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# **Probability Distribution of Rainy Days at Metropolitan Cities in India**

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**ABSTRACT:** Probability, recently defined on the basis of automatically happened outcomes by the application of the philosophy behind concept of empirical probability, has been applied in estimating the probability distribution of number of rainy days (monthly) at the four metropolitan cities in India with an objective of making the information required for estimating expected number of rainy days available. This article presents the estimated values of the probability distributions as planned in the study.

**KEYWORDS:** Automatically happened outcomes, rainy day, probability distribution, estimation

## **I. INTRODUCTION**

The theory of probability has become essentially useful for scientific analysis of data in almost every study of research and investigation type [22 , 23 , 24 , 25 , 27 , 31 , 32]. The evolution of theory of probability has progressed through five stages namely (1) Prehistoric era, (2) Scientific thinking era, (3) Bernoullian Era, (4) Russian School era, and (5) Modern era [47 , 53]. On the other hand, the development has been progressing six approaches namely (1) Subjective Approach [4], (2) Intuitive Approach [50 , 51 , 61], (3) Classical Approach [6 , 9 , 10 , 12 , 14 , 16 , 17], (4) Empirical Approach also termed as relative frequency approach or statistical approach [12 , 15 , 67 , 68], (5) Axiomatic Approach [7 , 9 , 49] and (6) Theoretical Approach [11 , 15 – 21 , 35 , 38 , 39].

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 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. Probability, recently defined on the basis of automatically happened outcomes by the application of the philosophy behind concept of empirical probability [43 , 44], has been applied in estimating probability distribution of number of rainy days (monthly) at the five metropolitan cities in India with an objective of making the information required for estimating expected number of rainy days available. This article presents the estimated values of the probability distributions as planned in the study. This study has been done due to the reason no study has yet been done on this particular topic though lot of studies had been done on various characteristics and behaviors of rainfall [1 – 3 , 5 , 13 , 28 , 33 , 34 , 36 , 37 , 40 , 42 , 45 , 46 , 48 , 52 , 54 – 60 , 62 – 66].



## II. NUMBER OF RAINY DAYS: PROBABILITY OF OCCURRENCE

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 the limiting value of the ratio  $\frac{n}{N}$  as  $N \rightarrow \infty$  i.e.  $P(E)$  can be approximated by the ratio  $\frac{n}{N}$  provided  $N$  is large.

**Definition (2):**

In a set of  $N$  repetitions of a natural phenomenon automatically happened, number of occurrence  $n$  of an event  $E$  with probability of occurrence  $P(E)$  is

the limiting value of the ratio  $N.P(E)$  as  $N \rightarrow \infty$

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

Suppose that  $E$  is an event that denotes occurrence of  $r$  rainy days in a specified period in year.

Consider the observations on happenings of rainfall in the period on a number of years (say  $N$  years) i.e. on  $N$  repetitions of the happenings.

Since the phenomenon has happened naturally, it is free from error that occurs due to performing of experiment.

Moreover, the natural happening of the phenomenon can be thought of as the performing of experiment on rainfall not by human but by nature and hence the definition of probability based on automatically happened outcomes is applicable in this case.

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

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

(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 the limiting value of the ratio  $\frac{r}{R}$  as  $R \rightarrow \infty$  and can be approximated by this ratio provided  $R$  is large.

## III. PROBABILITY OF RAINY DAYS IN METROPOLITAN CITIES IN INDIA

Probability defined on the basis of the data on automatically happened outcomes, as stated above, has been applied in estimating the probability distribution of occurrence of rainfall (in terms of number of rainy days with respect to month) at four metropolitan cities in India. In order to obtain a picture of non-rainfall tendency, the probability of occurrence of each of zero rainy day, one rainy day and either zero or one rainy day has been considered in the study. 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 [13, 27]. Estimated values of the respective probabilities obtained have been shown in Table - 1, Table - 2, Table - 3 & Table - 4.

## IV. CONCLUSION

If the probability of occurrence of zero rainy day at a place during a period is 1 then the period can be regarded as a certain to be non-rainy one. In reality, there may be rainfall during a non-rainy period due to some random cause that occurs accidentally but not regularly and not always so that 1 rainy day can occur during a non-rainy period with very small (near to 0) probability. Thus, if the probability of occurrence of zero rainy day during a period is not 1 but near to 1 and the probability of occurrence of 1 rainy day during the period is very small such that the probability of occurrence of either 0 rainy day or 1 rainy day is 1 (i.e. there are only 2 possible outcomes namely 0 and 1) then the period can be



regarded as almost certain to be non-rainy period. On the other hand, if the probability of occurrence of zero rainy day during a period is 0 then, the period can be regarded as a certain rainy period. Also, if the probability of occurrence of zero rainy day during a period is not 0 but very small and very near to 0 the period can be regarded as almost certain rainy period.

