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MANUAL VIII

Methods for Projections of Urban and Rural Population

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Methods for Projections of Urban and Rural Population

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FOREWORD

Pursuant to the recommendations of the Population Commission, the United Nations Secretariat has been preparing several manuals describing methods of demographic analysis, estimation and projection needed for economic and social policy purposes and suitable for use in many countries, including those where demographic statistics and methods of analysis are not yet well advanced. Some of those manuals deal with the analysis and evaluation of basic statistics, notably those of population censuses, and others are concerned with the projection of various population quantities which are needed in diverse fields of economic and social planning. This manual, concerned with the projection of urban and rural population, is part of this longer-range programme.

The following manuals have been published so far in the *Manuals on Methods of Estimating Population* series:

Manual I: Methods of Estimating Total Population for Current Dates; [1]

Manual II: Methods of Appraisal of Quality of Basic Data for Population Estimates; [2]

Manual III: Methods for Population Projections by Sex and Age; [3]

Manual IV: Methods of Estimating Basic Demographic Measures from Incomplete Data; [4]

Manual V: Methods of Projecting the Economically Active Population; [5]

Manual VI: Methods of Measuring Internal Migration; [6]

Manual VII: Methods of Projecting Households and Families; [7] and, related to this series,

Methods of Analysing Census Data on Economic Activities of the Population. [8]

[1] United Nations publication, Sales No. 52.XIII.5.

[2] United Nations publication, Sales No. 56.XIII.2.

[3] United Nations publication, Sales No. 56.XIII.3.

[4] United Nations publication, Sales No. 67.XIII.2.

[5] United Nations publication, Sales No. E.70.XIII.2 (in co-operation with the ILO).

[6] United Nations publication, Sales No. E.70.XIII.3.

[7] United Nations publication, Sales No. 73.XIII.2.

[8] United Nations publication, Sales No. E.69.XIII.2.

Also, within the context of this coherent and cumulative programme, two other publications should be mentioned; namely, *Estimating Future School Enrolment in Developing Countries, a Manual of Methodology*, published jointly by the United Nations and UNESCO, [9] and a technical report entitled *The Concept of a Stable Population: Application to the Study of Populations of Countries with Incomplete Demographic Statistics*, [10] which presents the theoretical background of part of the aforementioned *Manual IV*.

In this manual, projections of urban and rural population are dealt with on the assumption that methods of projection of a country's total population, or its total population by groups of sex and age, are already known, and that such projections have in fact already been carried out. Those methods have been dealt with in *Manual III* of the present series. It is also assumed here that the reader is somewhat familiar with the appraisal of accuracy in basic statistics, a subject developed at some length in the previous *Manual II*.

This manual has been drawn up especially with a view to its uses in less developed countries or countries whose population statistics are not very detailed. It is addressed mainly to population analysts possessing limited technical means, and it does not consider the possible uses of computer methodology. The methods are accordingly simple, but, depending on opportunities, may be elaborated further.

The United Nations is indebted to the Demographic Research and Training Centre (CELADE) in Santiago, Chile; the United States Bureau of the Census; K. V. Ramachandran of the Regional Institute for Population Studies in Accra, Ghana; and D. Courgeau of the Institut National d'Etudes Démographiques in Paris for their review of the draft of this manual, and the many useful suggestions which have been incorporated in its final version.

[9] United Nations publication, Sales No. 66.XIII.3.

[10] United Nations publication, Sales No. 65.XIII.3.

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INTRODUCTION

Although the concept of urban as distinct from rural places has existed since ancient times, urban and rural classifications were introduced into the compilations of European population statistics only during the nineteenth century.[1] Most of the statistics then available on an international basis, including many countries of the world, were compiled and discussed at the end of the nineteenth century by Adna Ferrin Weber.[2] Although some very famous cities had arisen even in ancient times,[3] most cities were relatively small at the opening of the nineteenth century, and the bulk of the world's population was for the most part rural. In 1800 it is estimated that there were only about 750 places with 5,000 or more inhabitants in the world, and that these places contained only 3 per cent of the world's population.[4] The number of cities with 100,000 or more inhabitants in 1800 may have been only 45. By contrast, a recent compilation lists 1,777 places with 100,000 or more inhabitants in the world in 1970.[5] The percentage of the world's population which is now urban is approximately 37,[6] and by the end of this century the world is expected to be at least half urban.[7] Moreover, the absolute quantities of both urban and rural populations have been swelled by the rapid rate of total population increase since 1800. It has become evident that rising levels of urbanization pose increasing problems in the fields of economic, social, administrative and physical development, and in the maintenance of environmental quality, which have to be investigated with reference to current and future estimates of urban and rural population.

USES AND APPLICATIONS OF URBAN AND RURAL POPULATION PROJECTIONS

Many detailed planning problems have arisen in connexion with the huge increases in both urban and rural population and the large transfers of population from rural to urban areas. As a minimum, it has become necessary to be able to estimate and to project, in each country, the total urban and rural populations. For many purposes there is the further need to anticipate what the sex and age compositions of urban and rural populations will be, as these factors affect greatly such things as the need for schools and services for children, jobs, housing, medical facilities and so on for the working-age population; the need for special services and facilities for the elderly; and many other important necessities of various age groups. In this context, Shryock and Siegel have suggested that in many instances it would often be sufficient to project urban and rural population at least in the following age categories: under 15, 15-44, 45-64, and 65 and over,[8] identifying approximately the school population, the child-bearing population, the potential labour force population and the elderly population. They took note that projections have often been prepared in considerable age detail (usually in five-year intervals), when the quality of the data available does not permit an accurate projection in great detail, and the intended users of the projections may not require it.

However, where suitable data are available, it may often be useful to calculate the projection in greater detail than is intended for the purposes of an efficient presentation of results. In some instances, results of a projection by five-year age groups may have to be further interpolated with respect to single years relevant for instance to school enrolment, voting rights or old-age pensions. Likewise, there may be a need for projections to be presented for individual calendar-year intervals, though the projection was originally calculated by time intervals of five years. Again, the required results may be obtained by interpolation with respect to time.

Educational, occupational, residential and public-service requirements are usually quite different in urban as contrasted with rural areas, on the one hand because of the differences in physical, as well as economic and social, environment; and on the other hand because of different sex and age compositions and different population distri-

[1] Henry S. Shryock and Jacob S. Siegel, *The Materials and Methods of Demography* (Washington, D.C., United States Bureau of the Census, 1971), vol. I, p. 151.

[2] See his *The Growth of Cities in the Nineteenth Century* (Ithaca, New York, Cornell University Press, 1963). Originally published in 1899 for Columbia University by the Macmillan Company, New York, as volume XI of *Studies in History, Economics and Public Law.*

[3] See, for example, Wolf Schneider, *Babylon is Everywhere: The City as Man's Fate*, translated from the German by Ingeborg Sammet and John Oldenburg (New York, McGraw-Hill Book Company, Inc.), published in Germany under the title *Überall ist Babylon* by Econ Verlag G.m.b.H.; L. Hilberseimer, *The Nature of Cities* (Chicago, Paul Theobald and Co., 1955); and Gideon Sjoberg, *The Preindustrial City* (Glencoe, Illinois, The Free Press, 1960).

[4] See estimates of Kingsley Davis and Hilda Hertz, as published in Philip M. Hauser, ed., *Urbanization in Asia and the Far East* (Calcutta, UNESCO Research Centre on the Social Implications of Industrialization in Southern Asia, 1958), pp. 56-57.

[5] Kingsley Davis, *World Urbanization 1950-1970: Analysis of Trends, Relationships, and Development*, vol. II, Population Monograph Series No. 9 (University of California, Berkeley, 1972).

[6] *Monthly Bulletin of Statistics*, November 1971 (United Nations publication), p. xxxvi. The following can be found in this publication for all countries of the world for dates beginning with 1960 and projected to 1985: (*a*) estimates of urban and rural population; (*b*) percentage of urban population; (*c*) annual rates of growth of urban and rural population. "National definitions" were used in these estimates and projections, i.e., the definition accepted by official statisticians within each country.

[7] *Growth of the World's Urban and Rural Population, 1920-2000* (United Nations publication, Sales No. E.69.XIII.3), p. 71.

[8] Shryock and Siegel, *op. cit.*, vol. II, p. 843.

butions in space. These factors give cause to different types of investment with different amounts of expenditure. For example, only minimum fire and police protection are offered in rural areas, and the *per capita* quantity and organization of medical facilities often has to be quite different between rural and urban areas. The occupational or industrial composition of the labour force, of course, differs immensely between the two areas of residence.

Urban population projections are one variety of subnational population projections. The general importance of a number of types of subnational projections was recognized at a conference devoted to that subject held at Bangkok in 1969, but provisions for implementing such projections by means of a demographically trained staff still appear to be scant. [9] Several of the methods here discussed may also be applicable in the population projections for regions, provinces or districts within a country. Furthermore, in some of the most urbanized countries with highly developed transportation facilities, the traditional distinction between urban and rural localities has lost much of its relevance in describing salient economic and social features and needs. In some of these countries, statistics are now being collected, distinguishing city-dominated regions such as metropolitan areas [10] within which there can be a further differentiation between the core city and the suburbs and satellite cities within the heavily urbanized periphery. Such areas will often include some rural population devoted to agriculture primarily for local metropolitan consumption. The projection techniques described herein for urban and rural populations may often be equally useful in the projection of metropolitan and non-metropolitan populations.

Within an individual country, innumerable combinations of subnational projections are possible. For instance, there might be lower-level projections of urban and rural population within major administrative territorial units or within territorial units defined by other criteria such as communications linkages or population density. There might also be interest in some countries in the further classification of urban and rural populations by ethnic composition. In highly urbanized countries, there may be good reason to project rural population or small-town population in two categories: (*a*) urban and rural population within the large metropolitan regions, and (*b*) urban and rural population outside those metropolitan regions. [11] Because of the great diversity of area units which can come into use in different countries, a United Nations manual cannot describe all the combinations which might become relevant in the particular instances. The reader may nevertheless observe that the methods described herein can be adapted to many special purposes.

Elements of projection: structure and trend components

There has been much hesitation in the calculation of urban and rural population projections by simple methods, especially because they do not usually yield directly the corresponding sex-age structures, for which there is also much interest. It will be demonstrated in this manual that simple methods are quite adequate to the estimation of sex and age composition in projected urban and rural population totals. For good reasons, the use of simple methods deserves encouragement, at least for simple forecasting purposes.

In this manual it will be assumed that methods of projecting national populations by groups of sex and age are already known, and that such projections have in fact been carried out. The task, then, is that of projecting the urban and rural segments of a population with reference to the national projections already calculated. Only in the last chapter will urban and rural population projections be considered, from which a national projection is subsequently derived as the sum of the two. Elsewhere it is a matter of projecting only the urban (or rural) population and obtaining the corresponding rural (or urban) population as a result of subtraction from projected national totals.

As distinct from most national projections, migratory transfers are a major factor affecting both urban and rural population structures and growth. Additional complications result from the fact that net migration is a balance of in-migration and out-migration, in each of which the trend and composition can vary. Other rural-to-urban population transfers result without migration where previously rural territory is reclassified as urban, whether for administrative or other reasons. Births and deaths occur among migrants, and in reclassified areas, and the latter areas are also affected by migration. Methods taking all these involved demographic factors into account can become unduly complex, hence the need for more summary methods.

As has just been mentioned, urban and rural population changes are heavily affected by migration between these areas of residence, and such migration can fluctuate widely and rather unpredictably in both volume and structure. In the resulting projections the element of uncertainty can be so great that the numerical results are of a low order of reliability. "High" and "low" alternatives, accordingly, should also be calculated and should be set rather far apart. Since the margins of error will hardly be reduced by the employment of

[9] See *Projections of Populations of Sub-National Areas: Report of a Working Group* (Bangkok, 1969) (E/CN.11/897).

[10] For example, in 1960 nearly two-thirds of the population of the coterminous United States lived within metropolitan areas, and 93 per cent of the total population lived within 100 miles of a metropolitan area. The latter included 96 per cent of the urban, 88 per cent of the rural-non-farm, and 82 per cent of the rural-farm population. See Dale E. Hathaway, J. Allan Beegle and W. Keith Bryant, *People of Rural America*, a 1960 census monograph (Washington, D.C. United States Bureau of the Census, 1968), p. 35.

[11] Such a classification scheme was employed in a study of small towns in the United States (in this case, incorporated places with less than 10,000 inhabitants) during the period 1940-1960. Within each region, small towns were classified by size of place and by location with respect to major cities. Is was found that within each region, small towns in each size of place group grew most rapidly if located within "urbanized areas" (as defined in the census), followed by small towns in other parts of metropolitan areas, and finally by towns in other non-metropolitan parts of the country. See Glen V. Fugitt and Donald W. Thomas, "Small-town growth in the United States: An analysis by size class and by place", *Demography* (Chicago), 1966, vol. 3, No. 2, especially p. 525.

elaborate methods, forecasts by simple methods are often quite sufficient. The frank use of simple methods has the further advantage that no illusion is generated as though the forecast could be precise. In fact, in many countries the use of elaborate methods is unwarranted because of the almost complete lack of detailed statistics bearing on the migration between urban and rural areas.

The matter is different, of course, when the projection is theoretical. Because of the nature of the arguments involved, precise (but not necessarily realistic) assumptions are then needed concerning each factor of urban and rural population change: fertility, mortality, migration and perhaps also the reclassification of previously rural areas as urban. The absolute numbers resulting in such a projection are of less significance, since attention is focused on the comparative results of alternatives. Uncertain or missing statistics may be substituted by reasoned assumptions, but the method of calculation must reflect the comparative dynamics of the particular factors under consideration.

Projections serving as forecasts and projections of models

Population projections can be made for two kinds of purposes which are logically distinct. The purpose of most population projections is to provide, however roughly, a forecast. Such projections are calculated on the assumption of some reasonable continuation or modification of observed population trends, to indicate the approximate future population magnitudes to be taken into account so that human needs may be met in the various fields of economic and social policy where they have relevance. Implied in such projections is the assumption that population trends may change gradually but, barring catastrophic developments, not abruptly. Catastrophic future events are of course possible, but cannot be reasonably foreseen in ongoing policies and plans. Reasonable forecasts can orient the targets to be included in rational economic and social programmes and can sometimes also indicate priorities among those programmes.

Some projections, on the other hand, are of a more theoretical nature, and these are often referred to as "models". These provide material for the discussion of the possible demographic consequences which might result from particular economic and social policies among which there is a choice. They may assist in arguing that the demographic consequences of one line of policy might be preferable to those of another, providing a *scenario* from which policy strategy can be debated, possibly leading to the selection, among alternatives, of the policy to be adopted.

Sometimes one set of projections is used for both purposes, as forecasts and as theoretical models, but care must then be taken to avoid fallacious reasoning because the nature of the argument differs in the two instances. In the forecast, the population trend is the independent variable from which certain economic and social implications may follow. In the theoretical projection, the population trends are assumed to be modifiable through economic and social action, hence a variety of economic and social policies may be contemplated in terms of their possible demographic consequences.

All projections which assume some continuation of past demographic trends, irrespective of any influence which other factors might exert on these trends, are also called "autonomous" projections. In contrast with these, there is one variety of theoretical population projections, namely the so-called "normative" projections, in which it is assumed that an already approved programme of national economic and social plans will be carried out with precision. The demographic consequences of the programme are then incorporated in the population projection. As the programme progresses, of course, targets may have to be modified on the basis of practical experience, and new demographic projections may then have to be computed in which the change of targets is also reflected. This manual is mostly concerned with "autonomous" projections.

Ideally, demographic, economic and social projections can be merged into one combined system where by means of computerized multiple feedbacks all possible interactions, causal as well as consequential, between modifiable demographic, economic and social conditions are dealt with simultaneously. For practical purposes, however, such a system will usually be too cumbersome and too unreliable, although it can constitute a precious conceptual exercise. In practice the nature of most of the interactions cannot be measured in isolation, and many missing statistical data will have to be substituted by guess-work whose combined errors can have cumulative effect. Because of those practical limitations of a more complete system, most population projections will remain of the forecasting variety, while some may be specialized for the illustration of possible demographic consequences of selected lines of economic and social action.

Whether serving as forecasts or for purposes of theoretical debate, the projections should be prepared in more than one alternative. The "medium" or, with momentarily available knowledge, "best" forecast will probably err, and for purposes of safe planning the likely magnitude of the error will also have to be appreciated. This can be done by supplementing additional "high" and "low" forecasts whose possible future realization should not be cause for surprise. The theoretical projections will necessarily be calculated in several alternatives specified according to the nature of the argument for which illustration is being sought.

Strictly demographic projection techniques

In the projection of urban and rural population, four types of methods can be distinguished, depending on the detail which enters the calculation, namely:

(*a*) Global methods; in these neither the sex-age composition of the population nor the component trends of urban and rural growth (fertility, mortality, migration and area reclassification) form part of the basic calculation;

(*b*) Composite methods: here, the calculation considers the sex-age composition of the urban and rural population, but not the separate effects of component trends (fertility, mortality, migration and area reclassification);

(*c*) Crude component methods: urban and rural trend components (fertility, mortality, migration and area reclassification) are considered separately, but not the sex-age composition of the population; and

(*d*) Cohort-survival methods, where use is made of the sex-age detail of the urban and rural population and the incidence of fertility, mortality and migration (and possibly area reclassification) by groups of sex and age.

The methods most often used are either of type (*a*) or type (*d*), sometimes described as "mathematical" and "demographic" methods, respectively. If so described, the methods of types (*b*) and (*c*) can be regarded as "mixed". To serve as forecasts, methods of types (*a*), (*b*) and (*c*) may be adequate, being comparatively simple. But if a theoretical model is required, the method will have to be of type (*d*), for only then can the precise effects of alternatives in fertility, mortality and migration trends upon the size and structure of the resulting populations be followed through. [12]

The use of a logistic transformation is an important feature of this manual. In some of the methods of type (*a*) and (*b*), a logistic progression in the percentage of urban population is used in the projections. In direct calculations of percentage growth over time, it is expected that relative growth will be uneven for equal time periods: slow at first, then more rapid and finally slower. In other words, the rise in the percentage over time follows an *S*-shaped curve. However, it is difficult to determine systematically what rise in percentage should be expected in any given time period. With the logistic transformation of percentage figures, a reasonable pattern of percentage growth can be projected by assuming equal amounts of change in the transformed logistic values.

It will be noted that only methods (*b*) and (*d*) result directly in projections of population detailed by groups of sex and age. However, auxiliary methods can be employed, with fairly adequate results, permitting the estimation of the sex-age detail in projections calculated by methods (*a*) and (*c*). [13] As illustrated in chapter VIII of this manual, there are also some useful methods in which age groups of urban and rural population are used but the detailed growth components are disregarded. For instance, there is what one might call the "migration-survival method", most suitable if at least two censuses have been taken at an interval of five or ten years. In the rural population, identical cohorts change from one date to the other under the combined influence of mortality and net migration (including area reclassification), and one may project on the assumption that the combined effect of these two components (though they are not distinguished) may remain the same; as for children, one may assume that child-woman ratios remain the same (combined effect of fertility, mortality and migration). The urban population can be obtained by subtraction of the projected rural from the projected total population.

Other techniques relevant to the projection of urban and rural population

Except for the last chapter, where the comparison of theoretical projections is envisaged, this manual is confined to "autonomous" demographic techniques. In these it is assumed that urban and rural populations will continue to grow and change on the basis of an inherent demographic momentum as measured in actual observations. Unless a large amount of geographic detail is sought, the corresponding calculations are not very complex and can be calculated with simple mechanical equipment. As the manual is intended largely (though not entirely) for application in less developed countries, where electronic computer facilities are not always available, it has not been carried to an advanced level of complexity. True, the methods here shown, if they are to be applied to numerous subcategories (e.g. urban population in each of numerous provinces and so on) may be advantageously adapted to computer programmes.

It is fully recognized, however, that methods of projecting urban and rural population are not thereby exhausted. Depending on special conditions, other methods such as those listed below may sometimes be more advantageous. It is certainly true that urbanization is interrelated with social and economic factors, though these can be numerous and also interrelated with each other.

In special instances, population growth can be closely dependent on one predominant function and should therefore be projected in relation to that function. This may be especially the case with residential suburbs where a given amount of housing capacity can be foreseen and where it is most reasonable to link future numbers of the population to the foreseen dwelling space. Similarly the population of a new mining town or town dominated by one major industry may develop in proportion to foreseen employment in that basic industry; it is then reasonable to multiply the foreseen basic employment with additional employments in complementary services and numbers of dependents in relation to the combined numbers of workers who presumably will be employed. At the national level or in large and industrially diversified cities, urban populations will also be influenced by economic and social changes. But the large city or the combined urban population of the entire country exercise more numerous functions than can easily be taken into account in a simple calculation. A simplification is then needed to establish a possible relationship between

[12] For discussion of a variety of types of demographic techniques currently used in urban and rural projections, see the following: Shryock and Siegel, *op. cit.*, vol. II, pp. 843-846; Jacob S. Siegel, "Some principles and methods of projections of urban-rural population by age and sex" in *Proceedings of the World Population Conference 1965* (United Nations publication, Sales No. 66. XIII.7), vol. III, pp. 91-96; and Statistical Commission and Economic Commission for Europe, Conference of European Statisticians, *Methods and Uses of Projections of Urban and Rural Populations in European Countries* (Conf. Eur. Stats/WG.35/4).

[13] John V. Grauman, "Population estimates and projections", in P. M. Hauser and O. D. Duncan, eds., *The Study of Population* (Chicago, University of Chicago Press, 1959), pp. 565-569; *Population Growth and Manpower in the Philippines, 1960* (United Nations publication, Sales No. 61.XIII.2); Raúl Benítez Zenteno and Gustavo Cabrera Acevedo, *Proyecciones de la población de México 1960-1980* (Mexico D.F., Banco de México, 1966); Alberto Cataldi D., *La situación demográfica del Uruguay en 1957 y proyecciones a 1982* (Santiago de Chile, Nationes Unidas Centro Latinoamericano de Demografía, 1964) (E/CN.CELADE/C.15 B.62.3.1/1) (series C); and *Human Resources of Central America, Panama and Mexico, 1950-1980, in Relation to some Aspects of Economic Development* (United Nations publication, Sales No. 60.XIII.1), pp. 39 and 94-95.

anticipated national development and the corresponding urbanization trends.

Paired projections

In instances where a projection exists of a variable known to be correlated with urbanization, projections can be made of future urban and rural population by assuming some constant multiplier or difference relationship between the level of urbanization and the correlated variable.[14] Similar results could be obtained by using regression equations.[15] The accuracy of such population projections depends on two factors:

(a) *The accuracy of the projection of the correlated variable.* Here it must be noted that although accurate population projections are difficult to make, the future behaviour of correlated economic variables may be even more uncertain. Population growth and distribution tend to be more constrained by biological and traditional factors which change rather slowly by comparison with the more volatile economic conditions.

(b) *The degree of correlation between urbanization and the paired variable.* Correlations with urbanization ranging between .70 and .87 have been observed in various studies for the following variables: males in non-agricultural activities, males in transport and communications, life expectancy, fertility, school enrolment, *per capita* consumption of energy from commercial sources, motor vehicles registered *per capita*, daily newspaper circulation per 1,000 inhabitants.[16]

It must be noted, however, that even the highest of these correlations, .87, explains only about three-fourths of the variance, and .70 would explain only about half of the variance. Moreover, the variables correlated with urbanization are often more highly correlated with one another than with urbanization,[17] so that rather little additional explained variance should be expected from a multiple regression approach.

Even though paired projections alone should be used with caution, they can still serve a useful function by providing a check on autonomous demographic projections for what can happen at least demographically may be constrained by environmental limitations, both economic and spatial. It would be desirable from the point of view of economic and social as well as demographic projections to assemble and analyse the entire correlation matrix of the many interdependent variables so that the reactions of the individual variables and combinations of variables upon each other could be evaluated.

Computerized projections

Economy-based population projections can be calculated without explicit consideration of probable changes in demographic trend components, provided that the assumption can safely be made that the population required for urban economic growth will be drawn to urban areas without exhausting its source of supply in the rural areas. However, changes in fertility and mortality are likely to modify the ratio of dependants in each household. Also female labour fource participation may be affected.[18]

In projections of urban and rural population for numerous regions in the Soviet Union, explicit account was taken of fertility and mortality which were considered separately for urban and rural areas. The models were based on a projection technique which has been in use in the Soviet Union since the first five-year economic development plan. The volume of migration was determined by the planning agencies on the basis of plans for the distribution of productive forces and manpower.[19] In its present detail, the method is very labour-consuming. For example, to estimate the population of a particular territorial unit twenty years ahead under such headings as urban and rural population, male and female population and so on, taking migration into account, it is necessary, with 2,000 items of basic data, to perform over 100,000 calculations.[20] However, with the use of computers such methods can now be used with considerable detail, which was not possible previously.

[14] Probably the variable most often paired with the level of urbanization is the proportion of the labour force in agriculture. In this approach, the rural population is implicitly estimated from the agricultural labour force and the urban population is obtained as a residual. For instance, in certain projections of urban and rural population in several Latin America countries a constant absolute difference was assumed between the proportion of the total labour force in agriculture and the proportion of total population in rural areas. This assumption was based on an examination of a time series of United States census data which showed that, although the proportion of rural had fallen from 92.8 per cent in 1820 to 43.8 per cent in 1930 and the porportion of labour force in agriculture had fallen from 71.8 per cent to 21.4 per cent, still the difference between the two variables at each decade had remained almost constant at about 21 or 22 percentage points. See *Human Resources of Central America, Panama and Mexico, 1950-1980, in Relation to Some Aspects of Economic Development* (United Nations publication, Sales No. 60.XIII.1), p. 37. Again in a projection of urban and rural population in the Philippines, it was assumed that the proportion of the population living in rural areas would decrease by the same ratio (from 65 per cent in 1957 to 56.5 per cent in 1977) as the decrease in labour force engaged in agriculture and related activities (from 59 per cent in 1957 to 51 per cent in 1977). See *Population Growth and Manpower in the Philippines* (United Nations publication, Sales No. 61.XIII.2), p. 12.

[15] See, for example, regression techniques for projecting economically active population used in various studies described in *Manual V: Methods of Projecting the Economically Active Population* (United Nations publication, Sales No. E.70.XIII.2), pp. 22-34. But the regression approach has seldom been used so far to project urban and rural population.

[16] *Urbanization: Development Policies and Planning*, International Social Development Review, No. 1 (United Nations publication, Sales No. E.68.IV.1), p. 27; Kingsley Davis and Hilda Hertz Golden, "Urbanization and the development of pre-industrial areas", *Economic Development and Cultural Change* (Chicago), vol. III, No. 1, October 1954, pp. 8 and 16; Leo F. Schnore, "The statistical measurement of urbanization and economic development", *Land Economics* (Madison, Wisconsin), August 1961, p. 234.

