Modeling and Projecting Population for Muslim of Urban Area in Bangladesh

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Abstract   In this paper, the population for Muslim of Urban region in Bangladesh is projected by using the exponential growth rate method. For this connection, the information of data for Urban Muslim population for male and female of Bangladesh is obtained from 1991 and 2001 censuses. The projections are computed in three stage procedures. In the first stage, the predictions are computed using negative exponential growth model estimated by the Quasi-Newton method using STATISTICA for the years 1991 and 2001. Using the cross validation predictive power (CVPP) criterion and R^2, the shrinkage coefficient (λ) is constructed. The shrinkage coefficient determines the adequacy of the first phase prediction. In the second stage, these predicted values are used to estimate the growth rate, for different age groups, by using the exponential growth rate method. In the third stage, that is, finally considering the observed population for Muslim of Urban region in Bangladesh for the Census year 2001 as the base population and using the estimated exponential growth rate, at different age groups, of the second stage estimation, the projections for the population of Muslim of Urban region are estimated for the years 2002 through to 2021 employing exponential growth rate method.

Keywords Urban Muslim Population of Bangladesh, Exponential Model, Cross- Validity Prediction Power (CVPP), Exponential Growth Rate Method, T-Test, F-Test

1. Introduction

Bangladesh is Muslim dominant country and approximately 90% population of Bangladesh is Muslim. The Muslim population was enlarged 10.9% in 1911 over 1901. On the other hand, comparatively lesser increasing trends have been found of 6.8% and 9.2% in 1921 and in 1931 respectively in accordance with high mortality, floods, droughts, epidemic, plague, pandemic and others various catastrophic diseases. And, it was risen 26.9% in 1961 over 1951 and 49.3% in 1974 over 1961. It is the cause that the emigrated number of Hindus after independence of 1947 was comparatively larger than the immigrated number of Muslims from India. And, it was increased approximately 18.3% in 2001 census [1].

Population census usually carried out at ten year interval of time is the most important source of data on size, structure and distribution of population by religion or any other demographic and socio-economic characteristics in Bangladesh. The Government and Non-government organizations do require the up-to-the-minute information on population. Consequently, one can easily use to make reasonable plans for development for the present and future time. The Government and demographers are not only the users of

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population but also trade unions, social organizations, university and other social research institutes and centres, market research analysis, housing developers and business communities frequently do need these estimates for their individual purposes. Moreover, population or population by religion (Muslim), age and sex serves as the denominator for the estimation of socio-demographic, health and development related indicators.

Furthermore, projected population is important and needed for sustainable development in the up to minute nuclear-technology, modernization and industrialization era. Indeed, population projections provide a signal to the planners as how the economy is to be adjusted according to the population and also how the population should be adjusted in accordance with the economy. Population projections can point up the probable population intensification and structural consequences of such presumed development. It was observed that age configuration for population of both sexes in Bangladesh follows negative exponential model[2]. It was investigated that the age structure for male, female and both sexes population of Bangladesh followed either negative exponential model or modified negative exponential model [3,4]. Islam et al.[5] observed that age construction for male population of Bangladesh in 1991 census follows modified negative exponential model. It was showed that proportion of married women of Bangladesh in the reproductive time-span follow cubic polynomial model[6].

Therefore, the fundamental aims and objectives of this study are given below:

i to build up mathematical models for the Urban Muslim population for male and female by age group in years for the census years of 1991 and 2001 and to apply CVPP to test the adequacy of the model, and

ii then to project Urban Muslim population for male and female by ages in Bangladesh by employing exponential growth rate method at different ages.

This paper is structured as follows. Introduction is included in the first section. Data and data sources of this study are presented in section 2. Section 3 describes the methods and methodological issues in which smoothing of age data by free hand curve method, model fitting, model accuracy test, F-test and exponential growth rate method. Application of model and discussion of results of this paper are reported in section 4. Finally, section 5 concludes the conclusion and concluding remarks of the manuscript.

2. Data and Data Sources of this Study

To fulfill the aforesaid objectives, the data on Urban Muslim population by sex and age groups in Bangladesh is taken from of the censuses of 1991[7] and 2001[1]. These have been utilized as raw resources of the present study and exposed in Table 1 and Table 2 for the censuses of 1991 and 2001 respectively.

