



Study on Probability Distribution of Rainfall in Bangladesh

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ABSTRACT

Probability Distribution is an important concern for a resource constraint country like Bangladesh. Reliable estimate of probability distribution with respect to various climatic parameters is a valuable guide for policy makers in determining return period and risk analysis of flood, drought, cyclones and other extreme climate events for the fixation of infrastructure required in future. Standard set of rainfall data for has been collected for 34 rainfall stations from Bangladesh Meteorological Department (BMD). Chi-square values were calculated for annual rainfall, pre, post and regular monsoons for each station by 6-types of probability distribution methods. From the analysis of weighted average method, best fitted distribution has been determined for each station and for the whole country.

Key Words – Probability distribution, Chi-square test, Rainfall, Bangladesh

INTRODUCTION

Probability distribution study is useful to estimate design variables for hydraulic structures, crop yield forecasting (Sarker et. al., 2012), predicting favorable and unfavorable climatic events. Climate unpredictability and change in climatic parameters have direct influence on environment and human existence. A negative change in the climate, always have its corresponding dysfunctional impacts on man and the ecosystem globally or locally. Flooding, poor agricultural yields, famine, and even death are some of the catastrophic effects of drastic climate change. Knowledge and information on the climatic variation parameters in an environment is very vital for environmental study assessment and proper planning. Therefore, the importance of knowing the future climatic variation parameters cannot be under-estimated (Olusina et. al. 2012). Previously, several researches have worked on probability distribution both in Bangladesh and abroad. Recently, several international studies of probability distribution have been performed by Wilson and Toumi (2005), Hanson and Vogel (2008), Sen and Eljadid (1999), Yue (2000), Michaelides et. al. (2009), Ben-Zvi (2009), Zaharim et. al. (2009), Morgan et. al. (2009), ¹Monahan (2006), ²Monahan (2006), Sherwood et. al. (2006), Kysely (2002), Krumm and Hariharan (2004),

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Punyawardena and Kulasiri (1996), Exell (1981), Pryor et. al. (2005), Ishihara et. al. (2005), Jaramillo and Borja (2004), Gierens et al. (1999), Haag et. al. (2003) and Zhang et al. (2003). In Bangladesh different studies associated with probability distribution were performed by Hossain et. al. (2002), Rashid et al. (2012), Saleque (1991) and Akhter (1992). BMD and BWDB data were used for these studies for mainly temperature and rainfall parameters. This study aimed at probability distribution of rainfall data in different weather stations of Bangladesh. BMD data of 34 meteorological stations are used in this research.

STUDY AREA AND METHODOLOGY

Study area & data

Bangladesh, a land of worlds one of the largest deltaic fluvial system, experienced a subtropical monsoon climate characterized by wide seasonal variations in rainfall, moderately warm temperatures and high humidity. For this particular analysis Bangladesh Meteorological Department's (BMD) data set were used. Among the 34 rainfall stations 27 had data between 1980 and 2008; Dinajpur had a bit larger data from 1980-2009. The rest 6 stations had smaller data, i.e. Chandpur and Patuakhali: 1981-2008, Chuadanga: 1989-2004, Mongla: 1991-2008, Syedpur: 1991-2004 and Tangail: 1987-2008.

Methodology

The collected climatic data are in complex format which were not suitable for analysis. At first the data were processed by spreadsheet program (LibreOffice Calc, Microsoft Office Excel 2003) to convert raw data into monthly total data series for rainfall. All the data are checked thoroughly. From the visual observation the wrong data (abrupt values) have been discarded from the data set. Some common error were found in data set like negative, starry (**) sign instead of real value. May be it was due to punching error. These types of error were also deleted from data set.