[17] *Population Bulletin of the United Nations, No. 7* (United Nations publication, Sales No. 64.XIII.2), pp. 145-147.

[18] John Stuart MacDonald, "Anticipating city growth and population projections for urban development planning", in *Proceedings of the World Population Conference 1965*, vol. III (United Nations population, Sales No. 66.XIII.7), pp. 72-73.

[19] P. G. Podyachikh, "Population projections in which allowance is made for migration", in *Proceedings of the World Population Conference 1965*, vol. III (United Nations publication, Sales No. 66.XIII.7), pp. 83-90; and A. F. Pobedina, "The use of electronic computers for population projections", in *Proceedings of the World Population Conference 1965*, vol. III (United Nations publication, Sales No. 66.XIII.7), pp. 34-39.

[20] A. F. Pobedina, *op. cit.*

Léon Tabah has described a computer model based on survival ratios which produces simultaneously projections with cross-classifications of population by sex, age, economically active and inactive, and urban and rural areas. [21]

Geographic projections

Anticipated area reclassifications can become difficult to introduce into the calculations of certain urban population projections. At least one detailed attempt has been made by Jerome P. Pickard, using his own definition of "urban regions" which are subject to geographic expansion. The definitions include the rural population expected to fall within the transportation, communications and market networks of the expanding city-dominated areas. Pickard projects not only future population of urban regions, but also the number of square miles that will be contained within these areas at future dates. A map area computer was used in this work as well as census map records and enumeration books for the United States going back to 1920. [22]

Even without detailed geographic information, it is possible to arrive at approximations of the amount of land which will come under urban settlement in the future. The simplest approach would be to project the future density of total urban population or of a particular city and to calculate the amount of land that would be necessary to accommodate the projected urban population at the projected density. [23] In places where improvements in transportation are expected, it is often reasonable to assume a future decrease in density. [24] However, in cases where heavy in-migration is expected the density may increase. There is also the possibility that spatial merging of two or more formerly separate urban areas will alter the average density. There could even be an agricultural limitation if the urban agglomeration spreads so far that it becomes difficult for the inner city population to be supplied with perishable foodstuffs and consequently the expected returns to agricultural uses of the land exceed the expected returns to urban uses. On the other hand, where cities grow by merger with other cities, there may remain pockets of agricultural land area within the legal city limits. For this reason, the United States Bureau of the Census has designated certain cities as "extended cities", and in the 1970 census figures both an urban and a rural population are shown for such cities. [25] Since conditions in different places may vary greatly, no generalized methods can as yet be proposed. [26]

ORGANIZATION OF THIS MANUAL

This manual, being developed by the United Nations Secretariat, naturally favours those methods of projection of urban and rural population which it has found most useful in some of its own work. For its own purposes, the United Nations requires methods having widest international applicability, including those countries for which statistical documentation is only scant. These methods may be too crude for some countries and too refined for others since available statistics and actual conditions vary widely from one country to another. The user of this manual is encouraged to make his own adaptations, which, according to judgment, may seem indicated in the case of his particular country. While, in these methods, extensive use is made of a logistic-scale curve (tablulated in annex I), the use can be flexible, permitting accelerations and slow-downs which might sometimes be reasonably expected. Reasons for the use of such a curve are discussed in chapter III. No less important than the particular schemes of calculation are problems of definition and formulation of suitable assumptions. The first three chapters accordingly deal with the clarification of some basic concepts.

Simple methods for projections of urban and rural populations (relative to national population totals) are discussed in chapter IV; the United Nations method is introduced in chapter V; and its extension to mutually consistent projections for individual cities is illustrated in chapter VI. The simple application of the United Nations method is facilitated by the logistic model tabulated in annex I.

All these are global methods of type (*a*), but they need not be limited to population totals. The consistent estimation of sex-age composition is always possible, whether by conventional methods (chapter VII, section A) or by an extension of the United Nations method (chapter VII, section B); methods of types (*b*) and (*c*) may

[21] Léon Tabah, "Représentations matricielles de perspectives de population active", *Population* (Paris), May-June 1968, pp. 437-476.

[22] Pickard's most extensive study is described in *Dimensions of Metropolitanism*, research monograph 14 (Washington, D.C., Urban Land Institute, 1967). Other published studies by Pickard can be found in: "Future growth of major U.S. urban regions", *Urban Land* (Washington, D.C.), February 1967; "U.S. urban regions: Growth and migration patterns", *Urban Land* (Washington, D.C.), May 1966; "Urban regions of the United States", *Urban Land*, (Washington, D.C.), April 1962; and *Metropolitanization of the United States*, research monograph 2 (Washington, D.C., Urban Land Institute, 1959).

[23] Such an approach was taken in Department of the Environment, *Long-Term Population Distribution in Great Britain—A Study: Report by an Interdepartmental Study Group* (London, Her Majesty's Stationary Office, 1971).

[24] Kingsley Davis, "Conceptual aspects of urban projections in developing countries", in United Nations, *Proceedings of the World Population Conference 1965* (United Nations publication, Sales No. 66.XIII.7), vol. III, pp. 61-65. Davis found, in a long-run study of the San Francisco Bay Area, that the population rose from 364,000 in 1890 to 3,217,000 in 1960, but the over-all density declined from 5,643 to 2,501 per square mile, because the territory expanded at a faster pace than the population. Reference is made in the article to a book which he published with Eleanor Langlois, entitled *Future Demographic Growth of the San Francisco Bay Area* (Berkeleys University of California, 1963).

[25] United States Bureau of the Census, *1970 Census of Population: Number of Inhabitants: United States Summary* (December 1971), p. ix (preliminary report).

[26] Kingsley Davis lists several types of criteria which could be used in evaluating which area units should be included within the boundaries of metropolitan areas. See his "Conceptual aspects of urban projections in developing countries" in *Proceedings of the World Population Conference 1965* (United Nations publication, Sales No. 66.XIII.7), vol. III, pp. 61-65. Even more numerous criteria have been used on occasion in the efforts of the United States Bureau of the Census to delineate the contours of metropolitan areas. See United States Bureau of the Census, *United States Census of Population: 1960* (Washington, D.C., United States Government Printing Office, 1961), vol. 1, part A, p. xxiv.

nevertheless often be preferable, and these are reviewed briefly in chapter VIII.

Chapter IX, finally, introduces the more detailed model of urban and rural population change by demographic components corresponding to the method of type (*d*), which may not be necessary for population forecasts, but is indispensable for comparative theoretical projections. A table of survival ratios (P_x) of model life tables for five-year age groups and five-year intervals of time is provided in annex II for use in this model.

The manual is designed for a variety of needs. As the discussions in chapters I through IV are largely preliminary, those readers who need only a simple method for projecting urban and rural totals which yields at least reasonably useful results under a wide variety of circumstances may wish to move directly to chapter V. Chapter VII explains simple methods for adding sex and age detail to these projections. Chapter VI tells how individual cities may be projected. Both chapters IV and VI are relevant also in the case of a small country most or all of whose urban population is that of one city. Finally, those readers who require component methods of varying complexity may move directly to the last two chapters of the manual.

Chapter I

PROBLEMS OF DEFINITION OF URBAN POPULATION

1. Before proceeding to a projection, it is necessary to examine the definitions according to which data on "urban" and "rural" population have been determined. Under some definitions, for instance, "urban" areas remain within constant geographic boundaries, and "urban" population, so defined, can grow by births, deaths and migration only. According to some other definitions, the geographic extent of "urban" areas can expand continuously; in such a case, the "urban" population grows by area reclassifications as well as by births, deaths and migration.

2. Definitions of "urban" localities vary from country to country, and within the same countries from time to time. In some countries, moreover, two or more definitions are maintained side by side. Urbanization being both a quantitative and qualitative process, different criteria of "urbanism" gain or lose relevance as time progresses.

3. A bewildering variety of criteria have been used, singly or in combination, to define "urban" localities.[27] Essentially, the definitions are mostly of the following types: administrative, economic and geographic. The type of definition must be ascertained when a projection is made since it determines whether or to what extent "urban" populations can also grow through reclassification of areas previously defined as "rural". Different types of definition, moreover, can be suitable according to the purposes which the forecast is intended to serve.

ADMINISTRATIVE DEFINITION: TYPE OF LOCAL GOVERNMENT

4. In many countries the minor territorial administrative units have local governing bodies of diverse forms or degrees of authority, making obvious the distinction of those which are of an "urban" type. The administrative boundaries of urban local governments then contain the population defined as "urban", all other areas being classed as "rural". The effects of such a definition vary, however, depending on the relationship between administrative area and the area built up at an urban density, and depending also on the frequency with which administrative boundary adjustments may occur.

5. The administrative area can be said to be "under-bounded" where there are additional, inmmediately adjacent, densely built-up areas outside the administrative boundary, such areas as may be called suburbs, possibly including administratively separate towns which have come to form conurbations. The administrative area can be said to be "over-bounded" when it is more extensive than the densely built-up area and includes also some population settled at much lower densities. The administratively "urban" population can thus be smaller than the population inhabiting urbanized terrain, and in some instances it can also be larger. The extent of coincidence between the two depends largely on administrative flexibility and on the speed with which built-up areas have expanded geographically. The administrative reforms in Japan in 1953, for instance, have had the effect that most cities, which previously were rather "under-bounded", suddenly became "over-bounded" with reference to contiguous built-up areas. As a consequence, 37.5 per cent of the population were classified as "urban" in the 1950 census, as against 56.3 per cent only five years later, at the census taken in 1955. While undoubtedly the urban settlements gained population rapidly in that period, the apparent growth would not have been so extraordinary if the administrative areas had remained the same, or if "urban" population had been defined on the two occasions in geographic or other terms.[28]

6. Countries vary considerably in the territorial flexibility of administrative areas. In some countries, local administrative boundary adjustments are made very rarely if at all, in others they happen from time to time, and in still others they occur with great frequency. This concerns both the recognition of additional areas as "urban" (through establishment of a new local government of an "urban" type) and the geographic expansion of existing "urban" areas through annexation of surrounding terrain previously under "rural" forms of government.

7. Where administrative boundaries remain unchanged, the growth of population in densely built-up areas is not fully reflected by the increases noted in the population of administratively "urban" areas. This is especially the case where, with urban growth, there is an increasing overspill of urbanized settlement beyond the administrative city limits, as happens generally where the city

[27] For a brief survey of definitions of "urban" population in the censuses of 123 countries taken around 1960, see *Growth of the World's Urban and Rural Population, 1920-2000* (United Nations publication, Sales No. E.69.XIII.3), pp. 7-10.

[28] The 1955 census of Japan included a table showing the 1950 population within areas classified as "urban" in 1955. In all, 53.5 per cent of Japan's 1950 population inhabited the "urban" areas of 1955. The comparison of figures suggests that between 1950 and 1955 as much as 16 per cent of the population of Japan were reclassified from rural to urban, and that between 1950 and 1955 the "urban" population ratio rose only slightly. However, without doubt, effectively urbanized areas within the "urban" areas of 1955 expanded significantly within the 1950-1955 period, a circumstance not reflected in this comparison of percentages.

is "under-bounded". In many countries there are now extensive urban agglomerations whose populations are multiples of those of the administrative central cities. In some large cities, because of city-to-suburb migration, the population of the agglomeration keeps growing even though the population within the administrative municipal limits decreases. In the London region population increases notably in areas situated outside the Green Belt, whereas in the agglomeration within the Green Belt it has been decreasing for some time.

8. To a lesser extent this is also true of "over-bounded" cities within fixed limits. Here, the expansion of the inner agglomeration is associated with some displacement or absorption of a population living at hitherto rural densities. However, since the displaced or absorbed rural population (with its lower densities) is usually comparatively small, the underestimation of rates of urban growth in most such instances is only slight.

9. The estimation and projection of urban population trends as defined within unvaried territorial limits has the advantage that change occurs only as a result of births, deaths and migration, but not from the reclassification of previously "rural" areas. Numerous other statistics referring to such constant areas can often also be assembled. There is no break of continuity in the statistical time series. It is convenient in many studies to compare population and other statistics which are available for the same fixed area.

10. In a large country where local administrative boundaries are flexible and frequently adjusted, the trend in "urban" population (administratively defined) may closely parallel the trend in the population of physically urbanized terrain. It can be assumed, in such a country, that administrative changes are made approximately in proportion to the geographic expansion of densely built-up areas. It can also be assumed that territorial adjustments will be made continuously in the future, having similar effect. Differences between administered "urban" terrain and the areas under dense settlement, in such an instance, may remain unimportant or negligible. For certain studies, however, the fact that continuous area changes are also involved must be borne in mind.

11. A problem arises especially in the instance of a country where administrative adjustments are made only from time to time. For in this case the adjustments can be abrupt and discontinuous, and it is difficult to predict what other modifications of "urban" boundary will be made in the future, if any. Projections of administratively "urban" population can then be scarcely made except on the uncertain assumption that administrative limits will remain unchanged. In relation to such an assumption, the past trend of administratively "urban" population would also have to be re-estimated in accordance with the most recent boundaries.

Administrative definition: seats of district government

12. In a number of countries basic administrative units of one single type cover the entire territory. Each unit is governed from one city or town situated within it, and the population of these cities or towns is considered as the "urban" population, the remainder being "rural".

13. In actual fact, the seats of regional (district, municipality, canton and so on) government are usually also the centres to which certain particular administrative measures apply, hence in at least that sense they have a different type of "local" government. This is typically the case in Latin American countries. The effects of such a definition can be similar to those already discussed in the previous subsection, except under certain limiting conditions. It can fairly be assumed that, in view of the degree of regional autonomy, the outer boundaries of the "urban" centres are usually adjusted to coincide approximately with those of the built-up urban terrain.

14. Whereas the delimitation of such urban centres may be flexible, that of the districts (of which they are the centres) is usually quite rigid. New "urban" centres will rarely appear because the establishment of new districts probably occurs rather seldom. This despite the fact that new compact settlements other than district centres can also emerge. A new mining town, for instance, may fail to make its appearance among administrative urban settlements. Some urban centres, furthermore, may grow so large that their physical limits encroach on the territory of neighbouring districts. Unless a territorial reorganization takes place, part of the growth of large cities will then fail to be reflected in the population trend of the "urban" centres of which one is assumed to lie within each of the districts.

Definition by size of administrative units

15. In many countries most of the basic administrative units are quite small, and there is no formal distinction of those of an "urban" type, all local governments being similarly constituted (in communes, circumscriptions and so on). This situation is found especially in some rather densely populated European countries. Since the area units are mostly small, the presence of a sizable population in any one of them usually indicates the presence of an urban cluster. Only in exceptional circumstances would an entirely rural commune comprise a large population. Moreover, where administrative areas are generally small, it can often happen that two or several neighbouring units are merged into one, permitting an expanding city to continue being administered as one unit. Territorially large units may emerge in time representing in each instance an expanding major city. Annexation of neighbouring communes into a city usually occurs only after some time lag, surrounding urban terrain or "suburbs" still being administered in the interim as separate units; but these also, for the most part, would be of greater population size than the more strictly rural units. The size of individual cities may often not be sufficiently reflected, but the size of the combined "urban" population (including separate suburbs which are also "urban") can well be represented by the population sum of all those units in which some minimum population size is exceeded.

16. The minimum size of units to be recognized as "urban", however, differs greatly between countries, varying in extreme instances from as little as 100 inhabi-

tants to as much as 30,000. Often the limit is 2,000, 2,500 or 5,000. A uniform limit cannot be prescribed for all countries since typical qualitative features or residential densities in settlements of a given size may differ among the countries. A few European countries have adopted a definition by which units with 10,000 or more inhabitants are considered as "urban", those with 2,000-9,999 inhabitants as "semi-urban", and those with less than 2,000 as "rural".

17. The trend of "urban" population defined in this fashion may well parallel that of population in built-up, urbanized areas. Part of the "urban" population growth will result from the surpassing of the minimum "urban" population size by additional administrative units, as a result of which those units are reclassified. But the growth of individual big cities may be inadequately reflected so long as many suburbs continue being administered separately.

Economic definition, applied to administrative units

18. In some countries, where basic administrative units are small and uniform, "urban" administrative units are defined as those in which at the most a small percentage—less than some stated maximum—of the economically active population (or active males) are engaged in agriculture. There are also some countries where units are defined as "urban" by combined criteria of size and type of economic activity.

19. Such a definition is of value particularly in those countries where some agricultural villages are apt to grow larger than some small towns in which urban features predominate (e.g. mining towns, small suburbs, local trading centres). In such countries, evidently, a definition based on an economic criterion has greater relevance than one based on population size only. Though it is recognized that non-agricultural activities exist in areas settled in a rural fashion, and that there can also be a small amount of agriculture among urban residents, the coincidence of a prevalence of agriculture with other features describing a rural environment usually remains considerable.

20. The effect of such a definition on population trends in "urban" places is similar to that where the definition merely involves a size limit. Administrative units are added to the "urban" category, in this case, when non-agricultural activities in them come to outnumber the agricultural ones to the extent implicit in the definition. It is difficult, however, to assess the past and future trend for "urban" areas so defined. Where it is a matter of size limit only, the population estimates themselves express whether an "urban" size has been or probably will be attained at given dates. It is not so easy to estimate and project trends in the agricultural and non-agricultural composition of the labour force in each individual locality.

Geographic definition: agglomerations

21. The internationally recommended definition of "localities" is that of population clusters within the contours of dense settlement, irrespective of administrative deliminations. This concerns localities of every size and economic type. The "locality" may consist of a small grouping of rural houses (e.g. a hamlet as distinct from completely dispersed rural population) and, at the other extreme, of an urbanized region comprising several administrative cities, assuming that the urbanized areas have coalesced. Among localities so delimited one may select those above a certain size, or those having mostly non-agricultural activities, to define "urban" agglomerations. It is evident that agglomerations expand geographically whenever there is building activity at their periphery. Upon occasion, two or several neighbouring agglomerations merge into one.

22. In some countries the delimination of agglomerations on the occasion of a census is made on the basis of detailed map work including, as in Sweden, the measurement of distance between individual houses to determine which of them should be considered as included in the same agglomeration. But simpler determinations can be made, for instance, by using as units the groups of contiguous census enumeration districts in which a minimal population density is exceeded. The boundaries of the agglomerations may then not be determined with geographic precision but nevertheless accurately enough for demographic studies. In the United States, "urbanized areas" are established at each census, adjacent to administrative cities of at least 50,000 inhabitants. In Japan, any group of contiguous census enumeration districts having more than a certain high population density and a combined population of at least 5,000 inhabitants are referred to as "densely inhabited districts". It is possible of course that both in Japan and in the United States densely urbanized areas smaller than entire census districts are not included, hence that the urbanized area is somewhat under-bounded. Other methods for an approximate delimitation of agglomerations have come into use elsewhere, such as the multicommunal agglomerations which have been defined in France.

23. Speaking somewhat schematically, one may say that a major agglomeration, or "urbanized area", ordinarily consists of a central city (i.e. an administrative urban unit) together with densely urbanized "tentacles" branching out alongside the major routes of travel, whether roads, rails or waterways. Such an urban "octopus" may with time absorb within it other urban centres, e.g. satellite towns, or it may come in contact with one or several neighbouring "octopuses" thus forming a conurbation. Between the extended "tentacles" there remain areas inhabited at lower densities which must still be regarded as rural. Geographic growth of the "octopus" occurs through a lengthening and thickening of the "tentacles" and lateral outgrowths, from them which, with time, form a tissue of lateral connexions. Actually, of course, particular geographic features, if not also deliberate action, for instance the construction of a circular road around the city, will prevent agglomerations from attaining precisely such a schematic shape.

24. The noteworthy fact remains that the growth of agglomerations is an accurate reflection of the areas inhabited under physical urban conditions, i.e. at urban

densities. The trends of growth include the transformation of previously "rural" into "urban" areas, hence they imply area reclassifications.

25. The analysis and projection of urban populations in terms of all agglomerations above some minimum size has certain drawbacks, however. On the occasion of each population census the areas have to be delimited afresh. It is not possible to follow their continuous expansion through intercensal or postcensal time periods. Nor is it possible, for areas whose limits differ from any administrative boundaries, and which vary continuously, to organize the collection of other statistics, such as those on births, deaths, school enrolment, retail trade, motor vehicle licenses, and so forth.

26. Since usually only major cities and towns are demarcated in a census as agglomerations, small towns, though they may have markedly urban features, remain omitted from this special "urban" category, unless they are already absorbed in a major agglomeration. The combined population of the selected major urbanized areas is generally less than the country's combined "urban" population under a definition which can include far more numerous smaller cities and towns.

Geographic definition: metropolitan areas

27. As has already been noted, administrative definitions often remain confined to constant areas, reflecting only part of the urban growth, with consequent insufficiencies in the measurement of the urban phenomenon. The definition of geographic agglomerations reflects the expansion of urban environments quite realistically, but has the disadvantage that no statistics other than those determined at each censuses can be collected for them, since their contours change continuously. Mainly to circumvent the disadvantages inherent in both types of definition, another concept has been formulated, namely that of metropolitan areas.

28. The metropolitan areas are usually conceived in such wide limits that they include all, or virtually all, of each agglomeration "octopus" and, in addition, the non-urbanized areas lying in the interstices between its "tentacles". The boundaries are drawn in such a way that they coincide with the outer limits of a group of existing minor administrative areas which are unlikely to change. These boundaries can, for a period of time, be left unaltered, and various types of statistics for each such group of administrative units can also be continuously secured. Reclassification of areas from "non-metropolitan" to "metropolitan", under these conditions, need not occur for some time. Of course, the average population density of metropolitan areas within their wide limits, is much lower than that of the more strictly urbanized terrain.

29. The determination of administrative units to be included in a metropolitan area often involves some quite precise criteria, such as the frequencies in travel and communications to and from the central city, establishing a high degree of economic and social interdependence with the city. Some areas under rural forms of settlement are included where proximity to the city presumably exerts a major influence on their types or methods of land use; hence it is not illogical to include them within the wider urban periphery. In a few instances, groups of contiguous metropolitan areas have been described as a "megalopolis".

30. Again, the determination of metropolitan areas is usually confined to major cities only (e.g. those whose centres have at least 50,000 or 100,000 inhabitants), leaving numerous separate towns which form no part of the metropolitan areas. On the other hand, partly because of actual internal economic interdependence and partly because of statistical convenience, metropolitan areas have often become official planning regions in programmes of regional development.

31. When compared with the corresponding agglomerations, the metropolitan areas can be considered as "over-bounded" urban entities. As has already been noted, in "over-bounded" cities rates of city growth are more adequately reflected than in "under-bounded" ones, owing to the comparative smallness of the rural population which becomes displaced or absorbed as a result of the urban expansion. The extensive delimitation makes it possible in many countries, where urban growth is not too rapid, to maintain a constant demarcation of metropolitan areas over extended periods of time. Eventually, however, a redefinition of metropolitan areas can become necessary because of continued geographic expansion of the corresponding agglomerations and a further widening of their spheres of influence. Where this happens, "geographic" methods of population projection may have to be adopted.

32. Because of the emerging new settlement patterns around the cities of industrialized countries, it will probably become increasingly useful to distinguish four types of areas, namely urbanized and non-urbanized areas within metropolitan regions, and urbanized and non-urbanized areas outside such regions. So far, few censuses permit the distinction of areas according to such a four-fold classification.

Other definitions

33. In some countries urban areas have been defined as administrative units presenting certain "urban features". Among such features there might be the network of paved streets, numbered houses, streetlights, domestic electricity, sewerage, mail delivery, the presence of a secondary school, a church, a medical establishment, a police station and so forth. The use of qualitative data describing urbanism has much conceptual appeal since, according to the conditions in a country, those might indeed appear to be the most distinguishing features. On the other hand, in the context of trend study and projection, the "urban" significance of any such features cannot be considered as permanent. Whereas at one time electric light or police stations may be mostly confined to urban areas, eventually such features can also spread over the countryside. The significance of an "urban" definition expressed in terms of such descriptive attributes can change with the passing of time.

PURPOSES SERVED BY VARIOUS DEFINITIONS

34. The projections of "urban" and "rural" population may have to serve various planning and policy purposes, among which may be mentioned, very roughly: economic plans, social measures and physical plans.

35. For the geographic disaggregation of economic plans, recourse is made increasingly to regional planning, including those regions which comprise each of the major cities. Such purposes are usually best served where the estimates and projections are made in the rather extensive terms of "metropolitan" and "non-metropolitan" population, preferably within constant boundaries. Internal linkage by an interconnected system of transportation can usually be assumed in such urban regions. Geographic priorities in particular investments can be reasonably determined in such a regional context.

36. Social policies depend for their implementation on existing organs of local government as described by law. For the formulation of social policies, therefore, it is preferable to define "urban" populations as those contained within "urban" administrative areas. Since the boundaries of these areas may or may not be flexible, as has been explained, the implications for a population projection can be various.

37. Physical plans, finally, are much concerned with environmental and traffic-flow management within areas inhabited at an "urban" density. In such contexts, it is probably most useful to project the population of agglomerations (or "urbanized areas") as distinct from other areas of lesser population size or density. But more than one purpose may have to be served by the same projections, and statistics on "urban" and "rural" population are not usually available in every convenient form. Depending on the nature of available statistics, there are usually inevitable constraints to the definitions which can practically be adopted for a population projection.

Chapter II

COMPONENTS OF URBAN AND RURAL POPULATION CHANGE

38. Even though it may be preferable to use only crude methods in forecasts of urban and rural population, some knowledge of the underlying dynamics will help in exercising good judgement. It is perhaps best to begin a discussion of components of population growth with a consideration of sex-age structures. The composition of populations by sex and age is a consequence of preceding population trends (births, deaths and migration). In its turn, this structure partly determines current and future demographic trends because each of the trend components, births, deaths or migration, have a varied incidence among population groups distinguished by sex and age. Reclassification is an additional factor which can affect the population composition.

Differences between urban and rural sex-age structures

39. The United Nations Secretariat has made a survey of sex-age patterns in urban populations throughout the world. It was found that each national population is urbanized to a varied extent when every sex-age group is considered separately. It was found, furthermore, that the sex-age patterns of urbanization vary among different parts of the world, no doubt owing to a diversity of social, economic and cultural conditions underlying urbanization trends, in factors causing differences between urban and rural fertility and mortality, and in the selection of rural migrants proceeding to urban areas by sex and age.[29]

40. Estimates have been made for 1960, largely based on census data, of the sex-age compositions of the urban and rural populations in eight major areas of the world, as summarized in table 1. It will be noted that in all eight areas the percentages of children, up to the age of 15, are smaller in urban as compared with rural places, certainly as a result of lower urban than rural birth rates. Likewise, in all areas the urban population has larger proportions at ages 15-44 than does the rural population because urban places attract especially those persons of principal working ages. In Europe, Northern America, Latin America and Oceania, but not in the other major areas, middle-aged and elderly adults are also relatively more numerous in urban than in rural places. It is probable that at least in these regions rural migrants, once settled in urban localities, prefer to remain there also at advanced ages.

