

RURAL-URBAN POPULATION PROJECTIONS FOR KENYA  
AND IMPLICATIONS FOR DEVELOPMENT

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## PREFACE

Roughly 1.6 billion people, 40 percent of the world's population, live in urban areas today. At the beginning of the last century, the urban population of the world totaled only 25 million. According to recent United Nations estimates, about 3.1 billion people, twice today's urban population, will be living in urban areas by the year 2000.

Scholars and policy-makers often disagree when it comes to evaluating the desirability of current rapid rates of urban growth in many parts of the globe. Some see this trend as fostering national processes of socio-economic development, particularly in the poorer and rapidly urbanizing countries of the Third World; whereas others believe the consequences to be largely undesirable and argue that such urban growth should be slowed down.

As part of a search for convincing evidence for or against rapid rates of urban growth, a Human Settlements and Services research team, working with the Food and Agriculture Program, is analyzing the transition of a national economy from a primarily rural agrarian to an urban industrial-service society. Data from several countries selected as case studies are being collected, and the research is focusing on two themes: spatial population growth and economic (agricultural) development, and resource/service demands of population growth and economic development.

This paper is one of several focusing on one of five case studies: Kenya. In it, a member of the Food and Agriculture Program (Shah) and his co-author from the Human Settlements and Services Area (Willekens), present several alternative projections of Kenya's urban and rural populations. They then examine the probable consequences of these alternative demographic futures on demands for jobs, food, health care, and education.

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## ABSTRACT

This paper projects the rural and urban populations of Kenya into the future by applying the methodology of multiregional demography. A base run and six alternative scenarios of fertility, mortality, and rural-urban migration are considered. The demographic consequences of these alternative scenarios on employment, demand for food, health, education, and on development in general are analyzed separately for the urban and rural sectors. A general framework for the study of the urbanization process is also proposed.



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## 1. INTRODUCTION

Kenya has one of the highest population growth rates in the world. The country had 5.4 million people in 1948; its population increased by 3.2 million in the period 1948-62 and by another 2.3 million people in the period 1962-1969, (Development Plan, 1974-1978, pp.99). This represents an annual growth rate of 3.2% in the period 1948-1962 and 3.4% in the period 1962-1969. The present population is about 14 million and the annual growth rate is about 3.5%. Hence, not only has Kenya's population been growing, but also the growth rate has increased substantially in the last two decades. At this rate of growth Kenya's population is expected to double within 20 years.

The principal source of Kenya's accelerated population growth has been a rapid decline in mortality; fertility has remained relatively constant. It is expected that with improving health services throughout the country, mortality will decline further whereas fertility is expected to remain constant, at least for the next two decades. The rapid population growth has created increasingly greater demands for employment, food, shelter, clothing and services such as education, water, sanitation, health, transportation, etc. In spite of the efforts of the government to provide basic services throughout the country, the population growth is causing an increasing gap between the availability of economic goods and services and the corresponding demands of the population.

Estimates of current population characteristics, as well as population trends which may be expected in the future, are essential for assessing the needs of Kenya's society in the future. It is important to divide the population projections into urban and rural components since Kenya has a dual economy: agriculture (rural areas) is the backbone of the economy, and manufacturing and industry (mainly urban areas) constitute an important growth sector. It should be noted that agriculture

and manufacturing will become complementary rather than competitive sectors of the economy in the sense that agriculture will provide both the raw materials for industrial exports and an expanding market for manufactured goods. About 85% of the population resides in the rural areas and the remaining 15% inhabits the urban areas. This is a low level of urbanization in comparison to many developing countries in Latin America and Asia. However, the rate of urbanization is high. In 1969, 1.1 million people resided in the urban areas; the present number is 2 million. This urbanization trend is likely to continue and may increase in the future.

The objective of this paper is to present some preliminary results on the projections of Kenya's rural and urban populations under present trends (base run) and under varying assumptions (Scenarios 1 to 6) of fertility, mortality and migration. The methodology of multiregional demography is applied to this two-region system (Rogers 1975). The advantage of this approach is that rural and urban populations can be projected simultaneously, as part of an interconnected two-region system.

A short review of the projection procedure is given in the Appendix. The actual simulation program used is described in detail elsewhere (Willekens 1978).

This paper is organized in seven sections. After this introduction, the origin of the input (base year) data is reviewed in detail and the procedures adopted to estimate missing data are discussed. The third section describes the six scenarios or alternative futures on which the alternative population projections are based. The demographic consequences of these alternative scenarios, i.e. the alternative population projections, are discussed in Section 4. Populations are projected by five-year age groups. Implications for school enrolment, demand for health services, employment and future food demand are analysed in Section 5. Finally Section 6 broadens the perspective of demographic growth in the two region (rural-urban) system. It proposes an approach to integrated demographic development of urban and rural areas through decentralized urbanization.

## 2. MEASUREMENT AND ESTIMATION OF INPUT DATA

### Population

In Kenya the censuses of non-African population were held in 1921 and 1926; in 1931 a few African respondents employed by non-Africans were included. The first count of the entire population was carried out in 1948 and the second in 1962. In these two censuses the count was effected partly on a de jure basis and partly by sampling. The census of population held in 1969 was the third general census to be undertaken in Kenya and the first since independence in 1963. The 1969 census differs from the two previous ones in that, for the first time, an attempt was made to enumerate the population on a de facto basis throughout the country.

In this paper the rural and urban population projections of Kenya are based on the demographic characteristics of the population on August 24-25th of the 1969 census year. The population by age, sex and region is given in Table 1. The last age group is open-ended and contains the population of 65 and over. The data are contained in Kenyan Population Census, 1969, Vol. I and II (urban areas, defined as towns which reported more than 2,000 people, in Vol. II, Table 5, pp. 75-78; total in Vol. I, Table 3, p. 118-123). These data may also be found in the United Nations Demographic Yearbook (1974, Table 7) and in the ILO's Bachue-Kenya report (1977, Appendix, pp. 127-128). However, the census report gives, for ages above 30, the population in 10-year age groups. Therefore, the ILO-data have been used in Table 1.

### Fertility

The required fertility data are age-specific rural and urban birth rates for the total population (Table 2). They are expressed as the total number of births to women in a certain age group divided by the total population in this age group. The use of these fertility rates of the total population introduces a bias since the age of the father is omitted from consideration. However, the error introduced by such a female dominant approach is negligible and can be avoided by using a two-sex model.

The age-specific fertility rates of the total population are derived by multiplying the total fertility rates (births per women in certain age groups) by the proportion of women in each

age group. The latter are derived from the Kenya Population Census Vol. IV, where the age-specific fertility rates for various districts in Kenya are given. The urban population of Kenya in 1969 was 1,079,908 and this included all centers with population of 2000 and above. In the derivation of the shape of the urban fertility schedule, the urban areas were assumed to consist of Nairobi and Mombasa only; these two cities account for 70% of the urban population. This assumption was made due to the lack of fertility data for the remaining 30% of the Kenyan urban area. The level of the fertility schedule, i.e. the area under the curve, was not taken from the Nairobi-Mombasa data. The relatively low fertility levels in those large cities are not representative for the fertility of all urban areas, including the small towns. Instead, it was assumed that the urban areas have a gross rate of reproduction of 2.75, whereas the rural areas have a GRR of 4.00. These numbers are derived from the ILO estimates of urban and rural total fertility rates (TFR) of 5.5 and 8.0 respectively, yielding a TFR for the country of 7.6 (ILO, Bachue-Kenya, 1977, Appendix p. 135). The implied sex ratio is unity.

#### Mortality

Rural and urban age-specific death rates are unknown. The number of deaths by age and sex in 1969 for the country as a whole are published by the United Nations (1974, pp. 540-541). However, the number of deaths with ages unknown is very high. They cannot be excluded and are therefore allocated proportionally to the various age groups (Table 3). The total number of deaths is divided by the total population yielding a national mortality schedule of the total population. To disaggregate this schedule into an urban and a rural mortality schedule, it is assumed that urban and rural crude death rates are 14% and 21%, respectively. This implies a national crude death rate of 20%. This disaggregation procedure is the same as the one used for migration. It will be described in the next section. The age-specific urban and rural death rates are given in Table 4. The implied urban and rural life expectancy is about 47 and 44 years respectively. This is below the official national estimates of 49 years, but closer to the 40 to 45 years observed in the 1962 census.

(Central Bureau of Statistics, 1971, p. 1.) Our estimates are therefore somewhat pessimistic.

### Migration

The required migration data consist of annual age-specific rural and urban outmigration rates for the base year. These data are not available. In a recent review Rempel (1976) reports on migration information that can be obtained from the August 24-25 1969 Kenya Census. The census data report for each district and for the nine largest towns the district of birth for males and females and for the age groups. Migration, therefore, is defined as life-time migration. The sum of people born outside the region is a measure of immigration. The census does not provide information on when the move was made. To project multiregional population systems, period-migration data are required, i.e. the number of people who changed residence in a well-defined time-interval must be known. ILO, Bachue-Kenya, reports on the level of migration by age during the 1962-1969 period. Although only net migration rates are available, they have been retained for this study (Table 5). The male migration rates are disaggregated for five-year age groups. The sum of the age-specific migration rates is 0.173, implying a gross-migra-production rate (GMR) of 0.865. The GMR is the area under the migration curve and is equal to the total of the age-specific rates times the age interval (in this case five years). Dividing the reference rates by the GMR yields a migration schedule having the same shape, which implies identical mean ages for each schedule. The problem therefore reduces to finding a GMR which is consistent with the assumed crude migration rates. We assume a net rural outmigration rate of 5 per thousand. The data for 1969 yields about 50,000 migrants. Note that a net rural outmigration rate of 5 per thousand is equivalent to a rural to urban migration rate of 5 per thousand and an urban to rural migration of 0 per thousand.

The crude migration rate from region  $i$  to region  $j$  is the weighted sum of the age-specific migration rates, the weights being the age structure of the population:

$$M_{ij} = \sum_x m_{ij}(x) c_i(x) \quad (1)$$

where  $m_{ij}(x)$  is the migration rate from  $i$  to  $j$  of age group  $x$  to  $x + 4$ .

$c_i(x)$  is the proportion of the population in age group  $x$  to  $x + 4$  in region  $i$ . Equation (1) may be written as

$$M_{ij} = GMR_{ij} \sum_x m_{ij}^u(x) c_i(x)$$

where  $m_{ij}^u(x)$  represents the unitary migration schedule. Assuming that  $M_{ij}$  and  $c_i(x)$  are known, and that  $m_{ij}^u(x)$  is equal to the reference schedule scaled to unit GMR, the  $GMR_{ij}$ , which is consistent with the crude migration rate  $M_{ij}$  is

$$GMR_{ij} = \frac{M_{ij}}{\sum_x m_{ij}^u(x) c_i(x)} \quad (2)$$

The derived values of  $GMR_{ur}$  and  $GMR_{ru}$  are 0.000 and 0.2380, respectively. The estimated migration schedule is given in Table 6.

From the given population distribution and the inferred age-specific rates, numbers of births, deaths and migrants have been computed (Table 7). These data provide the input information for the calculation of the multiregional life table and population projections (Willekens and Rogers, 1976, p.6). Detailed information of urban and rural population and on the total population is given in Table 8. A summary of base-year data is provided in Table 9. (Note our basic assumptions of urban and rural crude death rates of 14 and 21 per thousand and the net rural-urban migration rate of 5 per thousand.) The urban and rural crude birth rates of 58 and 50 per thousand are consistent with the age composition of the population and the prevailing fertility schedule (analogous to equation (1)). The higher urban birth rate is caused by the high proportion of urban population in fertile age groups, relative to the rural population, which has a higher share of children (Table 7b). For example, in urban areas, 36% of the population is between 15 and 30 years old. In the rural areas, only 25% belong to this age category. This difference may be related to migration.



Table 1. Kenya: population by sex, age and region: 1969.

Age	URBAN			RURAL			TOTAL
	Male	Female	Total	Male	Female	Total	Total
0 - 4	84719.	83315.	168034.	1016143.	992407.	2008550.	2176584.
5 - 9	65775.	65002.	130777.	788928.	774279.	1563207.	1693984.
10 - 14	45997.	48037.	94034.	656843.	642171.	1299014.	1393048.
15 - 19	59689.	57518.	117207.	523086.	515289.	1038375.	1155582.
20 - 24	93552.	61245.	154797.	386155.	412727.	798882.	953679.
25 - 29	84733.	43657.	128390.	307257.	346769.	654026.	782416.
30 - 34	66285.	28236.	94521.	253336.	292296.	545632.	640153.
35 - 39	53893.	23041.	76934.	205972.	238518.	444490.	521424.
40 - 44	34165.	14099.	48264.	175809.	197769.	373578.	421842.
45 - 49	27207.	11374.	38581.	140004.	159539.	299543.	338134.
50 - 54	9918.	6159.	16077.	120563.	130354.	250917.	266994.
55 - 59	7584.	4829.	12413.	92196.	102198.	194394.	206807.
60 - 64	5625.	3646.	9271.	68386.	77170.	145556.	154827.
65 +	8334.	5839.	14173.	101314.	123575.	224889.	239062.
<b>TOTAL</b>	647476.	455997.	1103473.	4835992.	5005061.	9841053.	10944526.

Source: ILO, *Bachue-Kenya*, 1977, Appendix, pp 127-128  
Kenya **Population** Census (1969), Vol. I and Vol. II, Nov. 1970

Table 2. Age-specific fertility rates for urban and rural Kenya, 1969.

Age	Births/Women (a)		Births/Total Population (b)	
	Urban	Rural	Urban	Rural
15 - 19	0.1112	0.1112	0.0871	0.0634
20 - 24	0.2423	0.2886	0.1529	0.1714
25 - 29	0.2432	0.2937	0.1319	0.1790
30 - 34	0.1699	0.2590	0.0810	0.1595
35 - 39	0.1185	0.1831	0.0566	0.1129
40 - 44	0.0564	0.1246	0.0263	0.0758
45 - 49	0.0303	0.0619	0.0143	0.0379
Total			0.0550	0.8000
Crude Birth Rate			0.0586	0.0505

(a) ILO, Bachue-Kenya, 1977, Appendix, p 140

(b) Births/total population =  
(a)\* female/(male + female)

Table 3. Deaths in Kenya: 1969: by age and sex.

	Unadjusted (a)		Adjusted (b)		
	Male	Female	Male	Female	Total
0	5606.	4426.	9936.	7258.	17194.
5	326.	352.	578.	577.	1155.
10	163.	114.	289.	187.	476.
15	135.	129.	239.	212.	451.
20	175.	154.	310.	253.	563.
25	203.	157.	360.	257.	617.
30	235.	139.	417.	228.	644.
35	258.	131.	457.	215.	672.
40	278.	125.	493.	205.	698.
45	272.	166.	482.	272.	754.
50	310.	148.	549.	243.	792.
55	243.	96.	431.	157.	588.
60	312.	173.	553.	284.	837.
65	270.	119.	479.	195.	674.
70	269.	149.	477.	244.	721.
75	181.	89.	321.	146.	467.
80	171.	147.	303.	241.	544.
85	279.	220.	495.	361.	855.
UNKNOWN	7482.	4500.			
TOTAL	17168.	11534.	17168.	11534.	28702.

(a) UN Demographic Yearbook, 1974, Table 25, pp 340-341

(b) In the adjusted data, the unknown deaths are allocated proportionally to the various age groups

Table 4. Age-specific mortality rates for urban and rural Kenya, 1969.

Age Group	Urban	Rural	Total
0 - 4	0.050561	0.060549	0.007899
5 - 9	0.004366	0.005226	0.000682
10 - 14	0.002191	0.002618	0.000342
15 - 19	0.002500	0.002990	0.000390
20 - 24	0.003779	0.004523	0.000590
25 - 29	0.005047	0.006047	0.000789
30 - 34	0.006443	0.007716	0.001007
35 - 39	0.008254	0.009879	0.001289
40 - 44	0.010588	0.012677	0.001654
45 - 49	0.014282	0.017099	0.002231
50 - 54	0.018971	0.022741	0.002967
55 - 59	0.018207	0.021796	0.002844
60 - 64	0.034624	0.042420	0.005404
65 +	0.105341	0.126156	0.016459
TOTAL	0.285122	0.341440	0.044546
Crude Rate	0.014000	0.021000	0.020294

Table 5. Reported relative net migration rate to Nairobi by age and sex in 1962 - 1969 period.

