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Research Paper Statistics

Modeling Fertility and Growth of Mising Community of Assam, India

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ABSTRACT

There are many studies available to model non-human population by Leslie Matrix, but few attempts are in literature so far as modeling human population is concerned. By using fertility rates, survival rates, and base population for a given population, this model can be used to calculate growth of human population also. The model can also be used to determine whether the given population will increase or decrease in each age class over a long period of time and also to project future population. In this paper we propose to carry out a study in order to investigate the fertility behavior and growth of population of the Mising community , Assam exploiting the above mentioned approaches and an about 3 per cent per five year long term growth of women population is indicative .

Keywords : Leslie Matrix, Fertility, Growth, Projection, Missing Community

1.0 Introduction

Matrix population models have become increasingly important and useful in predicting population growth. Projections of population growth on the basis of survival and fertility assumptions date back to 1895 by Cannan. In the early 40's, Bernardelli (1941), Lewis (1942), and Leslie (1945) successfully formalized the matrix methods introduced by Whelpton in 1936 to project populations. In 1945 Leslie wrote a paper that started by using the basic age-specific projection equations in a matrix form. In 1959 Leslie proposed a modified form of projection matrix to allow for the effect of the presence of other population members on population growth. Due to the importance of this deterministic model, J. H. Pollard developed a stochastic version of the basic model in 1966. In this paper we propose to carry out a study in order to investigate the fertility behavior and growth of population of the Mising community , Assam exploiting the above mentioned approaches .

2.0 The Matrix Population Model

The Leslie matrix population model is a discrete and age dependent. This matrix population model is widely used in population ecology and demography in order to determine the growth of a population, as well as the age distribution within the population over time.

Recognizing that men and women have different survival probabilities, but because only women have children, they constitute the "engine" of population dynamics. Given its one-sex formulation, the model is best interpreted as a model of the female population

Let us define following relevant terms of the model

$X_t(i)$ = number of females age class i at time t

f(i) = per-capita fecundity (daughters) of age class i females

S(i)) = survival from birth to age class i

The age distribution in period t + 1 is determined by the following system of equations,

$X_{t+1}(1) = f(1)X_t(1) + f(2)X_t(2) + f(3)X_t(3) + f(4)X_t(4)+\ldots.+ f(n)X_t(n)$

$X_{t+1}(2) = S(1)X_t(1)$

$X_{t+1}(3) = S(2)X_t(2)$

$X_{t+1}(4) = S(3)Xt(3)$

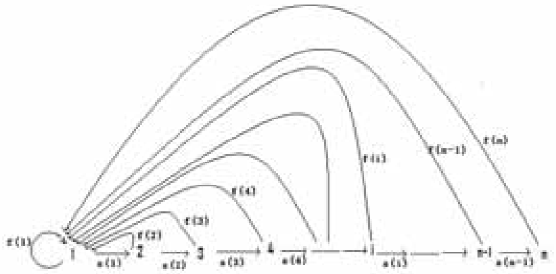
……………………..

……………………..

$X_{t+1}(n) = S(n-1)X_t(n-1)$ (1)

The process described by above system of equations can be shown in the diagram below.

Figure 1: Matrix Population Process



Intuitively, individuals currently in age class i contribute to next period's population in two ways: by surviving to age class i + 1, and by "sending back" children who begin life in age class 1.

To specify population process we can construct the Leslie matrix as

$$L = \begin{bmatrix} f(1) & f(2) & f(3) & f(4)........f(i)...........0.........f(n) \\ s(1) & 0 & 0 & 0 \quad 0 \quad 0 \quad 0 \\ 0 & s(2) & 0 & 0 \quad 0 \quad 0 \quad 0 \\ 0 & 0 & s(3) & 0 \quad 0 \quad 0 \quad 0 \\ 0 & 0 & 0 & s(4) \quad 0 \quad 0 \quad 0 \\ \cdots & & & \\ \cdots & & & \\ 0 & 0 & 0 & 0...........s(i) \quad 0 \quad 0 \\ \cdots & & & \\ \cdots & & & \\ 0 & 0 & 0 & 0...........0 \quad s(n-1) \quad 0 \end{bmatrix} \quad (2)$$

However fertility rates will be zero for women who are either too young or too old to have children. This fact can be captured by setting f(i) = 0 when i is very low or very high across age classes of the female population, so that X_t is the distribution of the female population across age classes.

