The Economic Journal of Nepal, Vol. 9, No. 2, Issue 34, April-June 1986 

# A Markov Chain Approach to Urban Area Distribution with Implications of Urbanization in Nepal

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## INTRODUCTION

Urbanization in Nepal has received much attention during the last decade and there is copious literature on the same. The heretofore approach to urban analysis is mostly concentrated on the percentage of urban population related to socio-economic variables of either change in size distribution or changes in the number of urban places. The urban analysis dealing with the urban area size distribution has not been, however, analyzed from demographic viewpoint, nor has any serious study been undertaken for a simultaneous analysis of changes in places and in size classes.

Markov chain models have been suggested as useful tool to deal with analysis concerning fertility, mortality, social and occupational mobility, educational and manpower systems etc., though its potential in urban analysis remains yet undeveloped. In this paper, an attempt is made to use the Markov chain model as an analytical tool to study the urban area size distribution.

## THE MODEL

Suppose that we have a closed system of urban areas distributed among k size classes, the number of urban areas in these size classes at some time $t (t = 0,1,2,...)$ being $C_1(t), C_2(t),..., C_k(t)$. If we denote by $C_{ij}(t)$ the number of urban areas moving from size class i to size class j in time $(t, t + 1)$ then it follows that

$$C_i(t) = \sum_{j=1}^{k} C_{ij}(t), \text{ for each } t = 0,1,2,...$$

and each $i = 1,2..., k$. Obviously $C_{ii}(t)$ denotes the number of cities remaining in class size i during the time $(t,t+1)$. If $p_{ij}$ denotes the probability of movement of an urban area moving from size class i to size class j then between any two adjacent time points we have the number of urban areas in size class j at time t + 1 as

$$C_j(t+1) = \sum_{i=1}^{k} C_i(t)p_{ij}$$

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which in matrix notation becomes

$$C(t + 1) = C(t)P.$$

Here C(t) and C(t+1) are the row matrices denoting the number of urban areas of size classes 1,2,...,k at times t and t + 1 respectively and

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1k} \\ p_{21} & p_{22} & \cdots & p_{2k} \\ \cdots & \cdots & \cdots & \cdots \\ p_{k1} & p_{k2} & \cdots & p_{kk} \end{bmatrix}$$

Under the assumption of continued operation of the transition matrix P through (0,t) we may write

$$C(t) = C(0)P^t$$

where C(0) may be termed the cohort of urban areas constituting the number of urban places at time 0 in the various size classes.

Such an analysis implicitely provides an opportunity to demonstrate the use of a closed Markov chain model in studying the changes in the structure of the cohort of urban areas when for each urban area it is assumed that the 'urban' status continues to hold and when during the entire period of observation no deletion or addition of urban areas are made.

THE DATA

Data on urbanization in Nepal are available for all 4 decinial censuses since 1952/54. But the data from these censuses are not comparable particularly due to changes in definitions over time and district boundaries after 1961, thus affecting the urban population of the district as well its adjoining district as well.

In this paper we shall take particular notice of the changing levels of urbanization by comparing the number of urban areas of given size classes over the subsequent censuses.

The data for the present analysis has been taken from Major Urban tables Vol. IV, Population Census 1971 and Urban Areas tables Vol. III, Population Census 1981. There are 16 urban areas in 1971 and 23 in 1981. But because of the assumptions made in the model, we study the transition structure for the 16 urban areas of the 1971 census only. This means we shall ignore the 7 new urban areas of the 1981 census and study the transition structure of one size class to other size class. The 7 urban areas of the 1981 census delated from this study are Dhankuta, Siraha, Chitwan, Dang, Surkhet, Kailali and Kanchanpur (Table 1).

Table 1

Distribution of urban areas according to size of urban area for the Censuses 1971 and 1981

| Size of Urban area | Number of urban areas in 1971 | 1981 Actual | 1981 After deleting new urban areas |
|---|---|---|---|
| Below 10,000 | 4 | 2 | 2 |
| 10,000- 20,000 | 5 | 5 | 2 |
| 20,000- 30,000 | 3 | 4 | 1 |
| 30,000- 40,000* | - | 4 | 4 |
| 40,000- 50,000 | 2 | 5 | 4 |
| 50,000- 100,000 | 1 | 2 | 2 |
| 100,000 & above | 1 | 1 | 1 |
| Total | 16 | 23 | 16 |

*Since there were no urban areas of size 30,000-40,000 in 1971, this class was merged with the preceding class 20,000-30,000 so as to have a valid transition probability matrix.

