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Probability of Occurrence of Rainy Day in Indian Context by Extended Statistical Approach

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ABSTRACT: The empirical definition of probability has, in a recent study, been extended to the situation where outcomes of the associated trials happen automatically. This article, which is based on a study on probability of occurrence of rainy days with a view of obtaining a picture of tendency of rainfall in India, presents the estimates of probability of occurrence of rainy days in each of the 12 months at the 30 stations in India obtained by the application of this extended definition. It has been found that no month at these stations carries proper non-rainfall tendency.

KEYWORDS: Probability, Extended Empirical Definition, Probability of Rainy Days

I. INTRODUCTION

What has happened on phenomenon can be known if its outcomes have not missed and what is happening can also be known if its outcomes are obtainable but what will happen and/or what will be happening is unknown at present if the phenomenon is not deterministic but probabilistic. On the other hand, people's thrust is to know what will happen and/or what will be happening. Statistics, whose theory is based on the concept of probability, is a branch of science which deals with this thrust of human being. Probability, which is a measure of chance of happening/occurrence of an outcome or of an event (or equivalently which measures to what extent an outcome or an event is likely to be happened/occurred), is the basis of statistical methods as well as of statistical tools of analysis of data on phenomena not deterministic in nature. It is not traceable when the development of probability theory had begun [60]. At the same time, it has come to our knowledge that the scientific development of theory of probability till this date is due to the four approaches namely
(1) A-priory Approach or Classical Approach introduced by James Bernoulli [6 , 7 , 9 , 11 , 13 , 14],
(2) Empirical Approach or Relative Frequency Approach or Statistical Approach developed by von Mises [9 , 12 , 66],
(3) Modern Approach or Axiomatic Approach developed by Bernstein & Kolmogorov [4 , 56]
and (4) Theoretical Approach as thought of by Chakrabarty [8 , 12 – 19 , 32 , 35 , 36].
Recently the statistical definition of probability introduced by von Mises, which was based on the outcomes of actually performed experimentation, has been extended to the situation where outcomes of the trials happen automatically [40 , 45 , 56 , 57].

In the empirical approach, probability is defined or determined on the basis of random experiment either performing the actual experimentation while in the classical approach probability is defined a-priory without performing the associated actual experimentation. The classical definition of probability, as formulated by Bernoulli, is a theoretical relationship between number of outcomes favorable to the happening of an event and the measure of chance of its happening. Data on outcomes of trials obtained from actual experimentation are not used in this definition. On the other hand, the empirical definition is based on data on outcomes of trials obtained from actual experimentation and it is also a relationship between the number of occurrence of an event and the measure of chance of its occurrence. Similarly, the extended definition of empirical probability is of the same nature as that of empirical definition of probability.

One can think of determining the probability of occurrence of rainy day(s) in a period by the extended empirical definition of probability extended to the situation where outcomes of the trials happen automatically. In the present study, attempt has been made on determining the probability of occurrence of rainy days in a period at a place with application to

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numerical data on rainy days in the context of India. This article, which is based on a study on probability of occurrence of rainy days with a view of obtaining a picture of tendency of rainfall in India, presents the estimates of probability of occurrence of rainy days in each of the 12 months at the 30 stations in India obtained by the application of this extended definition. It is to be mentioned the studies done so far on tendency of rainfall [1 – 3 , 5 , 10 , 26 , 30 , 31 , 33 , 34 , 37 , 39 , 41 – 44 , 47 – 55 , 58 , 59 , 61 – 65] are not based on probabilistic approach.

II. RAINY DAY IN A PERIOD – PROBABILITY OF OCCURRENCE

The classical definition of probability introduced by Bernoulli is as follows:
Suppose, a trial results in N mutually exclusive, exhaustive and equally likely outcomes. If out of these N outcomes, n outcomes are favorable to the happening / occurrence of an event E, then the probability of occurrence of the event E, denoted by $P(E)$, is given/defined by

$$P(E) = \frac{n}{N}$$

The extended definition of empirical / statistical probability, extended to the situation where outcomes of the associated trials happen automatically, is as follows:
If in a set of N repetitions of a natural phenomenon happened automatically, an event E has occurred n times then the probability of occurrence of E is given / defined by

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.

