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A Note on Logistic Method of Urban Forecasting

WITH fertility decline occurring in all major parts of the developing world, attention of demographers is shifting from the study of population explosion to study of population implosion i.e. population concentration and metropolitanization. This paper attempts to find mathematical laws of urban growth for different nations of the world and the States in India.

Urbanization is a process of population concentration. This emanates from the natural growth in the urban areas, graduation through the demographic growth of villages into towns and cities, absorption of hinterland, and mostly from the transfer of population from rural to urban areas. Each of these components of the growth of urban population is a complex socio-economic factor and, therefore, the quantification and forecasting of urban trends pose difficult problems. Some of the commonly used measures of urbanization are: proportion urban, urban-rural population ratio, Davis's index, Arriaga's degree of urbanization, entropy and redundancy measures, and scale of urbanization.¹ Saxena and Sharma have recently proposed a multidimensional approach to measurement of urbanisation based on quantitative techniques.² However, some of the conceptually more powerful techniques are of little application in calculating projections because they require efficient predictions of the dimensions and do not yield the aggregate urban population. Multidimensional factor analytic

1. A. K. Sharma, "Regional Variations in the Process of Urbanization in Uttar Pradesh", *Demography India*, 9 : 1 and 2, 1980, pp. 186-209.

2. P. C. Saxena, and A. K. Sharma, "Some Comments and Modifications on Arriaga's New Approach to the Measurement of Urbanization", in: K. Srinivasan, and S. Mukerji (Eds), *Dynamics of Population and Family Welfare in India*, Prakashan, Bombay, 1979, pp. 136-49.

measures demand a large data base which is not available for most countries at present. **Keyfitz** has recently noted that knowledge in the field of population is evidently not directly usable in forecasting and demographers are driven back to statistical and mathematical methods **that, in one form or another, are extrapolatory.**³ It can be mentioned here that rural-urban migration exhibits the highest **randomness** in the group of components of population growth in general e.g. fertility, mortality, internal migration and external migration. Unlike fertility and mortality, there do not exist global patterns and global socio-economic associations of migration. This is one of the least understood demographic **processes** and its underlying mechanism is largely unknown.

In this situation, United Nations has suggested a new method of projections of urban and rural **populations.**⁴ This is an improved version of forecasting and assumes that the level of urbanization calculated as the proportion of total population living in settlements defined as urban behaves in a logistic manner **over** time. The difference between the growth rates of urban and rural population is **assumed** to be constant and **this, mathematically, leads to the assumption of logistic growth pattern.** The nature of this **growth** is that the rate of urbanization increases at an accelerated rate in the beginning, reaches a peak when urbanization is around 50 percent, and decelerates thereafter. Eventually the growth of urbanization becomes asymptotical. United Nations has, **nevertheless, not given any method to determine the appropriate values of urban rural growth difference which are mostly estimated from recent past.** In India, **Raghavachari**⁶, and Saxena and **Sharma**⁷ have used the technique of logistic **model** for forecasting of urban populations. Saxena and **Sharma** have also used the same method for projecting the population of different cities in **Maharashtra.**⁸

The present exercise examines patterns of urban growth in the world with the following objectives in view:

3. Nathan Keyfitz, "Can Knowledge Improve Forecasts?" *Population and Development Review*, Vol. 8, No. 4, 1982, pp. 729-52.

4. United Nations, "Methods for Projections of Urban and Rural Population", *Population Studies*, No. 55, 1974,

5. United Nations, "Guidelines for Preparing Subnational Population Projections", *Asian Population Studies*, No. 32, 1974, pp. 37-39.

6. S. Raghavachari, "Population Projections, 1976-2001", In : Ashish Bose *et al.* (Eds.), *Population in India's Development, 1947-2001*, Vikas Publishing House Pvt. Ltd., Delhi, 1974, pp. 431-44.

7. P. C. Saxena and A. K. Sharma, "Projections of Rural and Urban Populations of Districts of Maharashtra", *IIPS News letter*, No. 52, 1976, pp. 1-5.

8. P. C. Saxena, and A. K. Sharma, "Population Projections for Cities of Maharashtra, 1971-2001" *IIPS News letter*, No. 55, 1976, pp. 10-14.

1. to examine whether the assumption of logistic growth is valid for contemporary urbanization;
2. to estimate mean and standard error of speed of urbanization at different levels of the process; and
3. to explore the implications of the present urban patterns in the world for prediction of urbanization in India.