Data analysis

The collected and processed data series are analyze mainly in two steps those are following

- Preliminary analysis
- Probability distribution studies

Preliminary analysis

To get the data more systematically the monthly data set was arranged considering various variables. The formulated variables are annual, total pre-monsoon (March to June), total monsoon (July to October), and, total post-monsoon (November to February). These four variables are used for the probability distribution studies. There are many continuous

probability distribution in addition to the normal distribution (Hann, C.T., 1977). Several probability distribution functions has been considered in this research, those are,

- ✓ Normal distribution
- ✓ Uniform distribution
- ✓ Exponential distribution
- ✓ Log normal distribution
- ✓ Poisson distribution
- ✓ EV-1 distribution

For each of the 34 data sets above six distributions are carried out by a spreadsheet software. (Libreoffice Calc, Microsoft Office Excel). The spreadsheet is programmed to make frequency distributions from the data sets and carry out probability distribution analysis to determine the chi-square value for that data.

Tabulation of Chi-Square value

After the estimation of chi-square value, the summary of chi-square values of six probability distributions of every station has been presented in tabular form in Appendix-1. Summary from each of the four selected variables have been listed in different tables.

Goodness of fit test and estimation of Chi-square value

To test the goodness of fit of data series to probability distributions, “Chi-Square Goodness of Fit Test” method have been carried out. For every six distribution, for the data series of each station, Chi-square value has been estimated. For any particular variable for the data set of a rainfall station, a lower chi-square value indicates better fitness of data in a particular distribution. To get a combined result from all the stations data, chi-square results from each rainfall station are ranked by converting them to an uniform scale so that sum of the scaled values of the six distributions equals to unity. These scaled scores for each type of distribution for all the 34 stations are added to determine a single best fit distribution for all the station. The distribution scoring lowest aggregate have been selected as the best distribution for overall fitness. To compare the difference among the six distributions, the ratio of the values were calculated with the lowest value as unity. This formulation for the combined best fit value has been shown in a side-by-side parallel table of the tabulated chi-square values.

Comparison of Chi-square value with critical Chi-square value

Chi-square value of selected best fitted distribution for each variable of every station of each climatic parameter has been compared with critical chi-square value for 95% confidence level. The data set fits the selected best fitted distribution adequately when computed Chi-square value smaller than the critical Chi-square value.

RESULTS AND DISCUSSIONS

Probability Distribution of different Rainfall Variables

The four variables, i.e. annual, pre-monsoon, monsoon and post-monsoon data series fits best in different distributions. Annual and monsoon data follows normal distribution. Pre-monsoon and post-monsoon data series follows EV-1 distribution. For all four parameters, log-normal distribution is ranked second with marginal difference from the best fitted value. The summary of results is presented in the following table; the analysis and results are presented in the appendix.

Table 1: Summary of best-fitted probability distribution for rainfall data

Parameter	Annual	Pre-monsoon	Monsoon	Post-monsoon
Rainfall	Normal	EV-I	Normal	EV-I

Comparison of Chi-square value with critical Chi-square value

For different rainfall variable, it has been seen that the chi-square value for the best fitted distribution for each variable are within in the range of critical chi-square value in most cases with 95% confidence level. The values meeting 95% confidence level are indicated by thicker fonts in the tabulated chi-square values in the Appendix.

Table 2: Calculation of critical chi-square values for 95% confidence level

Name of the distribution	k	l	$v = k-l-1$	Corresponding chi-square value for 95% confidence level
Normal distribution	5	2	2	5.99
Uniform distribution	5	2	2	5.99
Exponential distribution	5	1	3	7.81
Log-normal distribution	5	2	2	5.99
Poisson distribution	5	1	3	7.81
EV-1 distribution	5	2	2	5.99

K = number of class intervals
l = number of parameter

Table 3: Summary of chi-square tests for different distributions for all 4 parameters

Parameters	Different distributions					
	Normal	Uniform	Exponential	Log-Normal	Poisson	EV-1
Annual	1.00 (24) [#]	4.59 (4)	26.91 (0)	2.35 (21)	161.07 (0)	34.33 (18)
Pre-monsoon	1.72 (18)	3.06 (10)	7.05 (0)	1.31 (24)	137.25 (0)	1.00 (25)
Monsoon	1.00 (27)	4.60 (5)	21.40 (0)	1.25 (24)	140.37 (0)	38.84 (13)
Post-monsoon	3.67 (16)	7.07 (3)	4.21 (7)	2.82 (13)	152.93 (0)	1.00 (29)

Relative values of chi-square test aggregates along the row for different distributions – smaller is better. The value in the parenthesis indicates the number of stations that met the critical chi-square value out of the 34 stations.