41. The ratio of males to females, of all ages, is much greater in urban than in rural areas in South Asia and Africa, while the reverse is true in Northern America, Latin America and Oceania, and to a lesser extent also in Europe. Below age 15, except those aged 5 to 14 in Latin America, urban and rural sex ratios are nearly the same as might be expected since a majority of children of either sex will ordinarily reside with their parents. The high rural sex ratio in Northern America at ages 15 to 24 may in part be attributed to the stationing of military troops in rural localities. But probably for different reasons the excess of males over females aged 15 to 24 in rural areas is also considerable in Latin America and Oceania. In South Asia and Africa, by contrast, there is a considerable excess of males in urban areas at ages 15 to 24, and an even greater excess at ages 25 to 44. But despite such regional diversity, and for unknown reasons, at ages 65 and over all major areas show a lower urban than rural sex ratio, and the difference between the two is greatest in Northern America, Latin America and Oceania.

42. The economic, social and cultural reasons for such a diversity in regional modes of urbanization have not yet been systematically studied,[30] but it is evident that the age structures reflect urban-rural differences in demographic trends (fertility, mortality and migration). Since urban and rural structures differ so much, it is of considerable interest to detail urban and rural population projections according to sex and age. In the choice of a suitable method to obtain such results, it is of some importance to appreciate the relative roles of the several demographic trend components in producing such effects.

Urban residence ratios by sex and age

43. There is a more direct way to analyse the structural differences between the urban and rural population. If we can assume a sufficient degree of population mobility between the two types of residence (urban, rural) we can consider the percentage urbanized, in each sex-age group, as reflecting a specific preference for residence in urban, rather than rural, areas, varying according to sex and age. Those sex- and age-specific "urban residence ratios" can therefore be plotted in a curve much as one

[29] See "Sex and age patterns of the urban population" (ESA/P/WP.36); "Comparative regional typology of urbanization patterns by sex and age" (ESA/P/WP.42); and "Sex-age composition of the urban and rural population of the world, major areas, regions and individual countries in 1960" (ESA/P/WP.44).

[30] One further United Nations study suggests that there is an interrelation between patterns of urbanization and patterns of marital status, both of which may be partly determined by the role and status of women in a society. See "Urban-rural differences in the marital status composition of the population" (ESA/P/WP.51).

TABLE 1. PERCENTAGE AGE COMPOSITION OF MALE AND FEMALE POPULATIONS, AND AGE-SPECIFIC SEX RATIOS, IN URBAN AND RURAL AREAS IN EACH OF EIGHT MAJOR AREAS OF THE WORLD, AS ESTIMATED FOR 1960

Group	East Asia		South Asia		Europe		Soviet Union		Africa		Northern America		Latin America		Oceania	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Males																
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	12.8	15.2	14.7	17.1	8.8	10.3	11.5	14.4	15.6	18.1	11.8	17.4	15.6	18.1	10.8	14.9
5–14	21.0	25.2	23.8	25.4	16.6	19.5	19.7	23.6	22.6	26.5	19.8	21.8	23.8	27.5	19.7	23.3
15–24	22.1	18.1	21.3	18.2	15.6	15.1	19.2	16.9	21.6	18.6	13.2	15.6	18.1	18.3	14.3	16.6
25–44	28.8	24.7	26.9	24.6	27.8	25.4	31.0	24.8	28.3	23.0	27.2	23.6	25.8	22.1	27.8	25.8
45–64	12.7	13.1	11.1	11.6	23.3	21.4	15.1	14.4	10.0	10.9	20.1	18.6	13.0	11.0	20.0	14.8
65 and over	2.6	3.8	2.3	3.1	8.0	8.3	3.5	6.0	2.0	2.8	7.9	9.1	3.7	3.0	7.4	4.6
Females																
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	12.9	14.7	15.9	17.3	7.6	9.5	9.1	11.2	16.8	17.5	10.8	11.8	14.4	18.6	10.1	15.9
5–14	21.1	24.3	25.5	25.6	14.5	18.2	15.9	18.6	25.4	25.6	18.2	22.3	23.0	27.8	18.7	24.6
15–24	21.2	17.8	20.2	17.7	14.1	13.9	16.5	13.2	20.9	18.5	13.4	13.6	18.6	17.9	14.1	16.0
25–44	28.3	24.8	24.7	24.6	27.2	25.2	31.1	25.6	23.9	23.7	27.2	24.2	26.1	22.2	26.4	25.1
45–64	13.0	13.8	10.8	11.7	25.0	22.5	20.4	21.6	10.3	11.4	20.6	18.4	13.5	10.5	20.3	13.8
65 and over	3.7	4.6	2.9	3.0	11.6	10.1	7.0	9.8	2.8	3.2	9.8	9.7	4.4	3.0	10.3	4.6
Males per 100 females																
All ages	*103*	*99*	*112*	*102*	*91*	*97*	*83*	*82*	*110*	*97*	*94*	*108*	*95*	*106*	*99*	*113*
0–4	103	102	104	104	105	105	105	105	102	100	104	104	103	104	105	106
5–14	103	103	105	104	104	105	103	98	98	100	103	105	98	105	104	108
15–24	108	100	118	97	100	106	97	105	114	98	93	123	92	109	100	117
25–44	105	99	122	102	93	98	83	79	130	93	95	105	94	106	104	116
45–64	101	94	115	105	85	93	62	55	107	93	92	108	91	112	97	121
65 and over	74	82	89	97	63	76	42	51	80	84	76	101	80	105	71	112

can plot age-specific labour force participation rates, or age-specific percentages of married population, entries and departures from the category being possible at each age so as to result in a curve. There is, however, an important exception in the factors causing the varied urban residence ratios: the children of either urban or rural parents have no free choice of residence and ordinarily stay with their parents, or at least with their mothers. Only as age progresses into adolescence and beyond can one note the effects of the varying balance between entries into and departures from urban residence.

44. Almost invariably the urban residence ratios attain a peak near those ages at which migration is most frequent.[31] The age of greatest peak comes a few years of age sooner for females than for males. The height of the peak, on the whole, is greater for men than for women in Africa and Asia, but it is greater for women than for men in Latin America and in most of the more developed countries. Countries differ in the shape of the curve at ages past the peak. In some countries, for instance, a second peak appears at some more advanced ages, after an intervening depression. Probably the shape of the curve reflects to a considerable extent the past trends of net rural-to-urban migration which, of course, could have fluctuated. To an undetermined extent, however, the curve is also influenced by comparative levels and trends in urban and rural fertility, and mortality, respectively. As is known, age structure can be greatly affected by varying fertility trends of the more or less distant past, but only to a minor extent by varying mortality trends.

TABLE 2. PERCENTAGE OF NATIONAL SEX-AGE GROUPS RESIDING IN URBAN AREAS, COLOMBIA 1964 AND IRAN 1966

Age (years)	Colombia 1964		Iran 1966	
	Males	Females	Males	Females
0–4	49.1	49.5	35.0	35.6
5–9	48.5	49.8	35.9	36.3
10–14	49.3	53.7	42.0	42.6
15–19	50.7	60.3	46.9	42.9
20–24	51.4	58.5	51.2	42.2
25–29	51.8	57.0	41.5	38.2
30–34	52.4	57.0	38.7	37.5
35–39	49.3	55.1	38.7	40.6
40–44	49.1	55.1	36.8	36.6
45–49	47.8	55.6	39.8	42.2
50–54	47.3	56.2	39.8	41.8
55–59	49.0	58.3	37.1	41.3
60–64	45.3	56.7	37.7	38.7
65–69	49.0	59.1	35.4	36.5
70 and over	46.2	57.2		

Almost invariably, the urban residence ratios for small children fall below the level for women of ages at which they might be their mothers; this is a reflection of a usually lower fertility in urban areas as compared with rural ones. To illustrate this rather summary statement, the relevant ratios for Colombia (1964) and Iran (1966) are shown in table 2 and figure I.

[31] As further examined from intercensal balances in "The dynamics of rural-to-urban population transfers by sex and age" (ESA/P/WP.48).

45. An exact interpretation of the graphs is not possible owing to the accumulation of various effects in the course of time. Nor are the data very accurate: zig-zags at advanced ages can be the result of a different incidence of age misstatements in urban as compared with rural areas. A few facts are evident nevertheless: the young migrants to urban areas are predominantly female in Colombia and predominantly male in Iran: in both countries, female migrants are somewhat younger, on an average, than male migrants; in both countries, as witnessed by child-woman ratios, urban fertility is lower than rural fertility; and whereas probably most female migrants in Colombia establish permanent residence in urban areas, in Iran the residence of many young male migrants in urban areas is probably more temporary, leaving smaller balances past the age of 25. The impressions may be partly falsified by inaccuracy in the age data, and by possible and unknown fluctuations in net migration during decades of the past.

DIFFERENCES BETWEEN URBAN AND RURAL CRUDE DEATH RATES[32]

46. Conditions affecting mortality are apt to differ between urban and rural areas. For instance, in urban places medical facilities are more readily accessible. On the other hand, risks of contagion or motor vehicle accidents are probably less in the rural areas. Because of a differing incidence of various forms of pathology, it is possible that one of the two environments has relative advantages for persons of one or the other sex, or for individuals of different age. Whether, on balance, mortality is heavier in cities or in the countryside is a little-researched subject. It is believed that, because of the relative lack of health services, rural mortality appreciably exceeds the urban in the less developed countries, but it is not known how large the difference may be in the typical instances. In the more developed countries medical and sanitary services are very widely available, and mortality is generally so low that the differences between urban and rural areas cannot be very wide.

47. The United Nations has carried out some calculations of what the urban and rural crude death rates could have been around 1960 if mortality conditions in each region had been the same in urban and rural areas. Then assuming some differences at least in the less developed regions, the United Nations also calculated what the crude death rates might actually have been under those assumptions,[33] with further adjustments in these rates to make them compatible with a basic set of United Nations estimates pertaining to regional rates of population growth. The two sets of results are shown in table 3.

[32] In this and the following two sections, estimates are discussed as calculated in "The components of urban and rural population change: tentative estimates for the world and twenty-four regions for 1960" (ESA/P/WP.46).

[33] It was assumed that urban expectation of life at birth exceeded the rural by 5 years in East Asia (except Japan), South Asia, Africa, Melanesia, Polynesia and Micronesia, and by 2.5 years in Latin America. In Japan, Europe, the Soviet Union, Northern America and Australia and New Zealand urban and rural mortality were assumed to be the same.

FIGURE I

Percentage of national sex-age groups residing in urban areas, Colombia 1964 and Iran 1966

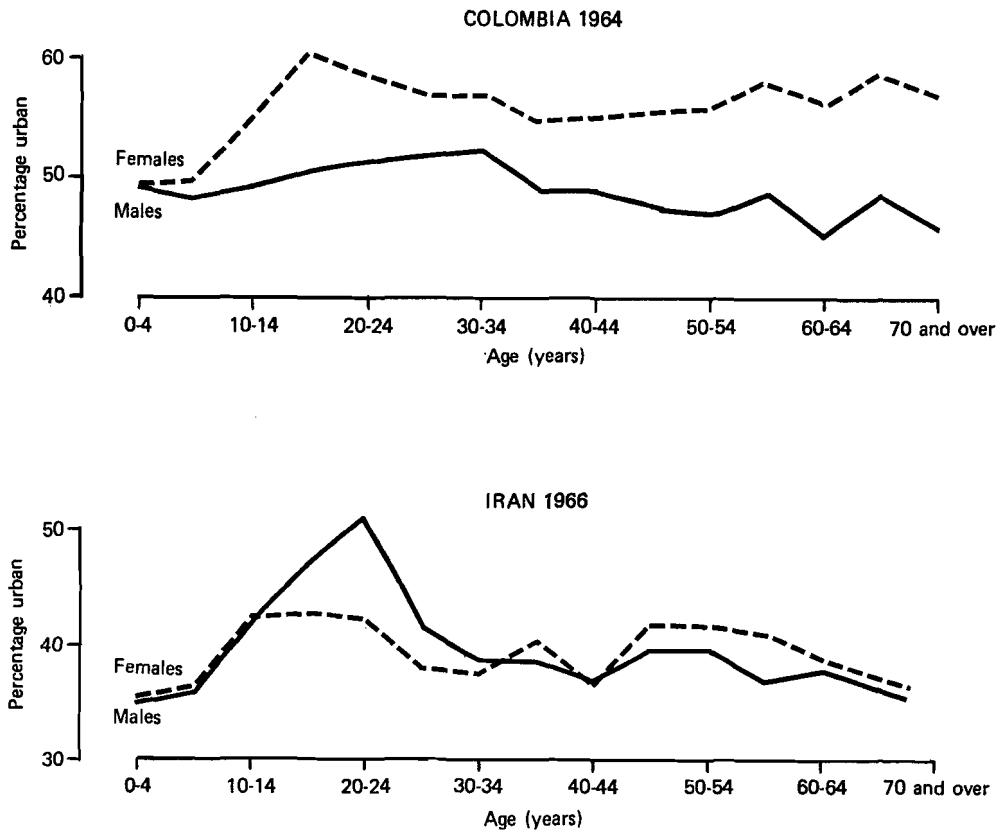


TABLE 3. URBAN AND RURAL CRUDE DEATH RATES WHICH WOULD RESULT IF URBAN AND RURAL MORTALITY WERE THE SAME, AND AS ACTUALLY ESTIMATED, AROUND 1960

Major area	*Assuming equal urban and rural mortality in each major area*			*As actually estimated (with adjustment)*		
	Urban death rate	*Rural death rate*	*Urban minus rural*	*Urban death rate*	*Rural death rate*	*Urban minus rural*
East Asia	14.9	18.6	−3.7	12.8	19.2	−6.4
South Asia	20.5	22.3	−1.8	17.1	22.8	−5.7
Europe	10.4	10.4	0.0	10.1	10.0	0.1
Soviet Union	6.5	8.3	−1.8	6.5	8.4	−1.9
Africa	20.9	24.3	−3.4	17.9	25.0	−7.9
Northern America	9.2	9.6	−0.4	9.0	9.3	−0.3
Latin America	11.6	12.0	−0.4	10.8	12.5	−1.7
Oceania	9.7	12.3	−2.6	8.7	13.1	−4.4

48. In the first three columns of table 3, differences between urban and rural crude death rates are due only to differences between urban and rural sex-age compositions. Since young adults predominate more in urban than in rural localities, and death risks for young adults are always comparatively low, these hypothetical death rates are generally lower in the urban areas, the differences being most considerable in East Asia, Africa and Oceania; in Europe, Northern America and Latin America, however, the differences are slight or negligible because in these major areas the urban localities contain also comparatively large shares of the aged population. In the last three columns of the table, however, it becomes evident that probably in many regions the difference between urban and rural crude death rates is actually larger than it would be for reasons of age structure only. As estimated, the urban death rate may have been almost 8 points less than the rural in

TABLE 4. URBAN AND RURAL CRUDE BIRTH RATES WHICH WOULD RESULT IF URBAN AND RURAL FERTILITY WERE THE SAME, AND AS ACTUALLY ESTIMATED, AROUND 1960

Major area	*Assuming equal urban and rural fertility in each major area*			*As actually estimated (with adjustment)*		
	Urban birth rate	*Rural birth rate*	*Urban minus rural*	*Urban birth rate*	*Rural birth rate*	*Urban minus rural*
East Asia	40.0	35.2	4.8	29.9	36.8	−6.9
South Asia	44.6	44.5	0.1	40.1	47.4	−7.3
Europe	19.5	17.9	1.6	17.8	21.8	−4.0
Soviet Union	27.2	22.4	4.8	20.9	26.6	−5.7
Africa	47.3	47.4	−0.1	41.8	48.0	−6.2
Northern America	25.4	22.1	3.3	24.3	24.9	−0.6
Latin America	43.7	37.0	6.7	35.3	44.5	−9.2
Oceania	28.1	26.5	1.6	22.4	36.6	−14.2

Africa, about 6 points less in East Asia and South Asia, and considerably less also in Oceania; in Europe and Northern America, on the other hand, the difference, if any, could have been only slight.

DIFFERENCES BETWEEN URBAN AND RURAL CRUDE BIRTH RATES

49. Virtually throughout the world the fertility of urban women is lower than that of rural women, and in many instances the difference is large. Fertility decline, where it has occurred, usually began first in urban areas and spread to rural areas later on. Thus, the urban-rural fertility difference can widen for a time, to narrow down again when the general decline in fertility comes to an end. The reasons for such differences between urban and rural fertility appear to be manifold. Various factors usually associated with lowered fertility, such as education, public health, non-agricultural activities, the economic activity of women, the prevalence of salaried employments and so forth, are associated with urbanization; hence it cannot be said to what extent the urban habitat itself, as an isolated factor, contributes to this fertility difference. One factor, which has not been sufficiently explored may be the different incidence of marriage among young urban or rural women: since urban women generally marry at a later age or more often remain single, the general fertility of urban women can be expected to be lower than that of the rural for this reason alone.[34]

50. Without going into the discussion of possible causes, we refer to United Nations estimates of urban and rural crude birth rates around 1960, analogous to the estimates of death rates already discussed. Comparison is made of the figures shown in table 4.

51. If fertility, calculated as the average number of births to women aged 15 to 44 years, were the same in urban and rural areas, differences between urban and rural crude birth rates would result as shown in the first three columns of table 4. These differences would have been due entirely to differences between urban and rural sex-age compositions. On this hypothetical basis, the urban birth rates would generally exceed the rural birth rates because of the prevalence of young adults in the urban areas. However, as already noted, in some regions the urban population has comparatively few women, and mainly for this reason equal urban and rural fertility would produce only a negligible difference between the hypothetical urban and rural birth rates of South Asia and Africa. In Latin America, where women predominate in the urban population, equal fertility would cause the urban birth rate to exceed the rural by nearly 7 points. Considerable excesses of the urban over the rural crude birth rate would have occurred also in East Asia, the Soviet Union and Northern America.

52. Actually, however, as calculated by reverse-survival of sex-age data, the urban crude birth rate was in general considerably below the rural crude birth rate. Only in Northern America was the difference rather slight. In Europe, the rural birth rate exceeded the urban by 4 points, in the Soviet Union and Africa by about 6 points, in East Asia and South Asia by about 7 points, in Latin America by 9 points, and in Oceania by 14 points.[35]

DIFFERENCES BETWEEN URBAN AND RURAL RATES OF NATURAL INCREASE

53. On the basis of age composition only, as has been argued, the urban areas would have higher crude birth rates and lower crude death rates than the rural areas. Therefore, on this hypothetical basis, the urban areas would have a greater potential for natural increase, assuming that urban and rural fertility and mortality could be equal. In actual fact, however, both the birth rates and the death rates are lower in urban than in rural places, and often the excess of the rural over the urban birth rate is greater than the excess of the rural over the urban death rate, with the consequence that the rate of natural increase is generally somewhat lower in urban, as compared with rural, populations. This reasoning is illustrated in table 5, showing the rates of natural increase which result from subtraction of the death rates

[34] In fact, women's age at marriage is almost everywhere higher in urban as compared with rural areas; and the proportions of married women are markedly lower in urban as compared with rural areas: "Urban-rural differences in the marital status composition of the population" (ESA/P/WP.51).

[35] In the case of Oceania it should be noted that most of the urban population is that of Australia and New Zealand, whereas much of the rural population is that of Melanesia, Polynesia and Micronesia.

TABLE 5. URBAN AND RURAL RATES OF NATURAL INCREASE WHICH WOULD RESULT IF URBAN AND RURAL FERTILITY AND MORTALITY WERE THE SAME, AND AS ACTUALLY ESTIMATED, AROUND 1960

Major area	*Assuming equal urban and rural fertility and mortality in each major area*			*As actually estimated (with adjustments)*		
	Urban natural increase	*Rural natural increase*	*Urban minus rural*	*Urban natural increase*	*Rural natural increase*	*Urban minus rural*
East Asia	25.1	16.6	8.5	17.1	17.6	−0.5
South Asia	24.1	22.2	1.9	23.0	24.5	−1.5
Europe	9.1	7.5	1.6	7.7	11.7	−4.0
Soviet Union	20.7	14.1	6.6	14.4	18.2	−3.8
Africa	26.4	23.1	3.3	24.0	23.0	1.0
Northern America	16.2	12.5	3.7	15.4	15.6	−0.2
Latin America	32.1	25.0	7.1	24.6	32.0	−7.4
Oceania	18.4	14.2	4.2	13.7	23.6	−9.9

in table 3 from the birth rates in table 4. Potentially, the urban natural increase could have exceeded the rural by more than 8 points in East Asia, by about 7 points in the Soviet Union and Latin America, by about 4 points in Northern America and Oceania, by 3 points in Africa and by smaller amounts in South Asia and Europe. However, as actually estimated, the reverse was the case, and the rural natural increase probably exceeded the urban by almost 10 points in Oceania, 7 points in Latin America, 4 points in Europe and the Soviet Union, and smaller amounts in East Asia and South Asia; in Northern America the estimated difference was slight, and in Africa the urban natural increase was estimated higher than the rural, though not by a large amount.

DIFFERENCES DUE TO THE EFFECTS OF INTERNATIONAL MIGRATION

54. At least in a few countries international migration can have a significant effect on the growth and composition of urban and rural populations. In earlier times there was much international migration originating from rural areas in one country, destined to settle in rural areas of another country. This may still be the case in some countries, such as in Africa. But elsewhere in recent times most international migration has had both an urban origin and an urban destination. The composition of the international migratory stream will have some effect on the sex-age structures of the populations affected. Countries where these considerations are of some importance are fewer than they used to be, nor are the effects as large as they were in earlier times. Unfortunately, in many countries the statistics on international migration are quite unsatisfactory, and even where they are fairly accurate the urban or rural origin of the migrants remains undetermined.

DIFFERENCES DUE TO INTERNAL RURAL-TO-URBAN MIGRATION

55. The most conspicuous cause of differences between urban and rural rates of population growth is the geographic shift of persons from rural to urban places of residence within the same countries. Throughout the world, urban populations grow with considerably greater speed than do the corresponding rural populations. Little of that difference can be attributed to differences in rates of natural increase or to international migration. It is therefore obvious that net migration between rural and urban areas plays a large role. The relative effect of internal migration will be greater on the urban population while this is still a minority in the national population, and greater on the rural population once the urban population makes up the majority. The sex-age selectivity of migration is important because of the resulting effects on urban and rural population structures. Unfortuntunately, difficulties are involved in the more detailed calculation of these migratory effects.

56. In a calculation of rates it is logical to attribute migration to the population in the areas of origin, namely the population at risk of sending migrants. Actually, however, the matter is more complicated since migration occurs in both directions, rural-to-urban and urban-to-rural. It is possible, for instance, that in certain age groups the balance of all movements is in favour of urban areas, while in some other age groups the balance is in the opposite direction. However, the separate calculation of the components of each migratory balance is a refinement depending on detailed statistics which are rare, and it may be unnecessary in projections made only for the purpose of forecasts. The more direct estimation of migratory balances by sex and age is discussed in chapter IX.

57. An important question, in assessing the net effects of rural-to-urban migration, is the extent to which migrants establish a permanent urban residence. Where they do, they contribute to urban population growth also in the long run, founding new urban families and producing offspring. In other instances, many young persons in urban areas constitute a floating population that is in a continuous state of turnover. The pool of short-term migrants is replenished by a continuous inflow of young persons, but considerably drained, at the same time, by a continuous return flow to rural areas.[36] The floating migratory population may increase at times when urban areas offer a particular attraction, but shrink again at other times when they do not. It may leave only a small residual of persons remaining in the urban area

[36] The large effect of return migration from an Asian city is documented by K. C. Zachariah, "Bombay Migration Study: A Pilot Analysis of Migration to an Asian Metropolis", *Demography* (Chicago), vol. 3, No. 2, 1966, pp. 378-392.

up to an advanced age. But where migration leads largely to continued urban residence, migrants of earlier date remain in the urban population at all ages following the age of peak migration. If a survey were to be made, it would be difficult to distinguish between the "floating" migrants and the more permanent migrants; persons who have migrated to town will often not know themselves whether they are likely to leave soon, or whether they are apt to stay a longer time or even indefinitely. In those few countries where the census draws a distinction between *de jure* and *de facto* population, the differences between the two categories in urban areas reflect to some extent the presence of temporary migrants.

58. The type of migration to urban places will also depend in part on the census definition of "urban" areas, already discussed. For instance, in many countries there is a considerable migration from city centres toward the suburbs. Often this is a migration of mature adults, perhaps aged in their thirties, who, having made a successful beginning in an economic career, wish to settle their young families in the more favourable suburban housing conditions. Where suburbs do not form part of the definition of "urban" localities, the so-called "urban" places may gain young adult migrants (aged, say, in their twenties), while losing those aged in their thirties together with their young children.

59. A desirable type of census data for population projections (usually carried out in five-year time intervals) would be those on places of residence five years previous to a census in relation to their places of current residence. Five-yearly migration rates, immigration as well as emigration, would then be directly calculable. The data would be even more fruitful if it could be determined whether the previous place of residence (such as, five years ago) was urban or rural,[37] but such figures are seldom secured as well as difficult to obtain because of possible definitional changes in urban and rural localities. A question remains also whether the places of previous residence have been stated accurately in the census.

Effects of rural-to-urban area reclassification

60. Depending on the kind of definition involved, rural-to-urban reclassifications can occur especially in two types of areas: (*a*) in villages or other settlements attaining the status of "towns"; and (*b*) in suburban areas being annexed by the administrative authorities of geographically expanding cities. The consequence in either event is a transfer of population from the rural to the urban category. Census data describing the sex-age composition of the transferred population are rarely available. The study of data in those countries where they are provided gives some indication of possible effects of these transfers upon the sex-age composition of the rural and the urban population.

61. If it is only a matter of rural localities attaining urban status, it can be conjectured, very roughly, that the sex-age composition of the marginal population involved is of a type intermediate between the typical compositions of urban and rural populations, respectively. This can be approximately the case because the localities concerned may usually have characteristics which place them near the border line between the two types of settlement. In a country whose population is about 50 per cent urbanized, it is possible that the sex-age composition of the reclassified areas resembles that of the combined national population. In less urbanized or more highly urbanized countries this should generally not be expected.