Data for this analysis are taken from *Demographic Year Book, Special Issue: Historical Supplement, 1979* of United Nations, and *World Data Sheet, 1980* of Population Reference Bureau, Table 1 shows the distribution of population

TABLE 1—LEVELS OF URBANIZATION IN MAJOR REGIONS OF THE WORLD

<i>Region</i>	<i>Population in 1980 (millions)</i>	<i>Urban Population (in per cent)</i>
Africa (incl. North)	472	26
West Africa	141	21
East Africa	135	13
Middle Africa	54	29
Southern Africa	32	44
South Asia	938	21
Hast Asia	1173	32
Latin America	360	01
Developing countries	3283	29
Developed countries	1131	69
World	4414	39

and levels of urbanization in different regions of the world. It is evident that in 1980 nearly 39 percent of the population of world lived in urban areas. However there are considerable differences in the levels of urbanization between developing and developed countries. In all the developing regions only 29 percent population lives in towns or cities, while in the developed countries, the share of urban population is about 69 percent. However, the developing regions show a great disparity in the level of urbanization. This ranges from 13 percent in East Africa to 61 percent in Latin America. For the present analysis,

all countries for which some historical data regarding **urbanization** during 1950-74 are **available** are selected. The corresponding levels of urbanization are observed and divided in 10 classes of uniform intervals. For each of the levels observed in all these classes, the annual increase in the levels is calculated as an index of speed of urbanization. Table 2 gives the mean, **coefficient of variation**, and

TABLE 2—MEAN, COEFFICIENT OF VARIATION, AND STANDARD ERROR OF SPEED OF URBANIZATION

<i>Level of Urbanization (in per cent)</i>	<i>No. of Observations</i>	<i>Mean</i>	<i>Mean as Ratio of Average Level</i>	<i>Coefficient of Variation</i>	<i>Standard Error</i>
< 10	7	0.49	0.10	0.78	0.14
10 — 20	19	0.63	0.04	1.09	0.16
20 — 30	27	0.82	0.03	0.76	0.12
30 — 40	45	0.71	0.02	1.42	0.15
40 — 50	34	0.58	0.01	1.81	0.18
50 — 60	22	0.23	0.00	4.11	0.20
60 — 70	20	1.19	0.01	0.81	0.21
70 — 80	12	0.21	0.00	3.09	0.19
80 — 90	11	-0.11	-0.00	4.24	0.14
90+	1	0.19	0.00	—	—
Total	198	0.61	—	1.52	0.07

standard error of the mean for each class of urbanization. The one way **analysis of variance** gives F ratio of 3.06 ($v_1 = 8, v_2 = 188$) for the speed of urbanization. This shows that the speed of urbanization observed at different levels of urbanization differs significantly at 5 percent level of confidence. **Further**, the speed of urbanization in recent times is consonant with the logistic growth model. The level of urbanization increases at accelerated pace till the population is 30 per cent urban; beyond this the levels increase at a decelerated pace at all **levels**, except 60-70 per cent and above 90 per cent. Between **80-90** per cent, the index of urbanization **shows** an unexpected decline. Lastly, there is only one country with level of urbanization higher than 90 per cent Macau. In **Macau**, the level is increasing at a rate of 0.19 per year. This is, **however**, the statistical pattern.

to analyse the causes for such a pattern, one needs to conduct a **countrywise** detailed analysis of urban systems and the socio-economic determinants and consequences. The analysis clearly shows that a model for urban growth may be of the following form:

$$\frac{1}{U_t} \frac{\Delta U_t}{\Delta t} = .0618 - .0010 U_t$$

($n = 10, r = -.92$)

where U_t is the level of urbanization at time t and Δ indicates the corresponding changes.

With regard to the changes in urbanization levels in countries that are urbanized to different degrees, following typology can be prepared:

RELATIVE DEGREE OF URBANIZATION

	Low (less than 50 per cent urban)	High (more than 50 per cent urban)
Rising Trends	Type I	Type III
Declining Trends	Type II	Type IV

Most of the developing countries belong at present to Type I. In these countries, the levels of urbanization are relatively low and they are growing at different rates. A few of the developing countries exhibit the Type II-model, in which the levels of urbanization are low and they are declining. For example, in Thailand the level of urbanization declined from 18.2 per cent to 13.2 per cent between 1960-70. Reunion, Turkey, Antigua, Honduras, Canal Z., Suriname, Jersey and Denmark also showed declining trends at various periods between 1950-70. Part of this decline can, however, be attributed to definitional changes in the respective countries.

Most of the developed countries that are also the most industrialized are urbanizing at various rates and they belong to Type III. Some of the countries in which more than 80 per cent population lives in cities are urbanizing faster than some of the least urbanized countries, in terms of absolute increase to per cent urban. Australia (83.3 per cent urban), for example, added more to its degree of urbanization annually (0.46) between 1966-71 than Uganda (0.31) between 1959-69 that is only 4.8 per cent urban or Guatemala (0.31) between 1964-73 that is only 33.6 per cent urban. Nevertheless, a number of countries

where levels of **urbanization** are relatively high, are de-urbanizing. They belong to Type IV e.g. **Behrain**, U. K., England and Wales, **Czechoslovakia**, Greenland, and Scotland.