3. Methods and Methodological Issues

3.1. Smoothing of Age Data by Free Hand Curve Method

It is observed that there is some sort of unexpected distortions in the data aggregate if the Urban Muslim population by age group is to be placed on graph paper. Therefore, an adjustment is needed to diminish these unpredicted distortions before going to fit the models to the data. As a result, a modification is made, that is, quinquennial age wise data is smoothened in the current study by Free Hand Curve Method. After that, the smoothed data have been used to fit mathematical model and these smoothed data for male and female Muslim population of the censuses of 1991 and 2001 are launched in Table 1 and Table 2 respectively.

3.2. Model Fitting

Using the scattered plot of smoothed age structure for Urban for male and female Muslim population by ages in years, it appears that this age wise population is negative exponentially distributed. Therefore, a modified negative exponential model is considered for the first stage prediction and the mathematical form of this model is given by

$$y = c + e^{(-ax+b)} + u \qquad (1)$$

Here, x represents the middle value of the age group; y represents the Urban Muslim population; a, b and c are unknown parameters and u is the stochastic disturbance term of the model. These models are constructed by handling the software STATISTICA.

3.3. Model Accuracy Test

In this paper, to assess the accuracy and reliability of these models, the CVPP, ρ_{cv}^2, is applied. The mathematical formula for CVPP is specified by

$$\rho_{cv}^2 = 1 - \frac{(n-1)(n-2)(n+1)}{n(n-k-1)(n-k-2)}(1-R^2)$$

In which, n is the number of classes, k is the number of regressors in the fitted model and the cross-validated R is the correlation between observed and predicted values of the predictand variable [8]. The shrinkage and contraction of the model is the positive value of (ρ_{cv}^2 - R^2); where ρ_{cv}^2 is CVPP & R2 is the coefficient of determination of the model. 1-shrinkage is the stability of R^2 of the model. The estimated CVPP related to their R^2 and information on model fittings are presented in Table 3. Note that CVPP was also employed as model validation or accuracy test by Islam [3, 4] and Islam et al. [2, 5]

3.4. F-test

To find out the measure of overall significance of the fitted models as well as the significance of R^2, the F-test is employed here[9].

3.5. Exponential Growth Rate Method

For the estimation of growth rate and projection of population, exponential growth rate method is considered in this study and the mathematical form of this method is given by

$$P_{t_2}^{a-a+5} = P_{t_1}^{a-a+5} \exp\left\{r^{a-a+5}(t_2 - t_1)\right\} [10] \qquad (2)$$

Where, $P_{t_1}^{a-a+5}$ is the predicted initial population at time t_1 in the age group a to a+5, $P_{t_2}^{a-a+5}$ = the predicted terminal population at time t_2 in the age group a to a+5, r^{a-a+5} is the inter censual annual growth rate in the age group a to a+5 and $(t_2 - t_1)$ = the time interval between inter censual period.

For the second phase procedure, the estimation of r^{a-a+5} is computed for different age groups from (2) as follows.

$$r^{a-a+5} = \frac{1}{(t_2 - t_1)} \ln\left(\frac{P_{t_2}^{a-a+5}}{P_{t_1}^{a-a+5}}\right) \qquad (3)$$

Years 1991 and 2001 are considered as the initial and the terminal populations respectively in estimating the inter censual annual age specific growth rates by using equation (3).

Finally, that is, for the third phase in view of projecting purpose, 2001 census Urban Muslim observed population for male and female by age group is considered as base population and inter censual annual growth rate by age groups during 1991 – 2001 obtained in the second phase is used in this study assuming fertility and mortality remaining unaltered during the projected period. Actually, age wise projected population of Urban Muslim is obtained from equation (2) using age specific growth rates estimated of the second phase and observed initial population of 2001 census running equation (2) successively 20 times.