Age <sup>(1)</sup>	Percent of Nairobi Net Immigrants 1962-69 <sup>b</sup>		Percent of 1969 Rural Population <sup>c</sup>		Relative Migration Probability	
	Male <sup>(2)</sup>	Female <sup>(3)</sup>	Male <sup>(4)</sup>	Female <sup>(5)</sup>	(6)=(2)/(4) Male	(7)=(3)/(5) Female
0 - 14	19.59	30.16	49.84	47.46	0.39	0.63
15 - 19	14.06	25.54	10.72	10.31	1.31	2.47
20 - 24	34.91	32.34	7.99	8.15	4.37	3.97
25 - 29	21.17	11.68	6.50	6.93	3.26	1.69
30 - 59	9.00	- 0.82 <sup>a</sup>	21.23	22.75	0.42	-0.04 <sup>a</sup>
60+	1.26	1.09	3.73	4.40	0.34	0.25

a The negative value implies net outmigration for this age group

b Nairobi City Council, Nairobi Metropolitan Growth Survey, Table 1.3

c Republic of Kenya, Population Census 1969

Source: ILO, Bachue-Kenya, 1977, Appendix, p 146

Table 6. Age-specific net rural outmigration rates, Kenya, 1969.

Age Group	Net Rural Out-migration Rate (a)	Adjusted Net Rural Outmigration Rate (b)
0 - 4	0.043700	0.012020
5 - 9	0.003900	0.001073
10 - 14	0.003900	0.001073
15 - 19	0.013100	0.003603
20 - 24	0.043700	0.012020
25 - 29	0.032600	0.008967
30 - 34	0.004200	0.001155
35 - 39	0.004200	0.001155
40 - 44	0.004200	0.001155
45 - 49	0.004200	0.001155
50 - 54	0.004200	0.001155
55 - 59	0.004200	0.001155
60 - 64	0.003400	0.000935
65 +	0.003400	0.000935
TOTAL	0.172900	0.047559
Crude Rate		0.005000

(a)

The migration rate in age-group 0 - 4 is taken to be the same as that of age-group 20 - 24, which implies that children move with their parents

(b) Assuming a crude net outmigration rate of 0.005

Table 7. Regional population, births, deaths and migrations, by age.

a. absolute value

REGION URBAN

AGE	POPULATION	BIRTHS	DEATHS	MIGRATION FROM URBAN	RURAL	URBAN TO
0	168034.	0.	8496.	0.	0.	
5	130777.	0.	571.	0.	0.	
10	94034.	0.	206.	0.	0.	
15	117207.	10203.	293.	0.	0.	
20	154797.	23672.	585.	0.	0.	
25	128390.	16937.	648.	0.	0.	
30	94521.	7653.	609.	0.	0.	
35	76934.	4355.	635.	0.	0.	
40	48264.	1268.	511.	0.	0.	
45	38581.	550.	551.	0.	0.	
50	16077.	0.	305.	0.	0.	
55	12413.	0.	226.	0.	0.	
60	9271.	0.	321.	0.	0.	
65	14173.	0.	1493.	0.	0.	
TOTAL	1103473.	64638.	15450.	0.	0.	

REGION RURAL

AGE	POPULATION	BIRTHS	DEATHS	MIGRATION FROM URBAN	RURAL	RURAL TO
0	2008550.	0.	121616.	24143.	0.	
5	1563207.	0.	8170.	1677.	0.	
10	1299014.	0.	3401.	1394.	0.	
15	1038375.	65868.	3105.	3742.	0.	
20	798882.	136924.	3613.	9603.	0.	
25	654026.	117075.	3955.	5865.	0.	
30	545632.	87025.	4210.	630.	0.	
35	444490.	50203.	4391.	514.	0.	
40	373578.	28327.	4736.	432.	0.	
45	299543.	11352.	5122.	346.	0.	
50	250917.	0.	5706.	290.	0.	
55	194394.	0.	4237.	225.	0.	
60	145556.	0.	6029.	136.	0.	
65	224889.	0.	28371.	210.	0.	
TOTAL	9841053.	496774.	206662.	49207.	0.	

b. percentage distribution

REGION URBAN

AGE	POPULATION	BIRTHS	DEATHS	MIGRATION FROM URBAN	URBAN TO RURAL
0	15.2277	0.0000	54.9903	0.0000	0.0000
5	11.8514	0.0000	3.6958	0.0000	0.0000
10	8.5216	0.0000	1.3333	0.0000	0.0000
15	10.6216	15.7848	1.8964	0.0000	0.0000
20	14.0282	36.6224	3.7864	0.0000	0.0000
25	11.6351	26.2029	4.1942	0.0000	0.0000
30	8.5658	11.8398	3.9417	0.0000	0.0000
35	6.9720	6.7375	4.1100	0.0000	0.0000
40	4.3738	1.9617	3.3074	0.0000	0.0000
45	3.4963	0.8509	3.5663	0.0000	0.0000
50	1.4569	0.0000	1.9741	0.0000	0.0000
55	1.1249	0.0000	1.4628	0.0000	0.0000
60	0.8402	0.0000	2.0777	0.0000	0.0000
65	1.2844	0.0000	9.6634	0.0000	0.0000
TOTAL	100.0000	100.0000	100.0000	0.0000	0.0000
M. AGE	22.2713	25.8206	19.7767	0.0000	0.0000

REGION RURAL

AGE	POPULATION	BIRTHS	DEATHS	MIGRATION FROM RURAL	RURAL TO URBAN
0	20.4099	0.0000	58.8478	49.0642	0.0000
5	15.8846	0.0000	3.9533	3.4081	0.0000
10	13.1999	0.0000	1.6457	2.8329	0.0000
15	10.5515	13.2591	1.5025	7.6046	0.0000
20	8.1179	27.5626	1.7483	19.5155	0.0000
25	6.6459	23.5671	1.9138	11.9190	0.0000
30	5.5444	17.5180	2.0371	1.2803	0.0000
35	4.5167	10.1058	2.1247	1.0446	0.0000
40	3.7961	5.7022	2.2917	0.8779	0.0000
45	3.0438	2.2851	2.4784	0.7032	0.0000
50	2.5497	0.0000	2.7610	0.5893	0.0000
55	1.9753	0.0000	2.0502	0.4573	0.0000
60	1.4791	0.0000	2.9173	0.2764	0.0000
65	2.2852	0.0000	13.7282	0.4268	0.0000
TOTAL	100.0000	100.0000	100.0000	100.0000	0.0000
M. AGE	20.3484	27.9948	20.4843	13.3839	0.0000

M Age : Mean Age



Table 8. Total population, births, deaths and migration, by age.

age	population number	births - % - number	deaths - % - number	arrivals - % - number	departures - % - number	birth	observed death	inmig ( x 1000 )	outmig	net mig
0	2176534.	19.89	0.	0.00	130112.	58.58	24143.	49.06	24143.	100.00
5	1693984.	15.48	0.	0.00	8741.	3.94	1677.	3.41	1677.	100.00
10	1333048.	12.73	0.	0.00	3607.	1.62	1394.	2.83	1394.	100.00
15	1155532.	10.56	76071.	13.55	3398.	1.53	3742.	7.60	3742.	100.00
20	953679.	8.71	160596.	28.51	4198.	1.89	9603.	19.52	9603.	100.00
25	782416.	7.15	134012.	23.87	4603.	2.07	5865.	11.92	5865.	100.00
30	640153.	5.85	94678.	16.86	4819.	2.17	630.	1.28	630.	100.00
35	521424.	4.76	54558.	9.72	5026.	2.26	514.	1.04	514.	100.00
40	421842.	3.85	29595.	5.27	5247.	2.36	432.	0.88	432.	100.00
45	338124.	3.09	11902.	2.12	5673.	2.55	346.	0.70	346.	100.00
50	266994.	2.44	0.	0.00	6011.	2.71	290.	0.59	290.	100.00
55	206807.	1.89	0.	0.00	4463.	2.01	225.	0.46	225.	100.00
60	154827.	1.41	0.	0.00	6350.	2.86	136.	0.28	136.	100.00
65	239062.	2.18	0.	0.00	29864.	13.45	210.	0.43	210.	100.00
tot	10344526.	100.00	561412.	100.00	222112.	100.00	49207.	100.00	49207.	100.00
gross crude(x1000)							3.817	0.209	0.209	0.000
m.age e(0)	20.54	27.74	20.44	13.38	13.38		51.296	4.496	4.496	0.000
							30.17	22.28	22.28	0.000
							47.11			
							43.52			



Table 8a. Urban population, births, deaths and migrations, by age.

age	population number - % -	births number - % -	deaths number - % -	arrivals number - % -	birth	observed death rates ( x 1000 )	immig	outmig	net mig
0	103034	15.23	0.	0.00	0.000	30.551	143.679	0.000	143.679
5	130777	11.85	0.	0.00	0.000	4.365	12.523	0.000	12.823
10	94034	8.52	0.	0.00	0.000	2.191	14.524	0.000	14.824
15	117207	10.62	10203	15.78	3742	2.500	31.926	0.000	31.926
20	154797	14.03	23572	36.62	152.923	3.779	62.936	0.000	62.036
25	120390	11.04	10937	25.20	5855	5.047	45.551	0.000	45.681
30	94521	5.57	7053	11.84	630	5.443	6.665	0.000	6.665
35	70934	6.97	4353	6.74	556	8.254	6.691	0.000	6.691
40	48404	4.37	1253	1.95	432	10.538	3.951	0.000	3.951
45	36531	3.50	550	0.85	346	14.282	8.968	0.000	8.963
50	10977	1.46	0.	0.00	14.255	18.971	0.000	0.000	18.038
55	12413	1.12	0.	0.00	0.000	18.207	18.126	0.000	18.126
60	9271	0.84	0.	0.00	0.000	34.624	14.669	0.000	14.669
65	14173	1.20	0.	0.00	0.000	105.341	14.817	0.000	14.817
tot	1103473	100.00	64633	100.00	49207	1.426	2.039	0.000	
gross crude(x1000)					58.577	14.001	44.593	0.000	44.593
age e(0)	22.27	25.82	19.78	13.38	27.53	47.06	22.14	0.00	
					47.51				

Table 8b. Rural population, births, deaths and migrations, by age.

age	population number - % -	births number - % -	deaths number - % -	departures number - % -	birth	observed death rates ( x 1000 )	immig	outmig	net mig
0	2003550	20.41	0.	0.00	0.000	60.549	0.000	12.020	-12.020
5	1553207	15.88	0.	0.00	0.000	5.226	0.000	1.073	-1.073
10	1293014	13.20	0.	0.00	0.000	2.618	0.000	1.073	-1.073
15	1033375	10.55	65358	13.26	63.434	2.990	0.000	3.604	-3.604
20	798882	8.12	136924	27.56	171.395	4.523	0.000	12.021	-12.021
25	634026	6.65	117075	23.57	179.007	6.047	0.000	3.958	-3.958
30	545632	5.54	87025	17.52	159.494	7.716	0.000	1.155	-1.155
35	444490	4.52	50203	10.11	112.945	9.879	0.000	1.156	-1.156
40	373578	3.80	28327	5.70	75.826	12.677	0.000	1.156	-1.156
45	299543	3.04	11352	2.29	37.893	17.099	0.000	1.156	-1.156
50	250917	2.55	0.	0.00	0.000	22.741	0.000	1.157	-1.157
55	194394	1.98	0.	0.00	0.000	21.796	0.000	0.934	-0.934
60	145556	1.48	0.	0.00	0.000	41.420	0.000	0.934	-0.934
65	224869	2.29	0.	0.00	0.000	126.156	0.000	0.934	-0.934
tot	9841053	100.00	496774	100.00	49207	1.707	0.000	0.238	
gross crude(x1000)					50.480	21.000	0.000	5.000	-5.000
age e(0)	20.35	27.99	20.48	13.38	30.41	47.06	0.00	22.40	
					43.17				

Table 9. Base year (1969) population characteristics.

REGION	POPULATION		RATES OF NATURAL INCREASE			INTERNAL MIGRATION RATES			GROWTH RATE
	IN THOU- SAND	PERCENT- AGE	MEAN AGE	BIRTH	DEATH	GROWTH	OUT	IN	NET
URBAN	1103.	10.0824	22.2713	0.058577	0.014001	0.044576	0.000000	0.044593	0.044593
RURAL	9841.	89.9176	20.3484	0.050480	0.021000	0.029480	0.005000	0.000000	0.005000
TOTAL	10945.	100.0000	20.5423	0.051296	0.020294	0.031002	0.004496	0.004496	0.000000

### 3. ASSUMPTIONS FOR PROJECTIONS

The base run assumes that during the projection period there will be no changes in the fertility, mortality and migration trends as discussed in the previous section. Table 10 shows the assumptions of the alternative scenarios. All changes are assumed to be linear in absolute terms over the period 1979-1999. Since the effects of these changes, for example fertility trends, become apparent after an extended time period, the results of the projections are given up to the year 2024.

#### Base Run

The assumptions on fertility, mortality and migration are given in Section 2 and it is assumed that these trends will continue up to the year 2024 (no change scenario).

#### Scenario 1

This is an all change scenario. Fertility (GRR) in the urban areas is assumed to decline linearly by 25% over the period 1979-1999 and then remain constant at this level up to the year 2024. Rural fertility remains unchanged. Infant mortality is assumed to decline linearly by 50% (urban areas) and 25% (rural areas) over the period 1979-1999 and then remain constant at this level up to the year 2024. It should be noted that here infant mortality is defined as the mortality of the age group 0 - 4 years. Therefore, a change in the mortality is measured by a variation in the mortality rate of the 0 - 4 year age group. Rural to urban migration is assumed to increase linearly by 60% over the period 1979-1999, i.e.  $GMR_{ru}$  increases from 0.2380 to 0.3808. This implies an increase of the crude net migration rate to about 0.8%.

This scenario is in a sense a likely one since trend changes in fertility, mortality and migration occur simultaneously. However, it would also be interesting to investigate the individual effect of changes in fertility, mortality or migration. These aspects are considered in the following Scenarios 2 to 6.

### Scenario 2

Fertility in the urban areas is assumed to decline linearly by 25% over the period 1979-1999 and remains constant at this level up to the year 2024. This scenario is relevant since the standard of living in the urban areas is much higher than the rural areas and it is expected that the first decline in fertility is likely to occur in the urban areas. Note that fertility is measured in terms of the gross rate of reproduction (GRR).

### Scenario 3

Fertility in the urban and rural areas is assumed to decline linearly by 25% over the period 1979-1999 and remains constant up to the year 2024. The Government in Kenya gives high priority to the development of the rural areas and it is feasible that with rapid development some fertility decline in the rural areas may be expected.

### Scenario 4

This scenario is concerned with the decline in infant mortality. Infant mortality (mortality rate of age group 0 - 4 years) is assumed to decline linearly by 50% (urban areas) and 25% (rural areas) over the period 1979-1999 and remains constant up to the year 2024. In recent years the rapid and extended development of health services, and in particular child health services, has caused a substantial decline in infant mortality; this trend is likely to continue.

### Scenario 5

As mentioned in Section 2, our assumption of a life expectancy of 47 in the urban areas and 44 in the rural areas is pessimistic in comparison to the published (Kenya Statistical Digest, June 1971) overall life expectancy of about 49 years. In this scenario we assume that life expectancy will increase linearly to 66 years in both the urban and rural areas over the years 1979-1999 and remain constant to the year 2024. It should be noted that a life expectancy of 66 years in 1999 will continue to increase up to the year 2024; for comparison

with other scenarios, however, we have assumed that it remains constant.

Scenario 6

The assumption here is that net rural-urban migration will increase linearly by 60% from  $GMR_{ru} = 0.2380$  in 1979 to  $GMR_{ru} = 0.3808$  in 1999. Due to the present lack of data, only one scenario on migration is presented.





#### 4. RESULTS OF THE PROJECTIONS

The base run and the alternative scenarios show that in the year 1999 Kenya will have a population two and a half to three times as great as her population in 1969. We first discuss the results of Scenarios 2 to 6 together with the base run and then consider the results of Scenario 1, which is the most likely to occur.

Scenario 2 (urban fertility decline) and Scenario 3 (urban and rural fertility decline) show that the total population in the year 2024 is 59.4 million and 45.8 million, respectively. There is a significant decrease compared with the base run projection of 62.9 million. Note that there is a drastic reduction in the growth rates; in the year 2024 the corresponding growth rates are 2.1%, 2.89%, and 3.08%. The figures for the average growth rates in the period 1969 - 2024 are 2.6%, 3.08% and 3.18%. The breakdown of these results for the rural and urban population are shown in Table 11.