This extended definition of statistical probability can provide estimate of the probability of happening / occurrence of event E.
Let us now consider a period (say month) M.
If the period consists of N days and if out of these N days, n days are favorable to be rainy days
then the probability that a day in the period M, selected at random, is a rainy day is given by the ratio $\frac{n}{N}$ as per the classical definition of probability.
In order to estimate the value of p, the definition of the extended statistical probability can be applied.
Let us consider R repetitions of the period M.
In the R repetitions, there are altogether RN days.
If among these RN days, r days have occurred as rainy
then by the definition of extended statistical probability, the probability that a day in the period M, selected at random, can be approximated by the ratio $\frac{r}{RN}$ as $R \rightarrow \infty$.
Thus the value of $\frac{r}{RN}$ for large R can be accepted as an estimate of the value of p.

III. APPLICATION TO NUMERICAL DATA

The extended empirical definition of probability extended to the situation where outcomes of the trials happen automatically, as mentioned above, have been applied in the data on number of rainy days in each of the 12 months at the following 30 stations in India:

Table – 3.1
Stations under Study

Agartala	Ahmadabad	Allahabad	Amritsar	Bangalore
Bhopal	Bhubaneswar	Bhunter	Chennai	Guwahati
Hisar	Hyderabad	Imphal	Jaipur	Kolkata
Lucknow	Mumbai	Nagpur	New Delhi	Palam
Panjim	Patna	Pondicherry	Port Blair	Pune
Shillong	Tezpur	Trivandrum	Udaipur	Varanasi

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The data have been collected from Indian Meteorological Department [10 , 26 , 31]. The dataset, that have been found available from the year 1969 onwards, consist of number of rainy days occurred in each of the 12 months at the above stations corresponding to the years.
The probability that a day in a month, selected at random, is rainy has been calculated by the extended definition of statistical probability for each of the 12 months and at each of the 30 stations. The estimated values obtained have been presented in **Table – 5.1**.

IV. RESULT AND DISCUSSION

If the probability of occurrence of a rainy day at a place during a period is 0 then the period can be regarded as a period having perfect non-rainfall tendency.
In reality, there may be rainfall during a period having non-rainfall tendency due to some random cause that occurs accidently but not regularly and not always so that the probability of occurrence of a rainy day in that period is very small (near to 0).
Thus, if the probability of occurrence of a rainy day in a period is not 0 but very small (near to 0) then the period can be regarded as a period having significant non-rainfall tendency.
The non-rainfall tendency of the period can be regarded as

significant or
highly significant
or almost fully significant

in accordance with the value of the probability of occurrence of a rainy day in the period is

< 0.05 but > 0.01
or < 0.01 but > 0.0027
or < 0.0027

respectively.

The months having non-rainfall tendency of different levels identified from the numerical findings of the estimates of the probabilities, shown in **Table – 5.1**, have been presenred in **Table – 5.2**.

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 extension of its empirical definition extended to the situation where outcomes of the associated trials happen automatically can be a convenient tool of estimating/approximating the probability occurrence of a rainy day at a place in a period. This tool can be used in estimating/approximating the probability occurrence of a rainy day in a period at other places not considered in this study. Thus one problem for researchers, at this stage, is to go for study the same at the other places of the globe by the application of this definition of probability. This type of study will carry significance in the interest of the globe.

It is to be mentioned thay in this study attempt has been made on estimating/approximating the probability occurrence of a rainy day at a place in a period. This has been done by the extension of its empirical definition extended to the situation where outcomes of the associated trials happen automatically. There is possible scope of applying this definition of probability, along with its classical definition, in estimating number days favorable to be rainy as well as expected number [46] of rainy days in a given period at a place.

Finally, one can conclude that the the extended definition of empirical probability extended to the situation where outcomes of the associated trials happen automatically 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 [20 – 25 , 27 – 29 , 38 , 47], the innovation of this extended definition of empirical probability can be regarded as a fundamental research carrying significant potentiality of application in analysis of data.

