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Numbers of Rainy Days at Chennai, Kolkata, Mumbai, and New Delhi: Most Likely to Occur

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Abstract – Definition of probability based on the data on automatically happened outcomes, formulated in a recent study by the application of the logic behind concept of empirical probability, has been applied in estimating most likely number of rainy days at each of the four stations in India namely Chennai, Kolkata, Mumbai, and New Delhi to be occurred in each of the 12 months. It has been found from the study that rainfall is almost certain to be occurred in each of the months from June to November at Chennai, from May to October at Kolkata, from June to September at Mumbai and from June to August at New Delhi while rainfall is certain to be occurred in each of the months from September to November at Chennai, from June to September at Kolkata, from July to September at Mumbai and from July to August at New Delhi. On the other hand, non-occurrence of rainy day or equivalently non-occurrence of rainfall is not certain in any month at any of the four stations.

Keywords: Automatically happened outcomes, probability, number of rainy days, most likely event, estimation.

1. INTRODUCTION

The theory of probability, which can be interpreted as the foundation of theory of statistics, has become essentially useful for scientific analysis of data not only in every branch of science but in every academic branch where research and study is done on the basis of data [9 , 19 , 23].

The evolution of theory of probability has progressed through five stages. Each of these stages can be regarded as an era of probability theory. These are

(1) Prehistoric era,

(2) Scientific thinking era,

(3) Bernoullian Era,

(4) Russian School era,

and (5) Modern era [9 , 16 , 23 , 37].

On the other hand, the development has been progressing six approaches namely

(1) Subjective Approach [4],

(2) Intuitive Approach [34 , 35 , 46],

(3) Classical Approach [6 , 10 , 12 , 14 , 15],

(4) Empirical Approach also termed as relative frequency approach or statistical approach [10 , 13 , 54, 55 , 56],

(5) Axiomatic Approach [7 , 8 , 31 , 33]

and (6) Theoretical Approach [9 , 13 , 14 , 15 , 16 , 17 , 18 , 23].

Subjective approach to probability is a biased one and hence unscientific while the concept of intuitive approach is not based on scientific logic. On the other hand, the other approaches are based on scientific logic. Probability is determined in an empirical approach by performing the associated experimentation while in classical approach probability is determined without performing the experimentation. Axiomatic approach is based on some conditions called axioms that are satisfied by probability, and it is silent about how to determine the value of probability. In theoretical approach, probability is defined in theoretically ideal situation and is determined in practically ideal situation by performing the associated experimentation.

In many real situations, experimentation need not be and/or cannot be performed but is automatically performed resulting in available outcomes. In order to handle this type of situation, a definition of probability has recently been formulated on the basis of automatically happened outcomes [28]. The definition has been formulated by the application of the logic behind concept of empirical probability. This definition has here been applied in estimating most likely number of rainy days at each of the four stations in India namely Chennai, Kolkata, Mumbai and New Delhi to be occurred in each of the 12 months. This paper is based on the findings obtained in this study. This study has been done due to the reason that there has not yet been any study on estimating most likely number of rainy days at a place though lot of studies had been done on various characteristics and behaviors of rainfall [1 – 3 , 5 , 11 , 20 – 22, 24 – 32 , 36 – 44 , 47 – 53].

2. DEFINITION OF PROBABILITY FOR AUTOMATICALLY HAPPENED OUTCOMES

Let us use the standard notation P(E) to denote the probability of occurrence or happening of event E .

Probability has recently been defined on the basis of automatically happened outcomes of a natural phenomenon as follows: [28]:

Definition (1):

If in a set of N outcomes of a natural phenomenon already happened, an event E has occurred n times then the probability of occurrence of E is

$$\text{the limiting value of the ratio } \frac{n}{N} \text{ as } N \to \infty$$

i.e. P(E) can be approximated by the ratio $\frac{n}{N}$ provided N is large

and thus the ratio $\frac{n}{N}$ is a reasonable estimate of P(E) provided the size N of outcomes is reasonably large.

Definition (2):

If in a set of N outcomes of a natural phenomenon already happened, an event E with probability of occurrence P(E) has occurred n times then the number n of occurrence of the event E namely n is

$$\text{the limiting value of the ratio } N.P(E) \text{ as } N \to \infty$$

i.e. n can be approximated by N.P(E) provided N is large

and thus N.P(E) is a reasonable estimate of n provided the size N of outcomes is reasonably large.