2.1 Fertility Measures

The first measure, called the gross reproduction rate(GRR), is defined as

$$GRR = f(1) + f(2) + f(3) + f(4) + \ldots\ldots + f(n) \quad (3)$$

The second measure is the net reproduction rate(NRR), defined as

$$NRR = S(1)\,f(1) + S(2)f(2) + S(3)\,f(3) + s(4)\,f(4) + \ldots + S(n)f(n) \quad (4)$$

where S(i) i=1,2,3………n are estimated rates of survival of females from initial age class to i^{th} age class

2.1 Projections of Future Populations

The system of equation given above can now be written as

$$X_{t+1} = L\,X_t$$

where X_t is a column vector. Given the initial age distribution X_o, we obtain

$$X_1 = L\,Xo$$

$$X_2 = L\,X_1 = L^2 X_O$$

$$X_3 = L\,X_2 = L^3\,X_O$$

and, hence by induction

$$X_t = L^t\,X_o \; (5)$$

By utilizing the above recurrence relation we can project future population in different age classes.

2.2 Long Term Growth

The long term growth of the population can be felt by the following theorem due to Perron-Probenious.

If L is a non-negative, primitive matrix, then (i) one of its eigenvalues is positive and is greater (in absolute value) than all the other eigenvalues, and (ii) there is a positive eigenvector (i.e., an eigenvector with positive elements) corresponding to that eigenvalue.

The particular eigenvalue described in this theorem is often called the dominant eigenvalue, which is the long term stable growth factor and the corresponding eigenvector is the long time limiting distribution of population.

3.0 Application to Mising Community of Assam

The Mising community in Assam whose population by 2001 Census is 587310 is still considered as backward community aggravated with the problems of poverty, unemployment and social and infrastructural inequalities. The community spreads over Lakhimpur (28.30%), Dhemaji. (31.73%),Jorhat (15.71%), Sibsagar (4.07%) , Sonitpur (7.52%) , Dibrugarh (1.59%),Golaghat (8.11%) and Tinsukia (2.94 %) in upper Assam. The data employed in this study were obtained by conducting field survey during 2008-10. Cluster Sampling with the probability in proportion to population size of the district is used in the study. The study covers 4764 women of the community. The fertility rates obtained have been put in the Table 1 bellow

Table 1: Fertility Status of Mising Women

(1) Age Class	(2) ASFR (Total)	(3) ASFR (Female Births)	(4) Survival from birth to age class i	(5) NetASFR (Female Births)
15-19	0.54404	0.27634	0.9569	0.42024
20-24	1.17092	0.59933	0.9503	0.37445
25-29	0.76243	0.38332	0.9430	0.22102
30-34	0.40046	0.19451	0.9336	0.16256
35-39	0.16978	0.07640	0.9147	0.15833
40-44	0.09404	0.06270	0.8980	0.15432
45-49	0.03175	0.01587	0.8841	0.10802
Total	3.17342 (TFR)	1.60847 (GRR)		1.49706 (NRR)

We prepare the following Leslie matrix for Mising women by writing the f(i) s along the first row and S(i) s at positions just below the diagonal elements.

The initial distribution of female in different age classes of reproductive span after adjusting the deaths is written in the matrix form as

$$X_o^T = \begin{bmatrix} 1431 & 1335 & 1257 & 579 & 901 & 1127 & 874 & 589 & 319 & 315 & 231 & 210 & 217 & 48 & 147 & 51 & 47 & 0 \end{bmatrix}$$

With initial age distribution X_O^T, we straightforwardly compute the age distribution of women for the next 40 periods (representing 200 years) using (5). And then we calculate the growth factors for each period by dividing the size of population in period by the size of population of next period. Growth rates of females successive periods and growth rates from initial period to every progressing period are also obtained. All these growth numbers are listed in the Table 2

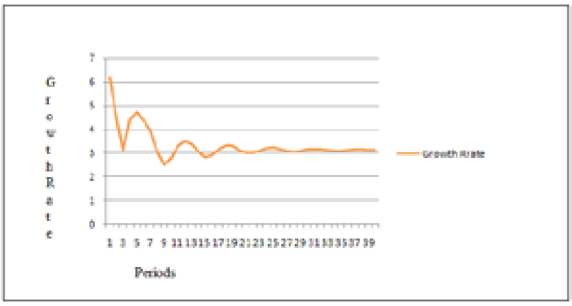
Table 2: Marginal and total growth of female in periods