The following matrix shows the position of the 16 urban areas in 1981 relative to their size in 1971. Clearly Ilam, Jhapa, Banke, Bhaktapur, Lalitpur and Kathmandu have maintained their relative position. Saptari, Palpa, Butwal, and Biratnagar have moved up one size up while Dhanusha, Makwanpur, Bhairahawa, Sunsari and Kaski have moved two sizes up during the decade 1971-81. During the same period Parsa moved three sizes up in the matrix (Table 2).

Table 2

Urban area size transition matrix for the censuses 1971 and 1981

| | Below 10,000 | 10,000- 20,000 | 20,000- 40,000 | 40,000- 50,000 | 50,000- 100,000 | 100,000 & above |
|---|---|---|---|---|---|---|
| Below 10,000 | Ilam, Jhapa | Saptari, Palpa | x | x | x | x |
| 10,000-20,000 | | x | Butwal, Dhanusa, Makwanpur, Bhairahawa | Parsa | x | x |
| 20,000-40,000 | | | Banke | Sunsari, Kaski | x | x |
| 40,000-50,000 | | | | Bhaktapur | Biratnagar | x |
| 50,000-100,000 | | | | | Lalitpur | x |
| 100,000 & above | | | | | | Kathmandu |

The transition probability matrix may be written as

$$P = \begin{bmatrix} 0.50 & 0.50 & - & - & - & - \\ & - & 0.80 & 0.20 & - & - \\ & & 0.33 & 0.67 & - & - \\ & & & 0.50 & 0.50 & - \\ & & & & 1 & - \\ & & & & & 1 \end{bmatrix}$$

The distribution of urban areas in the various size classes for the year 1971 may be represented by the vector

$$C(0) = (4, 5, 3, 2, 1, 1)$$

where the census year 1971 has been taken as the zero year, i.e., $t = 0$.

Using the equation (a) the transition probability matrix P and the C(0) vector, the following table on the expected redistribution of the 16 urban areas amongst the 6 size classes for the year 1981, 1991 and 2001 results.

Table 3
Expected distribution of the 16 urban areas of the 1971 census by their sizes in the years 1981, 1991 and 2001

| Size of urban area | Distribution of urban areas | | |
|---|---|---|---|
| | 1981 | 1991 | 2001 |
| Below 10,000 | 2 | 1 | 0 |
| 10,000-20,000 | 3 | 1 | 1 |
| 20,000-40,000 | 4 | 3 | 2 |
| 40,000-50,000 | 4 | 6 | 5 |
| 50,000-100,000 | 2 | 4 | 7 |
| 100,000 and above | 1 | 1 | 1 |
| Total | 16 | 16 | 16 |

From the above table, it is interesting to note that the number of urban areas of smallest densities are declining over the years while the number of urban areas with population of 40,000-100,000, particularly the size 50,000-100,000 is expected to increase considerably over the years; from 2 in 1981 to 7 in 2001. It shows that over the years, the urban population will concentrate more in this class size than in any other classes.

Based on the above estimation of the number of urban areas in various size classes, a rough estimate of the urban population for 16 urban areas for the year 1981-2001 may be obtained as follows. Let the mean population for the 6 size classes for the year 1971 be denoted by M(0), then M(0) = (7266, 14715, 41546, 42606, 59049, 150402). The distribution of the urban areas in the years 1981, 1991 and 2001 as given in Table 3 gives C(1), C(2) and C(3) respectively. The expected urban population for the years may then be obtained as

$$E(1) = C(1)M'(0) = 6,63,785$$

$$E(2) = C(2)M'(0) = 7,88,853$$

and, $$E(3) = C(3)M'(0) = 8,74,582.$$

The actual urban population for 1981 for these 16 urban areas was 7,95,933, the error in estimation being only 16.6 percent.

SOME REMARKS

The method demonstrated above may be followed for estimating the distribution of location size or distribution of panchayats by their sizes for any number of years hence. The error in estimation is not too high when we consider the fact that the transition probability matrix, on which our entire result depends, is based on just two time points. Moreover the same transition probability matrix is assumed to hold good for the period 1981-2001, which is not a very practical assumption. The margin of error may be reduced by spreading the observations over a very wide period of time and by taking into account the varying transition probability matrices for different periods of observations. Also if we take the class sizes in smaller intervals and without including any open classes, as in the present case, the estimation will again be of greater accuracy.

The main limitation of this method is that no new urban areas may be added to the list or old urban areas delated from the list. To do away with this defect, we need to consider the open Markov chain model which deals with the stochastic mechanism governing the gains and the losses to the system. Such a model will be the topic of a later paper.

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