Note:

(1) Content of Definition (1) is just the converse of that of Definition (2).

(2) Definition (1) provides a way of approximating/estimating the probability of occurrence of an event while Definition (2) provides a way of approximating/estimating the number of occurrence of the event.

(3) The happening of an event E is certain if P(E) = 1 and vice versa while the non-happening of E is certain if P(E) = 0 and vice versa.

(4) Happening or non-happening of an event E is uncertain if 0 < P(E) < 1 and vice versa. The uncertainty of happening or non-happening increases as P(E) increases from 0 or decreases from 1. The uncertainty is maximum when P(E) = 0.5 and vice versa.

(5) In a set of more than two mutually exclusive events, the event which has maximum probability (of occurrence) but less than 0.5 cannot be most likely to occur. In this case, the occurrence of either of the other events is more likely than this. Therefore, for an event to be most likely the probability (of occurrence) of it must be more than 0.5 and vice versa.

2.1. Most Likely Number of Rainy Days

Let us consider the number of rainy days in a period containing D number of days at a place. Let R denote the number of rainy days in the period occurred at the place. Then the possible values of R are

$$0 , 1 , 2, 3 , \ldots\ldots\ldots, D$$

(If month is considered as the period, the possible value of D are 28 , 29 , 30 , 31 depending upon length of the month.)

Suppose that R outcomes have already happened.

If out of R outcomes, d number of rainy days occurred r times

then by Definition (1), the probability of occurrence of r rainy days can be defined by

$$\text{the limiting value of the ratio } \frac{r}{R} \text{ as } R \to \infty$$

and can be approximated by this ratio provided R is large and thus can be reasonably estimated by this ratio provided the size R of outcomes is reasonably large.

The value of R that corresponds to the maximum value of probability of occurrence is the estimated most likely number of rainy days.

3. APPLICATION OF THE DEFINITION TO NUMERICAL DATA

Probability defined on the basis of the data on automatically happened outcomes, as stated above, has been applied in estimating most likely number of rainy days at each of the four stations in India namely Chennai, Kolkata, Mumbai and New Delhi to be occurred in each of the 12 months. The estimates have been computed

on the basis of data number of rainy days at these stations from 1969 onwards collected from Meteorological Department of India [28].

Estimates of the associated probabilities of number of rainy days at each of the five stations for each of the 12 months have been computed by the formulation as stated above. Then estimates of most likely numbers of rainy days have been computed from the corresponding values of probabilities obtained in the earlier stage.

It is to be noted that a single number (i.e. a point value) of most likely number of rainy day carries least the mostnificance in terms of acceptance in reality.

Moreover, the most likely numbers of rainy days with probability (of occurrence) less than 0.5 carry more uncertainty of occurrence. For this reason, estimates of most likely numbers of rainy days have been computed as interval values (closed intervals) and with probability (of occurrence) more than 0.9. The estimated values obtained have been shown in Table – 5.1. In addition to this, almost certain numbers of rainy days i.e. number of rainy days with probability (of occurrence) more than 0.99 have also been estimated which have been shown in Table – 5.2.

4. CONCLUSION

Most likely numbers of rainy days with probability (of occurrence) more than 0.9, shown in Table – 5.1, can be interpreted as or regarded as 90% confidence numbers of rainy days to be occurred. Similarly, almost certain numbers of rainy days with probability (of occurrence) more than 0.99, shown in Table – 5.21, can be interpreted as or regarded as 99% confidence numbers of rainy days to be occurred.
From the findings obtained in the study, the following facts have been observed in respect of the picture of rainfall at four stations namely Chennai, Kolkata, Mumbai and New Delhi:

(1) Rainfall is almost certain to be occurred in each of the months from June to November at Chennai, from May to October at Kolkata, from June to September at Mumbai and from June to August at New Delhi.

(2) Rainfall is certain to be occurred in each of the months from September to November at Chennai, from June to September at Kolkata, from July to September at Mumbai and from July to August at New Delhi.

(3) There exists neither certain nor almost certain non-rainy month at each of the four stations namely Chennai, Kolkata, Mumbai and New Delhi which means, the non-occurrence of rainy day or equivalently non-occurrence of rainfall is not certain in any month at any of the four stations.