CONCLUSIONS

From the probability distribution study of rainfall, it can be understood that, particular variable follows particular probability distribution. From the analysis of weighted average method, best fitted distribution has been fixed for a particular variable of rainfall. The annual and monsoon rainfall fits better with normal distribution whereas, pre and post monsoon rainfalls fit EV-I distribution. Comparison of chi-square value with critical chi-square value, it can be concluded that most of the chi-square value for the best fitted distribution for rainfall within in the range of critical chi-square value with 95% confidence level.

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Table A1. Determination of Best Fit Distribution
Chi-square values of Rainfall Data for different probability distributions

Annual	Scale						Appendix A									
	Station	Normal	Uniform	Exponential	Log-Normal	Poisson	EV-I	Rank		Comparison		Rank		Comparison		
								1	3	4	2	6	5			
1	Bairai	1.95	14.97	104.82	3.76	267.74	1.37	0.0049	0.0377	0.2693	0.0095	0.4751	0.0035			
2	Bhola	6.20	3.24	86.11	2.30	1001.74	7.04	0.0056	0.0029	0.0778	0.0023	0.9051	0.0084			
3	Bogra	1.49	7.35	48.22	0.94	902.32	3.70	0.0015	0.0076	0.0500	0.0010	0.9360	0.0038			
4	Chandpur	7.27	16.69	40.60	4.19	659.08	2.59	0.0098	0.0226	0.0671	0.0057	0.8913	0.0035			
5	Chittagong	11.30	18.41	104.56	9.65	1138.16	3.95	0.0088	0.0143	0.0813	0.0075	0.8850	0.0031			
6	Chwadanga	1.31	7.13	54.55	6.89	128.58	9.10	0.0063	0.0343	0.2628	0.0332	0.4195	0.0438			
7	Comilla	2.52	17.03	97.98	6.35	293.07	41.11	0.0055	0.0372	0.2139	0.0139	0.4398	0.0897			
8	Cox's Bazar	19.57	22.21	93.74	74.71	452.08	39097.77	0.0005	0.0006	0.0024	0.0019	0.0114	0.9833			
9	Dhaka	1.58	20.48	81.45	0.72	1919.11	0.47	0.0008	0.0101	0.0402	0.0004	0.9483	0.0002			
10	Dinajpur	1.25	7.38	42.63	3.63	404.60	5.83	0.0026	0.0152	0.1290	0.0075	0.8337	0.0120			
11	Faridpur	3.08	23.24	103.15	3.71	388.77	6.19	0.0058	0.0440	0.1953	0.0070	0.7361	0.0117			
12	Feni	2.54	3.59	53.64	4.39	546.02	9.69	0.0041	0.0058	0.0865	0.0001	0.8809	0.0156			
13	Hatiya	30.79	28.07	90.05	148.33	443.33	4.53E-11	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000			
14	Hazari	4.17	14.28	84.15	1.03	1620.67	3.89	0.0024	0.0083	0.0486	0.0006	0.9368	0.0033			