62. An example of sex-age compositions of populations in localities of differing size groups is provided in a special report of the 1965 population census of Japan. Table 6 shows percentage compositions of Japan's total population and of its population in different community size groups.[38] In examining these data it should be borne in mind that Japan is now a highly urbanized country. Two significant observations can be made. First, the percentage compositions vary in almost continuous fashion, as we proceed from settlements of the largest to those of the smallest size. For instance, males aged 20 to 24 years constituted 7.3 per cent in cities of 500,000 or more inhabitants, while in successively smaller localities they constituted 4.9, 4.2, 3.4, 3.0, 2.6 and 2.4 per cent. Secondly, the national sex-age composition of the population is most nearly approximated in towns having around 50,000 inhabitants. As a matter of fact, in 1965 nearly half the population of Japan inhabited towns of this size and larger.

63. If it is a case of annexation of suburban areas, the matter may be quite different. Aside from migratory balances between the urbanized areas and the rest of the country, important balances also usually exist between the central parts of each city and its suburbs. The latter migration is usually highly selective of groups of sex and age. In the United States, for instance, the suburban areas tend to be settled by men of career ages and their respective families, hence the suburbs have higher percentages of small children and persons in their thirties than do the city centres, whereas the latter have higher percentages of adolescents and young adults, as well as of adults in mature and advanced ages.

64. Census data for 1960 have been provided for major cities in the United States whose territory had been enlarged as a result of annexations between 1950 and 1960.[39] Percentages in each sex-age group of the combined city population residing in annexed areas can be calculated, and table 7 presents the results for the city of Dallas. The same data are also charted in figure II. As can be seen, the above statement regarding suburban population is well borne out. It is rather probable, however, that in a city like Dallas much of the migration to the annexed areas occurred subsequently

[37] Such data have been found in censuses of India and Greece. See *Manual VI: Methods of Measuring Internal Migration* (United Nations publication, Sales No. E.70.XIII.3), p. 37.

[38] Japan, Bureau of Statistics, *1965 Population Census of Japan: Results by Population Size of Shi, Machi and Mura and of DID's* (Office of the Prime Minister). The calculation was made for *shi*, *machi* and *mura*, those being the minor administrative divisions of the country.

[39] Miller and Varon, *Population in 1960 of Areas Annexed to Large Cities of the United States between 1950 and 1960 by Age, Sex and Color*, Analytical and Technical Reports No. 1 (Philadelphia, University of Pennsylvania, Population Studies Center, November 1961).

TABLE 6. PERCENTAGE COMPOSITION BY SEX AND AGE OF POPULATION IN JAPANESE ADMINISTRATIVE UNITS ACCORDING TO POPULATION SIZE, 1965

Sex and age	Japan total population	Size of administrative unit (number of inhabitants)						
		500,000 and over	100,000–499,999	50,000–99,999	30,000–49,999	10,000–29,999	5,000–9,999	Smaller than 5,000
Males	*49.1*	*50.8*	*49.1*	*48.6*	*48.2*	*48.3*	*48.4*	*49.0*
0–4	4.2	4.2	4.5	4.4	4.2	4.1	3.9	3.9
5–9	4.1	3.3	3.9	4.1	4.4	4.6	4.7	5.0
10–14	4.8	3.4	4.3	4.7	5.3	5.8	6.2	6.4
15–19	5.6	6.3	5.8	5.5	5.3	5.1	4.7	4.0
20–24	4.6	7.3	4.9	4.2	3.4	3.0	2.6	2.4
25–29	4.2	5.7	4.6	4.1	3.6	3.2	2.9	2.9
30–34	4.2	4.7	4.5	4.3	4.0	3.7	3.6	3.6
35–39	3.8	3.8	3.9	3.9	3.8	3.7	3.7	3.9
40–44	2.8	2.7	2.8	2.8	2.8	2.8	2.9	3.1
45–49	2.3	2.1	2.2	2.3	2.4	2.4	2.4	2.5
50–54	2.2	2.1	2.1	2.2	2.3	2.3	2.4	2.5
55–59	2.0	1.7	1.8	2.0	2.1	2.1	2.3	2.4
60–64	1.7	1.4	1.5	1.6	1.8	1.9	2.1	2.2
65–69	1.2	1.0	1.1	1.2	1.3	1.5	1.7	1.8
70–74	0.8	0.6	0.7	0.8	0.9	1.0	1.1	1.2
75+	0.8	0.4	0.6	0.7	0.8	1.0	1.1	1.3
Females	*50.9*	*49.2*	*50.9*	*51.4*	*51.8*	*51.7*	*51.6*	*51.0*
0–4	4.1	4.0	4.3	4.2	4.1	3.9	3.7	3.8
5–9	3.9	3.2	3.7	3.9	4.2	4.5	4.6	4.8
10–14	4.6	3.3	4.1	4.5	5.1	5.7	6.0	6.3
15–19	5.5	5.6	5.8	5.8	5.5	5.2	4.7	3.7
20–24	4.7	6.0	5.1	4.7	4.1	3.6	3.2	2.8
25–29	4.3	5.1	4.7	4.4	3.9	3.5	3.2	3.0
30–34	4.2	4.5	4.5	4.2	4.1	3.8	3.6	3.6
35–39	3.8	3.8	3.9	3.8	3.9	3.8	3.8	3.8
40–44	3.3	3.1	3.2	3.3	3.4	3.4	3.5	3.5
45–49	2.7	2.5	2.6	2.8	2.9	2.9	3.0	3.0
50–54	2.5	2.3	2.4	2.5	2.7	2.7	2.9	2.9
55–59	2.1	1.8	2.0	2.1	2.2	2.3	2.5	2.5
60–64	1.7	1.5	1.6	1.7	1.9	2.0	2.2	2.2
65–69	1.4	1.1	1.2	1.3	1.5	1.6	1.8	1.8
70–74	1.0	0.7	0.8	1.0	1.1	1.2	1.3	1.4
75+	1.2	0.7	1.0	1.2	1.3	1.5	1.7	1.9

TABLE 7. POPULATION OF DALLAS (UNITED STATES), 1960: PERCENTAGE OF EACH SEX-AGE GROUP CONTAINED IN AREAS ANNEXED BY THE CITY BETWEEN 1950 AND 1960, AND WITHIN THE 1950 BOUNDARIES (WHITE POPULATION ONLY)

Ages	Annexed areas		Within 1950 boundaries	
	Males	Females	Males	Females
0–4	38.4	38.9	61.6	61.1
5–9	40.0	39.9	60.0	60.1
10–14	33.8	33.9	66.2	66.1
15–19	26.1	23.7	73.9	76.3
20–24	17.8	20.5	82.2	79.5
25–29	27.5	33.6	72.5	66.4
30–34	36.8	37.2	63.2	62.8
35–39	35.9	31.8	64.1	69.2
40–44	29.3	24.4	70.7	75.6
45–49	23.6	18.7	76.4	81.3
50–54	18.8	15.6	81.2	84.4
55–59	16.7	13.2	83.3	86.8
60–64	13.4	11.7	86.6	88.3
65–69	13.1	11.3	86.9	88.7
70–74	12.2	10.5	87.8	89.5
75 and over	13.0	9.8	87.0	90.2

rather than prior to their annexation, with the implication that not so much adjustment is needed for this case of reclassification as the population data for the annexed areas would seem to suggest.

NET RURAL-TO-URBAN POPULATION TRANSFERS, I.E. COMBINED EFFECTS OF MIGRATION AND AREA RECLASSIFICATION

65. Whereas census data reflecting directly on rural-to-urban migration are rare, it is often possible to calculate the combined balance of net rural-to-urban population transfers resulting from the migratory balance as well as area reclassification. Given the rates of urban and rural population growth and the rates of urban and rural natural increase, simple subtraction can yield the rates of rural-to-urban transfers. It can usually be presumed that the greater part of the transfers is due to migration, and only a smaller portion to area reclassification, depending on whether the definition of urban areas is more or less flexible.[40]

[40] But this does not seem to hold true in Brazil, where the analysis of data suggests that reclassification contributed in a large measure to urban growth (see chap. IX).

FIGURE II

Population of Dallas (United States), 1960: percentage of each sex-age group contained in areas annexed by the city between 1950 and 1960

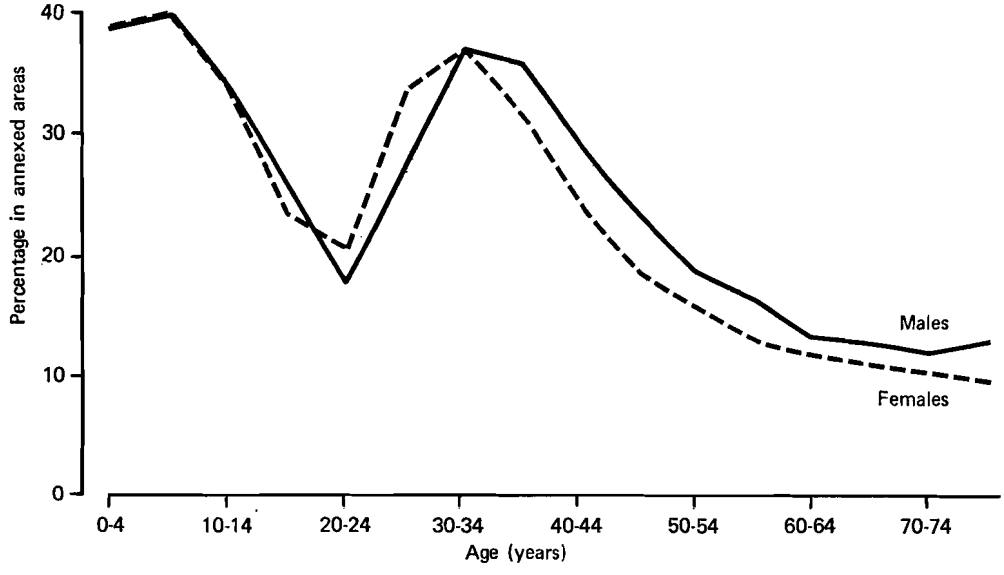


TABLE 8. RATES OF URBAN POPULATION GROWTH AND ITS COMPONENTS, AND RURAL RATES OF NATURAL INCREASE AND ITS COMPONENTS, AROUND 1960

Major area	*Urban population growth rate and its components (per 1,000 urban population)*			*Rural natural increase rate and its components (per 1,000 rural population)*		
	Growth rate	*Natural increase*	*Transfers from rural*	*Natural increase*	*Growth rate*	*Transfers to urban*
East Asia	47.0	17.1	29.8	17.6	8.8	8.7
South Asia	37.5	23.0	14.5	24.5	21.2	3.2
Europe	18.1	7.7	10.4	11.7	−4.3	16.0
Soviet Union	35.1	14.4	20.7	18.2	−2.1	20.3
Africa	45.8	24.0	21.9	23.0	18.2	4.8
Northern America	24.6	15.4	9.2	15.6	−1.8	17.4
Latin America	44.8	24.6	20.3	32.0	12.7	19.3
Oceania	26.5	13.7	12.9	23.6	13.2	10.3

66. The United Nations estimates of urban and rural rates of natural increase around 1960 in eight major areas of the world, already discussed (see table 5), have been ajusted to correspond with another set of estimates relating to urban and rural rates of population growth, [41] with results shown in table 8. The interdependence of these comparative figures is of course conditioned by the levels of urbanization. As estimated for 1960, the urban population constituted 70 per cent of the total in Northern America, 66 per cent in Oceania, 58 per cent in Europe, 49 per cent in the Soviet Union, 48 per cent in Latin America, 23 per cent in East Asia, and 18 per cent each in South Asia and Africa.

67. As estimated for 1960, urban rates of population growth were 45 to 47 per 1,000 in East Asia, Africa and Latin America, 35 to 37 per 1,000 in South Asia and the Soviet Union, 25 to 27 per 1,000 in Northern America and Oceania, and 18 per 1,000 in Europe. Urban rates of natural increase were 23 to 25 per 1,000 in South Asia, Africa and Latin America, 14 to 17 per 1,000 in East Asia, the Soviet Union, Northern America and Oceania, and 8 per 1,000 in Europe. It follows that the rates of net incoming population transfers, relative to the size of the urban population, were about 30 per 1,000 in East Asia, 20 to 22 per 1,000 in the Soviet Union, Africa and Latin America, and 9 to 14 per 1,000 in South Asia, Europe, Northern America and Oceania. *The proportion of urban population growth accounted for by transfers from rural areas* was thus 64 per cent in East Asia, 59 per cent in the Soviet Union, 58 per cent in Europe, 47 per cent each in Africa and Oceania, 46 per cent in Latin America, 38 per cent in South Asia, and 37 per cent in Northern America.

68. Rural rates of natural increase were 32 per 1,000 in Latin America, 23 to 24 per 1,000 in South Asia, Africa and Oceania, 16 to 18 per 1,000 in East Asia, the Soviet Union and Northern America, and 12 per 1,000 in Europe. The rates at which rural populations grew

[41] The growth rates were calculated as exponential rates (not compound rates) to maintain comparability with birth rates, death rates and rates of natural increase (ESA/P/WP.46).

were less, namely 21 per 1,000 in South Asia, 18 per 1,000 in Africa, 13 per 1,000 in Latin America and Oceania, and 9 per 1,000 in East Asia; in Europe, the Soviet Union and Northern America, the rural population underwent slow decreases. Relative to the size of the rural population, outgoing population transfers occurred at rates of 16 to 20 per 1,000 in Europe, the Soviet Union, Northern America and Latin America, at 10 per 1,000 in Oceania, at 9 per 1,000 in East Asia, and at comparatively low rates in South Asia and Africa whose rural populations, relative to the size of the urban, were still very large.[42] *The proportion of rural natural increase disposed of by transfers to urban areas* was thus 137 per cent in Europe, 112 per cent each in the Soviet Union and Northern America, 60 per cent in Latin America, 51 per cent in East Asia, 43 per cent in Oceania, 21 per cent in Africa, and 12 per cent in South Asia.

Implications for projection methodology

69. The foregoing review of components of urban and rural population change and of their influence upon urban and rural population structures demonstrates a complexity of factors difficult to isolate from each other unless the available statistics reflect all that detail with great accuracy.

70. To recapitulate, the urban and the rural populations can change by the incidence of urban and rural mortality, urban and rural fertility, internal migration from rural to urban and from urban to rural areas, international migration from abroad to urban and rural areas, and the population of previously rural localities being reclassified to an urban status. The incidence of all these events varies to an important degree by groups of sex and age, and it will be recalled that age itself changes as time progresses.

71. If we consider the urban population only we can derive a scheme of its change as follows. Let U_o and U_t be the urban population at the beginning and at the end of a time interval t; B the number of births occurring during that interval; D the number of deaths; Ii internal migrants from rural to urban areas; Ie internal migrants from urban to rural areas; Ei migrants to urban areas from abroad; Ee urban emigrants to other countries; and R the population being reclassified; we arrive at the equation

$$U_t = U_o + B - D + Ii - Ie + Ei - Ee + R$$

72. If the time interval t is very short, only a few individuals will undergo more than one of the indicated events. Over a longer period of time, such as in the course of five years, many individuals may experience two or several of the events noted in the equation. Thus, one person may move from the rural to the urban area, then emigrate abroad and then return to a rural place which in turn undergoes urban reclassification still within the same time period. In the first event, he is added to the urban population; in the second event, he is subtracted; in the third event, he is not registered in the urban population at all; and in the fourth event, he is again added. The net result is the addition of one individual to the urban population, but the events have been several. The fictitious example illustrates that the several events depend not only on the initial urban population, but on an urban population which changes while these and other events, some of them partly interdependent, occur. A complete independence of different events from each other can be postulated only when the time interval is infinitesimally short.

73. Some degree of statistical stability—whether a constant level, a continuous trend or fluctuations—can be imputed to the flow of events when these are taken in proportion to the population *at risk* of experiencing these events. Annual events occurring per thousand of the population at risk constitute demographic rates.[43] However, some difficulties occur in determining which is the population "at risk".

74. Clearly it is the urban population itself that is at risk of experiencing urban births and urban deaths. On the other hand, it is the rural population (and also the population of other countries) which is at risk of sending migrants to the urban areas. Furthermore, the rural population, or at least some sections of it are at risk of being reclassified to an urban status.[44]

75. In this connexion, it must be pointed out that the population "at risk" of sending emigrants from the urban areas is not necessarily the urban population itself. Many of the persons leaving an urban area are previous immigrants, either from a rural area or from abroad, who after a period of urban residence return to their places of origin. In so far as this is the case, the migrant population is the one "at risk". And since the risk of generating this migrant population (at least the internal migrants) pertains to the rural population of origin, it might even be said that the rural population itself is at risk of receiving back some of its previous emigrants.[45]

76. Statistics detailed and accurate enough to trace the frequency of every type of demographic event exist in some of the countries which have systems of population registers. However, where registers are maintained on a local basis, the statistics are usually biased: whereas most migrants register their arrival at the place of destination, some always fail to register their departure at the place of origin. Only in a centralized registration system is it possible to ensure that the resulting errors will be detected and reduced to a minimum.

77. The existence of a vital statistics system and repeated censuses of sufficient accuracy can suffice for calculations by which the balance of rural-to-urban

[42] As it happens (see also the first section of this chapter), the highest rates of rural out-migration occurred mainly in those regions where women predominated among the migrants; where the migration consisted mostly of men, the rates of rural out-migration were lower.

[43] As explained in the second section of chapter III, correct demographic rates are those related to the mean population of each time period, ordinarily represented by the mid-year population. The mid-year population, of course, is already affected by about one-half the events occurring in each year.

[44] In special instances, it is also possible that part of the urban population is at risk of being reclassified as rural.

[45] This would not be the case, however, where suburbs receive many migrants directly from the central city and the suburbs continue to be governed by administrations of a rural type.

migration and reclassification can be estimated.[46] In a few countries the censuses also contain data concerning place of residence at some prior fixed date, such as one or five years prior to the census, and these data are directly relevant to the calculation of migration in both the rural-urban and urban-rural directions. However, such data are often believed to be rather deficient and, even in the few instances where the urban or rural character of the previous place of residence is recorded, a residual uncertainty remains because some of those places may meanwhile have become reclassified. The vital statistics, even if accurate and detailed, may record births and deaths by place of occurrence rather than by place of usual residence, with the result that births and deaths occurring to rural residents at an urban hospital are attributed to the urban area.

78. In the absence of vital statistics, it is still possible to estimate levels of fertility and mortality from the relationship between a population's age structure and the estimated rate of population growth.[47] In that situation, one can no longer detect what differences in mortality conditions might exist between urban and rural areas, but in actual fact it is possible that those differences are not quantitatively important in a population projection. On the other hand, by the method of reverse survival the level of urban and rural fertility can be estimated separately, often with a tolerable degree of accuracy, even if the level of child mortality is estimated only by a rough approximation. The accuracy of these estimating procedures, however, can be much affected if the census age statistics are inaccurate.

79. All things considered, there are a fair number of countries in which the statistical data situation permits, without the risk of great error, to estimate at least the net migratory balance between urban and rural areas. In view of what has been said, the rural population can be considered at risk, not only of sending migrants to urban areas, but also of receiving some of them back as they return to their places of origin. This consideration can make it legitimate to attribute the net balance resulting from migration and return migration to the rural population as the one "at risk". One can go further and ascribe the combined balance of migration and area reclassification to the rural population, i.e. to consider the rural population "at risk" of producing a net rural-to-urban population transfer with these combined effects.[48] Projection methods therefore are applicable in which use is made of some combinations of the components of urban and rural population change, instead of the use of detailed assumptions concerning every one of the numerous components.

80. Unfortunately, the countries lacking sufficient statistics for urban and rural population projections by components of population change are more numerous. A large part of the manual is concerned with situations where detailed statistics are rather scant. It is obvious that in such countries the projections can be made only by rather summary methods. However, it does not follow that responsible projections can be made by the mechanical or indiscriminate application of a simple formula. Judgment is needed in selecting the formula most appropriate to the particular conditions. Such judgment depends on some knowledge and experience of factors likely to affect urbanization and its demographic components, as well as of the calculable interaction of the demographic components in some other countries where the statistical documentation is more satisfactory.

[46] See United Nations, *Manual VI: Methods of Measuring Internal Migration* (United Nations, Sales No. E.70.XIII.3).

[47] See United Nations, *Manual IV: Methods of Estimating Basic Demographic Measures from Incomplete Data* (United Nations, Sales No. 67.XIII.2).

[48] In this context it is worth mentioning that those areas often tend to be reclassified as urban where as a result of much recent migration a population size or density has been attained which can be assimilated with urban conditions elsewhere in the same country. In the circumstances, reclassification is partly determined by migration.

Chapter III

TEMPO OF URBANIZATION AND URBAN CONCENTRATION

General considerations

81. After examining the effect of definitions on the urban and rural population data and the likely influence of the components of population change, it is generally useful to study the trends in the two population categories (urban and rural) which have occurred in the past. In the absence of other criteria, it may sometimes be assumed in the population forecast that similar changes will continue in the future. There are several ways in which past urbanization trends can be measured, hence, depending on the measure used, the future forecast may differ. Different measurements can be relevant depending on whether the urbanization level is comparatively high, comparatively low or in some intermediate range.

82. Future assumptions, however, should not be derived uncritically from past observations. However it may be measured, the urbanization trend can vary from one period to another under the influence of numerous developments. The past period for which observations can be made may have been affected by special circumstances unlikely to be repeated in the future. Again, for future purposes government policy favouring either urban or rural developments (for instance, industry, agriculture or housing policy) may have effects on urbanization trends for which the past period does not constitute a suitable precedent. But even then the past period can provide a standard of comparison with assumptions drawn up more freely for the future. For instance, it may be assumed that the urbanization tempo (however measured) will either accelerate or slow down.

83. It should also be borne in mind that urbanization trends, despite their long-term inertia, are subject to fluctuations. While it is true that throughout the world the urbanization levels are continuously rising—apart from temporary effects of a disastrous period, e.g. a destructive war—it is also true that the rises differ among countries and from one decade to another.

84. There is no objective test for the distinction between trend and fluctuations in the urbanization tempo. If the past observations cover a long period, they may well be indicative of a trend; if they extend over a short period only, such as the most recent decade, they may be considerably influenced by temporary fluctuations; a very long past period, however, is not necessarily indicative of a future trend, because much time has elapsed since the beginning of the past period and relevant conditions may meanwhile have changed significantly.

85. Even for future periods it should be expected that the urbanization tempo will fluctuate again; but fluctuations are clearly unpredictable. A useful forecast should reflect a future long-run trend which, with currently available judgment, appears plausible. Actual future developments, subject to fluctuations, should not be expected to coincide closely with the forecast. For such reasons, a forecast should preferably be made for a period of at least twenty years, and with three variants, "high", "low" and "medium", such that it appears more likely that future trends will lie within the range between the "high" and "low" variants than outside it. The "medium" series should be the one most recommended for actual use, and the "high" and "low" series should be presented to indicate probable errors of a magnitude that should be no cause for surprise.

Concept of a growth rate

86. Perhaps the best known concept of a growth rate is that of the annual, or compound-interest rate. Because of its widespread use, it will also be employed in the calculations of this manual unless otherwise stated.

87. The compound interest rate rests on an assumption that by the end of each year an increment is added to an initial amount (such as interest to capital) which stands in a fixed proportion to the size of that amount at the beginning of each year. Thus, if r is the proportional annual increment, and t the time interval measured in years, then $P_t = P_o(1 + r)^t$, P_o and P_t being the magnitudes (of capital; of population; etc.) at the beginning and at the end of the time period. If r is unknown but P_o and P_t are given, r can be determined by transposition of that formula into the form $r = \sqrt{\frac{P_t}{P_o}} - 1$. The time interval t need not be an integral number of years and can also include fractions of a year. The relevant calculations are performed easily with reference to a conventional table of logarithms, i.e. logarithms with base 10, and such tables are widely available. It is not intended to discourage their use wherever appropriate.

88. For demographic purposes, however, the use of an annual rate is afflicted by some imperfections. First, it is to be noted that other demographic rates, such as birth or death rates, are not calculated with reference to the population at the beginning of each year but, ordinarily, with reference to mid-year or mid-period populations (being the best substitutes for period-mean populations). In growing populations, each mid-year figure is likely to be somewhat larger than the figure for the beginning of each year, some growth having occurred

already within the first half of each year. It follows that birth rates and death rates are ordinarily slightly smaller than they would have been if (which is not the practice) they had been calculated in proportion to the population at the beginning of each year. If a growth rate is to be consistent with other demographic rates, therefore, it should not be calculated on a compound interest basis.

89. Secondly, the compound interest rate lacks desirable mathematical properties. With this type of rate, for instance, different results are obtained if a given amount increases at a certain rate for two consecutive years, and if it increases at twice that rate for only one year. In the one instance, the relative increment becomes $(1 + r)^2$, which is $1 + 2r + r^2$, while in the other instance it becomes only $1 + 2r$, leaving a difference of r^2, which may be quite small so long as the rate is not high. At higher rates, or over extended periods of time, however, this internal inconsistency can become considerable.

90. These drawbacks are avoided when growth is measured by instantaneous, also called "exponential" rates, as expressed in the formula $P_t = P_o\, e^{ct}$, where c is the instantaneous rate and e is 2.71828, the basis of Napierian, also called "natural" logarithms. It may be noted that the relationship between the compound interest rate and the exponential rate takes the form $e^c = 1 + r$. The exponential increment, namely $c - 1$, if positive, is always at least slightly less than r, and if the rate is high it can be considerably less (in cases of decrease, the negative rate $c - 1$ is always at least slightly more than the rate r). This is so because in a steadily increasing population the amount of increment, per instant of time, rises continuously in proportion to the population increase itself. For some selected instantaneous increments the corresponding compound increments are as follows:

Instantaneous increment $(c - 1)$	*Compound increment* (r)
0.01	0.01005
0.02	0.02020
0.03	0.03045
0.04	0.04081
0.05	0.05127
0.06	0.06184
0.07	0.07251
0.08	0.08329
0.09	0.09417
0.10	0.10517

In some countries, urban populations grow at rates of 5, 6 or 7 per cent per year, and it is evident that an appreciable discrepancy can result between the two methods of measuring such a high growth rate.

91. The mathematical interaction between two or more instantaneous rates is evident from the fact that the variable is in the exponent. Thus, if c is the product of a and b, it must be true that e^{ct} equals e^{abt}. It also follows that the same increase is achieved whether growth occurs at a given rate over a given period of time, or at any multiple of that rate over a corresponding fraction of that time period, because nc times $\frac{1}{n}t$ is the same as ct. But to operate with the instantaneous, or exponential, rate it is most convenient to make use of a table of the exponential function if available.[49] Since the user of this manual may find no table of the exponential function readily at hand, in so far as possible the calculations have been performed according to the compound interest rate, whose mathematical shortcomings are here admitted. Certain methods, however, will be explained further on, which are derived from an exponential function. In the use of those methods, however, only one derived function is needed, and this is tabulated in annex I to this manual.