The results of Scenario 4 (infant mortality decline) and Scenario 5 (overall mortality decline) show that the population in the year 2024 will be 69.7 million and 77.6 million, respectively. The corresponding average growth rates for the period 1969 - 2024 are 3.37% and 3.56%, respectively. In these scenarios the projected urban population (about 20.5 million for Scenarios 4 and 5) is of the same order, whereas there is a significant difference in the projected rural population (Scenario 4, 49.3 million and Scenario 5, 57.1 million). This occurs because the present level of urbanization in Kenya is low.

The results of Scenario 6 (migration) show that the urban population in the year 2024 will be 22.3 million compared to 17.8 million in the base run. Note that due to rural-urban migration, the average growth rate in the period 1969 - 2024 has decreased to 2.55% from 2.77% (base run) in the rural areas and increased in the urban areas to 5.47% from 5.10% (base run).

Table 11. Results of alternative scenarios:

Projections of:

- A. Population in Thousands and
- B. Annual Growth Rates.

A. POPULATION : TOTAL

	BASE RUN	S C E N A R I O S					
		1	2	3	4	5	6
1969	10945	10945	10945	10945	10945	10945	10945
1974	12789	12789	12789	12789	12789	12789	12789
1979	15019	15019	15019	15019	15019	15019	15019
1984	17658	17693	17629	17426	17724	17842	17656
1989	20745	20851	20647	20009	20962	21342	20738
1994	24341	24544	24103	22747	24830	25771	24318
1999	28544	28875	28063	25616	29485	32031	28493
2004	33453	33931	32662	28940	34984	38280	33356
2009	39200	39865	37999	32653	41537	45706	39034
2014	45918	46813	44162	36707	49363	54572	45650
2019	53744	54898	51244	41070	58674	65114	53328
2024	62866	64292	59397	45804	69730	77614	62240
		<u>B. GROWTH RATES: TOTAL</u>					
1969	3.10	3.10	3.10	3.10	3.10	3.10	3.10
1974	3.15	3.15	3.15	3.15	3.15	3.15	3.15
1979	3.19	3.19	3.19	3.19	3.19	3.19	3.19
1984	3.20	3.23	3.17	2.99	3.26	3.29	3.20
1989	3.16	3.21	3.11	2.78	3.28	3.31	3.16
1994	3.15	3.20	3.05	2.60	3.32	3.32	3.13
1999	3.13	3.19	3.00	2.40	3.37	3.25	3.11
2004	3.13	3.18	2.99	2.39	3.39	3.23	3.10
2009	3.12	3.17	2.99	2.33	3.41	3.22	3.09
2014	3.11	3.15	2.94	2.24	3.41	3.22	3.07
2019	3.10	3.13	2.92	2.15	3.40	3.22	3.05
2024	3.08	3.10	2.89	2.10	3.40	3.20	3.03
Avg. Growth Rate	3.18	3.22	3.08	2.60	3.37	3.56	3.16

A. POPULATION: URBAN

YEAR	BASE RUN	S C E N A R I O S					
		1	2	3	4	5	6
1969	1103	1103	1103	1103	1103	1103	1103
1974	1616	1616	1616	1616	1616	1616	1616
1979	2190	2190	2190	2190	2190	2190	2190
1984	2868	2913	2840	2835	2884	2884	2926
1989	3715	3862	3616	3593	3768	3785	3910
1994	4756	5070	4518	4461	4887	4935	5193
1999	6058	6615	5576	5460	6331	6575	6872
2004	7621	8487	6830	6619	8099	8356	8907
2009	9524	10772	8323	7961	10297	10651	11396
2014	11819	13520	10063	9467	13019	13498	14410
2019	14544	16760	12044	11042	16341	16686	18006
2024	17835	20629	14367	12956	20442	20596	22343

B. GROWTH RATES: URBAN

(NATURAL GROWTH RATE IN PARENTHESES)							
1969	8.92(4.46)	8.92(4.46)	8.92(4.46)	8.92(4.46)	8.92(4.46)	8.92(4.46)	8.92(4.46)
1974	6.57(3.04)	6.57(3.04)	6.57(3.04)	6.57(3.04)	6.57(3.04)	6.57(3.04)	6.57(3.04)
1979	5.61(2.53)	5.61(2.53)	5.61(2.53)	5.61(2.53)	5.61(2.53)	5.61(2.53)	5.61(2.53)
1984	5.13(2.38)	5.42(2.32)	4.98(2.21)	4.92(2.23)	5.22(2.48)	5.18(2.44)	5.48(2.40)
1989	4.93(2.53)	5.33(2.35)	4.64(2.18)	4.53(2.21)	5.09(2.70)	4.99(2.60)	5.46(2.54)
1994	4.85(2.73)	5.26(2.42)	4.42(2.19)	4.28(2.25)	5.08(2.99)	4.90(2.80)	5.46(2.72)
1999	4.63(2.73)	5.07(2.32)	4.07(2.00)	3.89(2.06)	4.96(3.09)	4.60(2.74)	5.30(2.72)
2004	4.44(2.69)	4.80(2.33)	3.93(1.97)	3.71(2.02)	4.78(3.06)	4.43(2.71)	4.98(2.71)
2009	4.28(2.66)	4.56(2.32)	3.77(1.91)	3.47(1.93)	4.64(3.06)	4.26(2.66)	4.71(2.70)
2014	4.15(2.65)	4.34(2.30)	3.60(1.84)	3.23(1.82)	4.54(3.08)	4.12(2.64)	4.50(2.71)
2019	4.09(2.70)	4.19(2.31)	3.53(1.85)	3.10(1.81)	4.49(3.14)	4.12(2.71)	4.36(2.74)
2024	4.02(2.71)	4.05(2.30)	3.47(1.85)	3.02(1.81)	4.41(3.16)	4.09(2.75)	4.21(2.74)
Avg. Growth Rate	5.10	5.32	4.67	4.48	5.31	5.32	5.47

A. POPULATION: RURAL							
YEAR	BASE RUN	S C E N A R I O S					
		1	2	3	4	5	6
1969	9841	9841	9841	9841	9841	9841	9841
1974	11174	11174	11174	11174	11174	11174	11174
1979	12829	12829	12829	12829	12829	12829	12829
1984	14789	14781	14789	14592	14840	14957	14730
1989	17031	16989	17031	16416	17195	17557	16828
1994	19584	19474	19584	18286	19943	20836	19125
1999	22486	22261	22486	20156	23154	25456	21621
2004	25832	25444	25832	22321	26885	29924	24449
2009	29676	29093	29676	24692	31240	35055	27638
2014	34099	33293	34099	27240	36344	41074	31240
2019	39200	38139	39200	29696	42333	48428	35322
2024	45030	43664	45030	32849	49289	57018	39897
B. GROWTH RATES: RURAL							
(NATURAL GROWTH RATE							
IN PARENTHESES							
1969	2.45 (2.99)	2.45 (2.99)	2.45 (2.99)	2.45 (2.99)	2.45 (2.99)	2.45 (2.99)	2.45 (2.99)
1974	2.66 (3.17)	2.66 (3.17)	2.66 (3.17)	2.66 (3.17)	2.66 (3.17)	2.66 (3.17)	2.66 (3.17)
1979	2.78 (3.30)	2.78 (3.31)	2.78 (3.31)	2.78 (3.31)	2.78 (3.31)	2.78 (3.31)	2.78 (3.31)
1984	2.82 (3.35)	2.80 (3.41)	2.82 (3.35)	2.61 (3.14)	2.88 (3.41)	2.92 (3.45)	2.74 (3.35)
1989	2.77 (3.30)	2.73 (3.40)	2.78 (3.30)	2.39 (2.90)	2.89 (3.41)	2.95 (3.47)	2.62 (3.30)
1994	2.74 (3.25)	2.66 (3.40)	2.74 (3.25)	2.19 (2.65)	2.89 (3.40)	2.95 (3.44)	2.50 (3.24)
1999	2.73 (3.24)	2.63 (3.45)	2.73 (3.24)	1.99 (2.49)	2.94 (3.45)	2.91 (3.39)	2.42 (3.24)
2004	2.74 (3.25)	2.64 (3.50)	2.74 (3.25)	2.00 (2.50)	2.95 (3.47)	2.89 (3.37)	2.42 (3.24)
2009	2.75 (3.27)	2.66 (3.49)	2.75 (3.27)	1.97 (2.46)	2.98 (3.50)	2.91 (3.40)	2.42 (3.25)
2014	2.75 (3.26)	2.67 (3.50)	2.75 (3.26)	1.89 (2.38)	3.00 (3.53)	2.93 (3.42)	2.41 (3.24)
2019	2.73 (3.24)	2.66 (3.49)	2.73 (3.24)	1.80 (2.28)	3.00 (3.52)	2.91 (3.39)	2.39 (3.21)
2024	2.71 (3.23)	2.65 (3.48)	2.71 (3.23)	1.74 (2.22)	2.99 (3.51)	2.88 (3.37)	2.37 (3.19)
Avg. Growth Rate	2.77	2.71	2.77	2.19	2.93	3.19	2.55

The above results have shown the effect of independent changes in fertility, mortality and migration. In reality these changes occur simultaneously and hence in the present discussion we consider the results of the "all-change" Scenario, which is the one most likely to occur. Note that in these preliminary results we have restricted the mortality decline to a reduction in infant mortality. We could also consider a decrease in the overall mortality, i.e. an increase in life expectancy. The total projected population in the years 1999 and 2024 will be 28.9 million and 64.3 million, respectively (the base run projection yields 28.5 million and 62.9 million). In spite of a reduction in urban fertility, (rural fertility decline was not considered since in the authors' view, this event is unlikely to occur within the next two decades), the urban population has been growing at an average growth rate of 5.32% in the period 1969-2024, as compared with the base run figure of 5.1%. This is a result of the increased rural to urban migration and the constant fertility in the rural areas. The results of this scenario show that Kenya's population is expected to increase six-fold by the year 2024, and the growth rate in the year 2024 will be 3.1%.

## 5. APPLICATION OF THE PROJECTIONS

As mentioned in the introduction, population projections may be useful for the planning of the needs of Kenya's society in the future. Alternative projections of total population, pre-school age (0 - 4), school-age (5 - 14), active age (15 - 59), persons over 60, dependency ratio, are tabulated in Table 12. It should be noted that in Kenya the active age group is considered to be 15 - 59 years. This is a modification\* of the more usual international assumption of 64 years, as the upper age limit of members of the labour force. Here we will discuss only the result of the all-change Scenario 1.

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\* The modification is based on the different conditions of life expectancy in Kenya, Kenya Statistical Digest, June 1971, pp.4.

Table 12. Results of alternative scenarios:

Total, Rural and Urban Projections (1969, 1999, 2024) of:

- A. Population
- B. Pre-School Age (0- 4)
- C. School Age (5-14)
- D. Active Age (15-59)
- E. Persons 60+
- F. Dependency Ratio.

Base Year (1969) Data			Base Run: No Change in Fertility, Mortality and Migration Trends				SCENARIO 1: Fertility Mortality and Migration trends change				SCENARIO 2: Urban Fertility Decline				SCENARIO 3: Urban and Rural Fertility Decline			
AGE GROUPS	'000		1969		1999		2024		1999		2024		1999		2024		1999	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<b>TOTAL</b>																		
Population	10,945	100.0	28,544	100.0	62,866	100.0	24,544	100.0	28,063	100.0	59,397	100.0	25,616	100.0	45,804	100.0		
Pre-School Age (0 - 4)	2,177	19.9	5,895	20.7	12,842	20.4	5,013	20.4	5,630	20.1	11,728	19.8	4,400	17.2	7,642	16.7		
School Age (5 - 14)	3,087	28.2	7,832	27.4	17,097	27.2	6,910	28.2	7,640	27.2	15,829	26.7	6,587	25.7	11,086	24.2		
Active Age (15 - 59)	5,048	46.1	13,962	48.9	30,899	49.2	11,896	48.5	13,938	49.7	29,811	50.2	13,773	53.8	25,048	54.7		
Persons 60 +	394	3.6	855	3.0	2,028	3.2	725	3.0	855	3.1	2,028	3.4	355	3.3	2,028	4.4		
Dependency Ratio		112.1		104.4		103.5		105.3		101.3		99.2		86.0		82.9		
<b>URBAN</b>																		
Population	1,103	100.0	6,058	100.0	17,835	100.0	5,070	100.0	5,577	100.0	14,367	100.0	5,460	100.0	12,956	100.0		
Pre-School Age (0 - 4)	168	15.2	1,173	19.4	3,370	18.9	897	17.7	908	16.3	2,257	15.7	874	16.0	1,964	15.2		
School Age (5 - 14)	225	20.4	1,632	26.9	4,798	26.9	1,412	27.9	1,440	25.8	3,530	24.6	1,371	25.1	3,061	23.6		
Active Age (15 - 59)	687	62.3	3,078	50.8	9,157	51.3	2,630	51.9	3,054	54.8	8,071	56.2	3,040	55.7	7,422	57.3		
Persons 60 +	23	2.1	175	2.9	509	2.9	130	2.6	175	3.1	509	3.5	175	3.2	509	3.9		
Dependency Ratio		60.6		96.8		94.8		92.7		82.6		78.0		79.6		74.6		
<b>RURAL</b>																		
Population	9,841	100.0	22,486	100.0	45,030	100.0	19,474	100.0	22,486	100.0	45,030	100.0	20,156	100.0	32,849	100.0		
Pre-School Age (0 - 4)	2,009	20.4	4,722	21.0	9,471	21.0	4,116	21.1	4,722	21.0	9,471	21.0	3,526	17.5	5,677	17.3		
School Age (5 - 14)	2,862	29.1	6,200	27.6	12,299	27.3	5,498	28.2	6,220	27.7	12,299	27.3	5,217	25.9	8,025	24.4		
Active Age (15 - 59)	4,600	46.7	10,883	48.4	21,741	48.3	9,266	47.6	10,883	48.4	21,741	48.3	10,667	52.9	17,627	53.7		
Persons 60 +	370	3.76	681	3.03	2,519	3.37	595	3.1	681	3.0	1,519	3.4	681	3.4	1,519	4.6		
Dependency Ratio		113.9		106.6		107.1		110.1		106.8		107.1		88.3		86.4		



Base Year (1969) Data	Base Run: No Change in Fertility, Mortality and Migration Trends				SCENARIO 4: Urban and Rural Infant Mortality Decline				SCENARIO 5: General Mortality Decline				SCENARIO 6: Rural-Urban Migration Increase			
	'000		'000		'000		'000		'000		'000		'000		'000	
	1969	2024	1969	2024	1969	2024	1969	2024	1969	2024	1969	2024	1969	2024	1969	2024
<b>AGE GROUPS</b>	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<b>URBAN</b>																
Population	10,945	100.0	28,544	100.0	29,486	100.0	69,731	100.0	32,031	100.0	77,615	100.0	28,493	100.0	62,241	100.0
Pre-School Age (0 - 4)	2,177	19.9	5,895	20.7	6,158	20.9	14,504	20.8	6,210	19.4	14,854	19.1	5,859	20.6	12,560	20.2
School Age (5 - 14)	3,087	28.2	7,832	27.4	8,378	28.4	19,819	28.4	8,511	26.6	20,355	26.2	7,815	27.4	16,852	27.1
Active Age (15 - 59)	5,048	46.1	13,962	48.9	14,094	47.8	33,380	47.7	14,341	44.8	34,521	44.5	13,964	49.0	30,789	49.5
Persons 60 +	394	3.6	855	3.0	855	2.9	2,028	2.9	2,968	9.3	7,885	10.2	856	3.0	2,000	3.3
Dependency Ratio	112.1		104.4		109.2		108.9		123.2		124.8		104.1		102.2	
<b>RURAL</b>																
Population	1,103	100.0	6,058	100.0	6,332	100.0	20,442	100.0	6,575	100.0	20,596	100.0	6,872	100.0	22,343	100.0
Pre-School Age (0 - 4)	168	15.2	1,173	19.4	1,258	19.9	3,994	19.5	1,212	18.4	3,723	18.1	1,358	19.8	4,255	19.0
School Age (5 - 14)	225	20.4	1,632	26.9	1,788	28.2	5,842	28.6	1,712	26.0	5,384	26.1	1,898	27.6	6,072	27.2
Active Age (15 - 59)	687	62.3	3,078	50.8	3,112	49.1	10,097	49.4	3,117	47.5	9,815	47.7	3,436	50.0	11,429	51.2
Persons 60 +	23	2.1	175	2.9	175	2.8	509	2.5	535	8.1	1,674	8.1	180	2.6	587	2.6
Dependency Ratio	60.6		96.8		103.5		102.5		111.0		109.8		100.0		95.5	
<b>TOTAL</b>																
Population	9,841	100.0	22,486	100.0	23,154	100.0	49,289	100.0	25,457	100.0	57,018	100.0	21,621	100.0	39,897	100.0
Pre-School Age (0 - 4)	2,009	20.4	4,722	21.0	4,900	21.2	10,510	21.3	4,999	19.6	11,131	19.5	4,500	20.8	8,304	20.8
School Age (5 - 14)	2,862	29.1	6,200	27.6	6,591	28.5	13,977	28.4	6,800	26.7	14,971	26.3	5,917	27.4	10,780	27.0
Active Age (15 - 59)	4,600	46.7	10,883	48.4	10,982	47.4	23,283	47.2	11,225	44.1	24,705	43.3	10,528	48.7	19,366	48.5
Persons 60 +	370	3.76	681	3.03	681	2.9	1,519	3.1	2,434	9.6	6,211	10.9	676	3.1	1,453	3.6
Dependency Ratio	113.9		106.6		110.8		111.7		126.8		130.8		105.4		106.1	

## Education

In 1969 the total pre-school age population was 2.2 million and this will increase to 5.0 million in the year 1999 and 12.6 million in the year 2024. The corresponding figures of the school age population are 3.1 million (1969), 7.8 million (1999) and 17.1 million (2024). In other words, government investment in basic education will have to cater to one and a half times and four and a half times the 1969 school age population in the years 1999 and 2024, respectively. Table 13 shows the school enrollment and government expenditure in 1975 and the projections for the years 1999 and 2024. The results show that total government expenditure will have to increase by a factor of about three times in 1999 and by a factor of about seven times in 2024 as compared with the 1975 expenditure; in 1975 the government expenditure on primary and secondary education amounted to 40% of all expenditure on social services including education, health and other social services. The projected government expenditure on education are in rough orders of magnitude. In fact the already implemented government policy of universal free primary education (and a resultant increased demand for secondary education) will require government expenditure higher than that projected in Table 13.