Thus from the numerical findings of the estimates of the probabilities, shown in Table - 1, Table - 2, Table - 3 & Table - 4, it is possible to detect certain non-rainy month(s), almost certain non-rainy month(s), certain rainy month(s) and almost certain rainy month(s) at the stations under study.

One notable findings of the study is that no month, at the four metropolitan cities in India under study, has been found to have 100% rainy days while no month is certain to be completely free from influence of rainfall.

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 the probability distribution of number of rainy days at a place. This has been done by the application of definition of probability based on automatically happened outcomes. There is possible scope of applying this definition of probability in defining mathematical expectation [44] and thus in estimating expected number of rainy days in a given period at a place.

Finally, one can conclude that the logical derivation of definition of probability based on automatically happened outcomes can be a useful statistical tool of analysis of data obtained from automatically happened or naturally happened Phenomena. Therefore, as per the meaning of research [22 – 24 , 26 , 27 , 29 – 32 , 41], this extended definition of probability can be regarded as a fundamental research carrying significant potentiality of application in analysis of data. The concept of probability defined for automatically happened outcomes can be applied, in a similar manner, in estimating probability distribution and mathematical expectation of number of rainy days at other places of the globe also.

**V. TABLES OF FINDINGS**

**Table – 1**  
Estimated Probability Distribution of Number of Rainy Days at  
**Chennai**

<b>January</b>		<b>February</b>		<b>March</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.53333	0	0.8	0	0.76667
1	0.13333	1	0.066667	1	0.16667
2	0.1	2	0.1	2	0
3	0.13333	3 – 7	0	3	0.06667
4	0.066667	8	0.033333	> 3	0
5 – 6	0	> 8	0		
7	0.033333				
> 7	0				
<b>April</b>		<b>May</b>		<b>June</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.6	0	0.3	1	0.1
1	0.13333	1	0.36667	2	0.13333
2	0.16667	2	0.06667	3	0.13333
3	0.066667	3 – 5	0.26667	4 – 6	0.4



4	0.03333	> 5	0	7 – 9	0.23333
> 4	0			> 9	0
<b>July</b>		<b>August</b>		<b>September</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
1	0.06667	1	0.03333	< 2	0
2	0.03333	2	0.06667	2	0.06452
3 – 7	0.43333	3 – 7	0.36667	3	0.03226
8 – 12	0.46667	8 – 12	0.36667	4 – 8	0.51613
> 12	0	13 – 15	0.16667	9 – 13	0.38709
		> 15	0	> 13	0
<b>October</b>		<b>November</b>		<b>December</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
< 2	0	< 4	0	0	0.1
2 – 6	0.23333	4 – 8	0.33333	1	0.06667
7 – 11	0.36667	9 – 13	0.53333	2	0.1
12 – 16	0.36667	14 – 18	0.1	3	0.13333
17 – 20	0	19 – 20	0	4 – 8	0.43333
21	0.03333	21	0.03333	9 – 13	0.1
> 21	0	> 21	0	14	0.03333
				15 – 17	0
				18	0.03333
				> 18	0

**Table – 2**  
Estimated Probability Distribution of Number of Rainy Days at  
**Kolkata**

<b>January</b>		<b>February</b>		<b>March</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.42857	0	0.142857	0	0.35714
1	0.28572	1	0.39286	1	0.07143
2	0.17857	2	0.17857	2	0.21429
3 – 7	0.10714	3 – 7	0.28571	3 – 7	0.35714
> 7	0	> 7	0	> 7	0
<b>April</b>		<b>May</b>		<b>June</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.07143	1	0.03571	< 5	0
1	0.21429	2	0.07143	5 – 9	0.21428
2	0.17857	3	0.07143	10 – 14	0.46429
3 – 7	0.5	4 – 8	0.53572	15 – 19	0.25
8	0	9 – 11	0.25	20 – 22	0.07143
9	0.03571	12 – 15	0	> 22	0
> 9	0	16	0.03571		
		> 16	0		
<b>July</b>		<b>August</b>		<b>September</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
< 11	0	< 10	0	< 7	0