15	Jessore	0.84	11.52	73.36	2.69	526.00	3.49	0.0014	0.0186	0.1188	0.0042	0.8515	0.0055			
16	Khagpnara	1.94	13.59	93.72	3.35	272.35	11.37	0.0049	0.0343	0.2365	0.0085	0.4872	0.0287			
17	Kinuna	1.18	10.83	81.71	4.12	556.01	8.38	0.0018	0.0164	0.1234	0.0062	0.8396	0.0127			
18	Kurubdia	10.33	38.41	84.32	123.92	1110.13	217462.90	0.0000	0.0002	0.0004	0.0006	0.0051	0.9938			
19	M.Court	3.54	22.90	113.44	7.71	402.19	2.01	0.0064	0.0415	0.2056	0.0140	0.7289	0.0036			
20	Madaripur	2.04	11.52	91.48	3.49	287.62	43.37	0.0046	0.0260	0.2063	0.0124	0.6485	0.1023			
21	Mongla	0.91	8.67	46.85	2.52	901.39	1.78	0.0009	0.0090	0.0487	0.0026	0.9369	0.0018			
22	Moxnessingh	6.28	4.62	68.71	2.90	726.03	4.54	0.0077	0.0057	0.0845	0.0036	0.8029	0.0056			
23	Barakhalai	4.82	21.29	89.89	6.98	413.24	3.47	0.0089	0.0394	0.1666	0.0129	0.7657	0.0064			
24	Rajshahi	2.80	25.54	81.65	2.22	254.18	42.95	0.0068	0.0624	0.1995	0.0054	0.6210	0.1049			
25	Rangasati	2.16	13.24	63.88	5.89	340.65	4.97	0.0050	0.0307	0.1483	0.0137	0.7908	0.0115			
26	Rawalpur	3.41	16.34	61.79	2.22	3708.80	0.87	0.0009	0.0043	0.0163	0.0006	0.9777	0.0002			
27	Saidpur	8.53	26.44	86.18	1.16	1318.77	2.93	0.0059	0.0184	0.0597	0.0008	0.9131	0.0020			
28	Satkhira	2.10	21.17	143.70	4.33	148.01	3.06	0.0065	0.0657	0.4458	0.0134	0.4091	0.0095			
29	Shaitkunda	2.10	19.79	73.76	58.21	393.41	416.23	0.0022	0.0205	0.0766	0.0604	0.4583	0.4320			
30	Srimangal	5.73	15.57	78.86	32.18	292.72	77.22	0.0114	0.0310	0.1570	0.0641	0.5828	0.1537			
31	Syadpur	2.21	1.00	18.27	6.38	273.16	2.76	0.0073	0.0033	0.0602	0.0210	0.8992	0.0091			
32	Sylhet	9.07	11.52	107.72	6.57	1716.34	8.14	0.0049	0.0062	0.0379	0.0035	0.9231	0.0044			
33	Tangail	2.51	7.09	49.40	2.22	1755.80	2.84	0.0014	0.0039	0.0378	0.0012	0.9542	0.0015			
34	Teknaf	14.63	28.07	113.75	96.94	390.52	1.56E-08	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000			
Critical Chi Square Value (95% Confidence Level)		5.99	5.99	7.81	5.99	7.81	5.99	Σ	0.1477	0.6781	3.9740	0.3463	23.7844	5.0694		

Note: Chi square values less than the critical Chi square values at 95% confidence level are marked in bold & italic format

Table A2. Determination of Best Fit Distribution
Chi-square values of Rainfall Data for different probability distribution:
Total Pre-Monsoon (March-June)