The situation in the urban areas is expected to be even more demanding due to the much higher growth rates of the school age population. The 1976 Statistical Abstract, page 221, gives a figure of 153,120 children (6 - 12 years) in primary school in 1975. The projected school age (6 -14 years) population in the urban areas in 1999 will be 1,412,000 (average annual growth rate of about 9.3% for the period 1975-1999) and in 2024 will be 5,483,000 (average annual growth rate of about 7.3% for the period 1975-2024). The magnitude of the task of providing education for the rural and urban areas is great and long-term planning is crucial if these requirements are to be fulfilled.

Table 13. Education and government expenditure.

	1975	1999	2024	Average Growth Rate 1975-2024
Primary School Enrolment (Age 6 - 12)	2.9 million	5.5 million	11.6 million	2.8%
Secondary School Enrolment (Age 13 - 14)	0.1 million	1.4 million	5.9 million	8.3%
Total School Enrolment	3.0 million	6.9 million	17.7 million	3.6%
Number of Schools: (including 1160 secondary)	9341	21000	54000	3.6%
Average Number/School	330	330	330	
Government Expenditure:				
Primary School	K£43.6 million	K£104.9 million	K£221.3 million	3.3%
Secondary School	K£10.5 million	K£ 30.8 million	K£129.8 million	5.1%
Total Government Expenditure	K£54.1 million	K£135.7 million	K£351.1 million	3.8%

Source: 1977 Economic Survey of Kenya  
1976 Statistical Abstract, Kenya  
Projections Scenario 1

Exchange Rate: 1 U.S. Dollar = 8.31 Shillings, Kenya (31.12.1976)

Assumptions:

1. Secondary school education comprises Forms 1 - 6 and age group 13 - 18. For comparing school age population up to 14 we have assumed secondary education to be equivalent to Forms 1 and 2.
2. In the years 1999 and 2024, 20% and 33% of primary school children will enter secondary school. This compares with 17% of primary school children entering secondary school in 1976/77. Since 1975 primary education in Kenya has been free.
3. The cost of providing per capita primary and secondary education in 1999 and 2024 will be the same as in 1976 (i.e. an underestimate).

## Health Services

Table 14 shows some projections for health services in Kenya. The 1973 figures are derived from the Kenya Statistical Abstracts, 1976. Projections A assume that the proportion per thousand of hospital beds, doctors and nurses in 1999 and 2024 will be the same as in 1973. Projections B are based on an improvement in health services in Kenya. According to WHO publications, in Africa as a whole the number of medical doctors per thousand of the population was 0.125 in 1965. This is higher than the 1973 figure of 0.07 per thousand of the population in Kenya. It should also be noted that a high proportion of the doctors tend to be concentrated in the urban areas in Kenya. These figures can be compared with those of the developed countries: in 1975 the number of doctors per thousand of the population in Europe was 2.5 and in the Soviet Union 3.5; the number of hospital beds in Europe varies from 8 to 12 per thousand of the population. It would, perhaps, be very optimistic to assume that Kenya in the years 1999 and 2024 will reach the level of the present health services in Europe. For this reason we have assumed even lower figures, as shown in Table 14. An analysis of these projections shows that with improved health services Kenya will require a total of 88,750 hospital beds and 14,950 doctors in the year 1999 and 384,100 hospital beds and 77,300 doctors in 2024. This amounts to average growth rates in hospital beds of 7% (for the period 1973 - 1999) and 6% (for the period 1973-2024), and average growth rates in the number of doctors of 11% (for the period 1973 - 1999) and 9% (for the period 1973-2024).

The availability of health services in the rural and urban areas of Kenya by the year 1999 will require substantial investments within the next decade. For example in 1975 the enrollment in the Faculty of Medicine at the University of Nairobi was 569. In order to have available about 36,000 doctors/dentists by the year 1999 entails an annual enrollment increase of 14.3%. In fact the required increase will be about 20% since all that enrol do not necessarily graduate. Hence very large investments for training of medical personnel and health services with early planning is essential to achieve reasonable urban health services in Kenya by the year 1999 and the year 2024.

Table 14. Health services.

	Population	No. of Hospital Beds	Hospital beds per thousand	No. of Doctors / Dentists	No. of Doctors per thousand	Registered Nurses	Registered Nurses per thousand
1973	Rural	11.2 m	10500				
	Urban	1.6 m	4000	892	0.07	4990	0.40
<u>Projections A</u>							
1999	Rural	22.3 m	21000				
	Urban	6.6 m	16500	2023	0.07	9156	0.40
2024	Rural	43.7 m	40641				
	Urban	20.7 m	51750	4508	0.07	25760	0.40
<u>Projections B</u>							
<u>Improved Health Services: Projections Using Scenario 1</u>							
1999	Rural	22.3 m	55750				
	Urban	6.6 m	33000	36125	1.25	72250	2.5
2024	Rural	43.7 m	218500				
	Urban	20.7 m	165600	161000	2.5	322000	5.0

### Employment

In 1975 the total population of Kenya was about 12.8 million and the population of active age was 6.4 million; of this the urban population of active age was 876,000 and the rural population of active age was 5,500,000. In the urban areas\* 387,210 were in wage employment, and about 74,100 were in the urban informal establishments. Of the remaining 414,690, some were receiving higher education (University and Polytechnic 10,000, secondary and higher education 90,000), and the remaining 315,000 were seeking employment and/or were inactive. In the rural areas, 3,720,000 were in the small farm sector, about 150,000 were receiving secondary or higher education, 387,210 were in wage employment and the remaining 1.25 million people were working in the rural non-agricultural sector, in the large farms as pastoralists and seeking employment.

About 60% of the population of active age are working in the small farm sector. Table 15 gives some data on the population, and type of employment and earnings in the small farm sector. The small farm sector is extremely important in that, according to the government plan, in the future a considerable proportion (50%) of the entrants in the labour force will have to find their livelihood in the small farm sector. At the present the farm earnings in this sector are very low (average earnings Kf29.9) and the overall average of Kf49.5 is a result of other employment earnings (31% of total income) and transfers received (15% of total income). In comparison, the earnings from wage employment in Kenya are considerably higher. Table 16 shows the data on wage employment and earnings in the modern sector in Kenya. In 1975, the total wage labour force was 819,086 and this consisted of 53% in the urban areas and 37% in the rural areas. Here again there is a considerable difference in the rural earnings (average earnings Kf98.8) and the urban earnings (average earnings Kf213.5). This wide differential in urban and rural incomes is one of the reasons for the increasing rural to urban migration in Kenya and unless a considerable increase in rural incomes occurs, it is expected that rural to urban migration will

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\* Source: Statistical Abstracts, Kenya, 1976, pp 271 and Economic Survey, Kenya, 1977, pp 40.

increase at rates much higher than the rates assumed in the projections of Scenario 1.

In 1999 the active age of the urban and rural populations in Kenya will be 2.6 million and 9.3 million, respectively. The corresponding figures for the year 2024 are 11.1 million and 20.8 million. This represents a growth in the labour force of 4.5% annually over the period 1975 - 1999 and 5.2% annually over the period 1975 - 2024. In the urban areas and in the rural areas the annual growth rates in the labour force are 2.2% (1975 - 1999) and 2.7% (1975 - 2024). Table 17 shows employment projections for the urban areas. These results show that even if the creation of employment in the urban areas continues at a high rate of 3.5%, those unemployed or inactive will grow from 36% of the urban labour force in 1975, to 46% and 65% of the labour force in 1999 and 2024, respectively.

In the rural areas the situation is worse since agricultural land in Kenya is limited, amounting to 52,047,000 hectares. However only 19.1% (9,942,000 hectares) has medium high agricultural potential whereas the remaining 42 million hectares has low agricultural potential. In 1975 the good agricultural land per person of active age in the rural areas was 1.8 hectares and 0.5 hectares, respectively. Hence there will be a very rapid increase in the employment pressure in the agricultural sector and it is crucial that employment opportunities in the agricultural as well as the non-agricultural sector be created. This is also essential for the large number of unemployed people in the urban areas. In order to fulfill these requirements, an integrated approach to the development of the rural and urban areas is necessary. This is discussed in the next section.

Table 15. Some data on population, employment and earnings in the small farm sector in Kenya, 1974/75.

Total small farm population	10,341,174
Active age small farm population	3,948,661
Total land area of small farms	2,506,900 hectares
Total cultivated land area of small farms	2,506,900 hectares
Per capita land area of small farms	0.33 hectares
Per capita cultivated land area of small farms	0.24 hectares
<u>Total Income of Small Farms</u>	K£195,269,000
Income from farming	K£105,007,000
Income from other (urban) employment	K£ 60,647,000
Income from transfers (e.g. urban remittances)	K£ 29,615,000
Average earnings from farming (Number of people is 3,517,636)	K£ 29.9
Average earnings from other employment (Number of people is 410883)	K£147.6
Average income of active age small farm population	K£49.5
Per capita small farm income	K£ 16
G.N.P. per capita in Kenya	K£ 76

Small Farm Active Age Population

<u>Type of Employment</u>	<u>Number of People</u>
Heads of small farms	1,187,924
Operate another holding	20,142
Labour on another holding	48,339
Other rural work	132,301
*Teaching/Government employment	101,892
*Urban Employment	126,377
Other	1,974
Unpaid family labour on small farms	2,329,712
 TOTAL	 3,948,661

\* Assumed to be wage employment

Source: Integrated Rural Survey (1974/75), Republic of Kenya, 1977



Table 16. Wage employment and earnings in the modern sector in Kenya, Statistical Abstract 1976.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Average Growth Rate 1966-1975	1999 Assuming Same Growth Rates as 1966-1975	1999 Scenario 1 Total Active Age	% Outside Wage Employment
Total Wage Employment	585421	597369	606410	627214	644481	691186	719777	361375	826263	819086	857200	3.7%	2,005,320	11,895,000	83%
Total Urban Wage Employment	282682	297084	303948	302780	303575	322710	348706	354286	386291	387210	-	3.5%	896,900	2,630,000	66%
Total Rural Wage Employment	302739	300285	302462	324434	340906	368476	371071	407089	439972	431876	-	4.0%	1,108,920	9,266,000	88%
Total Wage Earnings (Kfm)	125.6	136.3	144.3	150.1	162.0	185.4	206.9	231.2	274.3	312.3	378.8	10.1%	3,543.7	-	-
Total Urban Wage Earnings (Kfm)	93.6	107.6	110.4	109.8	110.8	129.9	141.4	153.5	185.7	213.5	-	9.2%	1,924.8	-	-
Total Rural Wage Earnings (Kfm)	32.0	28.7	33.9	40.3	51.2	55.5	65.5	77.7	88.6	98.8	-	12.5%	1,618.9	-	-
Average Wage Earnings (Kfm)	214.5	228.2	238.0	239.3	251.4	268.2	287.5	303.7	332.0	381.2	442.0	6.4%	1,766.7	-	-
Average Urban Wage Earnings	331.1	362.2	363.2	362.6	365.0	402.5	404.8	433.3	480.7	551.4	-	5.7%	2,146.1	-	-
Average Rural Wage Earnings	105.7	95.6	112.1	124.2	150.2	150.6	176.5	190.9	201.4	228.8	-	8.6%	1,459.9	-	-

Table 17. Employment projections in urban areas.

<u>URBAN AREAS</u>	1975	1999	2024
Total Active Age Population	876,000	1,600,000	11,100,000
Urban Wage Employed	387,210	896,900	2,151,600
Informal Establishments	74,100	277,400	1,097,000
Higher Education	100,000	232,000	556,000
Unemployed/Inactive	315,000	1,193,700	7,195,400
% Unemployed/Inactive	36%	46%	65%

Assumptions

1. The annual growth rate in wage employment in urban areas in Kenya was 3.5% for the period 1966 - 75.  
This rate of growth is assumed to continue to 2024.
2. Informal establishments are assumed to grow at 5.5% annually over the period 1975 - 1999 and 1975 - 2024.  
This is equivalent to half the growth rate of 11.0% over the period 1974 - 76.
3. The active age population receiving higher education is assumed to grow at 3.5% annually up to 2024.

### Food Demand

The accurate projection of future demand of food commodities is important for the identification of priorities and investment targets for agricultural development, as well as the satisfaction of the basic food demands of the population. This is especially crucial since,

- 1) over 80% of the population resides in the rural areas and is engaged in the agricultural sector,
- 2) there are high and increasing rates of rural-urban migration, and
- 3) there is a wide variation in the demand for specific food commodities in the rural and urban sector due to wide differences in income levels, shifts in preferences, etc.

We will consider the projection of food commodities for three population projections, namely, Scenarios 1,3, and 5 of Section 4.

Here we will use the usual FAO demand projection procedure based on the assertion that population and income are the major shifters of demand. For simplicity we assume that the per capita consumption expenditure of the rural and urban population will grow at 2.2% per annum over the period 1975 to 1999 and 1975 to 2024. This growth rate is the "trend growth rate" as used in the FAO projections for Kenya for the period 1970-1980.

#### Population Projections (Scenarios 1,3,5)

The rural and urban population projections and calorie requirements for the years 1999 and 2024 under the assumption of Scenarios 1,3 and 5 are given in Table 18. The calorie requirements have been estimated from the age structure and activity level of the population and in a similar manner the requirements of other nutrients, namely, proteins, minerals and vitamins can also be calculated.

#### 1975: Base Year Food Consumption

The base year quantity consumption and expenditure elasticities of demand for the main food commodities for the rural and urban population are given in Table 19. These results have been

derived from the Integrated Rural Survey (1974/75), ILO, Bachue-Kenya (1977), and the Urban Food Purchasing Survey (1977).

#### Results of Food Demand Projections

Tables 20 and 21 show rural, urban and total demand for various food commodities in the years 1999 and 2024 respectively. The corresponding growth rates of total demand are given in Table 22. It is also useful to observe the change in the nutritional status of the population and these results are given in Tables 23a and 23b for the projection year 1999 and Tables 24a and 24b for the projection year 2024.

The results show that food demand in Kenya will significantly depend on the population projections as well as the level of urbanization. Note that the assumption of equal growth rate (2.2%) for the rural and urban population is not realistic. In 1975 the ratio of rural to urban incomes was approximately 1 to 4.4. In reality this ratio will change due to different growth rates of the rural and urban economies as well as the government policies. Food demand projections for Kenya under the assumption of various income growth and distribution policies for the rural and urban areas can be found in three forthcoming publications (Shah and Frohberg, forthcoming, and Shah, forthcoming).

Table 18. Population projections and calorie requirements.  
(1975, 1999 and 2024, rural-urban population.)