11 – 15	0.178571	10 – 14	0.21429	7 – 11	0.28571
16 – 20	0.75	15 – 19	0.57142	12 – 16	0.57143
21	0	20 – 22	0.21429	17 – 19	0.14286
22	0.071429	> 22	0	> 19	0
> 22	0				
<b>October</b>		<b>November</b>		<b>December</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.03571	0	0.39286	0	0.71429
1	0.03571	1	0.21429	1	0.07143
2	0.03572	2	0.21429	2	0.10714
3 – 7	0.5	3	0.14285	3	0.03571
8 – 12	0.39286	4	0.03571	4	0.07143
> 12	0	> 4	0	> 4	0

**Table – 3**  
Estimated Probability Distribution of Number of Rainy Days at  
**Mumbai**

<b>January</b>		<b>February</b>		<b>March</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.9375	0	0.90625	0	0.96875
1	0.0625	1	0.09375	1	0.03125
≥ 2	0	≥ 2	0	≥ 2	0
<b>April</b>		<b>May</b>		<b>June</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.90625	0	0.75	< 16	0
1	0.09375	1	0.09375	16 – 20	0.3125
≥ 2	0	2	0.03125	21 – 25	0.375
		3 – 7	0.125	26 – 28	0.3125
		> 7	0	> 28	0
<b>July</b>		<b>August</b>		<b>September</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
< 16	0	< 12	0	< 5	0
16 – 20	0.3125	12 – 16	0.125	5 – 9	0.21875
21 – 25	0.375	17 – 21	0.34375	10 – 14	0.3125
26 – 28	0.3125	22 – 26	0.4375	15 – 19	0.3125
> 28	0	27	0.09375	20 – 24	0.09375
		> 27	0	25	0.0625
				> 25	0
<b>October</b>		<b>November</b>		<b>December</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.1875	0	0.625	0	0.78125
1	0.0625	1	0.0625	1	0.125
2	0.15625	2	0.1875	2	0.09375
3 – 7	0.5	3 – 7	0.125	> 2	0
8 – 12	0.09375	> 7	0		
> 12	0				

**Table – 4**  
Estimated Probability Distribution of Number of Rainy Days at  
**New Delhi**

<b>January</b>		<b>February</b>		<b>March</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.30303	0	0.15625	0	0.28125
1	0.21212	1	0.34375	1	0.21875
2	0.30303	2	0.3125	2	0.25
3	0.12121	3 – 5	0.1875	3 – 5	0.25
4	0.06061	> 5	0	> 5	0
> 4	0				
<b>April</b>		<b>May</b>		<b>June</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.375	0	0.3125	1	0.0625
1	0.375	1	0.125	2	0.09375
2	0.125	2	0.25	3 – 5	0.5625
3	0.03125	3	0.1875	6 – 8	0.25
4 – 6	0.09375	4 – 6	0.125	9	0.03125
> 6	0	> 6	0	> 9	0
<b>July</b>		<b>August</b>		<b>September</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
< 4	0	< 3	0	0	0.0625
4 – 8	0.36364	3	0.03125	1	0.03125
9 – 13	0.42424	4 – 8	0.375	2	0.125
14 – 18	0.18182	9 – 13	0.4375	3 – 7	0.5625
<b>19 – 20</b>	<b>0</b>	14 – 18	0.15625	8 – 10	0.15625
21	0.0303	> 18	0	11	0.0625
> 21	0			> 11	0
<b>October</b>		<b>November</b>		<b>December</b>	
Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence	Number of Rainy Days	Probability of occurrence
0	0.4375	0	0.75	0	0.5
1	0.25	1	0.125	1	0.25
2	0.125	2	0.09375	2	0.15625
3 – 5	0.1875	3 – 5	0.03125	3 – 5	0.0625
> 5	0	> 5	0	6	0.03125
				> 6	0