92. For purposes of quick calculation, a third method is worth mentioning which is entirely independent of either logarithms or any other tabulated function, but it must be stressed that satisfactory results will be obtained only so long as the growth rate is not high and the time period under consideration is not long. Within such limits it can be demonstrated that a rough approximation to a growth rate is obtained in the formula $P_t = P_o \frac{2 + rt}{2 - rt}$ and its transformation $r = \frac{2(P_t - P_o)}{t(P_t + P_o)}$. The first formula can serve to determine P_t when r is known, and the second to determine r when P_t is known. But despite its "mathematical" appearance, this formula is a simplification of only limited use. It should be employed only to establish quickly an approximate order of magnitude, for instance to check whether no error was made in the more precise calculation of either a compound interest or an exponential rate.

Tempo of urbanization

93. The word "urbanization" has a double meaning: it can indicate a situation existing at any particular moment, in which instance it is best to speak of a *level of urbanization*; or it can be used to express the trend of urban developments, in which instance it is better to speak of the *tempo of urbanization.*

94. The level of urbanization is measured simply, and for present purposes satisfactorily, by the percentage of urban in the total population at any fixed date. True, some more complex concepts have been brought into use, such as indices of urbanization level weighted by the size classes of cities and towns,[50] but those special purpose measurements need not concern us here. It is also to be noted that different levels of urbanization will result where urban population is defined in two or more alternative ways.

95. There are several alternative ways in which the tempo of urbanization can be measured. The most

[49] See for instance, United States Department of Commerce, *Table of the Exponential Function* e^x (Washington, Government Printing Office, 1961). It is also possible to operate with conventional logarithms using the formula $\log_{10}P_t = \log_{10}P_0 + c.\log_{10}e.t$, where $\log_{10}e = 0.4342945$.

[50] For instance, $U = \frac{1}{P}\sum_{1}^{n} C_i^2$, where C_i is the population of city i, P is the total population of the country, and n is the number of cities. Eduardo E. Arriaga, "A New Approach to the Measurement of Urbanization", *Economic Development and Cultural Change* (Chicago), vol. 18, No. 2, January 1970, pp. 206-218.

TABLE 9. ALTERNATIVE MEASURES OF THE TEMPO OF URBANIZATION AS APPLIED TO ESTIMATES OF TOTAL AND URBAN POPULATION OF EIGHT MAJOR WORLD AREAS FOR 1960 AND 1970

Major area	Total population (in thousands)		Urban population (in thousands)		Level of urbanization (per cent urban in total)		Tempo of urbanization, as measured by (per cent per year): Annual rate of growth of urban population	Annual gain in percentage urban population	Annual rate of gain in percentage urban population
	1960	1970	1960	1970	1960	1970			
East Asia	780,071	929,932	176,349	274,902	22.61	29.56	4.54	0.70	2.72
South Asia	865,320	1,125,843	155,889	233,052	18.02	20.70	4.10	0.27	1.40
Europe	424,563	462,117	247,400	293,700	58.19	63.56	1.73	0.54	0.89
Soviet Union	214,238	242,512	106,018	138,568	49.49	57.14	2.71	0.77	1.45
Africa	269,577	344,487	48,488	76,652	17.99	22.25	4.69	0.43	2.15
Northern America	198,765	227,572	138,387	169,117	69.65	74.31	2.03	0.47	0.65
Latin America	213,422	283,251	103,299	159,209	48.40	56.21	4.42	0.78	1.51
Oceania	15,755	19,370	10,321	13,124	65.51	67.75	2.43	0.22	0.34

Note: Estimates according to *Monthly Bulletin of Statistics*. November 1971 (United Nations publication).

common-sense measures might seem to be these: the annual rate at which the urban population is growing; the annual amount by which the (percentage) level of urbanization is rising; and the annual rate at which the level of urbanization is rising.[51] When applied to several populations, differing in level of urbanization or in rate of population growth, comparative results will differ according to the measure used. Projections will also differ if the tempo of urbanization is assumed to continue but is measured in varied ways. The variety of results obtained by different measurements is illustrated in table 9.

96. Judging by rates of growth in urban population, the tempo of urbanization was highest in Africa (4.69), East Asia (4.54) and Latin America (4.42), and comparatively high also in South Asia (4.10), whereas in Europe it was the lowest (1.73). According to absolute rises in the percentage levels of urbanization, the tempo was highest in Latin America (0.78) and the Soviet Union (0.77), followed by East Asia (0.70) and Europe (0.54), whereas it was lowest in Oceania (0.22) and South Asia (0.27). According to rates of rise in those percentage levels, the tempo was highest in East Asia (2.72) and Africa (2.15), considerably lower in Latin America (1.51), and lowest in Oceania (0.34) and Northern America (0.65). Each of these different sets of measurement can have relevance, depending on the manner in which future projections are to be formulated. Their limitations in projections are illustrated in chapter IV.

97. If the United Nations method of projection is used, it is directly relevant to measure the tempo of urbanization as the net difference between the rate of growth in urban population and that in rural population, with the results shown in table 10. According to this measurement, the tempo is highest in East Asia (3.72), followed by Latin America (3.22) and the Soviet Union (3.10), being lowest in Oceania (1.03) and South Asia (1.78). The peculiar result for Oceania is to be attributed to the fact that most of the urban population is that of Australia and New Zealand (where natural increase is moderate), while much of the rural population is that of Melanesia (where natural increase is high).

TABLE 10. TEMPO OF URBANIZATION AS MEASURED BY THE DIFFERENCE BETWEEN URBAN AND RURAL RATES OF POPULATION GROWTH (ACCORDING TO THE SAME ESTIMATES AS SHOWN IN TABLE 9)

Major area	Rate of growth in urban population (per cent per year)	Rate of growth in rural population (per cent per year)	Urban rate minus rural rate (per cent per year)
East Asia	4.54	0.82	3.72
South Asia	4.10	2.32	1.78
Europe	1.73	−0.50	2.23
Soviet Union	2.71	−0.39	3.10
Africa	4.69	1.94	2.75
Northern America	2.03	−0.31	2.34
Latin America	4.42	1.20	3.22
Oceania	2.43	1.40	1.03

REASONS FOR USE OF THE URBAN-RURAL GROWTH DIFFERENCE AS A MEASURE OF THE TEMPO OF URBANIZATION

98. The measure illustrated in table 10, for simplicity, will be referred to as the urban-rural growth difference, or URGD for short. It has several interesting advantages over the measures illustrated in table 9, especially in its range of applicability. In a wide variety of circumstances, comprising virtually all those which will ever occur, the assumption can be made that an URGD observed in the past may also be maintained for an indefinite future period without leading to absurd results. This remains true irrespective of the current level of urbanization, the rate of growth in total population[52] or whether rural population is increasing or diminishing.

99. The avoidance of absurd results does not, of course, guarantee that such a projection will be an accurate prediction of the future course of events. No formula of any kind can offer a key to unlock the mystery of future human developments. These are always subject to the influence of unforeseeable changes in social

[51] Annual, i.e. compound interest, rates are used here, for simplicity. For a further explanation, see beginning of chapter IV.

[52] Assuming, of course, that the total population will not grow forever which, in the final result, eventually becomes impossible.

behaviour, difficult to identify and recognizable only in their consequences. But it can be argued on several grounds that the approach to the analysis of urbanization trends by means of the URGD is reasonable.

100. Let us first examine the three measures of the tempo of urbanization which have been illustrated in table 9.

101. Almost universally urban populations are now growing faster than the corresponding rural populations and therefore faster also than the total populations (urban and rural). If the rate of growth in urban population, higher than that in the total population, remains constant, sooner or later a time will come when the calculated future urban population begins to exceed the calculated future total population, a result which would obviously be absurd. Hence this measure of urbanization can have only limited use.

102. As regards the second measure (absolute rises, in the percentage of urban population), it is likewise evident that a trend, measured in these terms, cannot continue indefinitely, for eventually it would lead to the attainment and surpassing of a level of 100 per cent, which is inherently impossible.

103. As regards the third measure (relative rises in the percentage of urban population), an absurd result would appear at an even earlier date, because then the rises in percentage level would accelerate in proportion to the levels attained at each future moment.

104. Other measures, not illustrated here, can also be imagined. One might measure the tempo of urbanization, for instance, in terms of rural population growth, ordinarily slower than the growth in urban and total population. A constant rate of rural population growth, slower than the total, can in fact continue indefinitely, or at least as long as total growth continues, for it would remain consistent with rising levels of urbanization without ever reducing the rural population to zero or below. A constant amount of decrease in the percentage of rural population, however, would produce an impossible result, namely an eventual percentage of zero or less. On the other hand, no necessary absurdity is involved if the percentage of rural population is permitted to decrease at a constant rate: the absolute size of the rural population may eventually diminish—and this is not contradictory to observations already made in highly urbanized countries—but it would diminish by decreasing amounts without ever completely exhausting a rural residual.

105. Two measures in terms of rural population, therefore, are theoretically compatible with possible developments up to an indefinite future. But it has to be admitted that the measurement of urbanization in terms of rural population change does not suggest a common-sense approach. Except under very special conditions, unlikely to persist, it would be difficult to argue that the tempo of rural population change, by itself, determines how urbanization might progress. It is true, for instance, that in several Latin American countries, with accelerating growth in total population, rural populations in recent decades have grown at comparatively constant rates, whereas urban growth was all the more accelerated. But these observations may merely reflect a fortuitous coincidence because, as the level of urbanization rises very high, or the acceleration in the growth of total population subsides, rural population growth is bound to slow down. In fact, in nearly all highly urbanized countries the previous growth in rural population has come to an end and has given way to rural population decrease, a possibility not allowed for in an assumption of constant rates of rural population growth.

106. A measure might also be devised relating growth in the urban population to growth in the total population. For instance, there are now many countries, with high as well as low rates of growth in total population, where the rate of growth in urban population is approximately twice that in total population. But again it is evident that such a situation cannot continue indefinitely because an urban population growing faster than the total would eventually come to exceed the total.

107. All the alternative measures of urbanization tempo, discussed in the foregoing, have limitations either in terms of eventually absurd consequences or in terms of common sense. This is not to say that they are useless. In the analysis of past or current observations they may have much illustrative value. They may also serve in simple population projections over limited future periods during which unlikely eventual consequences would not yet occur. The remote future is extremely uncertain, no matter what method of projection may be used, and simplicity of future assumptions is in any event desirable. In many situations, and for limited periods, the use of one of those measures need not be discouraged.

108. By contrast it can be argued that the URGD measure offers at least three types of advantage: the avoidance of absurd consequences, the compatibility with common sense and the consistency with a logistic curve describing the rise of percentage in urban population. These three advantages are now discussed, each in turn.

109. In the most diverse combinations of population trends, indefinite continuation of a given level of URGD never produces an absurd result. While the percentage level of urbanization is low, the rural population increases almost as rapidly as the total population, and the corresponding urban population can increase considerably more rapidly than the total; when the percentage level of urbanization rises high, the urban population increases only slightly more rapidly than the total, and the rural population can increase considerably less rapidly, and possibly decrease. While total population increases at a fast rate, urban population may grow with very great speed, and rural population may also grow considerably; when growth in total population slows down, the growth in urban population may also slow down, while rural population growth may be much reduced, or give way to decrease. Such would be the consequences of an indefinite continuance of a given URGD, in diverse situations; they are at least possible, and also in rough conformity with observations actually made.

110. In terms of common sense, the urbanization process is influenced by comparative advantages or disadvantages perceived in both the urban and the rural environment, often referred to as relative "push" and

"pull". This makes it reasonable to imagine the usually greater attraction of urban over rural areas as a residual force reflected in the difference of growth rates; this can, of course, fluctuate within short time periods, but on an average is likely to change only very slowly within extended periods of time. A temporary unusually rapid transfer of people from rural to urban areas may produce an increased pressure on urban employment opportunities and other facilities while reducing that on rural facilities, and the opposite may happen in the contrary event. Regulatory mechanisms may then operate to maintain urban-rural growth differences more nearly at constant levels over the long run.

111. From another point of view, it can be argued that there are varying restraints on the rate of rise in the percentage level of urbanization, depending on the level attained at any moment. The level is likely to rise by smaller amounts per unit of time when it is either very low or very high, than when it is in some intermediate range. Rises in level, therefore, are apt to accelerate at first, to reach a maximum rate, and then to slow down again. Perhaps the simplest curve in which such a relationship between given level and rate of rise can be expressed is a logistic curve.

112. An analogy may help to suggest why rises in a growing proportion could generally be expected to be slow at first, then more rapid and eventually again slow. Let us consider the rates at which the percentage of literates in a population (say, aged 10 years and over) may rise. When the level is very low, only few literate persons will be available to teach literacy to others, hence a considerable effort is then involved in raising the general literacy level by any considerable amount. When a substantial proportion of the population, perhaps about one-half, are literate, the remaining illiterates that can be reached are still numerous, but so are also the potentially available teachers, hence, at this level, progress can be quite rapid. At a high level of literacy, most of the remaining illiterates will be those difficult to reach, whether because of their geographic remoteness, cultural resistance or physical and mental handicaps; at such a level, a large effort can secure only a comparatively small amount of additional progress.

113. Similarly the growth of urban residence will depend both on urban facilities already in existence (these would be in the role of "potential teachers", to use the analogy) and the comparative size of the rural reservoir from which additional urban population can be recruited (in the analogy, the remaining "illiterates"). Though the subject matter is entirely different, varied rates of rise in urbanization can be expected as logically as varied rates of rise in literacy, depending on levels already attained.[53]

[53] The notion that the interaction of "push" and "pull" factors in the process of urbanization may tend to be reflected in the rise of the urbanization level in accordance with a logistic curve has also been discussed in another source, including some empirical evidence. It was noted that other variables, such as school enrolment ratios or labour force participation ratios may also be considered from this point of view. M. Sivamurthy and K. V. Ramachandran, "An empirical investigation into the evolution of certain demographic variables", *Journal of Social Sciences, Karnatak University* (Dharwar), vol. IV, April 1968.

114. The relationship between the assumption of a constant URGD and that of a logistic curve in the percentage of urban population can be demonstrated as follows.

The general formula for a logistic curve is

$$Y_o = \frac{1}{k + ab^x},$$

which can also be put in the form

$$Y_o = \frac{k}{1 + e^{a+bx}};$$

in either case k is a constant, and e is the basis of natural logarithms, leaving a and b to be determined.[53a]

115. Now, let T_o, U_o and R_o be the total urban and rural populations at the beginning of a period ($t = 0$), T_t, U_t and R_t the same populations after t years, u and r the exponential rates of growth in the urban and rural population, and d the URGD, i.e. the difference between the rates, namely u-r. Then, at any given moment $U_t = U_o e^{ut}$, and $R_t = R_o e^{rt}$, so that

$$\frac{U^t}{R_t} = \frac{U_t}{T_t - U_t} = \frac{U_o}{R_o} e^{(u-r)t} = \frac{U_o}{R_o} e^{dt}.$$

Therefore,

$$100\frac{U_t}{T_t} = \frac{100\frac{U_o}{R_o} e^{dt}}{1 + \frac{U_o}{R_o} e^{dt}},$$

which is a simple formula for the logistic curve. In the above, of course, $100\frac{U_t}{T_t}$ is the urbanization level (urban as a percentage of total population). The formula holds true in the course of time though both u and r may vary with time, provided that the difference u-r remains constant. The formula is further simplified if we take the logistic's point of origin ($t = 0$) at the point where the urbanization level is 50 per cent. This is the point of inflexion, or of maximum rate of rise in the urbanization level, and about this point the logistic curve is symmetrical. Here, $U_o = R_o$, and the fraction $\frac{U_o}{R_o}$ is unity. The formula then becomes

$$100\frac{U_t}{T_t} = \frac{100\, e^{dt}}{1 + e^{dt}},$$

t being positive where the urbanization level is higher than 50 per cent, and negative where it is lower. If it is further assumed that d (the level of URGD, in per cent per year) is unity, the formula is reduced to

$$100\frac{U_t}{T_t} = \frac{100\, e^t}{1 + e^t}$$

Values of this curve ranging from less than one per cent to more than 99 per cent are tabulated in annex I.

[53a] For methods of computation see Croxton and Cowden, *Applied General Statistics*, 2d. ed. (Englewood Cliffs, N.J., Prentice, Hall Inc.), p. 310.

116. An additional observation is worth recording, making it possible to determine the value of e^d or, in other terms, (1 + URGD), without use of the logistic reference table. This can be shown as follows. One of the formulas in paragraph 115 was

$$\frac{U_t}{R_t} = \frac{U_o}{R_o} e^{dt},$$

from which it also follows that

$$\frac{\frac{U_t}{T_t}}{\frac{R_t}{T_t}} = \frac{\frac{U_o}{T_o}}{\frac{R_o}{T_o}} e^{dt}$$

expressing the same relationship in terms of proportions of the total population urban and rural, instead of absolute numbers urban and rural. By cross-multiplication from both sides of the equation we obtain both that

$$\frac{U_t . R_o}{R_t . U_o} = e^{dt},$$

and that

$$\frac{\frac{U_t}{T_t} \cdot \frac{R_o}{T_o}}{\frac{R_t}{T_t} \cdot \frac{U_o}{T_o}} = e^{dt}.$$

In either instance the exponential growth-difference rate e^d is obtained as the t-th root of the expression to the left side of the equation. This mathematical relationship may in some instances find a useful practical application. The extraction of the root, of course, will usually have to be performed with the use of conventional logarithms.

117. To provide a simple numerical example, let us suppose that a population is exactly 20 per cent urban at the date of one census, and exactly 25 per cent urban at the next census, taken ten years later. In this case $\frac{U_t}{T_t} = 0.25$, $\frac{R_t}{T_t} = 0.75$, $\frac{R_o}{T_o}, = 0.8$, $\frac{U_o}{T_o} = 0.2$ and $t = 10$. We find that, in this case, e^d is the 10th root of $\frac{0.25 \times 0.8}{0.75 \times 0.2}$, i.e. the tenth root of $\frac{0.2}{0.15}$, or the tenth root of 1.333333. With the help of logarithms we find that this comes to 1.0292, and we can say that the URGD, as an exponential rate, comes to 2.92 per cent per year.

118. As a final note, it is admitted that the assumption that urbanization may ordinarily proceed according to a logistic curve is arbitrary, and that it commends itself chiefly because of its simplicity of application. If there were more knowledge on the subject one might perhaps postulate, that urbanization tends to progress, say, like a normal probability curve (which resembles the logistic rather closely), or like some asymmetric curve, whether an asymmetric logistic, a modified exponential or a Gompertz curve. Any of these curves, and perhaps some others as well, might be compatible with the observations made so far. But the fact is that our knowledge is not so precise, hence it is advisable to seek the solution to the problem in the simplest terms.

Tempo of urban concentration

119. Generalizing further from the observations already made, we may also subdivide the urban population into two subpopulations, for instance the population of cities (larger than some minimum size, or a given list of cities) and that of towns (smaller than that size, or all urban localities outside a given list). The percentage of city population in the combined urban population, at any given time, may be called the *level of concentration of the urban population*, and increases (possibly also declines) in that level may be considered as measurable in terms of a *tempo of concentration* (or, in the event of decline, deconcentration). It is evident that similar types of relationships can be assumed to exist between city population and towns population within the combined urban population, as between urban population and rural population within the combined total population.

120. It is evident also that one can subdivide the urban population into that of the country's largest, or capital, city and the remainder of the urban population. Additional steps are possible, making it feasible to measure successively the tempos of concentration for each of a list of cities, for instance beginning with the largest city, then, after eliminating it from the total, proceeding to the next largest city and so forth. One may also deal similarly dividing a single city into segments, for instance distinguishing its core and its suburbs.

121. Where the URGD may serve in the projection of urban, relative to an already projected total, population, an analogous type of measurement can serve likewise in the projection of city, relative to an already projected urban population. If individual cities are taken up successively, this leads to the possibility of projecting their populations individually. The advantage of the URGD type of measurement is again that absurd results can be avoided, and that projections for individual cities remain consistent with a projection for the combined urban population.

122. Where such detailed use is made of this method of measurement it is necessary, of course, to bear in mind how the urban population and that of individual cities are defined, and whether the definitions are comparable in their geographic rigidity or flexibility. It would be unreasonable, for instance, to compare the growth of cities larger than, say, 100,000 inhabitants with the growth of the urban population of a country if the number of such cities is small: the fortuitous attainment of the 100,000 size limit by an additional previously smaller, city is then a discontinuous event, by which such measurement might be easily upset. In a large country having numerous cities of such size, the inclusion of additional cities attaining that size is a fairly continuous process, and there is no incongruity in assuming that an observed tempo of concentration, for such cities within the combined urban population, can continue.

123. On the other hand, the boundaries of some cities may have been widened, while in other cities this was not the case. In such instances it would not be reasonable to assume that cities of the first type will continue to grow faster than cities of the second type. The opposite may

happen. Cities with recently widened boundaries may for some future time experience few territorial additions, whereas in cities where boundary changes have not occurred recently the likelihood of this happening in the near future may be greater. Such considerations have implications for the validity of calculated differential rates of the URGD type. The tempo of concentration in large cities or in individual cities of the urban population may also fluctuate in time, depending on local developments, for instance government policies affecting the geographic distribution of investments which, because of resulting employment opportunities, may cause the population of some cities to grow faster than that of some others, at least at certain times.

Chapter IV

PROJECTION OF URBAN AND RURAL POPULATION TOTALS USING THE SIMPLEST METHODS

USE OF URBAN GROWTH RATES

124. The simplest projection is, perhaps, that resulting from an assumption of a constant rate of growth. In the examples which follow it will be assumed that the urban population grows at a constant (annual) rate. It will be assumed, however, that a projection of the corresponding total population already exists, and that in the latter projection the rate of growth in (total) population is not necessarily constant. The urban population, as projected by a constant rate, will then be subtracted from the total population, as projected by other means, to ascertain whether the growth in the residual, i.e. in the hypothetical rural, population remains plausible.

125. Three examples have been selected for an examination of how well the simplest mathematical methods may apply to populations of low, intermediate and high levels of urbanization. The examples concern the populations of the United Republic of Tanzania, Iran and Canada, and use is made of the latest estimates and projections calculated in the United Nations Secretariat. [54]

126. To take first the case of the United Republic of Tanzania, utilizing the United Nations projections of total population and a 1965 estimate of the size of the urban population, it will be assumed that the urban population may grow in the future at rates of 5, 6 or 7 per cent per year, resulting in increases by 27.62, 33.82 or 40.32 per cent, respectively, per five-year period. Estimated as 677,000 in 1965, the urban population would increase as follows (figures in thousands):

Year	Urban rate of increase (assumed)		
	At 5 per cent	*At 6 per cent*	*At 7 per cent*
1965	677	677	677
1970	864	906	950
1975	1,103	1,212	1,332
1980	1,408	1,622	1,868
1985	1,797	2,171	2,620

127. The total population of the United Republic of Tanzania has been estimated as 11,674,000 in 1965 and has been projected by the component method to 13,236,000, 15,150,000, 17,475,000 and 20,282,000 for 1970, 1975, 1980 and 1985, respectively, that is at successive annual average rates of 2.54, 2.74, 2.90 and 3.02 per cent. The above projections of the urban population, when subtracted from the projected total populations, leave the following future estimates of rural population as residuals:

Year	Urban rate of increase (assumed)		
	At 5 per cent	*At 6 per cent*	*At 7 per cent*
1965	10,997	10,997	10,997
1970	12,372	12,330	12,286
1975	14,047	13,938	13,818
1980	16,067	15,853	15,607
1985	18,490	18,086	17,667

128. Depending on the urban rate of increase, the rural population would grow at the following average rates:

Years	Urban rate of increase (assumed)		
	At 5 per cent	*At 6 per cent*	*At 7 per cent*
1965–1970	2.36	2.29	2.22
1970–1975	2.54	2.45	2.35
1975–1980	2.69	2.57	2.43
1980–1985	2.81	2.64	2.48

There is nothing implausible in the implied future rates of growth of rural population hence, in a country like the United Republic of Tanzania, to assume a constant growth rate in urban population over a stretch of twenty years is not necessarily unrealistic.

129. Using the same methods (assuming somewhat lower rates) in the case of Iran, we obtain the following projections of urban population:

Year	Urban rate of increase (assumed)		
	At 4 per cent	*At 5 per cent*	*At 6 per cent*
1965	9,172	9,172	9,172
1970	11,159	11,706	12,274
1975	13,577	14,940	16,425
1980	16,518	19,068	21,980
1985	20,097	24,336	29,414

130. Here, the total population was estimated as 24,549,000 in 1965, and projected to 28,358,000, 33,152,000, 38,769,000 and 45,050,000 for the subsequent dates, By subtraction, we obtain the following implied projections of rural population:

Year	Urban rate of increase (assumed)		
	At 4 per cent	*At 5 per cent*	*At 6 per cent*
1965	15,377	15,377	15,377
1970	17,199	16,652	16,084
1975	19,575	18,212	16,727
1980	22,251	19,701	16,789
1985	24,953	20,714	15,636

[54] *World Population Prospects as Assessed in 1968* (United Nations publication, Sales No. 72.XIII.4).

131. The following rates of increase in the rural population are implied:

Years	Urban rate of increase (assumed)		
	At 4 per cent	At 5 per cent	At 6 percent
1965–1970	2.26	1.60	0.90
1970–1975	2.68	1.80	0.79
1975–1980	2.60	1.58	0.07
1980–1985	2.32	1.01	−1.41

As can be noted, the implied rates of growth in rural population are far apart, hence at this level of urbanization the rural population is quite sensitive to the particular assumption concerning urban growth. It is surprising, furthermore, that the continuance of a high rate of growth in the urban population may soon result in absolute decreases in the rural population. This makes it evident that at an intermediate level of urbanization the assumption of a constant rate of growth in the urban population should not be carried very far. It is more likely then that, with time, urban growth will slow down somewhat.