Station	Scaling						Rank	Appendix A
	Normal	Uniform	Exponential	Log-Normal	Poisson	EVI		
1 Barisal	12.22	11.86	20.41	2.49	1589.21	5.51	0.0074	0.9880
2 Bhola	2.42	19.79	2.10	15.64	219.14	2.87	0.0088	0.0448
3 Bogra	1.09	6.69	29.04	9.82	881.90	2.52	0.0012	0.0312
4 Chandpur	31.91	30.48	28.90	3.85	2190.71	11.61	0.0139	0.0126
5 Chittagong	4.22	4.28	12.05	28.01	1356.88	6.75	0.0030	0.0086
6 Comilla	11.79	4.63	17.30	2.24	121.96	6.47	0.0101	0.0040
7 Cox's Bazar	4.32	6.00	29.05	1.50	302.82	2.65	0.0123	0.0126
8 Dhaka	2.38	12.21	19.12	5.51	1137.64	0.63	0.0020	0.0162
9 Dinajpur	13.63	10.83	40.73	7.63	573.31	7.44	0.0208	0.0165
10 Faridpur	6.86	18.41	48.29	3.04	1203.32	6.52	0.0050	0.0135
11 Feni	1.42	8.41	25.67	5.89	547.13	0.81	0.0024	0.0143
12 Feni	2.38	5.21	20.00	5.25	1222.82	1.10	0.0019	0.0042
13 Haitya	1.22	9.45	24.56	2.45	1286.36	1.32	0.0009	0.0071
14 Ishwardi	2.56	14.97	16.56	2.93	2450.87	0.74	0.0010	0.0043
15 Jessore	12.38	23.59	50.43	3.74	244.98	5.04	0.0364	0.0693
16 Khoprapa	5.21	7.72	35.30	4.06	1394.81	4.01	0.0036	0.0053
17 Khulna	7.78	26.69	37.26	0.89	207.17	2.16	0.0276	0.0647
18 Kustia	4.44	8.07	24.22	3.35	1290.28	6.52	0.0048	0.0060
19 M. Court	0.86	8.41	39.34	2.28	569.32	2.36	0.0014	0.0135
20 Madaripur	5.84	3.59	19.61	5.72	1728.73	6.38	0.0033	0.0020
21 Mongla	8.85	1.44	19.95	4.56	636.55	6.42	0.0131	0.0021
22 Moulvibazar	2.94	3.17	33.95	2.54	281.96	3.29	0.0117	0.0271
23 Narail	18.43	37.36	37.92	3.50	661.98	1.33	0.0244	0.0489
24 Rajshahi	8.66	25.66	28.67	12.25	183.78	1.73	0.0345	0.1023
25 Ramganjail	2.24	3.59	17.37	2.45	924.94	3.07	0.0023	0.0019
26 Rangpur	10.22	10.48	40.32	6.01	257.61	1.41	0.0119	0.0318
27 Sandwip	2.47	3.82	18.18	4.01	877.43	3.84	0.0027	0.0065
28 Sankhira	6.53	16.34	37.87	2.68	853.76	2.77	0.0071	0.0178
29 Shariatnagar	3.96	19.45	36.28	4.67	419.43	2.94	0.0081	0.0400
30 Sitakunda	12.08	14.86	29.26	19.03	292.26	5.03	0.0324	0.0399
31 Syedpur	8.11	2.43	16.94	7.14	443.43	6.48	0.0029	0.0043
32 Sylhet	2.42	2.55	37.65	7.92	772.92	5.01	0.0029	0.0031
33 Tangail	17.51	3.91	41.67	11.98	831.70	16.24	0.0190	0.0042
34 Tinnai	4.48	14.28	14.54	4.14	2248.59	3.28	0.0020	0.0062
Critical Chi Square Value (95% Confidence Level)	5.99	5.99	7.81	5.99	7.81	5.99	0.0369	0.6879

Note: Chi square values less than the critical Chi square values at 95% confidence level are marked in bold & italic format

Table A3. Determination of Best Fit Distribution
Chi-square values of Rainfall Data for different probability distribution:
Total monsoon (Jul-Oct)