(4) Non-rainy day is more likely to be occurred

(i) in each of the months February, March & April at Chennai,

(ii) in the month December at Kolkata,

(iii) in each of the months January, February, March, April, May & December at Mumbai &

(iv) in the month November at New Delhi.

It is to be mentioned that the findings obtained in this study are based on the assumption that data used in the analysis satisfy the condition(s) under which the definition of probability is valid. Thus the accuracy of findings is subject to the validity of this assumption.

At this stage, it can be concluded that the definition of probability formulated for automatically happened outcomes can be a convenient tool of determining most likely picture of rainfall at a place. Similar method

can be used in determining most likely picture of rainfall at other places not considered in this study. Thus, one problem for researchers, at this stage, is to go for study on finding the most likely picture of rainfall at the other places of the globe by the application of the definition of probability based on automatically happened outcomes. This type of study will carry significance in the interest of the globe.

One more point to be noted is that in this study attempt has been made on estimating/approximating most likely number of rainy days by the application of definition of probability. There is possibility that the same can be estimated by the application of the concept/definition of mathematical expectation [45]. Studying on the same by mathematical expectation can provide a way of finding the accuracy of the estimates of most likely number of rainy days.

5. TABLES OF FINDINGS

Table -5.1: (Most likely number of rainy days with probability (of occurrence) more than 0.9)

Month	Most likely number of rainy days at			
	Chennai	Kolkata	Mumbai	New Delhi
January	0 – 4	0 – 2	0	0 – 3
February	0 – 2	0 – 4	0	0 – 3
March	0 – 1	0 – 6	0	0 – 3
April	0 – 2	1 – 6	0	0 – 3
May	0 – 4	2 – 11	0 – 3	0 – 4
June	2 – 9	5 – 20	6 – 18	2 – 8
July	3 – 12	15 – 22	16 – 28	5 – 18
August	3 – 15	15 – 22	16– 27	4 – 18
September	4 – 13	8 – 18	6 – 25	2 – 11
October	5 – 15	2 – 12	0 – 10	0 – 3
November	5 – 18	0 – 3	0 – 3	0 – 2
December	2 – 14	0 – 3	0 – 1	0 – 2

Table -5.2: (Almost certain number of rainy days to occur)

Month	Almost certain occurrence of number of rainy at			
	Chennai	Kolkata	Mumbai	New Delhi
January	0 – 7	0 – 3	0 – 1	0 – 4
February	0 – 8	0 – 5	0 – 1	0 – 5
March	0 – 3	0 – 7	0 – 1	0 – 5

April	0 – 4	0 – 9	0 – 1	0 – 6
May	0 – 5	1 – 16	0 – 7	0 – 6
June	1 – 9	5 – 22	5 – 19	1 – 9
July	1 – 12	11 – 22	16 – 28	4 – 21
August	1 – 15	15 – 22	12– 27	3 – 18
September	2 – 13	7 – 19	5 – 25	0 – 11
October	3 – 21	1 – 12	0 – 10	0 – 4
November	4 – 21	0 – 4	0 – 5	0 – 4
December	0 – 18	0 – 4	0 – 2	0 – 6