4. Application of Model and Discussion of Results

The modified negative exponential model is chosen to fit the models for Urban Muslim population, Bangladesh for the census years 1991 and 2001 and the fitted models are described below:

$$y = -364.015 + \exp(-0.01995x + 7.5745) \text{ for male of 1991 census} \tag{1}$$

t-stats (-5.685)   (10.933)   (345.8104)

$$y = -471.36 + \exp(-0.01901x + 7.5742) \text{ for female of 1991 census} \tag{2}$$

t-stats (-10.971)   (16.79679)   (492.3955)

$$y = -1479.78 + \exp(-0.00909x + 8.1059) \text{ for male of 2001 census} \tag{3}$$

t-stats (-30.51) (31.03248) (606.4867)

$$y = -570.695 + \exp(-0.01824x + 7.7979) \text{ for female of 2001 census} \tag{4}$$

t-stats (-12.817)   (23.44393) (542.8209)

The results on model fittings and estimated CVPP alike to their R^2 of these models are revealed in Table 3. From this table it appears that all the fitted models (1), (2), (3) and (4) are highly cross- validated and their corresponding shrinkage coefficients (λ) are 0.00327, 0.001547, 0.00117 and 0.00076. These imply that the fitted models (1), (2), (3) and (4) will be stable more than 98%, 99%, 99% and 99% respectively. As well, it is found that the parameters of the fitted models (1)-(4) are highly statistically significant with proportion of variance is explained more than 98%. The stability for R^2 of these models is more than 99%.

The enumerated values of F statistic for these models are shown in the 9th columns of Table 3 while the analogous tabulated values of these models are demonstrated in the last column of the same table at 1% level of significance. These results are indicated that these models and their corre-sponding to R^2 are highly statistically significant and hence, these are well fitted to the data. The graph of observed, smoothed and predicted Urban Muslim population by age group in years for 1991 and 2001 census years of Bangladesh are depicted in Figure 1, Figure 2, Figure 3 and Figure 4 respectively.

It is to be noted that other models, i. e., linear, log linear, semi-log linear and polynomial model were also tried to employ here but seems to be worse fitted with respect to their coefficient of determination and shrinkage coefficients (λ). For that reason, the outcomes of those models were not publicized here.

For the second phase estimation, age specific inter censual annual growth rates during 1991-2001 are estimated by applying exponential growth rate method at each age group using the predicted values obtained by first phase procedure and these growth rates are demonstrated in Table 4 and displayed in Figure 5. From the table it is found that growth rate for male and female populations are positive that indicating that population are increasing during the inter censual period 1991-2001. Moreover, it is seen from the figure that these rates are showing increasing trends in accordance with ages.

Projected Urban Muslim population for male and female by age group are estimated employing exponential growth rate method using predicted values of the fitted models and presented in Table 4 and Table 5 respectively. It is found that the pattern of male and female Urban Muslim population at each year is downward due to ages. But the trend of these is increasing, i.e., upward with passing of time all over the period 1991-2021.

It is note that projected Urban Muslim population for both sexes by age group is easily obtained by adding the projected male and female Urban Muslim population by age group in years.

Table 1. Observed, Smoothed and Predicted Muslim Population by Age Group for Male and Female of Urban Area in Bangladesh in 1991 Census

Age Group	Male			Female		
	Observed	Smoothed	Predicted	Observed	Smoothed	Predicted
0-4	1292	1459	1478	1246	1357	1385
5-9	1371	1317	1310	1294	1224	1217
10-14	1217	1157	1157	1121	1089	1064
15-19	922	1047	1017	857	889	925
20-24	982	879	890	916	843	798
25-29	978	787	773	854	714	683
30-34	762	658	667	569	619	578
35-39	714	589	569	443	443	483
40-44	530	473	481	325	386	397
45-49	367	407	400	224	313	318
50-54	289	289	326	204	204	246
55-59	169	234	258	109	131	181
60-64	185	185	196	139	119	122
65-69	87	142	140	58	78	68
70+	174	127	88	126	76	19
Total	10041	9750	9750	8485	8485	8485

Table 2. Observed, Smoothed and Predicted Muslim Population by Age Group for Male and Female of Urban Area in Bangladesh in 2001 Census