<u>Population</u>	<u>Population '000</u>	<u>Average Calorie Requirement* per capita per day</u>
1975 Rural	11936	2380
Urban	1634	2250
Total	13570	2370
<u>Population Projection Scenario 1</u>		
1999 Rural	22261	2350
Urban	6615	2260
Total	28876	2330
2024 Rural	43664	2390
Urban	20629	2280
Total	64293	2360
<u>Population Projection Scenario 3</u>		
1999 Rural	20156	2470
Urban	5460	2290
Total	25616	2430
2024 Rural	32849	2470
Urban	12956	2290
Total	45805	2430
<u>Population Projection Scenario 5</u>		
1999 Rural	25456	2390
Urban	6575	2230
Total	32031	2360
2024 Rural	57018	2390
Urban	20596	2230
Total	77614	2360

\* Rural population: Very Active  
Urban population: Moderately Active

Table 19. Rural and urban food consumption and demand elasticities, 1975.

Commodity	Expenditure Elasticities of Demand				Per Capita Food Consumption	
	Rural		Urban		Rural	Urban
	$\eta$	F*	$\eta$	F	kg/year	kg/year
<u>Cereals</u>						
Wheat/Bread	0.8	2	0.53	3	6.6	18.6
Wheat/Flour	0.7	2	0.40	3	3.0	11.5
Rice	0.7	1	0.40	3	1.4	6.1
Maize Flour	0.4	3	-0.05	2	114.2	70.2
Other Cereal Flours	0.4	-3	-0.05	2	18.5	5.9
<u>Starchy Roots</u>						
English Potatoes	0.6	3	0.7	2	20.6	14.7
Other Roots	-0.2	2	-0.1	2	66.0	16.2
<u>Sugar</u>						
Sugar Raw Centre	0.7	3	0.5	3	8.4	16.0
Sugar Cane	0.05	2	-0.2	2	3.2	2.9
<u>Beans</u>	0.8	3	0.4	3	11.3	10.5
<u>Vegetables</u>						
Tomatoes	0.4	2	0.6	3	0.3	2.8
Other Vegetables	0.3	2	0.4	3	17.4	49.9
<u>Fruits</u>						
Bananas	0.2	2	0.7	3	11.5	20.2
Other Fruits	0.4	2	1.0	3	16.4	23.0
<u>Meat</u>						
Beef	1.0	2	0.7	2	6.8	11.9
Other Meat	0.8	2	0.7	2	5.9	6.5
<u>Eggs</u>	1.3	2	1.3	3	0.8	2.1
<u>Milk</u>						
Fresh Milk	0.9	3	0.5	3	46.3	36.7
Processed Milk	0.8	3	0.6	3	2.4	5.0
<u>Fats and Oils</u>						
Butter	1.2	2	1.1	2	0.1	1.7
Vegetable Oils	1.3	2	0.7	2	0.8	2.3
Animal Oils and Fats	1.0	2	0.4	2	0.1	1.9
<u>Spices</u>	0.4	2	0.5	2	0.5	0.9
<u>Stimulants</u>	0.4	2	0.6	2	0.4	1.0
<u>Alcoholic Bev.</u>	0.7	2	1.0	3	3.1	5.1

\* 1 Double-log, 2 Semi-log, 3 log-inverse

Source: M.M. Shah (forthcoming)

Table 20. Rural, urban, and total food demand projections, year 1999 (trend growth (2.2%) of per capita P.C.E., 1975-1999).

	Population Projection Scenario 1			Population Projection Scenario 3			Population Projection Scenario 5		
	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL
CEREALS									
WHEAT									
BREAD	208.9	126.2	335.2	189.2	152.9	342.1	145.1	152.0	297.1
FLOUR	91.4	74.0	165.4	82.8	89.6	172.4	63.5	89.1	152.6
RICE	45.1	39.2	84.3	40.8	47.5	88.4	31.3	47.3	78.6
MAIZE FLOUR	2837.9	479.5	3317.4	2569.6	560.9	3150.5	1970.4	577.4	2547.8
OTHER CEREAL FLOUR	637.3	31.4	668.7	577.1	38.0	615.1	442.5	37.8	480.3
STARCHY ROOTS									
ENGLISH POTATOES	586.5	109.9	696.4	531.0	133.2	664.2	407.2	132.4	539.6
OTHER ROOTS	1314.2	83.8	1398.0	1159.9	101.5	1291.4	912.4	100.9	1013.3
SUGAR									
SUGAR RAW CENTR.	249.2	107.2	356.4	225.6	129.9	355.5	173.0	129.1	302.1
SUGAR CANE	69.4	14.2	83.5	62.8	17.2	80.0	48.2	17.1	65.2
PULSES (BEANS)	349.2	67.6	416.8	316.2	81.8	398.0	242.5	81.3	323.8
VEGETABLES									
TOMATOES	8.1	19.6	27.6	7.3	23.7	31.0	5.6	23.5	29.2
OTHER VEGETABLES	448.7	321.0	769.7	406.2	388.9	795.2	311.5	386.6	698.1
FRUITS									
BANANAS	283.0	147.0	430.0	256.3	178.1	434.3	196.5	177.0	373.5
OTHER FRUITS	442.1	189.3	631.4	400.3	229.3	629.6	307.0	227.9	534.9
MEAT									
BEEF	231.2	89.0	320.2	209.4	107.8	317.2	160.6	107.2	267.7
OTHER MEAT	186.8	48.6	235.4	169.1	58.9	228.0	129.7	58.5	188.2
EGGS	30.0	19.5	49.6	27.2	23.7	50.9	20.8	23.5	44.4
FISH	53.8	50.0	103.8	48.7	60.5	109.3	37.4	60.2	97.5
MILK									
MILK FRESH	1490.7	246.0	1736.7	1349.7	298.0	1647.8	1035.0	296.2	1331.2
MILK OTHER	74.2	34.9	109.1	67.2	42.3	109.5	51.5	42.0	93.5
FATS & OILS									
BUTTER	3.6	14.7	18.3	3.3	17.8	21.1	2.5	17.7	20.2
VEGETABLE OILS	30.0	17.2	47.2	27.2	20.8	48.0	20.8	20.7	41.6
ANIMAL OIL+FATS	3.4	12.6	16.0	3.1	15.2	18.3	2.4	15.1	17.5
SPICES	13.5	6.2	19.7	12.2	7.5	19.7	9.4	7.5	16.8
STIMULANTS	10.8	7.2	18.0	9.8	8.7	18.5	7.5	8.7	16.1
ALCOHOLIC BEV.	94.5	42.5	137.0	85.6	51.5	137.1	65.6	51.2	116.8
POPULATION									
RURAL	22261000.			20156000.			15456000.		
URBAN	5460000.			6615000.			6575000.		
PER CAPITA PCE (1975)									
RURAL	495.			495.			495.		
URBAN	2160.			2160.			2160.		
PER CAPITA PCE (2000)									
RURAL	839.			839.			839.		
URBAN	3662.			3662.			3662.		

Table 21. Rural, urban and total food demand projections, year 2024 (trend growth (2.2%) of per capita P.C.E., 1975-2024.)

	Population Projection Scenario 1			Population Projection Scenario 3			Population Projection Scenario 5		
	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL	RURAL	URBAN	TOTAL
CEREALS									
WHEAT									
BREAD	536.8	341.9	878.6	403.8	544.3	948.1	700.9	543.4	1244.4
FLOUR	229.9	194.0	423.8	172.9	308.9	481.8	300.2	308.4	608.5
RICE	130.0	102.9	232.9	97.8	163.8	261.7	169.8	163.6	333.4
MAIZE FLOUR	6151.3	1105.6	7257.0	4627.7	1760.4	6388.2	8032.6	1757.0	9790.2
OTHER CEREAL FLOUR	1381.5	72.3	1453.8	1039.3	115.2	1154.5	1804.0	115.0	1919.0
STARCHY ROOTS									
ENGLISH POTATOES	1336.3	334.2	1670.5	1005.3	532.1	1537.4	1745.0	531.2	2276.3
OTHER ROOTS	2260.4	187.3	2447.6	1700.5	298.2	1998.7	2951.7	297.7	3249.4
SUGAR									
SUGAR RAW CENTR.	582.1	288.3	870.4	437.9	459.0	897.0	760.1	458.3	1218.4
SUGAR CANE	132.2	29.5	161.7	99.4	46.9	146.4	172.6	46.9	219.5
PULSES (BEANS)	836.4	177.1	1013.6	629.3	282.0	911.3	1092.3	281.6	1373.8
VEGETABLES									
TOMATOES	18.7	53.9	72.6	14.1	85.8	99.9	24.5	85.7	110.2
OTHER VEGETABLES	1005.5	841.7	1847.2	756.5	1340.3	2096.7	1313.0	1338.1	2651.1
FRUITS									
BANANAS	610.4	415.3	1025.7	459.2	661.3	1120.5	797.1	660.2	1457.3
OTHER FRUITS	1024.9	576.4	1601.3	771.1	917.8	1688.8	1338.4	916.3	2254.7
MEAT									
BEEF	617.1	270.5	887.6	464.2	430.7	894.9	805.8	430.0	1235.8
OTHER MEAT	479.8	147.8	627.6	361.0	235.3	596.3	626.6	234.9	861.5
EGGS	83.9	64.1	148.0	63.1	102.1	165.2	109.6	102.0	211.5
FISH	138.3	135.5	273.7	104.0	215.7	319.7	180.5	215.3	395.9
MILK									
MILK FRESH	3661.0	661.3	4322.3	2754.2	1052.9	3807.1	4780.6	1051.3	5831.9
MILK OTHER	177.7	96.2	273.9	133.7	153.2	286.9	232.0	153.0	385.0
FATS & OILS									
BUTTER	10.0	48.1	58.2	7.5	76.7	84.2	13.1	76.5	89.6
VEGETABLE OILS	83.9	52.3	136.2	63.1	83.3	146.4	109.6	83.1	192.7
ANIMAL OIL+FATS	9.1	35.2	44.3	6.8	56.1	62.9	11.8	56.0	67.9
SPICES	31.2	17.9	49.2	23.5	28.6	52.1	40.8	28.5	69.3
STIMULANTS	25.0	21.3	46.3	18.8	34.0	52.8	32.6	33.9	66.6
ALCOHOLIC BEV.	237.5	137.3	374.8	178.7	218.6	397.3	310.2	218.3	528.4
POPULATION									
RURAL	43664000.			32849000.			57018000.		
URBAN	12956000.			20629000.			20596000.		
PER CAPITA PCE (1975)									
RURAL	495.			495.			495.		
URBAN	2160.			2160.			2160.		
PER CAPITA PCE (2000)									
RURAL	1455.			1455.			1455.		
URBAN	6348.			6348.			6348.		





Table 23a. Rural nutrition status, 1975 and 1999.

R U R A L	CONSUMPTION YEAR = 1975				CONSUMPTION YEAR = 1999			
	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL
	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY
CEREALS								
WHEAT	6.6	47.	1.4	0.4	9.4	67.	2.0	0.5
BREAD	3.0	30.	0.9	0.1	4.1	41.	1.2	0.1
FLOUR	1.4	14.	0.3	0.0	2.0	20.	0.4	0.0
RICE	106.2	1046.	27.6	11.3	127.5	1233.	32.5	13.3
MAIZE FLOUR	24.3	228.	6.2	2.0	28.6	268.	7.3	2.4
OTHER CEREAL FLOUR								
STARCHY ROOTS	20.6	40.	0.8	0.1	26.3	51.	1.1	0.1
ENGLISH POTATOES	66.0	199.	1.6	0.2	59.0	178.	1.5	0.2
OTHER ROOTS								
SUGAR	8.4	79.	0.0	0.0	11.2	105.	0.0	0.0
SUGAR RAW CENTR.	3.2	30.	0.0	0.0	3.1	29.	0.0	0.2
SUGAR CANE	11.3	106.	6.8	0.5	15.7	147.	9.5	0.7
PULSES (BEANS)								
VEGETABLES	0.3	0.	0.0	0.0	0.4	0.	0.0	0.0
TOMATOES	17.4	10.	0.7	0.1	22.2	12.	0.8	0.1
OTHER VEGETABLES								
FRUITS	11.5	19.	0.3	0.0	12.7	21.	0.3	0.0
BANANAS	16.4	40.	0.4	0.1	19.9	46.	0.4	0.1
OTHER FRUITS								
MEAT	6.8	35.	2.7	2.6	10.4	54.	4.2	4.0
BEEF	5.9	29.	2.1	2.2	8.4	41.	3.0	3.1
OTHER MEAT	0.8	3.	0.2	0.2	1.3	5.	0.4	0.3
EGGS	1.7	3.	0.5	0.1	2.4	5.	0.7	0.2
FISH								
MILK	46.3	80.	3.9	4.4	67.0	116.	5.7	6.4
MILK FRESH	2.4	4.	0.2	0.2	3.3	6.	0.3	0.3
MILK OTHER								
FATS & OILS	0.1	2.	0.0	0.2	0.2	3.	0.0	0.4
BUTTER	0.8	19.	0.0	2.2	1.3	33.	0.0	3.7
VEGETABLE OILS	0.1	2.	0.0	0.3	0.2	4.	0.0	0.4
ANIMAL OIL+FATS	0.5	5.	0.2	0.0	0.0	0.	0.2	0.3
SPICES	0.4	1.	0.1	0.0	0.5	1.	0.1	0.0
STIMULANTS	3.1	3.	0.0	0.0	4.2	5.	0.0	0.0
ALCOHOLIC BEV.								
TOTAL		2075.	57.0	27.4		2496.	71.6	36.6

Table 23b. Urban nutrition status, 1975 and 1999.

U R B A N	CONSUMPTION YEAR = 1975				CONSUMPTION YEAR = 1999			
	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL
	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY
CEREALS								
WHEAT	18.6	133.	3.9	1.0	23.1	165.	4.9	1.3
BREAD	11.5	115.	3.5	0.4	13.6	135.	4.1	0.5
FLOUR	6.1	61.	1.2	0.1	7.2	71.	1.4	0.1
RICE	90.2	872.	23.0	9.4	67.8	849.	22.4	9.1
MAIZE FLOUR	5.9	55.	1.5	0.5	5.7	54.	1.5	0.5
OTHER CEREAL FLOUR								
STARCHY ROOTS								
ENGLISH POTATOES	14.7	29.	0.6	0.0	20.1	39.	0.6	0.1
OTHER ROOTS	16.2	49.	0.4	0.0	15.3	46.	0.4	0.0
SUGAR								
SUGAR RAW CENTR.	16.0	151.	0.0	0.0	19.6	185.	0.0	0.0
SUGAR CANE	2.9	27.	0.0	0.0	2.6	24.	0.0	0.0
PULSES (BEANS)	10.5	98.	6.4	0.5	12.4	116.	7.5	2.6
VEGETABLES								
TOMATOES	2.8	2.	0.1	0.0	3.6	2.	0.1	0.0
OTHER VEGETABLES	49.9	30.	1.9	0.3	56.6	35.	2.5	0.3
FRUITS								
BANANAS	20.2	33.	0.6	0.1	26.9	44.	0.7	0.1
OTHER FRUITS	25.0	56.	0.5	0.1	34.7	85.	0.8	0.2
MEAT								
BEEF	11.9	62.	4.8	4.6	16.3	85.	6.5	6.3
OTHER MEAT	6.5	32.	2.3	2.4	8.9	43.	3.2	3.3
EGGS	2.1	7.	0.6	0.5	3.6	12.	1.2	0.0
FISH	7.9	16.	2.4	0.6	9.2	18.	2.8	0.7
MILK								
MILK FRESH	36.7	63.	3.1	3.5	45.1	78.	3.6	4.3
MILK OTHER	5.0	8.	0.5	0.4	6.4	11.	0.7	0.5
FATS & OILS								
BUTTER	1.7	33.	0.0	3.8	2.7	53.	0.0	6.0
VEGETABLE OILS	2.3	56.	0.0	6.3	3.1	76.	0.0	8.6
ANIMAL OIL+FATS	1.9	46.	0.0	5.2	2.3	56.	0.0	6.3
SPICES	0.9	8.	0.3	0.4	1.1	11.	0.4	0.5
STIMULANTS	1.0	1.	0.2	0.0	1.3	2.	0.3	0.0
ALCOHOLIC BEV.	5.1	6.	0.0	0.0	7.8	9.	0.0	0.0
TOTAL		2049.	57.8	40.1		2304.	65.5	50.1

Table 24a. Rural nutrition status, 1975 and 2024.