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V. TABLES OF FINDINGS

Table – 5.1

Probability that of a Day in a month, Selected at Random, is Rainy

Month	Estimated Value of Probability				
	Agartala	**Ahmadabad**	**Allahabad**	**Amritsar**	**Bangalore**
January	0.0206	0.015	0.0524	0.0655	0.00615
February	0.0786	0.0126	0.0413	0.1147	0.01652
March	0.1045	0.0034	0.0242	0.1105	0.02218
April	0.288	0.0144	0.0219	0.0677	0.09479
May	0.4206	0.0246	0.0343	0.0694	0.22278
June	0.504	0.0629	0.151	0.1192	0.20521
July	0.5097	0.0865	0.3861	0.2933	0.23185
August	0.4994	0.0854	0.3777	0.2385	0.33468
September	0.3907	0.0677	0.2817	0.0094	0.33229
October	0.2142	0.0276	0.0583	0.0353	0.25907
November	0.0653	0.0254	0.0172	0.0172	0.13125
December	0.0219	0.0150	0.0135	0.0384	0.05746

Table – 5.1: Continuation (1)

Probability that of a Day in a month, Selected at Random, is Rainy

Month	Estimated Value of Probability				
	Bhopal	**Bhubaneswar**	**Bhunter**	**Chennai**	**Guwahati**
January	0.0409	0.0131	0.1873	0.0366	0.0415
February	0.0393	0.0635	0.2247	0.0190	0.0727
March	0.0183	0.0538	0.2612	0.0118	0.1290
April	0.0149	0.0667	0.1871	0.0267	0.3057
May	0.0300	0.1279	0.2029	0.0473	0.4160
June	0.2345	0.3333	0.1478	0.1522	0.4931
July	0.4583	0.4862	0.2882	0.2172	0.5495
August	0.4694	0.5012	0.2828	0.2581	0.4160
September	0.2556	0.3964	0.1622	0.2478	0.3345
October	0.0623	0.2385	0.0614	0.3247	0.1602
November	0.0368	0.0617	0.0511	0.3433	0.0513
December	0.0207	0.0143	0.0823	0.1742	0.0232

Table – 5.1: Continuation (2)

Probability that of a Day in a month, Selected at Random, is Rainy

Month	Estimated Value of Probability				
	Hisar	**Hyderabad**	**Imphal**	**Jaipur**	**Kolkata**
January	0.0401	0.0172	0.0394	0.0171	0.0334
February	0.0552	0.0154	0.1186	0.0368	0.0663
March	0.0479	0.0183	0.1970	0.0141	0.0749
April	0.0384	0.0478	0.3299	0.0240	0.0988
May	0.0587	0.0828	0.3359	0.0474	0.2200
June	0.1188	0.24	0.5149	0.1258	0.4214
July	0.2395	0.3115	0.5095	0.3288	0.5680
August	0.2097	0.3516	0.4160	0.3039	0.5415
September	0.1	0.2556	0.3138	0.1189	0.4429
October	0.0244	0.1849	0.2102	0.0364	0.2108
November	0.0104	0.0644	0.1083	0.0161	0.0405
December	0.0212	0.1222	0.0363	0.0104	0.0219

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Table – 5.1: Continuation (3)
Probability that of a Day in a month, Selected at Random, is Rainy

Month	Estimated Value of Probability				
	Lucknow	**Mumbai**	**Nagpur**	**New Delhi**	**Palam**
January	0.0416	0.0020	0.0400	0.4747	0.0484
February	0.0565	0.0034	0.0530	0.0603	0.0584
March	0.0292	0.0010	0.0430	0.0504	0.0430
April	0.0194	0.0031	0.0333	0.0396	0.0424
May	0.0562	0.0242	0.0541	0.0575	0.0583
June	0.1656	0.4365	0.2833	0.1495	0.1212
July	0.3809	0.7294	0.4472	0.3353	0.3167
August	0.3559	0.6956	0.4338	0.3185	0.2942
September	0.2806	0.4615	0.2711	0.1615	0.1510
October	0.0468	0.1179	0.0968	0.0383	0.0371
November	0.0161	0.0344	0.0345	0.0146	0.0146
December	0.0208	0.0100	0.0253	0.0313	0.0242

Table – 5.1: Continuation (4)
Probability that of a Day in a month, Selected at Random, is Rainy

Month	Estimated Value of Probability				
	Panjim	**Patna**	**Pondicherry**	**Port Blair**	**Pune**
January	0.0032	0.0452	0.0344	0.0538	0.0039
February	0.0012	0.043	0.0214	0.0357	0.0054
March	0.0011	0.0300	0.0194	0.0333	0.0078
April	0.0156	0.0333	0.0111	0.1409	0.0293
May	0.1011	0.0946	0.0523	0.5141	0.0743
June	0.7111	0.2111	0.09	0.6129	0.3
July	0.8452	0.4638	0.1570	0.6087	0.3939
August	0.7763	0.4093	0.2054	0.5911	0.3030
September	0.4122	0.3333	0.2056	0.5989	0.2455
October	0.1871	0.1046	0.3140	0.4766	0.1437
November	0.0778	0.0111	0.37	0.4140	0.0495
December	0.00651	0.0167	0.2054	0.1394	0.0127