Age Group	Male			Female		
	Observed	Smoothed	Predicted	Observed	Smoothed	Predicted
0-4	1467	1720	1760	1332	1700	1756
5-9	1530	1587	1616	1380	1580	1553
10-14	1730	1539	1478	1548	1400	1368
15-19	1532	1390	1347	1390	1218	1199
20-24	1439	1220	1221	1436	1055	1045
25-29	1372	1100	1101	1284	940	904
30-34	1133	1012	987	934	764	776
35-39	1013	870	877	767	645	658
40-44	816	778	772	532	532	551
45-49	585	619	672	367	436	453
50-54	460	557	577	311	327	364
55-59	251	460	485	163	260	283
60-64	269	400	398	200	200	208
65-69	137	300	315	93	150	140
70+	281	291	235	216	130	78
Total	14015	13843	13843	11953	11337	11337

Table 3. The Results of CVPP and Information on Model Fittings

Models	n	K	R^2	ρ_{cv}^2	Shrinkage Coefficient (λ)	Parameters	P-value	Cal. F	Tab. F (at 1% level)
1	15	1	0.98661	0.983337	0.00327	a	0.000	442.10	6.93 with (2, 12) d.f.
						b	0.00000		
						c	0.0000		
2	15	1	0.99367	0.992123	0.001547	a	0.000	941.87	6.93 with (2, 12) d.f.
						b	0.00000		
						c	0.0000		
3	15	1	0.99521	0.994039	0.00117	a	0.000	1246.61	6.93 with (2, 12) d.f.
						b	0.00000		
						c	0.0000		
4	15	1	0.99691	0.996155	0.00076	a	0.000	1935.75	6.93 with (2, 12) d.f.
						b	0.0000		
						c	0.0000		

Table 4. Estimated Growth Rate for Male and Female Population at each Age Group

Age Group	Growth Rate for Male	Growth Rate for Female
0-4	0.017462399	0.023733836
5-9	0.020992682	0.024379973
10-14	0.024485937	0.025131443
15-19	0.028102278	0.025944942
20-24	0.031620401	0.026966357
25-29	0.035369509	0.028033450
30-34	0.039187999	0.029457865
35-39	0.043262656	0.030918828
40-44	0.047311728	0.032779853
45-49	0.051879379	0.035384074
50-54	0.057094489	0.039182233
55-59	0.063118931	0.044694987
60-64	0.070833735	0.053351703
65-69	0.081093022	0.072213472
70+	0.098224870	0.141226985
Total	0.035036792	0.028980147