Station	Scaling						Rank	Appendix A
	Normal	Uniform	Exponential	Log-Normal	Poisson	EVI		
1 Barisal	2.55	9.10	76.69	1.12	550.08	6.41	0.0036	0.0141
2 Bhola	0.50	3.07	63.86	1.63	945.18	2.02	0.0005	0.0079
3 Bogra	1.79	14.28	53.30	0.23	298.78	1.64	0.0047	0.0385
4 Chandpur	3.11	3.17	2.09	2.09	1156.67	1.64	0.0061	0.0156
5 Chittagong	4.93	21.17	56.98	9.31	510.05	8.42	0.0081	0.0933
6 Comilla	2.67	5.33	52.42	2.25	1702.42	6.22	0.0015	0.0030
7 Cox's Bazar	4.64	7.38	65.37	6.33	924.04	6.33	0.0007	0.0040
8 Dhaka	47.38	31.91	126.09	94.19	444.45	7.09	0.0000	0.0000
9 Dinajpur	0.97	11.17	51.06	4.45	1364.30	5.57	0.0007	0.0078
10 Faridpur	2.54	17.38	56.57	4.58	377.89	7.68	0.0054	0.0572
11 Feni	0.97	8.07	25.67	9.93	1560.33	0.77	0.0008	0.0029
12 Feni	4.04	23.24	90.15	8.47	331.63	507.32	0.0042	0.0241
13 Haitya	8.16	18.41	65.29	132.42	440.25	416770.10	0.0000	0.0000
14 Ishwardi	13.19	7.55	78.84	5.88	1826.73	9.71	0.0068	0.0013
15 Jessore	18.28	69.83	69.83	7.69	458.32	27341.56	0.0003	0.0024
16 Khoprapa	2.16	11.52	93.42	2.57	1220.30	306.87	0.0033	0.0179
17 Khulna	1.32	16.34	70.70	3.91	263.01	30.02	0.0034	0.0424
18 Kustia	3.46	32.66	77.69	66.17	461.46	1.64	0.0003	0.0012
19 M. Court	10.92	30.14	100.18	1.56	911.83	20.02	0.0102	0.0283
20 Madaripur	2.48	6.69	61.53	0.49	589.32	6.51	0.0037	0.0100
21 Mongla	4.14	14.22	59.53	0.49	180.22	2.77	0.0200	0.0588
22 Moulvibazar	4.62	4.62	53.82	0.45	112.49	3.03	0.0019	0.0060
23 Narail	3.97	28.07	103.76	5.89	330.98	9.61	0.0082	0.0582
24 Rajshahi	1.75	16.69	71.10	1.49	297.95	6.68	0.0044	0.0422
25 Ramganjail	2.47	11.17	67.00	3.63	345.24	6.81	0.0067	0.0260
26 Rangpur	8.76	7.64	58.95	2.44	411.80	8.65	0.0080	0.0437
27 Sandwip	3.35	19.14	61.33	1.18	399.82	2.09	0.0069	0.0126
28 Sankhira	1.75	9.10	120.15	0.84	666.16	2.53	0.0022	0.0114
29 Shariatnagar	4.24	17.72	63.44	40.46	405.11	40.46	0.0001	0.0004
30 Sitakunda	4.45	15.21	99.75	18.04	179.73	30.48	0.0042	0.0141
31 Syedpur	4.00	3.29	23.96	7.63	269.99	1.62	0.0122	0.0161
32 Sylhet	1.75	20.48	93.48	1.63	309.95	6.36	0.0041	0.0479
33 Tangail	11.05	2.55	46.60	9.41	1414.37	6.01	0.0074	0.0017
34 Tinnai	4.35	18.76	88.14	50.81	387.94	29651.88	0.0001	0.0006
Critical Chi Square Value (95% Confidence Level)	5.99	5.99	7.81	5.99	7.81	5.99	0.1639	0.7532

Note: Chi square values less than the critical Chi square values at 95% confidence level are marked in bold & italic format

Table A4. Determination of Best Fit Distribution
Chi-square values of Rainfall Data for different probability distribution:
Total Post-monsoon (November-February)