132. Taking, finally, the case of Canada, as a country at a very high level of urbanization, we shall assume that the urban population may grow at rates of 2.0, 2.5 or 3.0 per cent, increasing by 10.41, 13.14 or 15.93 per cent in each five-year period. The urban population is estimated at 14,333,000 in 1965, and we obtain these results:

Year	Urban rate of increase (assumed)		
	At 2.0 per cent	At 2.5 per cent	At 3.0 per cent
1965	14,333	14,333	14,333
1970	15,825	16,216	16,616
1975	17,472	18,347	19,263
1980	19,291	20,758	22,332
1985	21,299	23,486	25,889

133. The total population is estimated at 19,644,000 in 1965 and projected to 21,426,000, 23,284,000, 25,299,000 and 27,348,000 at those future dates. Consequently, the following future rural populations are implied:

Year	Urban rate of increase (assumed)		
	At 2.0 per cent	At 2.5 per cent	At 3.0 per cent
1965	5,311	5,311	5,311
1970	5,601	5,210	4,810
1975	5,812	4,937	4,021
1980	6,008	4,541	2,967
1985	6,049	3,862	1,459

In the circumstances of Canada it is unlikely that the rural population will increase much, hence the assumption of a constant 2 per cent growth in urban population is not very probable. But it is just as unlikely that the rural population will decrease at a steep and accelerating rate, soon dwindling to quite small numbers. Therefore, to assume a 3 per cent growth in urban population is also unrealistic. It can be seen that, at this high level of urbanization, the constraints for a plausible assumption of a constant rate of increase in the urban population become narrow.

134. In conclusion, the assumption of a constant urban growth rate remains useful only so long as the level of urbanization is rather low. At intermediate or higher levels such an assumption soon tends to become unrealistic.

Use of rural growth rates

135. The same three examples are now worked through in terms of assumed rates of growth in rural population. First, for the United Republic of Tanzania it will be assumed that the rural population may grow at the constant rates of 2.0, 2.5 or 3.0 per cent. The following future estimates of rural population are obtained:

Year	Urban rate of increase (assumed)		
	At 2.0 per cent	At 2.5 per cent	At 3.0 per cent
1965	10,997	10,997	10,997
1970	12,142	12,442	12,748
1975	13,406	14,077	14,778
1980	14,801	15,927	17,132
1985	16,341	18,020	19,861

136. Subtracting from the projected total population, we obtain the following implied projections of urban population:

Year	Rural rate of increase (assumed)		
	At 2.0 per cent	At 2.5 per cent	At 3.0 per cent
1965	677	677	677
1970	1,094	794	488
1975	1,744	1,073	372
1980	2,674	1,548	343
1985	3,941	2,267	426

137. Following are the implied annual rates of urban growth:

Years	Rural rate of increase (assumed)		
	At 2.0 per cent	At 2.5 per cent	At 3.0 per cent
1965–1970	9.60	3.19	−6.55
1970–1975	9.33	6.02	−5.43
1975–1980	8.55	7.33	−1.62
1980–1985	7.76	7.63	−4.33

The constraints on the assumed rate of growth in rural population, at this low urbanization level, are noticeable. Urban population in the United Republic of Tanzania can be expected to grow at a fast rate, though perhaps not so fast as 9 per cent per year. This makes the rural rates of 2.0 and 3.0 per cent both rather improbable. Most likely, a rural rate of growth between 2.0 and 2.5 per cent can be sustained. For instance, if the rural rate were a constant 2.25 per cent, urban population would increase in the successive quinquennia at rates of 7.9, 8.5, 8.5 and 8.0 per cent. Provided that the rate of growth in rural population is selected with care, therefore, the assumption of constant growth rates in the rural population need not lead to implausible results for the urban population. Admittedly, this is a trial-and-error procedure, and it would be more logical to base the projection directly on an assumed rate of growth in the urban population, as was done before.

138. Next, we take again the example of Iran. Here it will be assumed that the rural population may grow at constant rates of 1.5, 2.0 or 2.5 per cent. The following future rural populations are obtained:

Years	Rural rate of increase (assumed)		
	At 1.5 per cent	*At 2.0 per cent*	*At 2.5 per cent*
1965	15,377	15,377	15,377
1970	16,566	16,978	17,398
1975	17,847	18,745	19,684
1980	19,227	20,696	22,270
1985	20,713	22,850	25,196

139. By subtraction from projected total populations, the implied urban populations are the following:

Year	Rural rate of increase (assumed)		
	At 1.5 per cent	*At 2.0 per cent*	*At 2.5 per cent*
1965	9,172	9,172	9,172
1970	11,792	11,380	10,960
1975	15,305	14,407	13,408
1980	19,542	18,073	16,499
1985	24,337	22,200	19,854

140. The implied rates of growth in urban population are as below:

Years	Rural rate of increase (assumed)		
	At 1.5 per cent	*At 2.0 per cent*	*At 2.5 per cent*
1965–1970	5.02	4.41	3.63
1970–1975	5.21	4.83	4.21
1975–1980	5.00	4.64	4.14
1980–1985	4.48	4.20	3.77

As can be seen, none of these results are necessarily implausible. Under any of the three assumptions regarding rural growth, a fairly steady rate of growth in urban population is obtained, first accelerating and then slowing down.

141. Coming finally to the example of Canada, we shall assume that the rural population remains constant, that it decreases annually by 0.5 per cent or that it decreases by 1.0 per cent. The following rural populations are thereby projected:

Year	Assumed rural rate of increase (or decrease)		
	At 0.0 per cent	*At −0.5 per cent*	*At −1.0 per cent*
1965	5,311	5,311	5,311
1970	5,311	5,179	5,051
1975	5,311	5,051	4,804
1980	5,311	4,926	4,569
1985	5,311	4,804	4,345

It is not necessary to adduce the implied urban populations and their rates of growth, as it can be readily seen that at this high level of urbanization no implausible result will be implied.

142. It can be concluded that constant rates of change in the rural population have a somewhat wider applicability than constant rates of change of urban population. There may be many situations in which such an assumption produces satisfactory results. It is understood, of course, that the rural population increases more slowly than the urban.

Ratio method

143. The ratio method rests on the assumption that an observed trend in the percentage of a subnational population to a country's total population will continue. It is a highly practical method in the estimation and projection of regional or provincial populations in relation to estimated and projected national totals. The method is also useful in the projection of urban and rural populations, subject to certain constraints, as will be shown.

144. The case of Iran is taken first. Here, according to United Nations estimates, 27.13 per cent of the total population was urban in 1950, and 33.18 per cent in 1960. Thus, the percentage had risen by 6.05 points in ten years, and it may go on rising by 3.025 points every five years. Projecting these percentages linearly and using the United Nations projection of the total population, we obtain the following projections of urban and rural population (in thousands):

Year	*Total*	*Per cent urban*	*Urban*	*Rural*
1965	24,549	36.205	8,888	15,661
1970	28,358	39.230	11,125	17,233
1975	33,152	42.255	14,008	19,144
1980	38,769	45.280	17,555	21,214
1985	45,050	48.305	21,761	23,289

145. The implied annual rates of increase in urban and rural population are the following:

Years	*Urban*	*Rural*
1965–1970	4.60	1.93
1970–1975	4.71	2.12
1975–1980	4.62	2.08
1980–1985	4.39	1.88

There is nothing implausible in such rates of growth of the urban and rural population, and the projection may be acceptable.

146. Now, let us use the same method with respect to the United Republic of Tanzania. Here, according to the estimates, the population was 3.50 per cent urban in 1950 and 4.98 per cent in 1960. The level had risen by 1.48 in ten years and it may rise by 0.74 every five years. In conjunction with the projected total population, we obtain the following urban and rural projections:

Year	*Total*	*Per cent urban*	*Urban*	*Rural*
1965	11,674	5.72	668	11,006
1970	13,236	6.46	855	12,381
1975	15,150	7.20	1,091	14,059
1980	17,475	7.94	1,388	16,087
1985	20,287	8.68	1,761	18,526

147. In these projections the annual rates of growth in urban and rural population would be the following:

Years	Urban	Rural
1965–1970	4.94	2.35
1970–1975	4.88	2.54
1975–1980	4.82	2.69
1980–1985	4.76	2.82

Again, the results may be acceptable. One is led to wonder, however, whether the rise in the percentage of urban population, at this low level of urbanization, would not have a tendency to accelerate, as higher and higher levels of urbanization are being reached. It should be recalled that in Iran the percentage level was estimated to rise 3.025 points every five years, whereas in the United Republic of Tanzania it rises only 0.740 points.

148. Moving now to the example of Canada, we note that 60.66 per cent of the population was estimated urban in 1950, and 68.45 per cent in 1960, a rise of 7.79 points in ten years, or 3.895 points in five years. Using the projection of total population, we obtain these results:

Year	Total	Per cent urban	Urban	Rural
1965	19,644	72.345	14,211	5,433
1970	21,426	76.240	16,335	5,091
1975	23,284	80.135	18,659	4,625
1980	25,299	84.030	21,259	4,040
1985	27,348	87.925	24,046	3,302

It can be noted that in this projection the rural population decreases at a rapidly accelerating tempo. Furthermore, the constant rise in the percentage cannot continue very long because then 100 per cent would be reached and surpassed already in the year 2001, which is absurd. At such a high level of urbanization, therefore, the use of the ratio method encounters a more severe limitation. It is evident that the rise in the ratio must eventually slow down.

149. In conclusion, the ratio method yields acceptable results at intermediate levels of urbanization, but it should not be used where the urbanization level is very low or very high.

Summary

150. Three methods have been examined, namely the method employing constant rates of growth in the urban population, that using constant growth (or decline) in the rural population, and the ratio method. From the observations made with estimates for a country of low urbanization level, one of intermediate level and one of advanced level, some general conclusions emerge.

151. At the low level of urbanization, the most adequate of the three methods appeared to be the one employing constant rates of growth in the urban population. At the intermediate level, the ratio method seemed to be most satisfactory; and at the advanced level it appeared best to make plausible assumptions concerning the growth (or decline) in the rural population. Not all three methods can fit any given situation equally well.

152. One is led to think that some modification of the ratio method may have the widest applicability if it makes provision for an acceleration in the rise of the urbanization level while it is low, a peak rate while it is intermediate, and a slow-down when it is high. These conditions can be met in a logistic curve, or some other curve having both an upper and a lower asymptote. As was shown in chapter III, the assumption of a constant difference between urban and rural rates of growth coincides with a logistic curve in the level of urbanization within the outer limits of zero and 100 per cent.

153. It would be difficult, however, and often impossible, to calculate the several parameters of a complex curve on the basis of limited past observations; and it would be inadvisable to make a forecast depend on parameters easily affected by temporary fluctuations or accidents. True, urbanization throughout the world progresses in the same direction, but the phenomenon is subject to variations in time and place which often elude measurement or prediction. To arrive at judgment it is important to bear in mind pertinent observations made in numerous countries.

154. It should also be recalled that the use of a mathematical curve courts the risk of misinterpretation on the part of the users of a forecast. It may seem to them that a forecast pretends to be exact because a precise formula was used. It will have to be stated clearly that the use of a formula does not imply accuracy in the results. Future developments will never conform to a mathematical artefact. To guard against misinterpretation, the assumptions should be presented flexibly and with an allowance for an error range. This is probably best done by calculating "high" and "low" alternatives in addition to a "medium" forecast.

155. A curve lending itself readily to comparison of observations throughout the world and to flexible application in alternative forecasts is therefore useful. The following chapter will show the ease with which a logistic curve can be applied.

Chapter V

UNITED NATIONS METHOD OF URBAN AND RURAL POPULATION PROJECTIONS

Actual observations concerning urban-rural growth differences

156. As already explained, the United Nations method of measuring the tempo of urbanization and projecting it is based on the difference between urban and rural population growth and its logistic transformation. For an appreciation of possible magnitudes in this measure—URGD for short—reference is made to table 11, presenting estimates of urbanization level in twenty-four regions of the world for 1960-1970,[55] now being revised on the basis of new data.

157. It will be noted that levels of urbanization in 1960 were distinctly higher in more developed regions, ranging from 44 to 80 per cent, than in less developed regions, where the range was from 2 to 46 per cent. Rates of population growth were distinctly lower in more

[55] *Monthly Bulletin of Statistics*, November 1971 (United Nations publication), special tables B-II and B-III.

Table 11. Levels of urbanization, 1960 and 1970, rates of growth in urban and rural population, 1960-1970, and differences between these rates, in nine more developed and fifteen less developed regions of the world

Region	Percentage urban population		Annual rates of growth, 1960-1970 (per cent)		
	1960	1970	Urban	Rural	Difference
More developed regions [a]	*61.0*	*67.5*	*2.2*	*−0.6*	*2.8*
Australia and New Zealand	79.9	83.4	2.4	0.0	2.4
Northern Europe	72.3	76.2	1.2	−0.9	2.1
Temperate South America [b]	71.1	78.3	2.7	−1.1	3.8
Northern America	69.7	74.3	2.0	−0.3	2.3
Western Europe	68.8	74.4	1.8	−1.0	2.8
Soviet Union	49.5	57.1	2.7	−0.4	3.1
Eastern Europe	48.8	54.0	1.8	−0.3	2.1
Southern Europe	45.0	50.8	2.1	−0.2	2.3
Japan [c]	44.3	58.9	3.1	−0.8	3.9
Less developed regions [a]	*24.6*	*29.6*	*4.7*	*1.8*	*2.9*
Tropical South America [d]	45.8	55.5	5.0	1.0	4.0
Middle America	44.9	51.4	4.8	2.1	2.7
Southern Africa	41.7	45.6	3.2	1.6	1.6
Caribbean	36.7	41.6	3.6	1.5	2.1
Other East Asia [e]	32.9	42.7	5.3	1.2	4.1
South West Asia	31.5	37.4	4.5	1.9	2.6
Northern Africa	29.9	34.9	4.4	2.1	2.3
China	18.1	25.5	4.9	1.0	3.9
South East Asia	17.5	21.0	3.7	2.3	1.4
Middle South Asia	16.9	18.9	3.8	2.4	1.4
Polynesia and Micronesia	15.8	20.1	5.4	2.7	2.7
Western Africa	15.3	19.9	5.4	1.9	3.5
Middle Africa	11.5	16.5	5.7	1.4	4.3
Eastern Africa	7.5	10.1	5.6	2.1	3.5
Melanesia	2.3	3.1	5.5	2.8	2.7

Source: *Monthly Bulletin of Statistics*, November 1971 (United Nations publication). A few regions have been regrouped as indicated in foot-notes.

[a] Unweighted average.

[b] Not including Paraguay.

[c] "Urban" population defined as that of densely inhabited districts; including former Ryukyu Islands.

[d] Including Paraguay.

[e] Republic of Korea. Democratic People's Republic of Korea. Hong Kong. Mongolia and Macao.

developed than in less developed regions. Thus, urban population grew at rates between 1.2 and 3.1 per cent in the first group, and between 3.6 and 5.7 per cent in the second group of regions. In more developed regions, the rural population declined (or did not change much, as in Australia and New Zealand), while in less developed regions, rural population grew at rates between 1.0 and 2.8 per cent per year, and this range is similar to the rates of growth of urban population in the more developed regions.

158. Despite these differences in urbanization level and growth rates, however, the differences between urban and rural growth rates in more developed and less developed regions are of the same order of magnitude. In the first group of regions, URGD ranges from 2.1 to 3.9 per cent, and in the second group, from 1.4 to 4.3 per cent. The unweighted average in both groups is nearly the same, 2.8 and 2.9 respectively. One can say that regardless of levels of development, levels of urbanization or the tempo of population growth, URGDs between about 2.0 and 4.0 are now typical throughout the world. Where there is no other detailed knowledge, projections may be made with reference to these observed ranges.

159. For the combined world population, the URGD is smaller as a result of distortions affecting the weighted averages. In 1960-1970, the more developed regions still included a majority of the world's urban population, but in these regions rates of population growth were comparatively moderate; the great majority of the world's rural population is in less developed regions where population growth is rapid. During 1960-1970, according to the estimates, the world's urban population grew from 986 to 1,358 million, and the world's rural population from 1,995 to 2,277 million, representing an urban rate of 3.3 per cent, a rural growth rate of 1.3 per cent and an URGD of only 2.0 per cent per year. This represents a slight acceleration when compared with world-wide estimates for the nineteenth and the earlier part of the twentieth century.

160. Davis and Hertz have estimated the world's population, and the world's urban population (defined as localities with at least 5,000 inhabitants) in 1800 and 1900.[56] According to them, the urban population grew in that century from 27 million to 219 million, and the remaining, or rural, population from 879 to 1,389 million. Average growth rates of the nineteenth century therefore amount to 2.1 per cent for the urban population, and 0.5 per cent for the rural population, leaving an URGD of 1.6 per cent. In view of the distorting effects already mentioned in the combined world figures for 1960-1970, URGD in individual countries or regions may for the most part have been higher.

161. Linking the estimates of Davis and Hertz for 1900 with our present estimates for 1960, we arrive at an average 1900-1960 urban growth rate of 2.5 per cent, a rural growth rate of 0.8 per cent and an URGD of 1.7 per cent, only slightly more than the world estimate for 1800-1900. The long continuation of urbanization with nearly the same momentum (as measured by URGD) is impressive, and it can be concluded that long-run urbanization trends have great inertia. Within shorter time periods, however, this process can fluctuate.

162. A long period of short-time changes can be observed in the decennial census data of the United States (see table 12). A break in the series occurs between 1940 and 1950, as the urban population was then redefined to take into account some of the more recent developments resulting mainly from suburbanization; the difference between the two rates, urban and rural, therefore is perhaps too low in 1930-1940 (redefinition having become due) and perhaps too high in 1940-1950 (an overdue redefinition having at last been adopted). There are also reasons to doubt the accuracy of the 1870 census, taken after the Civil War.

TABLE 12. RATES OF GROWTH IN URBAN POPULATION, IN RURAL POPULATION, AND DIFFERENCES BETWEEN THE TWO RATES, IN THE UNITED STATES, 1800-1960 (PER CENT PER YEAR)

Period	Annual growth rate		Difference between the two rates
	Urban	Rural	
Decades			
1800–1810.....	5.0	3.0	2.0
1810–1820.....	2.8	1.9	0.9
1820–1830.....	5.0	2.8	2.2
1830–1840.....	5.1	2.6	2.5
1840–1850.....	6.8	2.6	4.2
1850–1860.....	5.8	2.5	3.3
1860–1870 [a]	4.8	1.3	3.5
1870–1880 [a]	3.6	2.3	1.3
1880–1890.....	4.6	1.3	3.3
1890–1900.....	3.2	1.2	2.0
1900–1910.....	3.4	0.7	2.7
1910–1920.....	2.6	0.4	2.2
1920–1930.....	2.4	0.4	2.0
1930–1940 [b]	0.7	0.6	0.1
1940–1950 [c]	2.6	−0.5	3.1
1950–1960.....	2.7	0.0	2.7
40-year periods			
1800–1840.....	4.5	2.6	1.9
1840–1880.....	5.2	2.2	3.0
1880–1920.....	3.5	0.9	2.6
1920–1960 [c]	2.1	0.1	2.0

[a] Probable undernumeration of rural population in 1870,
[b] Period of economic depression,
[c] Including change-over to a new definition of urban population which had become necessary by 1950.

163. Over the entire 160-year period here considered, the difference between urban and rural rates of increase averages 2.4 per cent per year, including both favourable periods and others which were unfavourable to rapid urban growth. The average URGD was as high as 3.0 per cent during 1840-1880. It is noteworthy that during 1920-1960, a period when the level of urbanization was high, the difference between the two rates was no less than it had been during 1800-1840, a time when urbanization was still at a very low level.

[56] See M. Hauser, ed., *Urbanization in Asia and the Far East*, Proceedings of the Joint United Nations/UNESCO Seminar (in co-operation with the ILO) on Urbanization in the ECAFE Region, Bangkok, 8-18 August 1956, Tensions and Technology Series No. 7 (Calcutta, 1957), pp. 56-57.

164. It is evident that considerable fluctuations can occur in individual decades. Nevertheless, even at widely different urbanization levels, the span between urban and rural rates of population growth can be quite similar. Where no adverse conditions retard the tempo of urbanization, both across the world and in the long time perspective, a 2.5 or 3.0 per cent excess of urban over rural growth rates appears to be fairly normal, while growth differences between 2.0 and 4.0 per cent need not be regarded as unusual.

165. These general observations, however, do not dispense with the need to arrive at an independent judgement as regards the situation in each particular country, considering the probable or possible influence of varying economic and social conditions or policies. It is an advantage, and not a defect, of the method that varied assumptions of growth differences can be drawn up quite freely.

Formula for iterative calculation

166. The urban and rural population growth rates, and the difference between them, can be calculated either as instantaneous (exponential) or annual (compound interest) rates. Accordingly, there are two alternative modes of application of the growth-difference method for projections of urban and rural population. In either instance it is assumed that a projection of the national total population already exists. Often that projection may be available by five-year time intervals only.

167. If five-year time intervals only are required for the urban and rural projection, then the recommended method may very well be that of instantaneous rates of growth, for direct use can then be made of the logistic curve tabulated in annex I. But if projections of urban and rural population are desired for a series of individual calendar years, there may sometimes be an advantage in the use of annual rates, applied by a simple formula year by year. But then it is also necessary to refer to a projection of total population by individual calendar years. If that initial projection proceeds by five-year intervals only, a series of year-by-year interpolations is also needed.

168. The formula for the year-by-year projection of urban and rural population in relation to an existing projection of total population, employing annual rates of growth, can be derived as follows.

Let T, U and R be the total, urban and rural population for the year t, T', U' and R' the same populations for the year $t+1$, u and r the urban and rural rates of increase, and d the difference between them; then the following relationships obtain:

$$T = U + R, \text{ and } T' = U' + R',$$
$$U' = U(1+u) = U(1+r+d), \text{ and } R' = R(1+r),$$

whence

$$T' = U(1+r+d) + R(1+r) = (U+R)(1+r) + Ud = T(1+r) + Ud,$$

so that

$$T' - Ud = T(1+r).$$

Therefore,

$$\frac{U'}{U} = 1+u = (1+r) + d = \frac{T'-Ud}{T} + d,$$

and the final formula is

$$U' = \left(\frac{T'+dR}{T}\right)U.$$

The rural population is then obtained by subtraction of U' from T'. The computation can be repeated for each single year of the projection period.

Year-to-year interpolation of a five-yearly projection

169. There should be little problem in the interpolation of a projection of the total population by individual calendar years. The easiest method is perhaps the graphic one, where the projected population, at five-yearly intervals, is plotted, and the points are connected free-hand or with the use of French curves to obtain a smooth transition among gradually changing growth rates for the intervening individual years.

170. The use of a simple mathematical interpolation can also be recommended. The population of Iran, for instance, has been projected for five-yearly intervals with these results:

Year	*Population (in thousands)*
1965	24,549
1970	28,358
1975	33,152
1980	38,769
1985	45,050

A series of this type can usually be simply interpolated with the use of first and second differences, as shown in table 13. The detailed procedure is lengthy to explain in a text, but will be quite evident as described in the foot-notes to the table. This procedure is known as the "central difference method".

Applications of the method (by annual rates)

171. For Iran, an urban population of 9,172,000 has been estimated for 1965. Urbanization has been proceeding speedily in Iran, hence the URGD may perhaps be put at 3.0 per cent on a medium assumption. Alternative projections may put it as low as 2.0 and as high as 4.0 per cent. In applying the formula $U' = \left(\frac{T'+dR}{T}\right)U$, we obtain the following three series implying a high, medium or low tempo of urbanization, respectively. [57]

[57] To illustrate the first step of computation assuming the "high" tempo, we have the following quantities: $T = 24{,}549$, $T' = 25{,}225$, $U = 9{,}172$, $R = 15{,}377$ (i.e. 24,549 minus 9,172) and $d = 0.04$ (high assumption).

Substituting in the formula $U' = \left(\frac{T'+dR}{T}\right)U$ we have

$$U' = \frac{25{,}225 + 0.04 \,.\, 15{,}377}{24{,}549} \,.\, 9{,}172 = 9{,}654.$$

Subtracting U' from T', we obtain

$$R' = 25{,}225 - 9{,}654 = 15{,}571;$$

likewise for each successive year of the projection and for alternative assumptions.

TABLE 13. ANNUAL INTERPOLATION FOR A QUINQUENNIAL SERIES BY MEANS OF FIRST AND SECOND DIFFERENCES

Year (1)	Data (2)	Mean first difference (3)	Mean second difference (4)	Second difference interpolated (5)	First difference interpolated (6)	First trial, results (7)	Adjustments, interpolated (8)	Results, adjusted (9)
1965	*24,549*		(45) [c]			*24,549*		*24,549*
1966				44	675	25,224	1	25,225
1967				43	719	25,943	2	25,945
1968		762 [a]		42	762	26,705	2	26,707
1969				41	804	27,509	3	27,512
(1970)				40	845	(28,354) [d]	4 [e]	
1970	*28,358*		39 [b]			*28,358*		*28,358*
1971				38	884	29,242	1	29,243
1972				37	922	30,164	2	30,166
1973		959		36	959	31,123	2	31,125
1974				35	995	32,118	3	32,121
(1975)				34	1,030	(33,148) [d]	*4*	
1975	*33,152*		33			*33,152*		*33,152*
1976				32	1,060	34,212	1	34,213
1977				31	1,092	35,304	3	35,307
1978		1,123		30	1,123	36,427	4	36,431
1979				29	1,153	37,580	5	37,585
(1980)				28	1,182	(38,762) [d]	*7*	
1980	*38,769*		27			*38,769*		*38,769*
1981				26	1,205	39,974	1	39,975
1982				25	1,231	41,205	2	41,207
1983		1,256		24	1,256	42,461	4	42,465
1984				23	1,280	43,741	5	43,746
(1985)				22	1,303	(45,044) [d]	*6*	
1985	*45,050*		(21) [c]			*45,050*		*45,050*

[a] Equals 1/5 of (28,358 − 24,549). Other first differences are calculated in the same manner.
[b] Equals 1/5 of (959 − 762). Other second differences are calculated in the same manner.
[c] Extrapolated, in these instances equal 39 + (39-33), and 27 + (27-33).
[d] Trial results.
[e] Difference between trial result (in parenthesis) and original data (in italics), 28,358 − 28,354 in this instance.