R U R A L	CONSUMPTION YEAR = 1975				CONSUMPTION YEAR = 2024			
	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL
	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY
CEREALS								
WHEAT								
BREAD	6.6	47.	1.4	0.4	12.3	80.	6.6	0.7
FLOUR	3.0	30.	0.9	0.1	5.3	52.	1.0	0.2
RICE	1.4	14.	0.3	0.0	3.0	30.	0.6	0.2
MAIZE FLOUR	106.2	1046.	27.6	11.3	140.9	1382.	35.7	14.7
OTHER CEREAL FLOUR	24.3	228.	6.2	2.0	31.6	296.	6.1	2.6
STARCHY ROOTS								
ENGLISH POTATOES	20.6	40.	0.8	0.1	30.6	60.	1.3	0.1
OTHER ROOTS	66.0	199.	1.6	0.2	51.8	156.	1.3	0.1
SUGAR								
SUGAR RAW CENTR.	0.4	79.	0.0	0.0	13.3	126.	0.0	0.0
SUGAR CANE	3.2	30.	0.0	0.0	3.0	29.	0.0	0.0
PULSES (BEANS)	11.3	106.	6.8	0.5	19.2	179.	11.0	0.9
VEGETABLES								
TOMATOES	0.3	0.	0.0	0.0	0.4	0.	0.0	0.0
OTHER VEGETABLES	17.4	10.	0.7	0.1	23.0	14.	0.9	0.1
FRUITS								
BANANAS	11.5	19.	0.3	0.0	14.0	23.	0.4	0.0
OTHER FRUITS	16.4	40.	0.4	0.1	23.5	57.	0.9	0.1
MEAT								
BEEF	6.8	35.	2.7	2.6	14.1	74.	5.7	5.5
OTHER MEAT	5.9	29.	2.1	2.2	11.0	54.	3.4	4.1
EGGS	0.8	3.	0.2	0.2	1.9	6.	0.3	0.4
FISH	1.7	3.	0.5	0.1	3.2	6.	1.0	0.2
MILK								
MILK FRESH	46.3	80.	3.9	4.4	83.8	145.	7.1	6.0
MILK OTHER	2.4	4.	0.2	0.2	4.1	7.	0.4	0.3
FATS & OILS								
BUTTER	0.1	2.	0.0	0.2	0.2	4.	0.0	0.5
VEGETABLE OILS	0.8	19.	0.0	2.2	1.9	47.	0.0	5.3
ANIMAL OIL+FATS	0.1	2.	0.0	0.3	0.2	5.	0.0	0.6
SPICES	0.5	5.	0.2	0.2	0.7	7.	0.2	0.3
STIMULANTS	0.4	1.	0.1	0.0	0.6	1.	0.1	0.0
ALCOHOLIC BEV.	3.1	3.	0.0	0.0	5.4	6.	0.0	0.0
TOTAL		2075.	57.0	27.4		2833.	63.7	44.8

Table 24b. Urban nutrition status, 1975 and 2024.

U R B A N	CONSUMPTION YEAR = 1975				CONSUMPTION YEAR = 2024			
	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL	PER CAPUT DEMAND	CALORIE LEVEL	PROTEIN LEVEL	FAT LEVEL
	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY	KG/Y	CAL/DAY	GMS/DAY	GMS/DAY
CEREALS								
WHEAT	18.6	133.	3.9	1.0	26.4	189.	5.5	1.4
BREAD	11.5	115.	3.5	0.4	15.0	149.	4.5	0.5
FLOUR	6.1	61.	1.2	0.1	7.9	79.	1.5	0.1
RICE	90.2	872.	23.0	9.4	85.3	825.	21.7	8.9
MAIZE FLOUR	5.9	55.	1.5	0.5	5.6	52.	1.4	0.5
OTHER CEREAL FLOUR								
STARCHY ROOTS	14.7	29.	0.6	0.0	25.8	50.	1.1	0.1
ENGLISH POTATOES	16.2	49.	0.4	0.0	14.5	44.	0.4	0.0
OTHER ROOTS								
SUGAR	16.0	151.	0.0	0.0	22.3	210.	0.0	0.0
SUGAR RAW CENTR.	2.9	27.	0.0	0.0	2.3	21.	0.0	0.0
SUGAR CANE	10.5	98.	6.4	0.5	13.7	126.	6.3	0.6
PULSES (BEANS)								
VEGETABLES	2.8	2.	0.1	0.0	4.2	2.	0.1	0.0
TOMATOES	49.9	30.	1.9	0.3	65.0	39.	2.5	0.4
OTHER VEGETABLES								
FRUITS	20.2	33.	0.6	0.1	32.1	53.	0.9	0.1
BANANAS	23.0	56.	0.5	0.1	44.5	106.	1.0	0.2
OTHER FRUITS								
MEAT	11.9	62.	4.8	4.6	20.9	199.	6.4	8.1
BEEF	6.5	32.	2.3	2.4	11.4	56.	4.1	4.2
OTHER MEAT	2.1	7.	0.6	0.5	5.2	17.	1.4	1.1
EGGS	7.9	16.	2.4	0.6	10.5	21.	3.2	0.8
FISH								
MILK	36.7	63.	3.1	3.5	51.0	88.	4.3	4.9
MILK FRESH	5.0	8.	0.5	0.4	7.4	13.	0.6	0.6
MILK OTHER								
FATS & OILS	1.7	33.	0.0	3.8	3.7	73.	0.1	8.2
BUTTER	2.3	56.	0.0	6.3	4.0	98.	0.0	11.1
VEGETABLE OILS	1.9	46.	0.0	5.2	2.7	66.	0.0	7.5
ANIMAL OIL+FATS	0.9	8.	0.3	0.4	1.4	13.	0.4	0.6
SPICES	1.0	1.	0.2	0.0	1.6	2.	0.4	0.0
STIMULANTS	5.1	6.	0.0	0.0	10.6	12.	0.0	0.0
ALCOHOLIC BEV.								
TOTAL		2049.	57.8	40.1		2516.	72.0	60.0

## 6. URBANIZATION IN KENYA AND SOME IMPLICATIONS

Table 25 gives some data on past and projected urbanization in Kenya. In 1969 the cities of Nairobi and Mombasa accounted for 70% of the urban population in Kenya. At this time the major part of the modern sector (industry) was located in these two urban centres and hence these two cities were the major choice of the rural-urban migrants. The policy of the Government of Kenya is to develop (industrialize) other towns (Nakuru, Kisumu, Thika and Eldoret) and official projections for the population of these towns for 1980 are shown in the table. We have assumed that beyond 1980, the growth rates of Nairobi and Mombasa will be 4.5% and the growth rates of the remaining four towns will be 4%. This assumption is based on the consideration that beyond 1980 the urban facilities in the four towns will be at a level sufficient to attract industrial development and hence absorb a significant share of the rural-urban migrants. Also note that the high growth rates in the government urban population projections up to 1980 have not been used since these growth rates represent a government policy that rapidly develops specific urban centres (see Table 25) and over a longer time horizon we have assumed lower growth rates; the use of the official high growth rates of the urban centres would lead to an urban population of 8 million in 1999 whereas the projected urban population in 1999 is about 5 million.

From Table 25 it can be seen that the distribution of the urban population in the various centres is as follows:

<u>% of Urban Population</u>	<u>1948</u>	<u>1962</u>	<u>1969</u>	<u>1980</u>	<u>1999</u>	<u>2024</u>
Nairobi and Mombasa	70.3	78.5	69.9	70.2	71.6	54.3
Main Urban Centres (6)	85.1	92.9	80.4	84.7	84.0	62.6
Remaining Towns (11)	14.9	7.1	19.6	15.3	16.0	37.4

The distribution of the urban population as shown above is such that the urban centres and towns are spread throughout the country. One possible path of development would be to treat the 6 urban centres as mainly industrial centres and the remaining 11 towns as agricultural centres (e.g. some agro-processing, storage and

Table 25. Urbanization in Kenya (population '000).

	1948*	1962*	1969*	1980*	% Annual Growth* Rate 1969 - 80	Assumed % Annual Growth 1980 - 99	SCENARIO 1	
							1999	2024
Urban Population	276	671	1082	2200	6.5%	5.2%	5070	20629
% of Total Population	5.1	7.8	9.9	15.1	-	-	20.7	32.1
NAIROBI	119	347	509	1098	7.0	4.5	2581	7953
MOMBASA	75	180	247	447	5.4	4.5	1051	3238
NAKURU	18	38	47	79	4.7	4.0	169	459
KISUMU	11	24	33	124	12.0	4.0	265	721
THIKA	4	14	18	50	9.3	4.0	107	291
ELDORET	8	20	18	42	7.7	4.0	90	244
TOTAL: 6 Towns (Main Urban Centres)	235	623	870	1863	6.9	-	4263	12906
Other 11 Towns (+ 2000 people)	41	48	212	337	4.2	-	807	7723

\*Source: 1974 - 78 Development Plan, Republic of Kenya and  
Scenario 1 Projections

marketing of agricultural products etc). This decentralized urban development is extremely important in that these centres could supply the services (employment, health, education, marketing etc.) for the surrounding rural population.

In many countries in Africa and Latin America there has been a phenomenal growth in urban population in recent years and typically this urbanization has meant the growth of a limited number of urban centres. In contrast, the past urbanization in Europe has been characterized by growth rates lower than those encountered in many developing countries but at the same time the urbanization has been very much deconcentrated. In most developing countries the high growth in the urban population is due to the very high rates of rural to urban migration which is not only leading to serious socio-economic problems in the urban areas but also is draining a significant part of the more able population in the rural areas. The gap in the living standards in the rural and urban areas is ever widening. At present the level of urbanization in many countries in Africa is below 20% and hence if development is to reach the mass of the population then an integrated rural development strategy (including development of urban centres in predominantly rural areas) is crucial.

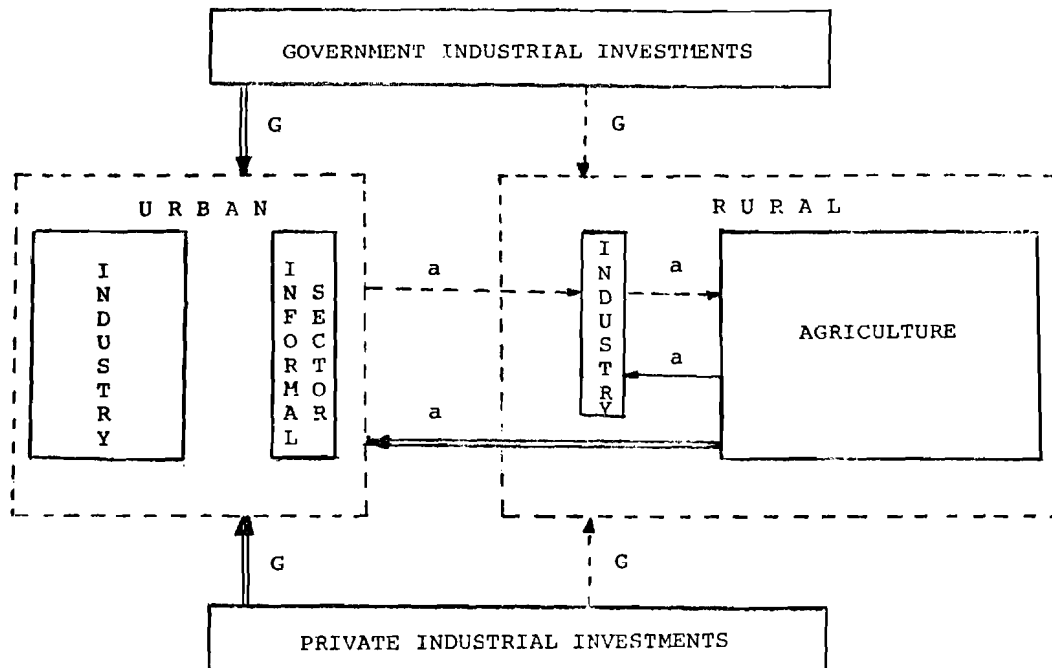
In Kenya in 1999 the urban population is expected to be between 5.07 million (Scenario 1) and 6.87 million (Scenario 6) people. Of this, about 72% will reside in Nairobi and Mombasa if the current trend continues. Less than 30% will live in the many other urban centres of population above 2,000. The government policy in Kenya is aimed at decentralized urbanization and here two basic questions are relevant.

1. How is it possible to allocate the urban population to the urban centres of various sizes? Which system of cities or urban hierarchy is optimal (the urban policy problem)?
2. Is the projected rate of urban growth desirable? If not, how can the urbanization process be curtailed? As mentioned before, this would require a greater emphasis on rural development (the rural policy problem).

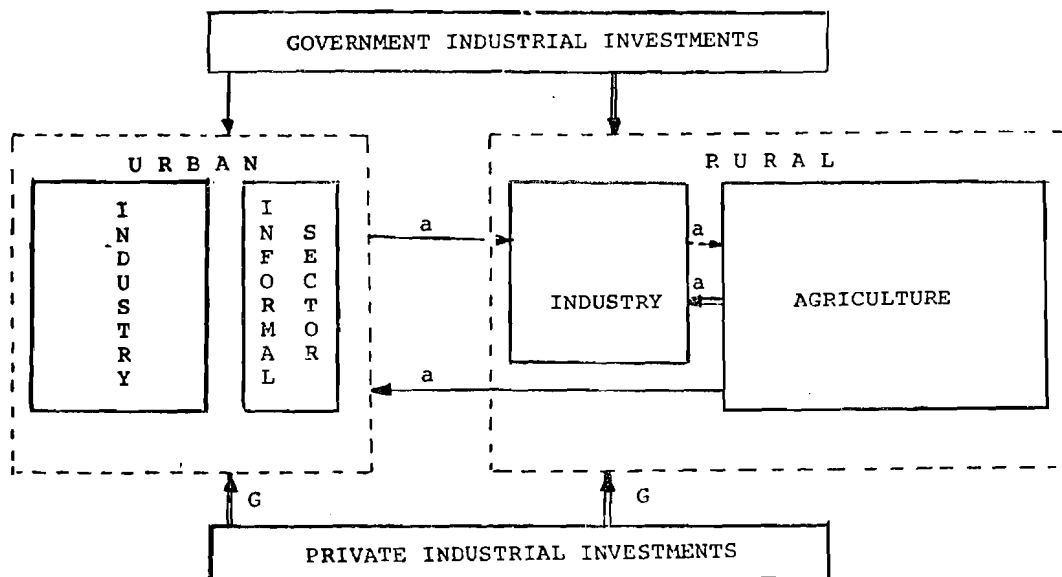


The rural and urban policy problems are not independent. Rural development may be enhanced by the creation of small towns with an industrial sector based on the existing agricultural activity. These small centres may on the other hand contain public facilities serving the population of the surrounding rural area. Therefore, integrated rural development and decentralized urbanization or deconcentration (concentration of urban development in regional and local centres) are closely related.

This interdependence is illustrated in Figure 1. The rural areas contain agricultural and industrial activities. The urban areas contain industry and an informal sector. The diagram shows two types of mobility. Geographical mobility or migration between rural and urban areas and sectoral mobility between agriculture and industry. The relatively undeveloped nonagricultural sector in rural areas explains the fact that most off-farm migration (sectoral mobility) coincides with leaving the rural areas (geographical mobility). To find alternative employment opportunities, people must move to urban areas and, as a consequence, they aggravate the urban problem. The development of a broader industrial basis in rural areas may relieve the urban problem by limiting rural outmigration. This may be associated with decentralized urbanization. It could even induce a flow in the opposite direction, from urban to rural areas (return migration). However, this development process can only materialize if both government and private industrial investments stop being urban-biased and open up nonagricultural opportunities in rural areas. This also implies a greater emphasis on sectoral mobility within rural areas than can be found in the recent literature on development.



1a. Concentrated Urbanization



1b. Deconcentrated Urbanization

———→ Major Flow  
 ———→ Intermediate Flow  
 - - - - -→ Minor Flow  
 a: Population Flow  
 G: Investment Flow

Figure 1. Integrated urban and rural development.

## 7. CONCLUSION

The objective of this paper was to provide alternative projections of rural and urban populations of Kenya and to trace the impact of alternative population growth paths on education, employment and demand for food and health services. Rural and urban areas are treated as components of an interconnected two-region population system. Demographic projections for both areas are performed simultaneously, by applying the methodology of multiregional demography. However, lack of data, in particular migration data, did not permit us to make full use of this recent methodology. For example, net migration rates were used in this report, although gross migration rates would yield better results. The estimation of gross migration rates from survey and census data and a more detailed treatment of fertility and mortality data will be considered at a later date.