Table 5.   Projected Male Muslim Population by Age Group of Urban Area in Bangladesh during 2002-2021 (in thousands)
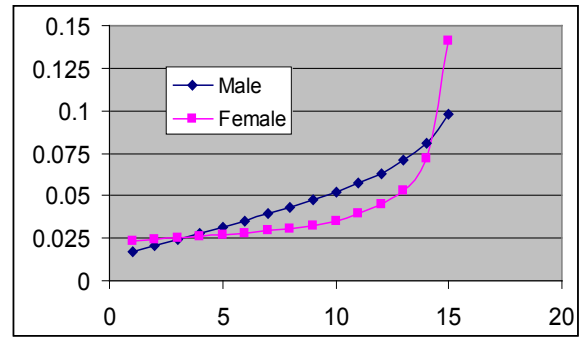
Age Group	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0-4	1791	1823	1855	1887	1921	1954	1989	2024	2060	2096
5-9	1650	1685	1721	1758	1795	1833	1872	1912	1952	1993
10-14	1515	1552	1591	1630	1670	1712	1754	1798	1842	1888
15-19	1385	1425	1465	1507	1550	1594	1640	1687	1735	1784
20-24	1260	1301	1342	1386	1430	1476	1524	1572	1623	1675
25-29	1141	1182	1224	1268	1314	1361	1410	1461	1514	1568
30-34	1026	1067	1110	1154	1201	1249	1299	1350	1404	1461
35-39	916	956	999	1043	1089	1137	1187	1240	1294	1352
40-44	809	849	890	933	978	1025	1075	1127	1182	1239
45-49	708	745	785	827	871	917	966	1018	1072	1129
50-54	611	647	685	725	768	813	860	911	965	1021
55-59	517	550	586	624	665	708	754	804	856	912
60-64	427	459	492	528	567	609	653	701	753	808
65-69	342	370	402	436	473	512	556	603	654	709
70+	259	286	316	348	384	424	467	516	569	628
Total	14357	14897	15463	16055	16675	17325	18007	18723	19474	20262
Age Group	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
0-4	2133	2170	2209	2247	2287	2327	2368	2410	2452	2496
5-9	2036	2079	2123	2168	2214	2261	2309	2358	2408	2459
10-14	1935	1983	2032	2082	2134	2187	2241	2297	2354	2412
15-19	1835	1887	1941	1996	2053	2112	2172	2234	2298	2363
20-24	1729	1784	1842	1901	1962	2025	2090	2157	2227	2298
25-29	1625	1683	1744	1807	1872	1939	2009	2081	2156	2234
30-34	1519	1580	1643	1708	1777	1848	1922	1998	2078	2161
35-39	1411	1474	1539	1607	1678	1752	1830	1911	1995	2083
40-44	1299	1362	1428	1497	1570	1646	1726	1809	1897	1989
45-49	1189	1252	1319	1389	1463	1541	1623	1710	1801	1897
50-54	1081	1145	1212	1283	1359	1438	1523	1613	1707	1808
55-59	971	1034	1102	1174	1250	1331	1418	1511	1609	1714
60-64	868	931	1000	1073	1152	1236	1327	1424	1529	1641
65-69	769	834	904	980	1063	1153	1250	1356	1470	1595
70+	692	764	843	930	1026	1131	1248	1377	1519	1676
Total	21091	21962	22879	23843	24859	25928	27056	28245	29500	30824

Table 6.   Projected Female Muslim Population by Age Group of Urban Area in Bangladesh during 2002-2021 (in thousands)
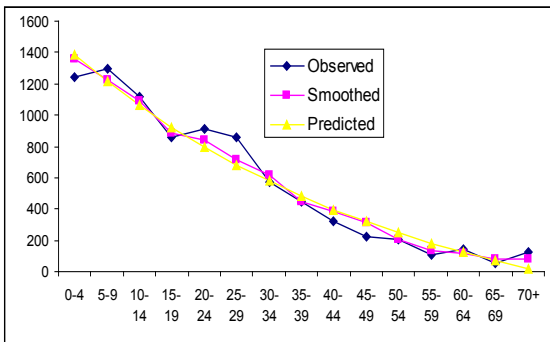
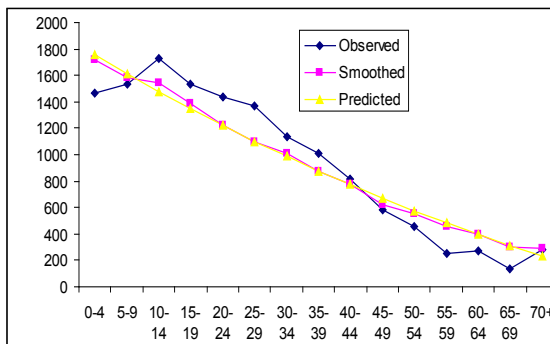| Age Group	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0-4	1798	1841	1886	1931	1977	2025	2073	2123	2174	2226
5-9	1591	1631	1671	1712	1754	1798	1842	1887	1934	1982
10-14	1403	1439	1475	1513	1551	1591	1631	1673	1715	1759
15-19	1231	1263	1296	1330	1365	1401	1438	1476	1514	1554
20-24	1074	1103	1133	1164	1196	1229	1262	1297	1332	1368
25-29	930	956	983	1011	1040	1070	1100	1131	1163	1197
30-34	799	823	848	873	899	926	954	982	1012	1042
35-39	679	700	722	745	768	792	817	843	869	896
40-44	569	588	608	628	649	671	693	716	740	765
45-49	469	486	504	522	541	560	580	601	623	645
50-54	379	394	409	426	443	460	479	498	518	539
55-59	296	309	324	338	354	370	387	405	423	442
60-64	219	231	244	257	272	286	302	319	336	355
65-69	150	162	174	187	201	216	232	249	268	288
70+	90	103	119	137	158	182	210	241	278	320
Total	11677	12030	12395	12775	13168	13576	14000	14441	14900	15379
Age Group	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
0-4	2280	2335	2391	2448	2507	2567	2629	2692	2757	2823
5-9	2031	2081	2132	2185	2239	2294	2351	2409	2468	2529
10-14	1804	1850	1897	1945	1994	2045	2097	2151	2205	2261
15-19	1595	1637	1680	1724	1769	1816	1864	1913	1963	2015
20-24	1406	1444	1484	1524	1566	1609	1653	1698	1744	1792
25-29	1231	1266	1301	1338	1377	1416	1456	1497	1540	1584
30-34	1073	1105	1138	1172	1207	1243	1280	1319	1358	1399
35-39	925	954	984	1014	1046	1079	1113	1148	1184	1221
40-44	790	817	844	872	901	931	962	994	1027	1061
45-49	669	693	718	743	770	798	827	856	887	919
50-54	560	583	606	630	655	681	709	737	766	797
55-59	463	484	506	529	553	579	605	633	662	692
60-64	374	395	416	439	463	488	515	543	573	605
65-69	310	333	358	385	414	445	478	514	552	593
70+	369	425	489	563	649	747	861	991	1141	1315
Total	15877	16398	16943	17513	18110	18738	19398	20094	20828	21605