URBAN AND RURAL POPULATION OF IRAN, 1965-1985, ACCORDING TO A PROJECTION OF TOTAL POPULATION AND THREE ASSUMED TEMPOS OF URBANIZATION

Year	Projected total	"High" tempo (4 per cent)		"Medium" tempo (3 per cent)		"Low" tempo (2 per cent)	
		Urban	Rural	Urban	Rural	Urban	Rural
1965	24,549	9,172	15,377	9,172	15,377	9,172	15,377
1966	25,225	9,654	15,571	9,597	15,628	9,540	15,685
1967	25,945	10,168	15,777	10,049	15,896	9,931	16,014
1968	26,707	10,714	15,993	10,529	16,178	10,345	16,362
1969	27,512	11,294	16,218	11,038	16,474	10,784	16,728
1970	28,358	11,908	16,450	11,576	16,782	11,247	17,111
1971	29,243	12,556	16,687	12,143	17,100	11,734	17,509
1972	30,166	13,239	16,927	12,739	17,427	12,245	17,921
1973	31,125	13,957	17,170	13,365	17,760	12,780	18,345
1974	32,121	14,712	17,409	14,021	18,100	13,340	18,781
1975	33,152	15,503	17,649	14,708	18,444	13,924	19,228
1976	34,213	16,329	17,884	15,424	18,789	14,531	19,983
1977	35,307	17,193	18,114	16,171	19,136	15,166	20,141
1978	36,431	18,093	18,338	16,949	19,482	15,822	20,609
1979	37,585	19,031	18,554	17,758	19,827	16,502	21,083
1980	38,769	20,006	18,763	18,598	20,171	17,207	21,562
1981	39,975	21,016	18,959	19,467	20,508	17,933	22,042
1982	41,207	22,062	19,145	20,366	20,841	18,683	22,524
1983	42,465	23,144	19,321	21,297	21,168	19,457	23,008
1984	43,746	24,263	19,483	22,258	21,488	20,255	23,491
1985	45,050	25,418	19,632	23,250	21,800	21,076	23,974

172. In accordance with these projections, the following percentage levels of urban population would be attained at future dates:

Year	"High" tempo	"Medium" tempo	"Low" tempo
1965	37.4	37.4	37.4
1970	42.0	40.8	39.7
1975	46.8	44.4	42.0
1980	51.6	48.0	44.4
1985	56.4	51.6	46.8

A noteworthy observation can here be made. At the low tempo (URGD = 2 per cent), a level of urbanization (46.8) is obtained after 20 years, which at the high tempo (URGD = 4 per cent) is obtained after 10 years. At the medium tempo (URGD = 3 per cent), the level of urbanization after 20 years (51.6) is that attained at the high tempo (URGD = 4 per cent) after 15 years. Evidently, the time taken to attain a given level of urbanization is inversely proportional to the tempo in URGD. [58]

173. On each of the three assumptions, the quinquennial gains in percentage levels would be by nearly equal amounts in each five-year period. Accordingly, the simple method might have yielded fairly similar results. As indicated by the results for the "medium" tempo, the use of a constant rate of growth in the rural population might also have yielded satisfactory results. Results will differ to a greater extent from those of the simpler methods when the level of urbanization is either very low or very high, not intermediate as in the example given.

174. As a further check on the consistency of these projections, one may also consider average annual rates of growth (per cent) in urban and rural population, respectively, resulting from the projections, as shown above. There is nothing inherently implausible in these figures. A more detailed knowledge of relevant circumstances in Iran, however, might give cause to modify such a tentative judgment.

175. One might wonder whether the same method also leads to acceptable results when the level of urbanization is either very low or very high. It has therefore also been applied to the urban and rural populations of the United Republic of Tanzania and those of Canada. Again, URGD has been assumed as 4 per cent for the "high", 3 per cent for the "medium", and 2 per cent for the "low" projection. The calculations were also carried out from interpolated figures by individual calendar year. For brevity, the results are shown for five-year intervals only.

176. In the case of the United Republic of Tanzania (low level of urbanization), a relatively wide divergence in projected urban populations is obtained, depending on the assumed URGD. Relative to its size, the rural population is projected within narrower limits, being more closely dependent on the projection of the total population. The following levels of urbanization are obtained (per cent of total):

Year	"High" tempo	"Medium" tempo	"Low" tempo
1965	5.8	5.8	5.8
1970	6.9	6.6	6.4
1975	8.3	7.6	6.9
1980	9.9	8.7	7.6
1985	11.7	9.9	8.3

It can be seen that the level of urbanization rises by increasing amounts. This is reasonable where urbanization is still in a phase of increasing momentum. As shown on the next page both the urban and rural populations increase at accelerating rates, but the acceleration is moderate. One might have obtained similar results by assuming rates of growth in the urban population, such as 5.0, 6.0 and 7.0 per cent per year, respectively, as was already done in chapter IV.

	Average annual rate of growth								
	"High" tempo			"Medium" tempo			"Low" tempo		
Years	Urban	Rural	URGD	Urban	Rural	URGD	Urban	Rural	URGD
1965–1970	5.4	1.4	4.0	4.8	1.8	3.0	4.2	2.2	2.0
1970–1975	5.4	1.4	4.0	4.9	1.9	3.0	4.4	2.4	2.0
1975–1980	5.2	1.2	4.0	4.9	1.9	3.0	4.3	2.3	2.0
1980–1985	4.9	0.9	4.0	4.6	1.6	3.0	4.1	2.1	2.0

[58] The findings are slightly inexact when made on the basis of annual rates. With exponential rates these findings would be mathematically precise.

URBAN AND RURAL POPULATION OF THE UNITED REPUBLIC OF TANZANIA, 1965-1985, IN FIVE-YEAR INTERVALS OF TIME, ACCORDING TO A PROJECTION OF TOTAL POPULATION AND THREE ASSUMED TEMPOS OF URBANIZATION (URGD)

Year	Projected total	"High" tempo (4 per cent)		"Medium" tempo (3 per cent)		"Low" tempo) (2 per cent)	
		Urban	Rural	Urban	Rural	Urban	Rural
1965	11,674	677	10,997	677	10,997	677	10,997
1970	13,236	919	12,317	879	12,357	841	12,395
1975	15,150	1,255	13,895	1,150	14,000	1,053	14,097
1980	17,475	1,723	15,752	1,514	15,961	1,328	16,147
1985	20,287	2,372	17,915	2,003	18,284	1,684	18,603

Years	Average annual rate of growth								
	"High" tempo			"Medium" tempo			"Low" tempo		
	Urban	Rural	URGD	Urban	Rural	URGD	Urban	Rural	URGD
1965–1970.....	6.3	2.3	4.0	5.4	2.4	3.0	4.4	2.4	2.0
1970–1975.....	6.4	2.4	4.0	5.5	2.5	3.0	4.6	2.6	2.0
1975–1980.....	6.5	2.5	4.0	5.7	2.7	3.0	4.8	2.8	2.0
1980–1985.....	6.6	2.6	4.0	5.8	2.8	3.0	4.9	2.9	2.0

177. In the case of Canada (high level of urbanization), the relative divergence of results is most marked in the projected rural population, as shown below.

178. In these projections, the rise in the percentage level of urbanization gradually slows down, as can be noted in the following figures:

Year	"High" tempo	"Medium" tempo	"Low" tempo
1965	73.0	73.0	73.0
1970	76.7	75.8	74.9
1975	80.0	78.4	76.7
1980	83.0	80.8	78.4
1985	85.7	83.0	80.0

This slowing-down in the rise of level is necessary at high levels so that an absurd result of 100 per cent or more will never be attained.

179. The average annual increases or decreases in urban and rural population are as shown on the next page. It can be noted that the urban population increases at diminishing rates and the rural population decreases at increasing rates, except in the "low" tempo where the rural population also increases at a diminishing rate. The sensitivity of the rural population to the assumptions selected is evident, since the projection of the urban population depends ever more closely on the projection of the total population. [59]

180. As can be seen, the URGD method has the merit of equal applicability under a wide range of conditions and is therefore suitable for international comparisons. The method may be equally useful in the projection of urban and rural populations among provinces or regions of the same country, assuming that provincial or regional projections of total population already exist.

181. The method raises, however, an important problem. In the foregoing examples, a URGD of 4 per cent was assumed as a "high", 3 per cent as an intermediate, and 2 per cent as a "low" assumption. These three tempos can be related to world-wide average observations. In the particular countries in question, however, developments may be of a kind deviating more widely from those average circumstances. Assumptions must then be drawn up independently, in the light of detailed knowledge concerning each particular country. Past trends noted in the same country provide an important background for reference.

182. When applying the same method to a wide variety of examples, one arrives invariably at the following experience:

(*a*) With any given URGD, the percentage level of urbanization rises in the manner of a logistic curve, with a continuous acceleration at the low levels, a point of inflection about 50 per cent and a continuous slow-down thereafter;

(*b*) These rises in percentage level are independent of the rate of growth in total population; and

(*c*) The time taken to attain a particular urbanization level, starting from the same initial level, will be inversely proportionate to the URGD.

183. With the use of annual rates of growth, these features are obtained to a high degree of approximation; with the use of instantaneous (exponential) rates, the observations are precise because, as already explained in chapter III, the curve in the level of urbanization is then an exact logistic.

[59] The meaning to be attached to the rural trend may also have to be judged in the light of the changing features of the "rural population". There is probably a tendency towards suburbanization in areas of residence sometimes defined as "rural", depending on local administrative circumstances.

URBAN AND RURAL POPULATION OF CANADA, 1965-1985, IN FIVE-YEAR INTERVALS OF TIME, ACCORDING TO A PROJECTION OF TOTAL POPULATION AND THREE ASSUMED TEMPOS OF URBANIZATION

Year	Projected total	"High" tempo (4 per cent)		"Medium" tempo (3 per cent)		"Low" tempo (2 per cent)	
		Urban	Rural	Urban	Rural	Urban	Rural
1965.....	19,644	14,333	5,311	14,333	5,311	14,333	5,311
1970.....	21,426	16,432	4,994	16,238	5,188	16,041	5,385
1975.....	23,284	18,642	4,642	18,258	5,026	17,853	5,431
1980.....	25,299	21,012	4,287	20,448	4,851	19,834	5,465
1985.....	27,348	23,432	3,916	22,708	4,640	21,884	5,464

Years	"High" tempo			"Medium" tempo			"Low" tempo		
	Urban	Rural	URGD	Urban	Rural	URGD	Urban	Rural	URGD
1965–1970.....	2.8	−1.2	4.0	2.5	−0.5	3.0	2.3	0.3	2.0
1970–1975.....	2.6	−1.4	4.0	2.4	−0.6	3.0	2.2	0.2	2.0
1975–1980.....	2.6	−1.4	4.0	2.3	−0.7	3.0	2.1	0.1	2.0
1980–1985.....	2.2	−1.8	4.0	2.1	−0.9	3.0	2.0	0.0	2.0

SAME METHOD, USING EXPONENTIAL RATES

184. A table of the logistic curve, $100\frac{U_t}{T_t} = \frac{100e^{dt}}{1+e^{dt}}$, is tabulated in annex I. A computation formula for the URGD method, using exponential rates, is therefore not needed. All pertinent calculations can be carried out very simply by reference to that table. The table is arranged in two columns, one identified as $100dt$ (a combination of time and the urban-rural growth rate difference), and the other as $100\frac{U_t}{T_t}$ (the percentage level of urbanization).

185. It should be noted that the first column of that table represents a fictitious time scale, measured from the point where the urbanization level is exactly 50 per cent, with negative values where urbanization is lower and positive values where it is higher. The intervals in that time scale are exact calendar years if URGD is exactly 1.0 per cent (d=0.01). If the URGD is some multiple of 1.0 per cent, the intervals in the fictitious time scale are corresponding fractions of calendar years. For instance, if the URGD is exactly 2.0 per cent (d=0.02), the intervals are half-years, hence exactly two successive intervals represent an interval of one year in actual time.

186. The URGD, of course, is not always an exact integral multiple of 1.0, and it may include further decimals. Interpolations will then have to be made in the fictitious time scale to obtain the corresponding points on the scale of actual time.

187. The fictitious time scale, for instance, is about −219.7 at the point where the urbanization level is 10 per cent, and about +219.7 where it is 90 per cent. Thus, about 439.4 years would have to elapse for a 10 per cent urbanized population to become 90 per cent urbanized, if URGD is at a constant 1.0 per cent. Only a quarter of that time, about 110 years, would be needed if URGD were at a constant 4.0 per cent. Assuming that an actual population has progressed from 10 per cent to 90 per cent urban in the space of, say, 250 years, the URGD needed to reach this effect is 439.4 divided by 250, which is about 1.76 per cent. The relationship between actual time, urbanization levels and URGD, represented by the table in annex II, is thus illustrated.

188. The table thus facilitates two types of procedure. Given the urbanization levels at two dates in the past, e.g. as observed in the results of two successive censuses, the URGD for that time interval can be calculated directly: it is the ratio between the time interval between the actual dates of the past (e.g. the interval between the two censuses) and the interval in the fictitious time scale of the table. For instance, the population of Colombia was 29.1 per cent urban at the census of 5 August 1938, and 38.0 per cent urban at the census of 9 May 1951, i.e. after an actual time interval of 12.68 years; in the table, an urbanization level of 29.1 per cent corresponds to the fictitious data of −89, and a level of 38.0 to the fictitious date of −49, a fictitious time interval of 40 years; dividing 40 by 12.68 we obtain 3.15, and this is the value of URGD for Colombia during 1938-1951.

189. Given URGD, on the other hand, we can readily project the urbanization levels. For instance, the urbanization level of Colombia in mid-year 1960 has been estimated as 47.8 per cent. Let it be assumed that during 1960-1970 URGD was at the same level as during 1938-1951, namely 3.15. Ten years later, in mid-year 1970, the urbanization level should have progressed by 31.5 years (10 times 3.15) in the fictitious time scale of the table. The level of 47.8 per cent (Colombia, in 1960) corresponds to the year −9 in the table. Ten years later, i.e. progressing by 31.5 years in the table, we arrive at the year 22.5 in the table. At that point in the table, the urbanization level is 55.6 per cent (by interpolation), and this, according to assumption, might have been the urbanization level of Colombia in 1970.

190. The table thus makes it possible to project urbanization levels directly and to calculate urban and rural populations according to those levels from a projection of the total population. This is a considerable simplification of the procedure.

191. As an illustration, we may take the case of Canada and assume, for this purpose, that URGD = 2.5. The annual rises in urbanization level will then correspond to rises noted every 2.5 intervals in the table (where URGD = 1.0).

192. According to the available estimates, 72.96 per cent of the population of Canada was urban in 1965, a level which occurs in the table (with an interpolation) at the point 99.25. The future levels, year by year, will be those occurring in the table at the points 101.75, 104.25, and so forth, each time advancing by 2.5 intervals. The following urbanization levels will then be attained.

193. Applying now these urbanization levels to available population estimates for the years 1965-1969 and to a projection of the total population from 1970 up to 1985, which was interpolated for individual calendar years, we obtain the following results.

Calendar year	Point in the table	Percentage
1965	99.25	72.96
1966	101.75	73.45
1967	104.25	73.93
1968	106.75	74.41
1969	109.25	74.88
1970	111.75	75.35
1971	114.25	75.81
1972	116.75	76.27
1973	119.25	76.72
1974	121.75	77.16
1975	124.25	77.60
1976	126.75	78.03
1977	129.25	78.46
1978	131.75	78.88
1979	134.25	79.29
1980	136.75	79.70
1981	139.25	80.10
1982	141.75	80.49
1983	144.25	80.88
1984	146.75	81.27
1985	149.25	81.65

Year	Total population	Percentage urban	Urban	Rural
1965	19,644	72.96	14,333	5,311
1966	20,050	73.45	14,727	5,323
1967	20,441	73.93	15,112	5,329
1968	20,772	74.41	15,456	5,316
1969	21,089	74.88	15,791	5,298
1970	21,426	75.35	16,144	5,282
1971	21,786	75.81	16,516	5,270
1972	22,151	76.27	16,895	5,256
1973	22,522	76.72	17,279	5,243
1974	22,899	77.16	17,669	5,230
1975	23,284	77.60	18,068	5,216
1976	23,675	78.03	18,474	5,201
1977	24,073	78.46	18,888	5,185
1978	24,477	78.88	19,307	5,170
1979	24,886	79.29	19,732	5,154
1980	25,299	79.70	20,163	5,136
1981	25,714	80.10	20,597	5,117
1982	26,128	80.49	21,030	5,098
1983	26,541	80.88	21,466	5,075
1984	26,948	81.27	21,901	5,047
1985	27,348	81.65	22,330	5,018

FLEXIBLE ASSUMPTIONS

194. Under certain conditions it may be reasonable to assume, instead of a constant URGD, that the URGD will change in the course of time. This may be the case where there is a development plan intended to shift the balance of future developments between urban and rural areas. If rural developments are emphasized, the URGD may decline with time. If the stress is on urban or industrial developments, the URGD may increase.[60] Assumptions of URGD may then be drawn up accordingly. The table in annex I is well suited for the derivation of a population projection in which URGD undergoes a change.

[60] But URGD may decrease if there occurs much settlement of suburban places which remain under a "rural" type of local administration.

195. In our example of the United Republic of Tanzania, for instance, let us assume that the Government entertains plans for a continuously accelerating industrialization. In this connexion, perhaps a flexible URGD should be assumed, rising continuously with time. For the sake of the example, let it be assumed that the URGD is initially 2.5 and that it may rise to the level of 4.5 in the course of twenty years. It would then rise by 0.1 each year. Since the urbanization level of the United Republic of Tanzania in the year 1965 is estimated as 5.8 per cent, which occurs in the table near the point −279, the following future urbanization levels can be estimated.

Calendar year	URGD	Point in table	Percentage urban
1965	...	−279.00	5.79
1966	2.55	−276.45	5.92
1967	2.65	−273.80	6.11
1968	2.75	−271.05	6.24
1969	2.85	−268.20	6.40
1970	2.95	−265.25	6.59
1971	3.05	−262.20	6.77
1972	3.15	−259.05	6.97
1973	3.25	−255.80	7.19
1974	3.35	−252.45	7.42
1975	3.45	−249.00	7.66
1976	3.55	−245.45	7.91
1977	3.65	−241.80	8.18
1978	3.75	−238.05	8.47
1979	3.85	−234.20	8.77
1980	3.95	−230.25	9.10
1981	4.05	−226.20	9.43
1982	4.15	−222.05	9.79
1983	4.25	−217.80	10.17
1984	4.35	−213.45	10.58
1985	4.45	−209.00	11.01

196. Applying now these urbanization levels to a projection of the total population interpolated by individual years, we obtain the following results.

Year	Total population	Percentage urban	Urban	Rural
1965	11,674	5.79	676	10,998
1966	11,966	5.92	708	11,251
1967	12,267	6.11	750	11,517
1968	12,578	6.24	785	11,793
1969	12,900	6.40	826	12,074
1970	13,236	6.59	872	12,364
1971	13,585	6.77	920	12,665
1972	13,951	6.97	972	12,979
1973	14,333	7.19	1,031	13,302
1974	14,733	7.42	1,093	13,640
1975	15,150	7.66	1,160	13,990
1976	15,584	7.91	1,233	14,351
1977	16,034	8.18	1,312	14,722
1978	16,500	8.47	1,398	15,102
1979	16,980	8.77	1,489	15,491
1980	17,475	9.10	1,590	15,885
1981	17,985	9.43	1,696	16,289
1982	18,514	9.79	1,813	16,701
1983	19,066	10.17	1,939	17,127
1984	19,653	10.58	2,079	17,574
1985	20,287	11.01	2,234	18,053

197. To vary the example, let us suppose that the Canadian Government, concerned over an expected decline in rural population, engages in a large programme of rural rehabilitation and development. If this should be the case, the URGD can be assumed to diminish. Let us assume that it declines from 3.0 in 1965 to 1.5 in 1980, and then remains at that level. The following percentage levels of urbanization can then be read from the table in annex II.

Calendar year	*URGD*	*Point in the table*	*Percentage urban*
1965	...	99.25	72.96
1966	2.95	102.20	73.54
1967	2.85	105.05	74.09
1968	2.75	107.80	74.61
1969	2.65	110.45	75.11
1970	2.55	113.00	75.58
1971	2.45	115.45	76.03
1972	2.35	117.80	76.46
1973	2.25	120.05	76.86
1974	2.15	122.20	77.24
1975	2.05	124.25	77.60
1976	1.95	126.20	77.94
1977	1.85	128.05	78.25
1978	1.75	129.80	78.55
1979	1.65	131.45	78.83
1980	1.55	133.00	79.08
1981	1.50	134.50	79.33
1982	1.50	136.00	79.58
1983	1.50	137.50	79.82
1984	1.50	139.00	80.06
1985	1.50	140.50	80.29

198. In relation to the interpolated projection of the total population, this leads to the following results.

199. In the above example, the assumptions suffice to produce a stabilization in the rural population by 1974. By 1981 the 1965 size of the rural population would be recuperated. Such a calculation need not be carried out as a forecast, but rather to provide a rough model which

Year	*Total population*	*Percentage urban*	*Urban*	*Rural*
1965	19,644	72.96	14,332	5,312
1966	20,050	73.54	14,745	5,305
1967	20,441	74.09	15,145	5,296
1968	20,772	74.61	15,498	5,274
1969	21,089	75.11	15,840	5,249
1970	21,426	75.58	16,194	5,232
1971	21,786	76.03	16,564	5,222
1972	22,151	76.46	16,937	5,214
1973	22,522	76.86	17,310	5,212
1974	22,899	77.24	17,687	5,212
1975	23,284	77.60	18,068	5,216
1976	23,675	77.94	18,452	5,223
1977	24,073	78.25	18,837	5,236
1978	24,477	78.55	19,227	5,250
1979	24,886	78.83	19,618	5,268
1980	25,299	79.08	20,006	5,293
1981	25,714	79.33	20,399	5,315
1982	26,128	79.58	20,793	5,335
1983	26,541	79.82	21,185	5,356
1984	26,948	80.06	21,575	5,373
1985	27,348	80.29	21,958	5,390

can serve to guide policy. The fictitious rural rehabilitation and development programme would have to be on a sufficient scale to reduce the URGD at least to 2.0, and preferably to 1.5, as assumed in the above. The approximate implication would be a halving in the average annual rural-to-urban transfers (net migration and reclassifications). Estimates can then be made of the expenditures required to achieve such an effect. In practice, however, the meaning of such a model will also depend very much on the definition of the "rural" population, whose living conditions in an advanced country can become qualitatively similar to those of the urban population, except for densities of settlement. In fact, in the absence of administrative change, an increasing proportion of the population may come to inhabit suburbs which are technically classified as "rural".

Chapter VI

PROJECTIONS FOR INDIVIDUAL CITIES, GROUPS OF CITIES AND DISTINCT GROUPS OF LOCALITIES

METHODS NOT DEALT WITH IN THIS MANUAL

200. Forecasts of the population for one or several distinct cities are usually made by economic and geographic methods. These methods can comprise much detail, but they must be adapted in each instance to known economic and geographic circumstances, and these can differ remarkably from one city to another. Since a general discussion of such locally specialized adaptations would be difficult, the presentation of such methods is outside the scope of this manual. It is to be doubted whether a set of methods suitable in the forecast for a particular city can be applied without considerable transformations to a city in another country where circumstances and available information are of a different kind.

201. The economic method is probably most suitable in countries with central economic plans where those plans include expectations of labour force in the chief branches of industry to be employed at future dates in each of the various locations. Multipliers can then be applied to represent ratios of total population (including labour force in complementary industrial and service sectors and the dependents of the labour force in every sector) to arrive at corresponding total populations. These forecasts for individual regions and cities may have to be reconciled with the over-all population projections for the whole nation since, logically, the sum of regional forecasts should agree with the national totals. It is then possible to foresee also the migratory movements necessary to reach the planning targets.

202. An alternative method, also making use of multipliers, is pertinent in particular to the foreseeable population of individual city quarters, residential towns or suburbs for which the construction of a given quantity of residential dwelling space can be foreseen. Given the amounts of dwelling space estimated for the future and assuming full or a high degree of occupancy, one can calculate the corresponding estimates of future population. Again, the method is most pertinent where housing construction is centrally planned. And future population estimates according to housing space may have to be reconciled with future population estimates derived from projected employment in basic industries to arrive at consistency in the respective plans.

203. However, elements of judgment concerning comparative rates of city growth will not be lacking in countries whose economy is not centrally planned. City growth has been studied in relationship to numerous other changes, including the correlated growth of employment in industry and services, available means of transport, taxes and subsidies, rising levels of education, discontent with conditions in rural areas and small towns and so forth. Cities containing certain key industries may grow faster than other cities. Chain effects of migration are also known, such as the attraction to a city of additional migrants once a viable local community has been formed by previous migrants pertaining to a particular ethnic group, caste or region of origin. The subject is ramified and cannot be dealt with at length in this technical manual. As will be sen in this chapter, several alternative methods of projecting city populations in consistency with national total and urban populations are possible, and they can lead to a range of alternative results. The elements of judgement here suggested will have a bearing on the selection of those alternatives which might be of best practical use to the authorities in need of a plausible forecast.

204. In this chapter, methods are proposed which ensure that the population projections for one or several cities will not be inconsistent with those for other cities or the rest of the country's population. Such assurance would be lacking if population projections were decentralized and carried out independently in each city. The procedures suggested here are sensitive to the relative position of each city within the urban system. But they should not be used too mechanically. Where elements of judgement indicate it, a corresponding adjustment should be introduced in an otherwise too systematic procedure.

205. The methods suggested here may also serve in projections for portions of a city, for instance its centre and its periphery, but care should be taken in such a case that well-known circumstances are not being disregarded. In population forecasts with respect to individual city quarters geographical considerations should perhaps be given some weight. Use can be made, for instance, of the empirical observation of gradients of residential housing density as a function of distance from the city's core and progressive changes therein. In virtually all large cities it is observed that in the most central areas the resident population tends to decline. Immediately surrounding the centre are areas of very high residential density, but densities decrease with distance from that area, and rates of population growth reach a maximum further and further away from the city centre. Forecasting methods based on such observations are of special interest where separate population

estimates for the central parts and the peripheries of a city are desired. The geographic method can be made more detailed having regard to the shifting distribution of areas used for business, industry, residence, transport, recreation and so forth. Such forecasts depend, of course, on detailed knowledge of each city's geography.

206. In preceding chapters, urban populations have been projected with reference to the projected total population. The same methods can be employed to project the population of a leading city or of a group of cities with reference to the projected urban population. The point of interest in these methods is that consistency is maintained between the projected population of individual cities and the combined urban population.

Ratio method

207. For the projection of individual city populations in relation to a projection of the combined urban population, the ratio method is sometimes most suitable, at least so long as the unusual growth rate of a particular city does not lead to extremes where the assumption of a constant linear change in a percentage can become unreasonable.

208. A projection of the urban population of Iran has already been presented in chapter IV. Table 14 illustrates how the population of individual cities (the six largest in 1966) may be projected, in relation to the projected urban population, with the use of the ratio method. As a result of these calculations, the population of Tehran may grow almost threefold between 1965 and 1985, the populations of Esfahan, Mashdad and Shiraz may grow more than twofold, the population of Tabriz may grow by two-thirds, but the population of Abadan may decline considerably from 1975 onward. It is to be questioned whether the latter result can be accepted. Since Abadan has grown at a comparatively low rate between the censuses of 1956 and 1966, it is possible that prospects for growth are comparatively limited in that city (a question which would have to be resolved with more detailed knowledge of relevant local circumstances). But a projection in which growth at first slows down, and thereafter gives way to decline, may have to be questioned seriously. The fault may lie, in part, with the method of calculation, making it desirable to calculate with a different method, and then compare the results.

