the values in the situation 'c' then

$$(pR_{1b}).(pR_{2b}). \ldots\ldots .(pR_{12b}) = R_{1c} . R_{2c} . \ldots\ldots . R_{12c}$$

which implies

$$(pR_{1b}).(pR_{2b}). \ldots\ldots .(pR_{12b}) = (p_1 R_{1b}).(p_2 R_{2b}). \ldots\ldots .(p_{12} R_{12b})$$

which further implies

$$p = (p_1 . p_2 . \ldots\ldots . p_{12})1/n$$

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i.e.

$$p = \left(\frac{R_{1c} \cdot R_{2c} \cdot \ldots\ldots\ldots \cdot R_{12c}}{R_{1b} \cdot R_{2b} \cdot \ldots\ldots\ldots \cdot R_{12b}}\right)1/n$$

This can be regarded as a measure of overall relative change of rainfall in the situation 'b' to the values in the situation 'c'.

This measure can be interpreted as **index of rainfall index** or **rainfall index** in the situation 'b' to the values in the situation 'c'.

Usually, index is expressed as percentage.

Accordingly, **rainfall index** in the situation 'c' to the values in the situation 'b' denoted by

$$I_{bc}(R) = I_{bc}(R : R_1 , R_2 , \ldots\ldots\ldots , R_{12})$$

can be defined by

$$I_{bc}(R) = I_{bc}(R : R_1 , R_2 , \ldots\ldots\ldots , R_{12}) = \left(\frac{R_{1c} \cdot R_{2c} \cdot \ldots\ldots\ldots \cdot R_{12c}}{R_{1b} \cdot R_{2b} \cdot \ldots\ldots\ldots \cdot R_{12b}}\right)1/n \times 100$$

Note:

(1) The formula of $I_{bc}(R)$ implies that **rainfall index** in the situation 'c' with respect to the situation 'c' can be defined as the geometric mean of

$$p_1 = \frac{R_{1c}}{R_{1b}} , p_2 = \frac{R_{2c}}{R_{2b}} , \ldots\ldots\ldots , p_{12} = \frac{R_{12c}}{R_{12b}}$$

i.e. the geometric mean of the change relatives of the respective values of the variables in the situation 'c' to the respective values of the variables in the situation 'c' c.

(2) The formula of $I_{bc}(R)$ can also be expressed as

$$I_{bc}(R) = \{(R_{1c} \cdot R_{2c} \cdot \ldots\ldots\ldots \cdot R_{12c})1/n / (R_{1b} \cdot R_{2b} \cdot \ldots\ldots\ldots \cdot R_{12b})1/n \} \times 100$$

This means, rainfall index in the situation 'c' with respect to the situation 'b' can be defined as the ratio

of the geometric mean of the values of the variables in the situation 'c'

to the geometric mean of the values of the variables in the situation 'b'.

Reasonability of the Measure:

If the value of the overall change of the group of variables

$$R_1 , R_2 , \ldots\ldots\ldots , R_{12}$$

in the situation 'c' with respect to the situation 'b' is v

then logically the value of the overall change of the group of reciprocals of these variables in the situation 'c' with respect to the situation 'b' will have to be 1/v.

Moreover, the value of the overall change of the group of the same variables in the situation 'b' with respect to the situation 'c' will also have to be 1/v.

In the case of the measure, derived above, it follows from the formula of Icb(R) that

$$I_{bc}(1/R_1 , 1/R_2 , \ldots\ldots\ldots , 1/R_{12}) = 1/I_{bc}(R_1 , R_2 , \ldots\ldots\ldots , R_{12})$$

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$$\& \quad I_{cb}(R_1, R_2, \ldots\ldots, R_{12}) = 1/I_{bc}(R_1, R_2, \ldots\ldots, R_{12})$$

Thus, the measure, derived above, is a reasonable one.

An Useful Property of the Measure:

It also follows from the formula of Icb(R) that

$I_{bc}(R) \cdot I_{cd}(R) = I_{bd}(R)$,

$I_{bc}(R) \cdot I_{cd}(R) \cdot I_{de}(R) = I_{be}(R)$,

$I_{bc}(R) \cdot I_{cd}(R) \cdot I_{de}(R) \cdot I_{ef}(R) = I_{bf}(R)$

and so on.

This property can be interpreted as Chain Property of Rainfall Index.

Meaning of Rainfall Index:

$I_{bc}(R)$, defined above, implies that rainfall in the situation 'c' is overall $_{Ibc}(R)/100$ times of the that in the situation 'b'

and that

the overall amount of change of rainfall in the situation 'c' from that in the situation 'b' is

$\{I_{bc}(R) - 100\}\%$.