Figure 1. Observed, Smoothed and Predicted Muslim Population by Age Group for Male of Urban area in Bangladesh in 1991 Census. X axis represents Age Group and Y axis represents Male Population
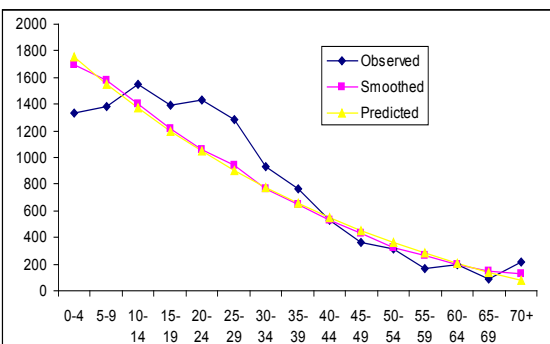

Figure 2. Observed, Smoothed and Predicted Muslim Population by Age Group for Female of Urban area in Bangladesh in 1991 Census. X axis represents Age and Y axis represents Female Population

Figure 3. Observed, Smoothed and Predicted Muslim Population by Age Group for Male of Urban area in Bangladesh in 2001 Census. X axis represents Age Group and Y axis represents Male Population

Figure 4. Observed, Smoothed and Predicted Muslim Population by Age Group for Female of Urban area in Bangladesh in 2001 Census. X axis represents Age and Y axis represents Female Population

Figure 5. Age Specific Growth Rates for Male and Female for Muslim of Urban Region of Bangladesh. X axis represents Age Group and Y axis represents Growth Rate

5. Conclusions

It is observed that the age pattern of Urban Muslim population for the censuses of 1991 and 2001 follow three parameters modified negative exponential model. It is hoped that one can use this predicted Urban Muslim population by age group for further advanced study as more smoothened data than observed. It is expected that these projected Urban Muslim population for the duration of the period 2002 – 2021 might be more used for higher developed research as well as it can be used in the planning of government and NGOs to boost up the socio-economic, demographic, and health related characteristics and other social indicators at the same time as most of the cases the population is normally used as denominator for the estimation of various socio-economic, demographic, health related and development indicators.

Moreover, population projections are required and used for setting employment target, for manpower planning, for planning how to increase productivity, for opening schools, for teachers training, for planning expansion of hospitals, for supply of goods and services of various types, for providing inputs to agriculture and industry, for calculating food requirements, for planning allotment system, for looking after dietary needs, for planning housing creation programs, for planning transportation requirements, for planning energy supply needs, for developing mining, for planning information and communication technology to strengthen the knowledge in this sector to vie the competitive global market, for conducting and scheduling elections, for planning the institute of law and order mechanism, etc. Further research may be done using world population data or Asian data.

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