REFERENCES

[1] Agarwal S., Suchithra A.S. and Singh S.P. (2021), "Analysis and Interpretation of Rainfall Trend using Mann-Kendall's and Sen's Slope Method", Indian Journal of Ecology, 48(2), 453 – 457.
[2] Arvind G., Ashok Kumar P., Girish Karthi S. and Suribabu C. R. (2021): "Statistical Analysis of 30 Years Rainfall Data: A Case Study", Disaster Advances, 7(5), 67 – 75. 012067DOI 10.1088/1755-1315/80/1/012067.
[3] Athwani M. and Pandey R. (2020), "Trend analysis of rainfall pattern in Uttar Pradesh and its comparison with other states", International Journal of Creative Research Thoughts, 8(3), 662 – 667.
[4] Bayes T. (1763): "Thomas Bayes Essay towards Solving a Problem in the Doctrine of Chances, (Studies in the History of Probability and Statistics 9) ", Reprinted from Philos. Trans. Roy. Soc.London, Ser A 53, with a Biographical Note by G. A. Bernard, in Biometrika 45, 293 – 315, 1958.
[5] Caloiero T., Coscarelli R. and Pellicone G. (2021), "Trend Analysis of Rainfall Using Gridded Data over a Region of Southern Italy", Water 2021, 13, 2271. https://doi.org/10.3390/w13162271 .
[6] Bernoulli . J. (1713): "Arts Conjectandi ", Impensis Thurmisiorum Fratrum Basileae.
[7] Bernstein S. N. (1927): "Sur l'extension du theoremelimite du calcul des probabilities aux summes des quantities dependents, Math. Ann. 97, 1 – 59.
[8] Bernstein S. N. (1946): "The Theory of Probabilities (Russian)", Moscow, Leningrad.
[9] Dhritikesh Chakrabarty (2004): "A Theoretical Definition of Probability Based on Common Sense ", Bulletin of Pure and Applied Sciences, 23E-2, 343 – 349. https://www.researchgate.net/publication/265315010_A_theoretical_definition_of_probability_based_on_common_sense?
[10] Dhritikesh Chakrabarty (2005): "Probability: Link between the Classical Definition and the Empirical Definition ", J. Ass. Sc. Soc., 45, June, 13 – 18. https://www.researchgate.net/publication/322759139_Probability_Link_Between_the_Classical_Definition_and_the_Empirical_Definition?
[11] Dhritikesh Chakrabarty (2005): "Probabilistic Forecasting of Time Series", Report (Thesis) of Post Doctoral Research Project, University Grants Commission, DOI: 10.13140/RG.2.2.12952.98569. https://www.researchgate.net/publication/358634406_Post_Doc_Research_-_Report_Thesis?
[12] Dhritikesh Chakrabarty (2006): "Non-Equally Likely Outcomes: The Classical Definition of Probability ", Bulletin of Pure and Applied Sciences, 25E-2, 471 – 481. https://www.researchgate.net/publication/264911628_Non-equally_likely_outcomes_the_classical_definition_of_probability?
[13] Dhritikesh Chakrabarty (2007): "Empirical Definition of Probability: Special Case of Its Theoretical Definition ", Int. J. Agricult. Stat Sc., 3(1), 261 – 267. https://www.researchgate.net/publication/267078755_Empirical_definition_of_probability_Special_case_of_its_theoretical_definition?
[14] Dhritikesh Chakrabarty (2008) : "Bernoulli's Definition of Probability : Special Case of Its Chakrabarty's Definition ", Int. J. Agricult. Stat. Sci., 4(1), 23 – 27.

https://www.researchgate.net/publication/265477707_Bernoulli's_definition_of_probability_special_case_of_its_Chakrabarty's_definition?

[15] Dhritikesh Chakrabarty (2009): "Probability: Chakrabarty's Definition from its Classical Definition", Int. J. Agricult. Stat. Sci., 5(1), 181 – 187. https://www.researchgate.net/publication/299265157_PROBABILITY_CHAKRABARTY'S_DEFINITION_FROM_ITS_CLASSICAL_DEFINITION?

[16] Dhritikesh Chakrabarty (2010): "A Method of Determining the Value of Probability", Int. J. for Statisticians, 1(1), 5 – 7. https://www.researchgate.net/publication/322758586_A_Method_of_Determining_the_Value_of_Probability?

[17] Dhritikesh Chakrabarty (2010): "Probability As The Maximum Occurrence of Relative Frequency", Arya Bhatta Journal of Mathematics & Informatics., 2 (2), 339 – 344. www.abjni.com .

[18] Dhritikesh Chakrabarty (2010): "Chakrabarty's Definition of Probability: Additive and Multiplicative Laws ", Bulletin of Pure and Applied Sciences - E., 29E (2), 265 – 274. https://www.researchgate.net/publication/267991650_Chakrabarty's_definition_of_probability_additive_and_multiplicative_laws?

[19] Dhritikesh Chakrabarty (2011): "Probability in Ideal Situation and in Practical Situation", Arya Bhatta J. Math. & Info. , 3 (1), 161 – 168. www.abjni.com .