Although the focus of this paper has been on alternative demographic projections, the place of these projections in overall development planning has been discussed. Section 6 of the paper addressed some important issues which have to be dealt with in order to solve the urban problem and to promote a self-sustaining rural development in developing countries. However, much more research is needed to prepare consistent policies. Some suggestions for priority research are listed below:

1. Migration research: analysis of sectoral and geographical mobility for integrated rural development with particular emphasis on
  - a. agricultural development (rural to rural migration),
  - b. deconcentrated urban development (rural to local urban centres-migration),

2. the economics of urbanization in a developing country where the level of urbanization is still low (<20%) with reference to
  - a. economics of agglomeration (optimal city size),
  - b. the effect of the development of local urban centres on surrounding rural areas,
3. industrial development research: relevance of industrial development in rural areas; the main issues are:
  - a. the composition of industry and whether industry in the rural areas should serve primarily the agricultural sector or not, whether it should be small scale, labor intensive or the like,
  - b. the attraction of industry and its incentives and facilities to attract private investments into new industrial centres located in the rural areas.

The above mentioned topics are relevant to the issues of development and in particular, rural development and urbanization. An integrated interdisciplinary approach is crucial, not only for understanding the dynamics of the above mentioned topics, but also for planning in these areas.

## APPENDIX

### PROJECTION PROCEDURE

The projection procedure adapted in this study differs from conventional procedures that project populations by region. The urban and rural populations are projected simultaneously, using the multiregional growth model developed by Rogers (1973, 1975). The growth model is described in the first section of the Appendix. Section 2 presents a general review of the multiregional life table, which underlies the projection model, and of some other interesting demographic statistics. The final section compares the multiregional demographic growth model with other methods for regional population projection.

### The Multiregional Growth Model

The multiregional demographic growth model has been developed by Rogers (1973, 1975) as a generalization of the Leslie (1945) model or cohort-survival model. This generalization is simplified by using matrix notations.

Denote the number of people in urban and rural areas at time  $t$  and aged  $x$  to  $x + h$  by  $\{\tilde{K}^{(t)}(x)\}$ :

$$\{\tilde{K}^{(t)}(x)\} = \begin{bmatrix} K_u^{(t)}(x) \\ K_r^{(t)}(x) \end{bmatrix} . \quad (B1)$$

In this paper we consider five-year age groups, i.e.  $h = 5$ . The multiregional population projection is to determine how  $\{\tilde{K}^{(t)}(x)\}$  for all  $x$ , changes over time. We consider first the projection of the population already alive at time  $t$ , and next the projection of the births and the subsequent children in the zero to four-year age group.

### Population Alive at Time t

The people aged  $x$  to  $x + 4$  at time  $t$  can survive, migrate within the country, emigrate or die in the unit interval\*.

Denote by  $s_{ru}^{(t)}(x)$  the proportion of the people in rural areas and  $x$  to  $x + 4$  years old at time  $t$ , who survive to be  $x + 5$  to  $x + 9$  years old five years later at time  $t + 1$  and are then in the urban areas. Equivalently,  $s_{uu}^{(t)}(x)$  denotes the proportion of the people  $x$  to  $x + 4$  years old who remain in the urban areas. Ignoring immigration, the number of people of age  $x + 5$  to  $x + 9$  in urban areas at time  $t + 1$  is given by

$$K_u^{(t+1)}(x+5) = s_{uu}^{(t)}(x) K_u^{(t)}(x) + s_{ru}^{(t)}(x) K_r^{(t)}(x) \quad (B2)$$

Note that  $s_{uu}^{(t)}(x)$  includes in principle the persons who left urban areas but returned in the same time interval. For projection purposes the complete migration history of an individual is not important, but the places of residence at the beginning and at the end of the projection interval are. Equation (B2), written for the rural areas yields

$$K_r^{(t+1)}(x+5) = s_{ur}^{(t)}(x) K_u^{(t)}(x) + s_{rr}^{(t)}(x) K_r^{(t)}(x) \quad (B3)$$

Expressions (B2) and (B3) may be combined in the matrix operation:

$$\begin{bmatrix} K_u^{(t+1)}(x+5) \\ K_r^{(t+1)}(x+5) \end{bmatrix} = \begin{bmatrix} s_{uu}^{(t)}(x) & s_{ru}^{(t)}(x) \\ s_{ur}^{(t)}(x) & s_{rr}^{(t)}(x) \end{bmatrix} \begin{bmatrix} K_u^{(t)}(x) \\ K_r^{(t)}(x) \end{bmatrix}$$

$$\{K^{(t+1)}(x+5)\} = \tilde{S}^{(t)}(x) \{K^{(t)}(x)\} \quad (B4)$$

---

\* The projection interval is assumed to be the same as the age interval, i.e. five years. The superscript  $t$  refers to the time period and not to the exact year.

The matrix of survivorship proportions  $\tilde{S}^{(t)}(x)$  may be derived directly from observed age-specific mortality and migration rates. In general, however, it is derived from the multiregional life table. The computation procedure will be discussed later.

### Births

The children of 0 - 4 years at time  $t+1$  are born during the unit projection interval. Let  $F_u^{(t)}(x)$  and  $F_r^{(t)}(x)$  be the annual birth rate of people aged  $x$  to  $x + 4$  in urban and rural areas respectively. It is assumed that children, born in the unit time interval  $(t, t+1)$ , are born in the region of residence of the parents at time  $t$ . The number of births in urban areas at  $t$  to people aged  $x$  to  $x + 4$  is

$$B_u^{(t)}(x) = F_u^{(t)}(x) K_u^{(t)}(x) \quad . \quad (B5)$$

The multiregional distribution of births is

$$\{\tilde{B}^{(t)}(x)\} = \tilde{F}^{(t)}(x) \{\tilde{K}^{(t)}(x)\}$$

where

$$\{\tilde{B}^{(t)}(x)\} = \begin{bmatrix} B_u^{(t)}(x) \\ B_r^{(t)}(x) \end{bmatrix} \quad \text{and} \quad \tilde{F}^{(t)}(x) = \begin{bmatrix} F_u^{(t)}(x) & 0 \\ 0 & F_r^{(t)}(x) \end{bmatrix} .$$

The number of births during the five-year period starting at  $t$  to people aged  $x$  to  $x + 4$  is

$$\{\tilde{B}^{(t,t+1)}(x)\} = \int_0^h \tilde{F}^{(t)}(x+t) \{\tilde{K}^{(t)}(x+t)\} dt \quad .$$

The integral equation may be approximated by the linear interpolation:

$$\begin{aligned} \{\tilde{B}^{(t,t+1)}(x)\} &= \frac{5}{2} [\tilde{F}^{(t)}(x) \{\tilde{K}^{(t)}(x)\} + \tilde{F}^{(t+1)}(x+5) \{\tilde{K}^{(t+1)}(x+5)\}] \\ &= \frac{5}{2} [\tilde{F}^{(t)}(x) + \tilde{F}^{(t+1)}(x+5) \tilde{S}^{(t)}(x)] \{\tilde{K}^{(t)}(x)\}. \end{aligned}$$

Of these births, only a fraction will be in urban and rural areas at the end of the time interval, i.e. at  $t+1$ , and then be members of the first age group. Denote these fractions by the matrix

$$\hat{\tilde{P}}^{(t)} = \begin{bmatrix} \hat{p}_{uu}^{(t)} & \hat{p}_{ru}^{(t)} \\ \hat{p}_{ur}^{(t)} & \hat{p}_{rr}^{(t)} \end{bmatrix} \quad (B6)$$

where an element  $\hat{p}_{ij}^{(t)}$  is the proportion of babies born in region  $i$  during time interval  $(t, t+1)$ , who survive and are in region  $j$  at the end of the time interval. This matrix takes into account the migration of children in the first age group.

Writing

$$\tilde{B}^{(t)}(x) = \frac{5}{2} \hat{\tilde{P}}^{(t)} [\tilde{F}^{(t)}(x) + \tilde{F}^{(t+1)}(x+5) \tilde{S}^{(t)}(x)] ,$$

the population in the first age group at time  $t+1$  is

$$\{\tilde{K}^{(t+1)}(0)\} = \sum_x \tilde{B}^{(t)}(x) \{\tilde{K}^{(t)}(x)\} . \quad (B7)$$

The summation is over all the fertile age groups. If  $\bar{\alpha}$  and  $\bar{\beta}$  are respectively the lowest and the highest age group of the reproductive period, then the summation is from  $\bar{\alpha}$  to  $\bar{\beta}$ .



# The Complete Growth Model

The two equation systems (B4) and (B7) describe the growth of a multiregional population. Both systems may be combined into a single matrix expression of an extremely simple form:

$$\{K(t+1)\} = G(t) \{K(t)\} , \quad (B8)$$

where

$$\{K(t)\} = \begin{bmatrix} \{K^{(t)}(0)\} \\ \{K^{(t)}(5)\} \\ \vdots \\ \{K^{(t)}(x)\} \\ \vdots \\ \{K^{(t)}(z)\} \end{bmatrix}$$

and

$$G(t) = \begin{bmatrix} 0 & 0 & B^{(t)}(\bar{\alpha}) & \cdots & B^{(t)}(\bar{\beta}) & 0 & \cdots & 0 & 0 \\ \tilde{s}^{(t)}(0) & 0 & & & & & & \vdots & \vdots \\ 0 & \tilde{s}^{(t)}(5) & & & & & & \vdots & \vdots \\ \vdots & & \ddots & & & & & \vdots & \vdots \\ 0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \tilde{s}^{(t)}(z-5) & 0 \end{bmatrix} \quad (B8')$$

with  $z$  being the last age group. The matrix  $G(t)$  is called the generalized Leslie matrix (Feeney, 1973, p. 36; Rogers, 1975, p. 123).

If the growth matrix is constant in time, then the population growth model may be written as:

$$\{K^{(t)}\} = G^t \{K^{(0)}\} , \quad (B9)$$

with  $\{K^{(0)}\}$  the base year population.

## Estimation of the Survivorship Proportions

### The Multiregional Life Table

The multiregional life table is a table expressing the mortality and migration history of hypothetical regional populations (birth cohorts), as they age. The multiregional life table was developed by Rogers (1975, Chapter 2) and is a fundamental concept of multiregional demography. It contains several interesting demographic statistics derived from observed age-specific rates of mortality and migration. The most important life table statistic is the life expectancy. For projections, the relevant statistics consist of the survivorship proportions. In this section, we will describe in general terms the multiregional life table and the derivation of  $\tilde{S}(x)$ . We drop the time-superscript for convenience.

The life table functions are derived from a set of age-specific mortality and migration rates. These rates are arranged in a particular matrix  $\tilde{M}(x)$ . Let  $M_{ij}(x)$  denote the annual rate of migration from  $i$  to  $j$  of age group  $x$  to  $x + 4$ , and let  $M_{i\delta}(x)$  be the annual age-specific death rate in region  $i$ . Then

$$\tilde{M}(x) = \begin{bmatrix} M_{u\delta}(x) + M_{ur}(x) & -M_{ru}(x) \\ -M_{ur}(x) & M_{r\delta}(x) + M_{ru}(x) \end{bmatrix} \quad (B10)$$

The mortality and migration experience of a birth cohort in the life table are expressed in terms of probabilities. Let  $\hat{\ell}_{ij}(x)$  denote the probability that a person born in region  $i$  will be in region  $j$  at exact age  $x$ . The set of possible probabilities in a two-region system (urban-rural) is contained in the matrix  $\hat{\ell}(x)$ :

$$\hat{\ell}(x) = \begin{bmatrix} \hat{\ell}_u^u(x) & \hat{\ell}_u^r(x) \\ \hat{\ell}_r^u(x) & \hat{\ell}_r^r(x) \end{bmatrix} .$$

For example,  $\hat{\ell}_{ur}(x)$  denotes the probability that a person born in the urban area will be in the rural area at age  $x$ . The diagonal element  $\hat{\ell}_{uu}(x)$  is the probability that he is born in the urban area and is there at age  $x$ . Note that this does not imply that he has always been in the urban area. He may have spent some time in rural areas before reaching age  $x$ . The matrix  $\hat{\ell}(x)$  tells something about the regions of residence of a person at two points in time.

Assuming that the probabilities of survival and of migrating at a certain age only depend on the region of residence at that age and are independent of previous residences, then  $\hat{\ell}(x)$  may be written as the product of conditional probabilities:

$$\hat{\ell}(x) = \hat{P}(x-5) \hat{P}(x-10) \dots \hat{P}(y) \dots \hat{P}(0) ,$$

where

$$\hat{P}(y) = \begin{bmatrix} p_{uu}(y) & p_{ru}(y) \\ p_{ur}(y) & p_{rr}(y) \end{bmatrix}$$

and an element  $p_{ij}(y)$  denotes the probability that a person of region  $i$  and  $y$  years old will survive and be in region  $j$  five years later (age interval). Note that  $p_{ij}(y)$  is a conditional probability.

The matrix of conditional probabilities  $\hat{P}(y)$  is computed from observed or estimated age-specific rates (Rogers and Ledent, 1976)

$$\hat{P}(y) = [\hat{I} + \frac{5}{2} \hat{M}(y)]^{-1} [\hat{I} - \frac{5}{2} \hat{M}(y)] . \quad (B11)$$

Therefore, the matrix  $\hat{\ell}(x)$ , in terms of the observed rates is:

$$\hat{\ell}(x) = \prod_{y=x-5}^0 [I + \frac{5}{2} M(y)]^{-1} [I - \frac{5}{2} M(y)].$$

The number of people at exact age  $x$  and their regional distribution is easily derived. If the regional birth cohorts are contained in the diagonal of the diagonal matrix  $\ell(0)$ , then the number of people of age  $x$  by place of birth and place of residence is

$$\ell(x) = \hat{\ell}(x) \ell(0).$$

The definition of  $\ell(x)$  leads to the problem of computing the number of people in age group  $x$  to  $x + 4$ , by place of birth and place of residence  $L(x)$ :

$$L(x) = \begin{bmatrix} u^{L_u}(x) & r^{L_u}(x) \\ u^{L_r}(x) & r^{L_r}(x) \end{bmatrix},$$

where an element  ${}_iL_j(x)$  denotes the number of people in region  $j$  and aged  $x$  to  $x + 4$ , who were born in region  $i$ . The matrix  $L(x)$  is given by

$$L(x) = \int_0^5 \ell(x+t) dt = [ \int_0^5 \hat{\ell}(x+t) dt ] \ell(0).$$

Assuming a uniform distribution of outmigrations and deaths over the five-year age interval, we may evaluate the integral by linear

interpolation:

$$L(x) = \frac{5}{2} [\underline{\ell}(x) + \underline{\ell}(x+5)].$$

This formula is of course equivalent to  $\underline{L}(x) = \frac{5}{2} [\underline{I} + \underline{P}(x)] \hat{\underline{\ell}}(x) \underline{\ell}(0)$ . Aggregating  $\underline{L}(x)$  over all ages gives the total number of people that would evolve if the mortality and migration rates of an observed population are applied to regional birth cohorts. This population is called the life table population. It is a stationary (zero growth) population, since deaths are equal to births. The age distribution of this stationary population is given by  $\underline{L}(x)$ . Expressing this distribution in relative terms; namely, in unit births, we have  $\hat{\underline{L}}(x) = \underline{L}(x) \underline{\ell}^{-1}(0)$ .