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## AUTHOR'S BIOGRAPHY

Dr. Dhritikesh Chakrabarty passed B.Sc. (with Honours in Statistics) Examination from Darrang College, Gauhati University, in 1981 securing 1<sup>st</sup> class & 1<sup>st</sup> position. He passed M.Sc. Examination (in Statistics) from the same university in the year 1983 securing 1<sup>st</sup> class & 1<sup>st</sup> position and successively passed M.Sc. Examination (in Mathematics) from the same university in 1987 securing 1<sup>st</sup> class (5<sup>th</sup> position). He obtained the degree of Ph.D. (in Statistics) in the year 1993 from Gauhati University. Later on, he obtained the degree of Sangeet Visharad (in Vocal Music) in the year 2000 from Bhatkhande Sangeet vidyapith securing 1<sup>st</sup> class, the degree of Sangeet Visharad (in Tabla) from Pracheen Kala Kendra

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in 2010 securing 2<sup>nd</sup> class, the degree of Sangeet Pravakar (in Tabla) from Prayag Sangeet Samiti in 2012 securing 1<sup>st</sup> class, the degree of Sangeet Bhaskar (in Tabla) from Pracheen Kala Kendra in 2014 securing 1<sup>st</sup> class and Sangeet Pravakar (in Guitar) from Prayag Sangeet Samiti in 2021 securing 1<sup>st</sup> class. He obtained Jawaharlal Nehru Award for securing 1<sup>st</sup> position in Degree Examination in the year 1981. He also obtained Academic Gold Medal of Gauhati University and Prof. V. D. Thawani Academic Award for securing 1<sup>st</sup> position in Post Graduate Examination in the year 1983.

Dr. Dhritikesh Chakrabarty also did post doctoral research under the Post Doctoral Research Award by the University Grants Commission for the period 2002 – 05.

He attended five of orientation/refresher course held in Gauhati University, Indian Statistical Institute, University of Calicut and Cochin University of Science & Technology sponsored/organized by University Grants Commission/Indian Academy of Science. He also attended/participated eleven workshops/training programmes of different fields at various institutes.



(Dr. Dhritikesh Chakrabarty, 2<sup>nd</sup> from the left, with some of his colleagues in his last official working day (December 31, 2021) at Handique Girls' College)

Dr. Dhritikesh Chakrabarty, currently an independent researcher, served Handique Girls' College, Gauhati University, during the period of 34 years from December 09, 1987 to December 31, 2021, as Professor (first Assistant and then Associate) in the Department of Statistics along with Head of the Department for 9 years and also as Vice Principal of the college. He also served the National Institute of Pharmaceutical Education & Research (NIPER) Guwahati, as guest faculty (teacher cum research guide), during the period from May, 2010 to December, 2016. Moreover, he is a Research Guide (Ph.D. Guide) in the Department of Statistics of Gauhati University and also a Research Guide (Ph.D. Guide) in the Department of Statistics of Assam Down Town University. He has been guiding a number of Ph.D. students in the two universities. He acted as Guest Faculty in the Department of Statistics and also in the Department of Physics of Gauhati University. He also acted as Guest Faculty cum Resource Person in the Ph.D. Course work Programme in the Department of Computer Science and also in the Department of Biotechnology of the same University for the last six years. Dr. Chakrabarty has been working as an independent researcher for the last more than thirty years. He has already been an author of 260 published research items namely research papers, chapter in books / conference proceedings, books etc. He visited U.S.A. in 2007, Canada in 2011, U.K. in 2014 and Taiwan in 2017. He has already completed one post doctoral research project (2002 – 05) and one minor research project (2010 – 11). He is an active life member of the academic cum research organizations namely (1) Assam Science Society (ASS), (2) Assam Statistical Review (ASR), (3) Indian Statistical Association (ISA), (4) Indian Society for Probability & Statistics (ISPS), (5) Forum for Interdisciplinary Mathematics (FIM), (6) Electronics Scientists & Engineers Society (ESES) and (7) International Association of Engineers (IAENG). Moreover, he is a Reviewer/Referee of (1) Journal of Assam Science Society (JASS) & (2) Biometrics & Biostatistics International Journal (BBIJ); a member of the executive committee of Electronic



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Scientists and Engineers Society (ESES); and a Member of the Editorial Board of (1) Journal of Environmental Science, Computer Science and Engineering & Technology (JECET), (2) Journal of Mathematics and System Science (JMSS) & (3) Partners Universal International Research Journal (PUIRJ). Dr. Chakrabarty acted as members (at various capacities) of the organizing committees of a number of conferences/seminars already held.

Dr. Chakrabarty was awarded with the prestigious SAS Eminent Fellow Membership (SEFM) with membership ID No. SAS/SEFM/132/2022 by Scholars Academic and Scientific Society (SAS Society) on March 27, 2022.

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