Now the question arises: how does the present analysis help in predicting the urban future of India? According to the Census of India, 1981, the level of urbanization in India is 23.73. The results of the global **analysis** are: (1) at the levels of urbanization between 20-30 per cent, the annual increase in the level is 0.82, (2) the 95 per cent control **limits** for projections are 0.82 ± 0.36 i.e., between 1.18-0.46. In other words, with the 95 per cent confidence level, it can be **said** (hat the urbanization in **India** in 1991 would be between 35.53-28.33 per cent. It is true that in the past the growth of **urbanization** in India was slower. Between 1911-71, the period in which the urbanization in India increased **in** the class 10-20 per cent urban, the average annual increase was only 0.15 point. This is much slower than the contemporary growth standards of the other countries of globe i.e., 0.49. **Between** 1971-81 again the annual increase in per cent urban is only 0.35 lower than the global average of **0.63 point**.⁹

This apparent discrepancy is easy to explain. In the **past**, though **urbanization** was **slow**, the growth of urban population was towards the higher side of the global spectrum. For **example**, between 1971-81 the urban population in India grew at an average annual rate of 4.6 per cent which is higher than the growth **rates** of urban populations in any major region of the world except **Africa**.¹⁰ Relatively greater size and growth of rural **population** in India are responsible for projecting India in critical region of the global distribution. In future, with the success of family planning programme and reduction in **the** birth rates, India would join the world race for urbanization. In that case the analysis of contemporary world trends may help more than the static U. N. model of forecasting of urbanization.

To throw more light on **the** process of urbanization in India, data on the trends of urbanization in various States during the decade 1971-81 are presented in Table 3. The **mathematical** model of the urban growth in Indian States in **this** period is found to be

$$\frac{1}{\Delta t} = .0522 - .0014 U_t$$

($n = 20, r = -.45$)

Though the value of coefficient of determination in the case of the above model is relatively low, it is statistically significant at 5 per cent level of confidence.

9. **M. K. Jain**, 'Growth of Cities and Urban Agglomerations in **India, 1971-81**', *Paper Presented in the Seventh Annual Conference of IASP*, S. V. University, Tirupati, 1982.

10. **United Nations, 1974**, *op. cit.*, pp. 5-35.

TABLE 3—URBANIZATION IN INDIA, 1971-81

<i>State/India</i>	<i>Per cent Urban</i>		<i>Decadal Change in Per cent Urban</i>	<i>Annual Change in the Decade as Ratio of Initial Level</i>
	<i>1971</i>	<i>1981</i>		
Maharashtra	31.17	35.03	3.86	.0124
Tamil Nadu	30.26	32.98	2.72	.0090
Gujarat	28.08	31.08	3.00	.0107
Karnataka	24.31	28.91	4.60	.0089
Punjab	23.73	27.72	3.99	.0168
West Bengal	24.75	26.49	1.74	.0070
Manipur	13.19	26.44	13.25	.1004
Andhra Pradesh	19.31	23.25	3.94	.0204
Haryana	17.66	21.96	4.30	.0243
Rajasthan	17.63	20.93	3.54	.0201
Madhya Pradesh	16.29	20.31	4.02	.0247
Kerala	16.24	18.78	2.54	.0156
Meghalaya	14.55	18.03	3.48	.0239
Uttar Pradesh	14.02	18.01	3.99	.0285
Sikkim	9.37	16.23	6.86	.0732
Nagaland	9.95	15.54	5.59	.0562
Bihar	10.00	12.46	2.46	.0246
Orissa	8.41	11.82	3.41	.0405
Tripura	10.43	10.98	.55	.0053
Himachal Pradesh	6.99	7.72	.73	.0104
India	20.22	23.73	3.51	.0174

SOURCE: **Computed** from Registrar General and Census Commissioner for **India, Provisional Population Totals: Rural-Urban Distribution, Paper 2 of 1981, Census of India 1981. Series-1, India, p. 28.**

The present analysis clearly shows that for both nations of the world as well as **Indian States**, slope of the model is negative and roughly of the same inclination. The annual amount of change in the levels of urbanization in Indian States between 1971-81 increases **with the level till a 20 per cent mark is reached** beyond which the annual **increment** starts declining, in **the following** manner;

<i>Level of Urbanization</i>	<i>Average Annual Change 1971-81</i>
<10	.0414
10--20	.0421
20--30	.0333
> 30	.0329

To sum up, the present analysis shows the empirical justification of **using the** logistic model for forecasting of urban **trends**. The model was derived initially in a theoretical manner with the **assumption** that the urban-rural growth difference follows a pattern which was for most purposes **assumed** constant. Our regression models developed for various countries in the world, and the States in India separately **lend** support to this pattern of urban growth. Individual exceptions have also been shown. One **difference** that should be shown between the **U. N. model** and the empirical **models** is that **while** in U. N. pattern urbanization **increases at accelerated** pace till the country is 50 per cent urban, **empirically** such a point is observed at 30 per cent for world model and 20 per cent for the model of Indian States,