Station	Scaling						Rank	Appendix A
	Normal	Uniform	Exponential	Log-Normal	Poisson	EVI		
1 Barisal	5.55	13.43	8.41	5.93	1622.02	2.38	0.0045	0.0081
2 Bhola	5.48	19.14	14.03	12.28	527.49	4.98	0.0094	0.0030
3 Bogra	3.66	15.93	6.42	2.76	155.43	0.51	0.0199	0.0866
4 Chandpur	12.50	10.57	19.22	7.46	3271.89	7.79	0.0038	0.0032
5 Chittagong	43.12	54.14	65.39	6.42	527.18	17.03	0.0061	0.0758
6 Comilla	3.31	4.37	9.32	21.79	1251.67	3.19	0.0026	0.0035
7 Cox's Bazar	3.94	13.79	9.55	5.19	732.63	2.68	0.0051	0.0180
8 Dhaka	2.42	5.32	4.64	4.64	699.96	6.68	0.0030	0.0030
9 Dinajpur	13.36	5.21	13.50	5.20	2592.06	6.50	0.0050	0.0020
10 Faridpur	2.64	20.48	14.85	3.14	190.89	1.99	0.0236	0.0837
11 Feni	9.64	9.64	7.89	7.07	188.83	6.87	0.0018	0.0018
12 Feni	0.99	23.43	7.02	0.78	205.60	4.52	0.0401	0.0944
13 Haitya	10.96	10.96	10.96	10.96	2573.77	2.42	0.0023	0.0023
14 Ishwardi	3.51	7.00	11.39	10.25	767.21	2.42	0.0044	0.0087
15 Jessore	10.77	11.64	15.15	20.79	4871.48	10.03	0.0022	0.0024
16 Khoprapa	4.3	13.79	6.96	6.96	49.89	0.89	0.0421	0.0849
17 Khulna	5.19	15.93	12.87	2.62	1805.98	4.07	0.0028	0.0086
18 Kustia	6.19	17.00	16.88	0.31	815.73	3.54	0.0077	0.0196
19 M. Court	6.49	18.14	24.87	7.07	150.64	2.12	0.0070	0.0247
20 Madaripur	4.36	18.79	8.29	5.45	179.01	6.11	0.0201	0.0866
21 Mongla	11.44	6.89	12.74	6.89	257.09	2.60	0.0052	0.0052
22 Moulvibazar	3.14	11.29	5.64	3.17	577.09	1.27	0.0052	0.0188
23 Narail	14.09	21.64	12.44	19.27	1051.62	5.89	0.0125	0.0192
24 Rajshahi	4.24	12.36	7.89	7.07	188.83	6.87	0.0141	0.0681
25 Ramganjail	4.97	4.86	10.67	25.69	1822.13	1.63	0.0027	0.0026
26 Rangpur	11.44	11.44	11.44	11.44	2573.77	2.42	0.0023	0.0023
27 Sandwip	18.75	27.63	18.92	19.19	156.77	4.83	0.0679	0.1001
28 Sankhira	1.99	11.63	9.44	0.33	1817.11	6.83	0.0011	0.0001
29 Shariatnagar	8.22	22.00	10.76	213.47	213.47	2.13	0.0112	0.0888
30 Sitakunda	15.21	14.38	16.47	12.05	1884.34	7.71	0.0080	0.0074
31 Syedpur	5.83	8.15	7.59	4.74	54.77	6.67	0.0704	0.0896
32 Sylhet	2.99	11.39	9.15	4.24	629.92	3.69	0.0019	0.0019
33 Tangail	3.76	11.14	4.64	4.84	253.82	1.10	0.0062	0.0183
34 Tinnai	30.32	10.30	7.81	10.30	25.34	10.30	0.0022	0.0022
Critical Chi Square Value (95% Confidence Level)	5.99	5.99	7.81	5.99	7.81	5.99	0.7260	1.3995

Note: Chi square values less than the critical Chi square values at 95% confidence level are marked in bold & italic format

Rank	Scaling						Rank	Appendix A
	1	2	3	4	5			