[20] Dhritikesh Chakrabarty (2014) : "Natural Limits of Annual Total Rainfall in the Context of India ", Int. J. Agricult. Stat. Sci., 10(1), (ISSN : 0973 – 1903), 105 – 109. https://www.researchgate.net/publication/296323600_Natural_limits_of_annual_total_rainfall_in_the_context_of_India?

[21] Dhritikesh Chakrabarty (2019): "Significance of Change of Rainfall: Confidence Interval of Annual Total Rainfall", Journal of Chemical, Biological and Physical Sciences (E- ISSN : 2249 – 1929), Sec. C, 9(3), 151 – 166. www.jcbsc.org . DOI: 10.24214/jcbps.C.9.

[22] Dhritikesh Chakrabarty (2021): "Annual Total Rainfall in India: Confidence Interval and Significance of Change", International Journal of Advanced Research in Science, Engineering and Technology, (ISSN : 2350 – 0328), 8(11), 18540 – 18550. www.ijarset.com .

[23] Dhritikesh Chakrabarty (2022): "Latest Definition of Probability: Link with Its Earlier Definitions", Uploaded in Research Gate on May 15, 2022. DOI: 10.13140/RG.2.2.28013.15844. https://www.researchgate.net/publication/360612422_Latest_Definition_of_Probability_Link_with_Its_Earlier_Definitions?

[24] Dhritikesh Chakrabarty (2022): "Integral Valued Numerical Data: Measure of Central Tendency", Partners Universal International Research Journal (PUIRJ), 01(03), 74 – 82. www.puirj.com . DOI:10.5281/zenodo.7123662 .

[25] Dhritikesh Chakrabarty (2022): "Determination of Tendency of Rainfall at Delhi and Mumbai", International Journal of Advanced Research in Science, Engineering and Technology, (ISSN : 2350 – 0328), 9(12), 20210 – 20219. www.ijarset.com .

[26] Dhritikesh Chakrabarty (2022): "Method of Determination of Central Tendency of Non-negative Integral Valued Data: Application in Rainfall Data at Mumbai", Partners Universal International Research Journal (PUIRJ), ISSN: 2583-5602, 01(04), 67 – 74. www.puirj.com . DOI:10.5281/zenodo.7422267.

[27] Dhritikesh Chakrabarty (2023): "Determination of Tendency of Rainfall in India Described by Number of Rainy Days", Partners Universal International Research Journal (PUIRJ), ISSN: 2583-5602, 02(01), 95 – 102. www.puirj.com . DOI:10.5281/zenodo.7770100 .

[28] Dhritikesh Chakrabarty (2023): "Definition of Probability Based on Automatically happened outcomes: Application in Identifying Rainy and Non-Rainy Period", Partners Universal International Innovation Journal (PUIIJ), 01(04), 259 – 267. www.puiij.com . DOI:10.5281/zenodo.8282811.

[29] Fakhri Alam, Muhammad Salam, Nasir Ahmad Khalileta1 (2021): "Rainfall trend analysis and weather forecast accuracy in selected parts of Khyber Pakhtunkhwa, Pakistan:", SN Applied Sciences, 3, 575, 1 – 14. https://doi.org/10.1007/s42452-021-04457-z

[30] Hills R. C. (1974): "The Presentation of Central Tendencies in Rainfall Statistics", East African Agricultural and Forestry Journal, 39(4), 424 – 430. Published online: 11 December 2015 .

[31] Jack Barone & Albert Novikoff (1978): "A History of the Axiomatic Formulation of Probability from Borel to Kolmogorov", Archive for History of Exact Sciences, 18(2), 8.III, Springer. Stable URL: https://www.jstor.org/stable/i40049719.

[32] Jagannathan P. and Parthasarathy B. (1973): "Trends and periodicities of rainfall over India", Monthly Weather Rev, 101, 371 – 375.