Now we are able to derive the matrix of survivorship proportions defined in (B4), and to define  $\underline{P}$  of (B6) in terms of life table statistics. Recall that an element  $s_{ij}(x)$  of  $\underline{S}(x)$  denotes the proportion of individuals aged  $x$  to  $x+4$  in region  $i$ , that survives to be  $x+5$  to  $x+9$  years old five years later and are then in region  $j$ . The matrix  $\underline{S}(x)$  relates the population in one age group to the population in the previous age group:

$$\underline{S}(x) = \underline{L}(x+5) \underline{L}^{-1}(x). \quad (B12)$$

Recently, it has been shown that  $\underline{S}(x)$  may be expressed directly in terms of the matrices of observed age-specific rates (Ledent, 1978):

$$\underline{S}(x) = [\underline{I} + \frac{5}{2} \underline{M}(x+5)]^{-1} [\underline{I} - \frac{5}{2} \underline{M}(x)] \quad (B13)$$

for  $x < z-5$ .

and for,  $x = z-5$

$$\underline{S}(z-5) = \frac{1}{5} \underline{M}^{-1}(z) [\underline{I} - \frac{5}{2} \underline{M}(z-5)]. \quad (B14)$$

Recall that the matrix  $\hat{\tilde{P}}$  of (B6) contains the proportions of children born in the unit time interval that survives until the end of the interval or beginning of the next interval. In the life table population  $\tilde{L}(0)$  is the number of children in the first age group and  $\tilde{\ell}(0)$  is the number of births. Hence the proportion of the births that survives to become members of the first age group is

$$\begin{aligned}\hat{\tilde{P}} &= \frac{1}{5} \tilde{L}(0) \tilde{\ell}^{-1}(0) = \frac{1}{2} [\tilde{I} + \tilde{P}(0)] \tilde{\ell}(0) \tilde{\ell}^{-1}(0) \\ &= \frac{1}{2} [\tilde{I} + \tilde{P}(0)] \quad .\end{aligned}\tag{B15}$$

Finally, we derive a most interesting life table statistic; namely, the expectation of life. The life expectancy at age  $x$  is the average number of years remaining to a person of exact age  $x$ . In multiregional demography, the life expectancy is disaggregated by place of residence. It is the sum of conditional probabilities:

$$\tilde{r}_e(x) = \left[ \int_x^\omega \hat{\tilde{\ell}}(t) dt \right] \hat{\tilde{\ell}}^{-1}(x) .\tag{B16}$$

$$\tilde{r}_e(x) = \begin{bmatrix} \tilde{r}_{eu}(x) & \tilde{r}_{er}(x) \\ \tilde{r}_{eu}(x) & \tilde{r}_{er}(x) \\ \tilde{r}_{eu}(x) & \tilde{r}_{er}(x) \end{bmatrix} .\tag{B17}$$

An element  $\tilde{r}_{ij}(x)$  denotes the average remaining number of years spent in region  $j$  by a person living in region  $i$  and  $x$  years of age. It denotes the life expectancy by place of current residence and place of future residence. Expression (B16) is evaluated as follows \*:

$$\tilde{r}_e(x) = \left[ \sum_{y=x}^z \tilde{L}(y) \right] \tilde{\ell}^{-1}(x) .\tag{B18}$$

---

\*Note that  $\tilde{L}(y)$  denotes on the one hand the number of people in age group  $y$  to  $y + 4$  by place of birth and place of residence and on the other hand the average number of years lived by the birth cohorts between ages  $x$  and  $x + 5$  by region of residence and region of birth.

The life expectancy may also be expressed by place of birth instead of place of current residence. Define the diagonal matrix  $\bar{\ell}(x)$  within the diagonal the elements of the vector  $\{1\}' \ell(x)$ , i.e. the total number of people at exact age  $x$  by place of birth. The life expectancy matrix by place of birth is

$$b_e(x) = \left[ \sum_{y=x}^z L(y) \right] \bar{\ell}^{-1}(x) \quad . \quad (B19)$$

Note that for age 0,  $r_e(0) = b_e(0)$

Table A1 gives the multiregional life table for rural-urban Kenya. The total life expectancy of a person born in the urban areas is 47.51 years on the average, whereas for a rural-born person it is 43.59 years. Note that the expectation of life of an urban-born only depends on the age-specific mortality rates of the urban areas since no migration out of these areas is assumed. Therefore, a person born in urban areas will spend his whole lifetime there. The life expectancy of a rural-born person, on the other hand, depends not only on rural mortality rates, but also is affected by urban rates since an average rural-born person spends some time in urban areas\*. Table A1 shows that of the total average lifetime of 43.59 years, 6.34 years are expected to be lived in urban areas. This implies a migration level of

$$2^{\Theta}_1 = \frac{2^{e_1}(0)}{2^e(0)} = 0.1454.$$

In other words, about 15% of a rural-born person's lifetime is expected to be lived in urban areas. During this time, he experiences the demographic behavior (age-specific rates) of the urban population.

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\*Recall the assumption that the mortality, fertility and migration behavior of a person is determined by his place of residence at the time the event takes place.

### Related Statistics

The multiregional life table pictures the demographic meaning of observed schedules of mortality and migration. It applies the observed age-specific rates to a set of regional cohorts. The interesting feature of the life table is that its statistics only depend on the age-specific rates and are independent of the age and regional distribution of the observed population. From these age-specific rates, a population is generated by age and region. It is distributed according to  $\tilde{L}(x)$  and is uniquely determined by the age-specific rates of mortality and migration. A convenient way of expressing  $\tilde{L}(x)$  in relative terms, is in unit births:  $\hat{\tilde{L}}(x)$ . Note that  $\sum_x \hat{\tilde{L}}(x)$  is the life expectancy matrix at birth. It also denotes the number of people in the multiregional population system by place of residence and place of birth in terms of unit births.

The matrices  $\hat{\tilde{L}}(x)$  of the multiregional life table express a relative age and regional composition of a population that is uniquely determined by the schedules of mortality and migration. It is the life table population, free of the effect of the distribution of the observed population. To this life table population, we may apply the observed fertility schedule. The matrix  $\phi(x) = \tilde{F}(x) \hat{\tilde{L}}(x)$  is the generalized net maternity function (Rogers, 1975, p. 93). The sum of  $\phi(x)$  over all ages is the net reproduction rate matrix:

$$\tilde{NRR} = \sum_x \phi(x) = \sum_x \tilde{F}(x) \hat{\tilde{L}}(x) \quad (B20)$$

where

$$\tilde{NRR} = \begin{bmatrix} {}_uNRR_u & {}_rNRR_u \\ {}_uNRR_r & {}_rNRR_r \\ \hline {}_uNRR_{\cdot} & {}_rNRR_{\cdot} \end{bmatrix} \quad (B21)$$

The total  ${}_iNRR_{\cdot}$  denotes the expected number of children to be born to a parent born in region  $i$ . Some children,  ${}_iNRR_i$ , will be born in the region of birth of the parent and some,  ${}_iNRR_j$ , will be born in region  $j$ . The matrix  $\tilde{NRR}$  is the multiregional analogue of the net rate of reproduction. It not only gives the expected number of descendents but also where they will be born.



Table A1. Multiregional (two-region) life table: urban and rural Kenya.\*

age	q(x,1)	p(x,1,1)	p(x,2,1)	l(x,1,1)	l(x,2,1)	ll(x,1,1)	ll(x,2,1)	m(x,2,1)	md(x,1)	s(x,1,1)	s(x,2,1)	e(x,1,1)	e(x,2,1)
0	0.224437	0.775563	0.000000	100000	0.	4.43891	0.00000	0.000000	0.050561	0.864164	0.000000	47.51	0.00
5	0.021595	0.978405	0.000000	77556	0.	3.83595	0.00000	0.000000	0.004366	0.983697	0.000000	55.53	0.00
10	0.010594	0.989406	0.000000	75831	0.	3.77341	0.00000	0.000000	0.002191	0.988346	0.000000	51.70	0.00
15	0.012422	0.987578	0.000000	75055	0.	3.72944	0.00000	0.000000	0.002500	0.984450	0.000000	47.25	0.00
20	0.018719	0.981281	0.000000	74123	0.	3.67144	0.00000	0.000000	0.003779	0.978209	0.000000	42.81	0.00
25	0.024921	0.975079	0.000000	72735	0.	3.59144	0.00000	0.000000	0.005047	0.971730	0.000000	38.58	0.00
30	0.031734	0.968295	0.000000	70922	0.	3.43991	0.00000	0.000000	0.006443	0.964001	0.000000	34.50	0.00
35	0.040432	0.959555	0.000000	68674	0.	3.36427	0.00000	0.000000	0.008254	0.954111	0.000000	30.55	0.00
40	0.051573	0.948427	0.000000	65897	0.	3.20939	0.00000	0.000000	0.010588	0.939370	0.000000	26.73	0.00
45	0.063947	0.931053	0.000000	62499	0.	3.01720	0.00000	0.000000	0.014282	0.920632	0.000000	23.05	0.00
50	0.080551	0.909439	0.000000	58189	0.	2.77773	0.00000	0.000000	0.018971	0.911102	0.000000	19.57	0.00
55	0.087070	0.912930	0.000000	52920	0.	2.53080	0.00000	0.000000	0.018207	0.878445	0.000000	16.27	0.00
60	0.103329	0.896671	0.000000	48312	0.	2.22316	0.00000	0.000000	0.034524	1.734251	0.000000	12.58	0.00
65	1.000000	0.000000	0.000000	40615	0.	3.85552	0.00000	0.000000	0.105341	0.000000	0.000000	9.49	0.00

age	q(x,2)	p(x,2,2)	p(x,1,2)	l(x,2,2)	l(x,1,2)	ll(x,2,2)	ll(x,1,2)	m(x,1,2)	md(x,2)	s(x,2,2)	s(x,1,2)	e(x,2,2)	e(x,1,2)
0	0.261934	0.692873	0.045163	100000	0.	4.23218	0.11291	0.012020	0.060549	0.805886	0.031864	37.24	6.36
5	0.025734	0.963992	0.005224	69237	4516.	3.41056	0.23242	0.001073	0.003226	0.975252	0.005270	44.72	8.46
10	0.013000	0.981713	0.005283	67139	4781.	3.32625	0.24651	0.001073	0.002618	0.974704	0.011393	41.15	8.36
15	0.014819	0.967555	0.017616	65911	5034.	3.24211	0.28163	0.003634	0.002990	0.944455	0.037041	37.00	8.12
20	0.022235	0.920569	0.057176	63773	6182.	3.06202	0.39734	0.012021	0.004523	0.923960	0.050133	32.92	7.84
25	0.027530	0.927643	0.042677	58708	9712.	2.82919	0.54219	0.003953	0.006047	0.941583	0.024738	29.18	7.43
30	0.037832	0.956610	0.005553	54460	11976.	2.66311	0.59685	0.001155	0.007716	0.931572	0.005524	25.80	6.84
35	0.043131	0.946306	0.005513	52097	11899.	2.53491	0.59003	0.001156	0.003979	0.939906	0.005464	22.62	6.17
40	0.061412	0.933143	0.005445	49293	11705.	2.38257	0.57635	0.001156	0.012677	0.923280	0.005366	19.57	5.50
45	0.081956	0.912711	0.005333	46003	11369.	2.19978	0.55501	0.001155	0.017099	0.900553	0.005241	16.65	4.84
50	0.107540	0.887254	0.005206	41933	10831.	1.93104	0.52249	0.001156	0.022741	0.839232	0.005225	13.93	4.21
55	0.103304	0.891461	0.005235	37254	10069.	1.76161	0.48639	0.001157	0.021796	0.852362	0.004493	11.36	3.60
60	0.187509	0.803503	0.003638	33210	9387.	1.50153	0.43319	0.000934	0.041420	1.407062	0.016903	8.48	2.85
65	1.000000	0.000000	0.000000	26851	8020.	2.11274	0.78011	0.000934	0.126156	0.000000	0.000000	6.06	2.24

1 = urban  
2 = rural.

\* Explanation of column headings: see next page.

Table A1 (continued)

$q(x,i):$	probability of dying in region $i$ for an individual at exact age $x$ , before reaching age $x + 5$ .
$p(x,j,i):$	probability that an individual at age $x$ in region $i$ will be in region $j$ at age $x + 5$ , five years later.
$l(x,j,i):$	number surviving at exact age $x$ in region $j$ , of 100,000 born in region $i$ . This is also the probability that a baby born in region $i$ , will survive and be in region $j$ at exact age $x$ , multiplied by 100,000.
$ll(x,j,i):$	total years lived between ages $x$ to $x + 5$ in region $j$ , per unit born in region $i$ .
$m(x,j,i):$	age-specific migration rate from region $i$ to $j$ (equal to observed value).
$md(x,i):$	age-specific death rate in region $i$ (equal to observed value).
$s(x,j,i):$	proportion of people in region $i$ and aged $x$ to $x + 4$ , who will survive to be in region $j$ and aged $x + 5$ to $x + 9$ , five years later.
$e(x,j,i):$	part of expectation of life of $i$ -born people at age $x$ , that will be lived in region $j$ , i.e. the average number of years lived in region $j$ by $i$ -born people, subsequent to age $x$ , (life expectancy by place of birth).

The NRR for Kenya is:

Table A2. Net reproduction rate matrix for Kenya.

Place of Birth of Children	Place of birth of Parents	
	Urban	Rural
Urban	1.960224	0.261599
Rural	0.000000	2.212129
Total	1.960224	2.473727

The table shows that of the average of 2.47 children born per rural-born person, 0.26 or 10.6% are born in urban areas.

The growth matrix ( $B_8'$ ), derived from the multiregional life table and the observed fertility rates is illustrated in Table A3. Note that the survivorship proportions are identical as those in Table A1.

Table A3. The multiregional growth matrix.

AGE	<u>REGION URBAN</u>		<u>REGION RURAL</u>	
	FIRST ROW		FIRST ROW	
	URBAN $b_{11}$	RURAL $b_{12}$	URBAN $b_{21}$	RURAL $b_{22}$
0	0.000000	0.000000	0.000000	0.000000
5	0.000000	0.000000	0.000000	0.000000
10	0.190954	0.000000	0.000000	0.000000
15	0.527333	0.000000	0.025291	0.476774
20	0.625811	0.000000	0.033691	0.712679
25	0.467406	0.000000	0.023029	0.696583
30	0.300814	0.000000	0.015765	0.564931
35	0.181270	0.000000	0.010718	0.389814
40	0.088051	0.000000	0.006426	0.234498
45	0.031641	0.000000	0.002139	0.080196
50	0.000000	0.000000	0.000000	0.000000
55	0.000000	0.000000	0.000000	0.000000
60	0.000000	0.000000	0.000000	0.000000
AGE	SURVIVORSHIP PROPORTIONS		SURVIVORSHIP PROPORTIONS	
	URBAN	RURAL	URBAN	RURAL
	$s_{11}$	$s_{12}$	$s_{21}$	$s_{22}$
0	0.864164	0.000000	0.031864	0.805886
5	0.983697	0.000000	0.005270	0.975252
10	0.988347	0.000000	0.011393	0.974704
15	0.984449	0.000000	0.037041	0.944455
20	0.978209	0.000000	0.050133	0.923960
25	0.971730	0.000000	0.024738	0.941583
30	0.964001	0.000000	0.005524	0.951572
35	0.954111	0.000000	0.005464	0.939906
40	0.939970	0.000000	0.005366	0.923280
45	0.920632	0.000000	0.005241	0.900563
50	0.911102	0.000000	0.005225	0.889232
55	0.878445	0.000000	0.004495	0.852362
60	1.734251	0.000000	0.016908	1.407062

$b_{ij}(x)$ : proportion of babies born in region  $i$  to mothers of  $x$  to  $x + 4$  years old, that survives and that is in region  $j$  at the end of the time interval.

$s_{ij}(x)$ : proportion of people in region  $i$  and  $x$  to  $x + 4$  years old at time  $t$ , that survives to be  $x + 5$  to  $x + 9$  years old five years later at time  $t + 1$  and is then in region  $j$ .

The Multiregional Approach Compared with Conventional Approaches

In its report "Methods for Projections of Urban and Rural Population", the United Nations (1974) reviews a number of projection techniques.

The methods differ in consideration of the sex-age composition of the population and of the components of demographic change.

The four approaches to rural-urban population projection are given in Table A4:

Table A4. Rural-urban demographic projection techniques.

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Level of Detail		
<u>Method</u>	<u>Sex-Age Composition</u>	<u>Components of Demographic Change</u>
Global Methods	-	-
Composite Methods	+	-
Component methods	-	+
Cohort-survival method	+	+

The cohort-survival method is endorsed by the UN because

...it becomes possible to compare the demographic consequences of alternative assumptions regarding each of the component factors of urban and rural population change: initial size and sex-age composition of the urban and rural population; urban and rural fertility and its incidence by age groups of women; urban and rural mortality and its incidence by groups of sex and age; and rural-to-urban population transfers, whether by migration or area reclassification, their volume and sex-age composition. Valid comparisons on the results of modification of any one of these factors are possible only if the projections are calculated on the basis of such detail (United Nations, 1974, p. 82).

The method adopted in this report is an improvement and multiregional extension of the cohort-survival method. The major differences are the following:

(i) The two regions (urban and rural) are treated simultaneously. They are connected by origin-destination specific gross migration flows (in this report, net flows are considered because of lack of data). The advantage is that the effects on urban areas of changes in rural areas, say, are explicit and direct. The cohort-survival model treats both urban and rural regions as separate entities only indirectly connected.

(ii) The survivorship proportions, which enter the demographic growth matrix, are derived from a multiregional life table. Although survivorship proportions may be derived directly from the data (the so-called Option 2 method, Rogers, 1975), their pattern of change with age is much less regular and the results obtained are relatively unstable.

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