Period	Successive Growth factor	Successive Growth	Growth From Initial Class
1	1.0616	6.1600	6.1590
2	1.0439	4.3900	10.8202
3	1.0313	3.1300	14.2872
4	1.0441	4.4100	19.3359
5	1.0473	4.7300	24.9817
6	1.0434	4.3400	30.4075
7	1.0394	3.9400	35.5504
8	1.0307	3.0700	39.7088
9	1.0251	2.5100	43.2073
10	1.0279	2.7900	47.2085
11	1.0330	3.3000	52.0687
12	1.0352	3.5200	57.4212
13	1.0340	3.4000	62.7841
14	1.0307	3.0700	67.7805
15	1.0286	2.8600	72.5673
16	1.0293	2.9300	77.6265
17	1.0316	3.1600	83.2303
18	1.0333	3.3300	89.3265
19	1.0331	3.3100	95.5902
20	1.0315	3.1500	101.7492
21	1.0301	3.0100	107.8140

22	1.0301	3.0100	114.0672
23	1.0311	3.1100	120.7290
24	1.0322	3.2200	127.8307
25	1.0324	3.2400	135.2048
26	1.0317	3.1700	142.6626
27	1.0309	3.0900	150.1519
28	1.0306	3.0600	157.8087
29	1.0311	3.1100	165.8217
30	1.0317	3.1700	174.2432
31	1.0319	3.1900	182.9894
32	1.0317	3.1700	191.9556
33	1.0312	3.1200	201.0684
34	1.0310	3.1000	210.3907
35	1.0311	3.1100	220.0587
36	1.0314	3.1400	230.1246
37	1.0316	3.1600	240.5677
38	1.0316	3.1600	251.3250
39	1.0314	3.1400	262.3442
40	1.0314	3.1400	273.6357

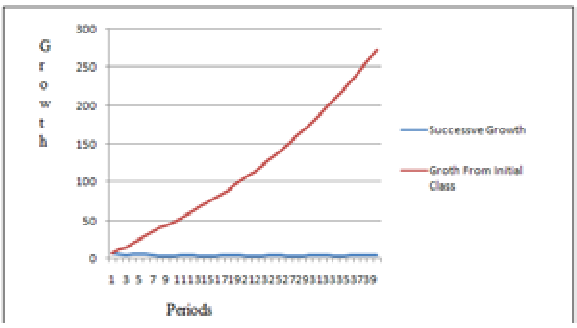
Here we have seen that the women population is indeed converging to a stable growth equilibrium, with a long-run stable growth rate of 3.14 percent per five year period.

Figure 2: Growth rates in each progressing period



After achieving 273.64 per cent growth from initial female populatin number, it will contnue to grow at the stable growth rate of 3.14 per cent per five year period.

Figure 3: Growth rates from initial period to a each progressing period with respect to growth in successive periods



Now let us look into the growth of Mising female of individual age classes from initial period to stable growth equilibrium distribution. The growth rates are presented in the fourth column of the Table 3.

Table 3: Growth from initial period to stable growth equilibrium.

Age Class (1)	Initial Distribution (2)	Stable Growth Distribution (3)	Growth Rate from Initial to Stable period (4)
1	0.1299	0.1223	-6.00
2	0.1398	0.1150	-17.74
3	0.1317	0.1073	-18.38
4	0.0606	0.0996	64.52
5	0.0944	0.0917	-2.86
6	0.1243	0.0839	-32.66
7	0.0915	0.0759	-17.27
8	0.0617	0.0673	9.08
9	0.0334	0.0586	76.05
10	0.033	0.0503	53.03
11	0.024	0.0419	75.00
12	0.022	0.0332	50.45
13	0.0227	0.0243	6.61
14	0.005	0.0159	218.00
15	0.0154	0.0086	-44.16
16	0.0053	0.0034	-33.96
17	0.0049	0.0007	-85.71
18	0	0.0001	-

From the Table 3 we have seen that age classes 1,2,3,5,6,7,15,16 and 17 will experience negative growth and age classes 4,9,10,11,12,13 and 14 will experience positive growth. Highest growth of 218 per cent will be in the age class 14.

4.0 Conclusion

The fertility of the age group 20-25 is highest in Mising and the TFR of Mising is 3.17 which is slightly higher than the TFR of all India tribals of 3.12. The NRR of Mising women is found to be 1.50 which indicates that Mising population will grow in future. Here we find that the women population of Mising is indeed converging to a stable growth equilibrium with a long-run stable growth rate of 3.14 percent per five year period. The growth of population still continues to be alarming which needs a special attention of the authorities concerned to resolve and address the situation.

The Matrix Population Model is a fair innovation in mathematics, and it has been found to be very useful in determining population growth. There are many studies available to model non-human population by Leslie Matrix, but few attempts are made to model human population by it. By using fertility rates, survival rates, and base population for a given population, this model can be used to calculate growth of human population also. The model can also be effectively used to determine whether the given population will increase or decrease in each age class over a long period of time and also to project future population.

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