[33] Kolmogorov A. N. (1956): "Foundations of the Theory of Probability", 2nd English Edition, Chelsea Publishing Company, New York: A Translation of Grundbergriffe der Wahrscheinlichkeitsrechnung.
[34] Koopman . B. O. (1940): "The Axioms and Algebra of Intuitive Probability", Ann. of Math.(2), 41, 269 – 292.
[35] Koopman . B. O. (1940): "The Bases of Probability", Bulletin of American Mathematical Society, 46, 763 – 964.
[36] Kammun (2019), "Rainfall Analysis - A Review", International Research Journal of Engineering and Technology, 6(12) 2614 – 2617.
[37] Maistrov L. E. (1974): "Probability Theory: A Historical Sketch", Academic Press, New York & London.
[38] Mooley D. A. and Parthasarthy B. (1984): "Fluctuations of all India summer monsoon rainfall during 1871–1978", Climatic Change, 6, 287 – 301.
[39] Muhammad Touseef, Lihua Chen,2Kaipeng Yang and Yunyao Chen ( ): "Long-Term Rainfall Trends and Future Projections over Xijiang River Basin, China" Advances in Meteorology, Volume 2020, Article ID 6852148. https://doi.org/10.1155/2020/6852148 .
[40] Nadhir Al-Ansari, Mawada Abdellatif, Mohammad Ezeelden et al (2014): "Climate Change and Future Long-Term Trends of Rainfall at North-East of Iraq", Journal of Civil Engineering and Architecture (ISSN 1934-7359), 8(6), 790 – 805.
[41] Namdev K. and Madan S. (2021), "Study of Rainfall Variation in Parbhani District of Maharashtra (2000-2016)", International Journal of Creative Research Thoughts, 9(6), 135-140.
[42] Nikumbh A. C., Chakraborty A, Bhat G. S. (2019): "Recent Spatial Aggregation Tendency of Rainfall Extremes over India", Science Report, 9(1):10321. doi: 10.1038/s41598-019-46719-2. PMID: 31311996; PMCID: PMC6635486.
[43] Padhiary J., Das D. M., Patra K. C. and Sahoo B. C. (2018), "Trend analysis of rainfall and temperature using the Mann kendall test in Jaraikela catchment of Brahmani river basin", International Journal of Agriculture Sciences, 10(19), 7309 –7313.
[44] Partal T. and Kahy, E. (2006): "Trend analysis in Turkish precipitation data", Hydrol. Processes, 20, 2011–2026.
[45] Ross Sheldon M. (2019): "*Introduction to probability models* (Twelfth edition of 1972 original ed.), Section 2.4.1., London: Academic Press. doi.10.1016/C2017-0-01324-1. ISBN 978-0-12-814346-9. MR 3931305.
[46] Savage L. J. (1954): "The Foundations of Statistics", John Wiley, New York.
[47] Sharma M. R. (2017), "Trend and Variability of Rainfall in Punjab: A Statistical Analysis, 1981- 2010", Research Guru Online Journal of Multidisciplinary subjects, 11 (3), 73 – 81.
[48] Sharma N. K., and Sharma S. (2019), "Frequency Analysis of Rainfall Data of Dharamshala Region", International Journal of Science and Research, 8(2), 886 – 892.
[49] Sinha Ray K. C. and De U. S. (2003): "Climate change in India as evidenced from instrumental records", WMO Bulletin, 52, 53 – 58.
[50] Shyam Lochan Bora, Kalyan Bhuyan, Partha Jyoti Hazarika, Junmi Gogoi and Kuldeep Goswami (2022): "Analysis of rainfall trend using non-parametric methods and innovative trend analysis during 1901–2020 in seven states of North East India", CURRENT SCIENCE, 122(7), 801 – 811.
[51] Subodh Kant Pandey & H. L. Tiwari (2021): "RAINFALL TREND DETECTION – A REVIEW", International Journal of Creative Research Thoughts (IJCRT), 9(11), 521 – 524. www.ijcrt.org .
[52] Tank G., Dongre P, Obi Reddy G. P. and Sen P. (2021), "Rainfall Trend Analysis – A Review", International Research Journal of Engineering and Technology, 8(4), 4028 – 4030.
[53] Vijay Kumar, Sharad K. Jain and Yatveer Singh (2010): "Analysis of long-term rainfall trends in India", Hydrological Sciences Journal, 55(4), 484 – 496.
[54] von Mises R. (1930): " Varoyatmosti statistika ", Moscow-Leningard. (English Edition" Probability and Statistics", Academic Press, New York, 1964).
[55] von Mises R. (1931): "Wahrscheinlichkeits Rechnung. (English Edition: "Mathematical Theory of Probability and Statistics", Academic Press, New York, 1964).
[56] von Mises R. (1939): "Probability, Statistics and Truth ", Mcmillan.