Table – 5.1: Continuation (5)
Probability that of a Day in a month, Selected at Random, is Rainy

Month	Estimated Value of Probability				
	Shillong	**Tezpur**	**Trivandrum**	**Udaipur**	**Varanasi**
January	0.0484	0.0478	0.0323	0.0097	0.0484
February	0.0753	0.0689	0.0509	0.0127	0.0582
March	0.1279	0.1279	0.0753	0.0042	0.0174
April	0.2869	0.3529	0.2189	0.0189	0.0148
May	0.5104	0.4049	0.3140	0.0419	0.0422
June	0.6274	0.5046	0.5433	0.1589	0.1449
July	0.5910	0.5295	0.4333	0.2636	0.4194
August	0.4988	0.4238	0.3323	0.3192	0.4126
September	0.5476	0.3954	0.2967	0.1690	0.3154
October	0.2684	0.1824	0.3720	0.0495	0.0695
November	0.0872	0.0536	0.3078	0.0230	0.0192
December	0.0409	0.0382	0.1398	**0.0078**	0.0202

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Table – 5.2
Month having Non-rainfall Tendency

Station	Month having Non-rainfall Tendency		
	Significant	Highly Significant	Almost Fully Significant
Agartala	January , December	Nil	Nil
Ahmadabad	January , February , April , May , October , November , December	March	Nil
Allahabad	February , March , April , May , November , December	Nil	Nil
Amritsar	October , November , December	September	
Bangalore	February , March ,	January	
Bhopal	January , February , March , April , May , November , December	Nil	Nil
Bhubaneswar	January , December	Nil	Nil
Bhunter	Nil	Nil	Nil
Chennai	January , February , March , April , May ,	Nil	Nil
Guwahati	January , December	Nil	Nil
Hisar	January , March , April , October , November , December	Nil	Nil
Hyderabad	January , February , March , April ,	Nil	Nil
Imphal	January , December	Nil	Nil
Jaipur	January , February , March , April , May , October , November , December	Nil	Nil
Kolkata	January , November , December	Nil	Nil
Lucknow	January , March , April , October , November, December	Nil	Nil
Mumbai	May	November	January , February , March , April
Nagpur	January , March , April , November, December	Nil	Nil
New Delhi	January , April , October , November, December	Nil	Nil

Palam	January , April , October , November, December	Nil	Nil
Panjim	April	December	January , February , March
Patna	January , February , March , April , November, December	Nil	Nil
Pondicherry	January , February , March , April	Nil	Nil
Port Blair	February , March	Nil	Nil
Pune	April , November, December	January , February , March	Nil
Shillong	January , December	Nil	Nil
Tezpur	January , December	Nil	Nil
Trivandrum	January	Nil	Nil
Udaipur	May , October , November	January , February , March , April , December	Nil
Varanasi	January , March , April , May , November, December	Nil	Nil

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Dr. Dhritikesh Chakrabarty passed B.Sc. (with Honours in Statistics) Examination from Darrang College, Gauhati University, in 1981 securing 1st class &1st position. He passed M.Sc. Examination (in Statistics) from the same university in the year 1983 securing 1st class & 1st position and successively passed M.Sc. Examination (in Mathematics) from the same university in 1987 securing 1st class (5th 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 (inVocal Music) in the year 2000 from Bhatkhande Sangeet vidyapith securing 1st class, the degree of Sangeet Visharad (in Tabla) from Pracheen Kala Kendra in 2010 securing 2nd class, the degree of Sangeet Pravakar (in Tabla) from Prayag Sangeet Samiti in 2012 securing 1st class, the degree of Sangeet Bhaskar (in Tabla) from Pracheen Kala Kendra in 2014 securing 1st class and Sangeet Pravakar (in Guitar) from Prayag Sangeet Samiti in 2021 securing 1st class. He obtained Jawaharlal Nehru Award for securing 1st 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 1st position in Post Graduate Examination in the year 1983.

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

(Dr. Dhritikesh Chakrabarty, 3rd from the left, with some research scientists in The 3rd International Conference on Fuzzy Systems and Data Mining (FSDM 2017) held at National Dong Hwa University, Hualien, Taiwan, during Nov 24 –27, 2017)

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, 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

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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 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.