If $I_{bc}(R)/100 > 1$ or $I_{bc}(R) > 100$, then rainfall in the situation 'c' is higher than that in the situation 'b' and the amount of its increase in the situation 'c' with respect to the situation 'b' is $\{I_{bc}(R) - 100\}\%$.

If $I_{bc}(R)/100 < 1$ or $I_{bc}(R) < 100$, then rainfall in the situation 'c' is lower than that in the situation 'b' and the amount of its decrease in the situation 'c' with respect to the situation 'b' is $\{100 - I_{bc}(R)\}\%$.

3. AN EXAMPLE-INDEX OF RAINFALL IN ASSAM

The thrust here is to know the degree/amount of overall change of rainfall in Assam over the last decade. It is to be noted that the change may be affected by some irregular factor in some year(s). Therefore, to eliminate irregular fluctuation, it has been decided to measure the overall change between the periods 2009 – 2011 and 2020 – 2021.

Data on monthly of rainfall occurred in the three years belonging to the period 2009 – 2011 and also occurred in the three years belonging to the period 2020 – 2021 have been collected from statistical report on rainfall published by the Directorate of Economics and Statistics, Government of Assam. Table – 1 shows these data and the calculated values on total monthly rainfall occurred in each of the two periods 2009 – 2011 & 2020 – 2022.

Table -1: (Monthly Rainfall in Assam)

Month	Amount of Rainfall (in mm)							
	During 2009 – 2011				During 2020 – 2021			
	2009	2010	2011	Total	2020	2021	2022	Total
January	4.2	0.2	10.1	14.5	17.5	11.1	23.5	52.1

February	10.0	2.4	10.3	22.7	15.5	2.8	51.9	70.2
March	40.0	87.2	90.0	217.2	22.8	38.4	44.3	105.5
April	145.2	360.0	74.7	579.9	124.7	70.8	317.6	513.1
May	185.3	329.6	226.4	741.3	407.9	214.0	399.2	1021.1
June	270.7	443.5	267.6	981.8	597.9	381.4	669.6	1648.9
July	341.2	326.0	382.0	1049.2	581.4	288.0	277.9	1147.3
August	409.4	319.4	268.8	997.6	271.5	296.7	190.3	758.5
September	160.6	287.8	191.6	640.0	427.8	966.1	202.7	1596.6
October	118.1	82.9	31.4	232.4	164.6	120.2	193.3	478.1
November	12.6	9.2	11.4	33.2	20.1	3.9	0	24.0
December	2.9	7.1	2.3	12.3	1.1	9.5	5.2	15.8
Annual	1700.2	2255.3	1566.6	5522.1	2652.7	2402.9	2375.5	7431.2

Source of data: Statistical Handbook Assam: Page 86 of 2010, Page 51 of 2011, Page 60 of 2012, Pages 42 – 43 of 2012, Published by Directorate of Economics and Statistics, Government of Assam, Page 60. des.assam.gov.in.

After computation by applying the formula of rainfall index derived above it has been found the following result:

Rainfall Index, based on Monthly Rainfall, in the period 2020 – 2021 with respect to the period 2009 – 2011

= 137.014801956797022030661004988 65

4. DISCUSSION AND CONCLUSION

The rainfall index, described above, is a reasonable measure of overall change of rainfall over two different situations. It provides the value of overall relative change together with the value of overall absolute change of rainfall from one situation to another.

It has been found that rainfall index in Assam, based on monthly rainfall, in the period 2020 – 2021 with respect to the period 2009 – 2011 is

137.014801956797022030661004988 65.

This means, rainfall in Assam occurred in the period 2020 – 2022 is

1.370148019567970220306610049886 5 times

of that occurred in the period 2009 – 2011 with

37.014801956797022030661004988 65 %

of increase.

It is observed in **Table – 1** that annual rainfall in the period 2020 – 2022 is

1.345719925390702812335886709766 2 times

of that occurred in the period 2009 – 2011 with

34.571992539070281233588670976 62 %

of increase.

This also gives an indication that rainfall index is a reasonable and valid measure of overall change of rainfall. The difference between the two values is due to the fact that the latter is a crude measure of change.

It is to be the formula of rainfall index, derived above, is for two different situations symbolically 'b' & 'c' (as used here). The different situations are like different times (for example, different points of time, different periods of time etc.), different locations/regions and suitably defined situations. Accordingly, this formula of formula of rainfall index can also be used to measure the overall change of rainfall over two different regions and consequently compare rainfall occurred in two and/or more regions.

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