209. Perhaps an assumption should be made that changes in percentage level, as extrapolated linearly in table 14, will gradually slow down until some future date when all cities grow at the same rate as the combined urban population. The interpolated and extrapolated percentage levels of table 14 will then be modified, changing more and more slowly, eventually becoming constant. The growth of Tehran, Esfahan and Mashdad, which occurred in 1956-1966 at faster rates than the combined urban growth, could be made to slow down somewhat, while, in the same procedure, the slower growth of Tabriz, Abadan and Shiraz would be correspondingly accelerated. Eventually, depending on the date assumed for the convergence of growth rates, all cities would grow at the same rates as the combined urban population. It will have to be recognized, however, that the assumption of a future date of convergence of growth rates is arbitrary and serves only to avoid eventually unreasonable results.

United Nations method

210. A more satisfactory alternative method, then, may be the URGD method which has already been illustrated in the projection of urban relative to total population. Proceeding in much the same way, the population of individual cities can be projected in relation to the urban population as already projected. The steps involved in such a calculation are illustrated in table 15, on page 47. Linear changes are now interpolated and extrapolated, not in terms of the percentages themselves, but rather in terms of logistic levels corresponding to those percentages as tabulated in annex I.

Table 14. Calculation of population projections for individual cities of Iran, 1965-1985, using the ratio method (population in thousands)

Category	*Urban population*	*Tehran*	*Esfahan*	*Mashdad*	*Tabriz*	*Abadan*	*Shiraz*
Census, November 1956	5,954	1,512	255	242	290	226	171
Census, November 1966	9,794	2,720	424	410	403	273	270
Percentage of urban, 1956	100.0	25.40	4.28	4.06	4.87	3.80	2.87
Percentage of urban, 1966	100.0	27.77	4.33	4.18	4.12	2.79	2.76
Annual change in percentage ...	...	0.237	0.005	0.012	−0.073	−0.101	−0.009
Percentages, interpolated and extrapolated to mid year							
1965	...	27.44	4.320	4.16	4.220	2.930	2.740
1970	...	28.63	4.345	4.22	3.845	2.425	2.685
1975	...	29.82	4.370	4.28	3.470	1.920	2.630
1980	...	31.01	4.395	4.34	3.095	1.415	2.575
1985	...	32.20	4.420	4.40	2.720	0.910	2.520
Population projections, mid year							
1965	9,172	2,517	396	382	387	269	251
1970	11,576	3,314	503	489	445	281	311
1975	14,708	4,386	643	630	510	282	387
1980	18,598	5,767	817	807	576	263	479
1985	23,250	7,486	1,028	1,023	632	212	586

TABLE 15. CALCULATION OF POPULATION PROJECTIONS FOR SIX PRINCIPAL CITIES OF IRAN, 1965-1985, WITH THE URGD METHOD

Category	*Tehran*	*Esfahan*	*Mashdad*	*Tabriz*	*Abadan*	*Shiraz*
Census, November 1956						
Urban population [a]	5,954	4,441	4,187	3,945	3,655	3,429
Population of city	*1,512*	*255*	*242*	*290*	*226*	*171*
Percentage in city	25.40	5.73	5.78	7.35	6.19	4.98
Census, November 1966						
Urban population [a]	9,794	7,075	6,650	6,241	5,837	5,564
Population of city	*2,720*	*424*	*410*	*403*	*273*	*270*
Percentage in city	27.77	5.99	6.16	6.46	4.68	4.85
Logistic level of percentage						
November 1956	−107.2	−280.0	−279.1	−253.4	−271.8	−294.9
November 1966	−95.6	−275.3	−272.4	−267.3	−301.4	297.7
Interpolation and extrapolations to mid year						
1965.....	−97.2	−275.90	−273.30	−265.40	−297.4	−297.3
1970.....	−91.4	−273.55	−269.95	−272.35	−312.2	−298.7
1975.....	−85.6	−271.20	−266.60	−279.30	−327.0	−300.1
1980.....	−79.8	−268.85	−263.25	−286.25	−341.8	−301.5
1985.....	−74.0	−266.50	−259.90	−293.30	−356.6	−302.9
Corresponding percentages, mid year						
1965.....	27.45	5.96	6.11	6.57	4.86	4.87
1970.....	28.62	6.09	6.30	6.16	4.22	4.80
1975.....	29.82	6.23	6.50	5.77	3.66	4.74
1980.....	31.05	6.37	6.71	5.40	3.16	4.68
1985.....	32.30	6.51	6.92	5.05	2.75	4.61
Population projections, mid year						
1965						
Urban population [a]	9,172	6,654	6,257	5,875	5,489	5,222
Population of city	*2,518*	*397*	*382*	*386*	*267*	*254*
1970						
Urban population [a]	11,576	8,263	7,760	7,271	6,823	6,535
Population of city	*3,313*	*503*	*489*	*448*	*288*	*314*
1975						
Urban population [a]	14,708	10,322	9,679	9,050	8,528	8,216
Population of city	*4,386*	*643*	*629*	*522*	*312*	*389*
1980						
Urban population [a]	18,598	12,823	12,008	11,336	10,724	10,385
Population of city	*5,775*	*817*	*806*	*612*	*339*	*486*
1985						
Urban population [a]	23,250	15,740	14,715	13,697	13,005	12,647
Population of city	*7,510*	*1,025*	*1,018*	*692*	*358*	*583*

[a] Each time excluding cities listed in preceding columns,

211. To be more specific and to maintain consistency with projections already made, the procedure will have to be applied to one city at a time, preferably beginning with the largest, proceeding to the second largest, and so forth.

212. In table 15, the percentage of Tehran's population in the combined urban population rose from 25.40 in 1956 to 27.77 in 1966, that is from logistic level −107.2 to logistic level −95.6, or by 1.16 steps in logistic level per year. Interpolating and extrapolating, we obtain logistic levels progressing from −97.2 in 1965 to −74.0 in 1985. The percentages corresponding to those levels progress from 27.45 to 32.30. When these percentages are applied to the projected urban population (9,172,000 in 1965, and 23,250,000 in 1985), the population of Tehran is projected to increase, progressively, from 2,518,000 to 7,510,000.

213. When the projection for the first city is completed, it is possible to proceed to the next city, excluding this time the first city from the combined urban population. In the urban population from which Tehran is excluded, Esfahan occupied 5.73 per cent in 1956, and 5.99 per cent in 1966, and the logistic level rose from −280.0 to −275.3. Again, the logistic levels can be extrapolated linearly, corresponding percentage levels can be established, and future populations of Esfahan can be calculated from the projection of urban population from which the projection for Tehran has already been subtracted. The same procedure can be repeated for each subsequent city, each time relating that city to the urban population from which all the preceding cities have been subtracted.

214. The results obtained in table 15 may now be compared with those in table 14. For the year 1985 they differ by less than one per cent in the cases of Esfahan, Mashdad and Shiraz, and in view of possible errors in any projection such differences are negligible. As compared with table 14, the results in table 15 are slightly larger for Tehran, noticeably larger for Tabriz and considerably larger for Abadan. Even so, Abadan is still projected to grow much more slowly than the other cities, and it may be overtaken to an increasing extent, for instance, by the population of Shiraz. But this is not the only plausible expectation. Special circumstances may have accounted either for the slow growth of Abadan or the rapid growth of Shiraz in the 1956-1966 period. Perhaps the boundaries of one city were widened while those of the other were not. Compensatory future developments may perhaps have to be foreseen as a result of which Abadan may again increase more rapidly or Shiraz more slowly.

215. There is every freedom to modify the implied assumptions to take such specific considerations into account. Knowledge of recent conditions and prospects in individual cities of Iran would be necessary if assumptions were to be modified. In the absence of such detailed knowledge, only the rather mechanical result of the projection in table 15 can be presented here.

Fixed groups of cities

216. While the projections for individual cities may be considerably in error, it is possible that the errors are partly compensated, some cities being over-estimated while some others are underestimated. It may seem safer, therefore, to make a forecast for the combined population of a group of cities. As regards the six largest cities of Iran, this may be done as follows.

217. At the 1956 census, the six cities combined had a population of 2,696,000, which was 45.28 per cent within an urban population of 5,954,000; at the 1966 census, they had 4,500,000 within an urban population of 9,794,000, which is 45.95 per cent. Using the logistic scale in annex I and interpolating and extrapolating, we arrive at the following percentages that may be comprised by those six cities in mid year 1965, 1970, 1975, 1980 and 1985: 45.70, 45.99, 46.26, 46.52 and 46.73 per cent. Applying these percentages to the urban population, we arrive at the totals shown below; in addition, the sums are shown resulting from the individual city projections of table 15.

Year	*Population of six principal Iranian cities*	
	As projected directly in relation to the urban population	*Sum of city populations, as projected individually (see table 14)*
1965	4,204	4,204
1970	5,343	5,355
1975	6,844	6,881
1980	8,721	8,835
1985	10,975	11,186

It will be noted that a slightly faster population growth results in the combination of individually projected cities than in the direct projection of the combined cities. This follows from the varying speed with which the percentages advance or fall off on a logistic scale, depending on their levels. The combined population of the six cities is nearly 50 per cent of the combined urban population, and at that level hardly any acceleration occurs in the logistic rise of a percentage. On the other hand, cities smaller than Tehran each time constitute only a small percentage of the urban population (after exclusion of cities of larger size, as in table 15), and at such low levels, according to the logistic, the rise of the percentage accelerates. At any rate, the difference resulting between these two methods of calculation is only rather slight.

218. The foregoing is an example in the projection for a fixed group of cities, the cities remaining the same throughout the projection period. The matter is different when it is desired to project, to any future date, the combined population of all cities having at least some minimal size. Since with time additional cities come to surpass that minimal size, the group of cities so defined is an expanding one, comprising more numerous cities as time progresses.

Expanding groups of cities

219. In a country like Iran it may be inadvisable to make a projection for the expanding group of cities above a high size limit, such as 100,000. At the 1956 census, apart from Tehran, Iran had eight cities of such size, and at the 1966 census it had thirteen such cities, since five additional cities had meanwhile entered the group. But two of the additional cities had almost 100,000 inhabitants already in 1956, namely Hamedan with 99,909 and Ghom with 96,499. The exact number of additional cities that may enter the group, say, in future five-year periods will depend much on accident; by coincidence, there may be some time periods when many cities happen to enter the group, and others when few or perhaps no additional city happens to reach such size. It is preferable to make calculations for all individual cities of such size that their attainment of 100,000 by the end of the projection period (e.g. by 1985) is possible. In this way one can also estimate how many cities of such size may exist at any future date, and what the combined population of the expanding group might be.

220. When a lower size limit is chosen sufficient to make the cities of the group quite numerous, these reservations regarding the direct projection for the group become unnecessary. In Iran, for instance, there were 49 cities and towns of at least 20,000 inhabitants in 1956, and 73 in 1966. While there may be yearly fluctuations in the number of additional towns which attain

TABLE 16. PROJECTION FOR THE GROUP OF CITIES IN IRAN WHICH HAD AT LEAST 100,000 INHABITANTS IN 1956, AND FOR THE GROUP OF CITIES WHICH MAY HAVE AT LEAST 100,000 AT ANY SUBSEQUENT DATE, 1965-1985

Date	Population (thousands)			Percentage of urban population (excluding Tehran)		Logistic level	
	Urban (excluding Tehran)	Cities 100,000+ in 1956 [a]	Cities 100,000+ at any date	Cities 100,000+ in 1956 [a]	Cities 100,000+ at any date	Cities 100,000+ in 1956 [a]	Cities 100,000+ at any date
A. *Projection*							
Censuses							
1956	4,441	1,538	1,538	34.63	34.63	−63.5	−63.5
1966	7,075	2,318	2,947	32.76	41.66	−71.9	−33.3
Mid-year estimates							
1965	6,654	2,198	2,710	33.03	40.73	−70.7	−37.5
1970	8,263	2,652	3,671	32.10	44.43	−74.9	−22.4
1975	10,322	3,219	4,973	31.19	48.18	−79.1	− 7.3
1980	12,823	3,885	6,661	30.30	51.95	−83.3	+ 7.8
1985	15,740	4,631	8,767	29.42	55.70	−87.5	+22.9

Date	Combined urban population	Tehran	Cities 100,000+ in 1956 [a]	New cities 100,000+ at any date	Urban places smaller than 100,000
B. *Composition of urban population (including Tehran)*					
1. In thousands					
1965	9,172	2,518	2,198	512	3,944
1970	11,576	3,313	2,652	1,019	4,592
1975	14,708	4,386	3,219	1,753	5,349
1980	18,598	5,775	3,885	2,776	6,162
1985	23,250	7,510	4,631	4,136	6,973
2. Percentage					
1965	100.0	27.4	24.0	5.6	43.0
1970	100.0	28.6	22.9	8.8	39.7
1975	100.0	29.8	21.9	11.9	36.4
1980	100.0	31.0	20.9	14.9	33.2
1985	100.0	32.3	19.9	17.8	30.0

[a] Including Hamedan (99,909 inhabitants in 1956), excluding Tehran.

TABLE 17. MODIFIED PROJECTION FOR THE GROUP OF CITIES IN IRAN WHICH HAD AT LEAST 100,000 INHABITANTS IN 1956, AND FOR THE GROUP OF CITIES WHICH MAY HAVE AT LEAST 100,000 AT ANY SUBSEQUENT DATE, 1965-1985

Date	Population (thousands)			Percentage o, urban population (excluding Tehran)		Logistic level	
	Urban (excluding Tehran)	Cities 100,000+ in 1956 [a]	Cities 100,000+ at any date	Cities 100,000+ in 1956 [a]	Cities 100,000+ at any date	Cities 100,000+ in 1956 [a]	Cities 100,000+ at any date
A. *Projection*							
Censuses							
1956	4,441	1,638	1,638	36.88	36.88	−55.9	−55.9
1966	7,075	2,442	2,947	34.52	41.66	−64.0	−33.3
Mid-year estimates							
1965	6,654	2,314	2,728	34.78	41.00	−62.90	−36.4
1970	8,263	2,798	3,616	33.86	43.76	−66.95	−25.1
1975	10,322	3,402	4,806	32.96	46.56	−71.00	−13.8
1980	12,823	4,112	6,332	32.07	49.38	−75.05	− 2.5
1985	15,740	4,911	8,216	31.20	52.20	−79.10	+ 8.8

Date	Combined urban population	Tehran	Cities 100,000+ in 1956 [a]	New cities 100,000+ at any date	Urban places smaller than 100,000
B. *Composition of urban population (including Tehran)*					
1. In thousands					
1965	9,172	2,518	2,314	414	3,926
1970	11,576	3,313	2,798	818	4,647
1975	14,708	4,386	3,402	1,404	5,516
1980	18,598	5,775	4,112	2,220	6,491
1985	23,250	7,510	4,911	3,305	7,524
2. Percentage					
1965	100.0	27.4	25.2	4.5	42.9
1970	100.0	28.6	24.2	7.1	40.1
1975	100.0	29.8	23.1	9.5	37.6
1980	100.0	31.0	22.1	11.9	35.0
1985	100.0	32.3	21.1	14.2	32.4

NOTE : This is a modification of the projection in table 16. The modification consists in including the city of Hamedan among those with at least 100,000 inhabitants already in 1956.

[a] Including Hamedan (99,909 inhabitants in 1956), excluding Tehran.

20,000 inhabitants, the fluctuations in added population are probably quite small in relation to the increase in size of the combined population of all localities of at least 20,000. No appreciable error is introduced, in such a case, if the addition of new localities is regarded as a fairly continuous process.

221. The foregoing considerations will now be illustrated with the results of actual calculations. First, two calculations are made for Iran's cities other than Tehran with 100,000 or more inhabitants, distinguishing cities which already had at least 100,000 inhabitants at the 1956 census from those additional cities which may attain such size at any subsequent date. The first calculation (table 16) shows the results strictly according to the census data. But the same type of calculation is repeated (see table 17) to show the difference in results when one additional city (Hamedan) is also included among those with 100,000 inhabitants already in 1956: according to the census, it then had 99,909 inhabitants, i.e. virtually 100,000.

222. Let us consider first the calculations in table 16. Cities other than Tehran with 100,000 inhabitants already in 1956 had a population of 1,538,000 in 1956 and 2,318,000 in 1966; thus their proportion in the combined urban population (without Tehran) fell from 34.63 per cent to 32.76 per cent. After interpolation and extrapolation on the logistic scale, conversion into percentages and application of the percentages to the projected urban population (without Tehran), we find that the combined population of this fixed group of cities may grow from 2,198,000 in 1965 to 4,631,000 in 1985. The same type of calculation was made for the population of all cities other than Tehran having at least 100,000 inhabitants at any time. This is an expanding group, and its combined population rose from 1,538,000 in 1956 to 2,947,000 in 1966; the projection indicates a rise in population from 2,710,000 in 1965 to 8,767,000 in 1985.

223. Subtracting the projection for the fixed group from that of the expanding group of cities we find, as shown in part B1 of table 16, that new cities of 100,000 and more inhabitants which had not yet had such a size in 1956 may rise from a combined population of 512,000 in 1965 to 4,136,000 in 1985. Such rapid growth in the population of new cities reaching 100,000 at any time, while not impossible, appears rather surprising, for it is calculated that by 1985 these new cities will combine almost as much population as the eight cities which had such size already in 1956. It can be roughly estimated that the number of new cities of such size would rise to about twenty-three by 1985.[61] It is a matter of speculation whether such a development appears plausible, and one may have to examine whether there is a sufficient supply of cities with hitherto less than 100,000 inhabitants, which can reasonably be expected to surpass that limit by 1985.

224. Still considering table 16, we note that from 1965 to 1985 Tehran may increase 3.0-fold; the fixed group of cities, 2.1-fold; the expanding group of cities, 3.2-fold (not much more rapidly than Tehran, despite increase in the number of cities); and the population of towns smaller than 100,000, 1.8-fold, which is not much slower than the growth of the fixed group of cities, despite the fact that cities attaining 100,000 inhabitants are continuously being lost to that last-named group. The several projections are not necessarily inconsistent with each other.

225. The fact that five new cities attained 100,000 each between the censuses of 1956 and 1966, however, may have to be regarded as rather accidental, especially in view of the fact that at the 1956 census two of these cities already had very nearly 100,000 inhabitants (Hamedan with 99,909, and Ghom with 96,499). A more plausible trend of developments may be suggested by counting at least the city of Hamedan among cities with 100,000 inhabitants already in 1960, so that only four additional cities join the group between 1956 and 1966. The calculations in table 17 are the same as those in table 16, with this modification. The resulting projection is perhaps somewhat more realistic than the one previously shown.

226. As compared with table 16, we now find (in table 17) that the 1965-1985 growth in Tehran may be 3.0-fold (as before); the growth in the fixed group of cities (including Hamedan), 2.1-fold (approximately as before); the growth in the expanding group of cities, 3.0-fold (slightly less than before); and the growth in towns smaller than 100,000, 1.9-fold (slightly more than before). For reasons stated, the projection in table 17 should perhaps be preferred. It may be noted that the modification is not very substantial. It can be roughly estimated[62] that the calculation implies eighteen new cities reaching 100,000 between 1956 and 1985.

Projection of population by size group of locality

227. Before proceeding to the projection of Iranian towns and cities greater than 20,000 inhabitants, the general line of approach should first be discussed. As has been shown, the consistency with other projections, notably projections for cities of other size groups, remains a consideration of interest, especially as a test of the plausibility of the results. Separate projections have already been made for the population of Tehran (much larger than any other city, hence a category apart), of the urban population without Tehran, and of the population of cities either larger or smaller than 100,000. A projection of the rural population is also shown in chapter V. With the further introduction of a lower size-limit, we can obtain, relative to the projection of Iran's total population, the following component categories: Tehran; other cities of at least 100,000; towns and

[61] Allowing for growth of already existing new cities in any five-year period at rates similar to the growth of old cities, we obtain balances for additional new cities of any five-year period. For instance, the population of 512,000 (new cities of 1965) may represent four cities having each recently surpassed 100,000; these may increase to about 650,000 by 1970, leaving a further increase by about 369,000 (1,019,000 minus 650,000), the equivalent perhaps of another three new cities; and so forth. The calculation is hypothetical and very rough.

[62] See foot-note 61 for the method of estimation.

cities with 20,000-99,999 inhabitants; towns smaller than 20,000; and rural areas; altogether five categories, which comprise between them the total population of Iran.

228. When dealing with such successive categories, it becomes desirable to apply a systematic procedure. This can be done in two alternative ways. In one procedure, which we may call the downward procedure, we begin with the total population and make the appropriate calculations in respect to Tehran; then we take up the total population without Tehran and carry out the same type of exercise with regard to other cities of at least 100,000 inhabitants; and so forth with the remaining categories, until we arrive at the rural population. The opposite, or upward procedure, would be as follows: again we begin with the total population and make a calculation concerning the rural population; then we take up the urban population and do the respective calculation for towns smaller than 20,000 inhabitants; and so forth with other categories, until finally we arrive at Tehran.

229. All the foregoing experiments in projecting Iran's urban population and that of cities or groups of cities have been based on the arbitrary assumption (see chapter V) that the urban-rural growth difference, or URGD, is at the level of 3.0 per cent. Actually, between the censuses of November 1956 and November 1966, the urban population grew from 5,954,000 to 9,794,000, that is at an instantaneous rate of 4.98 per cent; and the rural population increased from 14,362,000 to 16,950,000, i.e. at an instantaneous rate of 1.62 per cent; the difference between these two rates, or URGD, is 3.36 per cent. All the calculations which follow will be derived strictly from the census data, hence the results will differ from those in the foregoing calculations.

230. The data which will be used are the available projection of the total population for 1965-1985, the 1956 and 1966 populations in each of the five categories, and the cumulative populations of successive categories including either all preceding categories or all subsequent categories.

231. To recapitulate, the total population of Iran has been projected as follows (in thousands):

Year	*Population (in thousands)*
1965	24,549
1970	28,358
1975	33,152
1980	38,769
1985	45,050

The populations enumerated in 1956 and 1966 in each category, and in cumulated categories, were as follows (in thousands):[63]

Census date	*Tehran*	*Other cities 100,000+*	*Towns with 20,000–99,999*	*Towns smaller than 20,000*	*Rural population*
			Population in each category		
1956	1,512	1,538 [a]	1,543	1,361	13,001
1966	2,720	2,947	2,462	1,665	15,285
			Cumulative population, including all subsequent categories		
1956	18,955 [b]	17,443	15,905	14,362	13,001
1966	25.079 [b]	22,359	19,412	16,950	15,285
			Cumulative population, including all preceding categories		
1956	1,512	3,050	4,593	5,954 [c]	18,955 [b]
1966	2,720	5,667	8,129	9,794 [c]	25,079 [b]

[a] Includes Hamedan. [b] i.e. the total population. [c] i.e. the urban population.

232. To illustrate the first two steps in the downward procedure, the figures on the next page show how the population of Tehran can be projected in relation to the country's total population and how the population of other cities can be calculated with reference to the country's total population without Tehran.

233. Continuing these operations for the remaining categories, we obtain the results shown in table 18 in the order in which they were calculated.

234. In the inverted, or "upward" procedure, first a projection of the rural population is obtained in relation to the projection of the total population; then a population for towns smaller than 20,000 is derived in relation to the projection for the urban population; and so forth. The manner of calculation is the same and need not be illustrated. The results are as shown in table 19, in the order of the successive calculations.

235. A comparison of the results of the two procedures (tables 18 and 19) shows that in the "downward" procedure (calculations beginning with Tehran and ending with the rural population), the city of Tehran is projected to grow with appreciably greater speed than in the "upward" procedure (calculations beginning with the rural population and ending with Tehran). On the other hand, in the "downward" procedure the rural population is projected to grow somewhat less than in the "upward" procedure. The projections for cities of at least 100,000 inhabitants (without Tehran) and for towns smaller than 20,000 inhabitants do not differ much in the two procedures; for towns with 20,000-99,999 inhabitants, the two procedures produce virtually identical results.

[63] For reasons already discussed, the city of Hamedan is included among those with 100,000 or more inhabitants in 1956.

	Total population	Population of Tehran	Percentage Tehran in total	Logistic level	Total without Tehran
Censuses					
1956	18,955	1,512	7.98	−244.5	17,433
1966	25,079	2,720	10.85	−210.5	22,359
Mid-year estimates					
1965	24,549	2,556	10.41	−215.2	21,993
1970	28,538	3,434	12.11	−198.2	24,924
1975	33,152	4,655	14.04	−181.2	28,497
1980	38,769	6,288	16.22	−164.2	32,481
1985	45,050	8,406	18.66	−147.2	36,644

	Total population without Tehran	Other cities 100,000+	Percentage 100,000+ in total without Tehran	Logistic Level	Total without Tehran and cities 100,000+
Censuses					
1956	17,443	1,538	8.82	−233.6	15,905
1966	22,359	2,947	13.18	−188.5	19,412
Mid-year estimates					
1965	21,993	2,747	12.49	−194.70	19,246
1970	24,924	3,781	15.17	−172.15	21,143
1975	28,497	5,215	18.30	−149.60	23,282
1980	32,481	7,120	21.92	−127.05	25,361
1985	36,644	9,535	26.02	−104.50	27,109

236. Whether the results are internally consistent may be tested by comparing the calculated 1965-1985 increases in each category. In the "downward" procedure, Tehran increases 3.3-fold; other cities of 100,000 inhabitants or more increase 3.5-fold; towns with 20,000-99,999 inhabitants increase 2.3-fold; small towns increase 1.4-fold; and the rural population grows 1.3-fold. In the "upward" procedure the growth of Tehran is 3.0-fold; that in other cities of 100,000 or more inhabitants, 3.4-fold; that in towns of 20,000-99,999 inhabitants, 2.3-fold; that in small towns, 1.4-fold; and that in the rural population, 1.3-fold.

237. It is reasonable to expect that the group of cities of 100,000 or more inhabitants—which is an "expanding" group, growing more numerous with time—may grow faster than Tehran, though not all individual cities will grow so fast. It is also reasonable to expect that with dwindling size classes rates of growth become progressively lower. It appears somewhat peculiar, nevertheless, that the population of towns smaller than 20,000 is projected to increase hardly any faster than the rural population. With time, new small towns may come into existence or villages may acquire the size or characteristics which make them classifiable as towns. It appears that, with unchanging census definitions of "urban" localities, little expansion of the small-town category is provided for. Perhaps the census definition has identified in 1956 and 1966 the same identical towns, making no allowance for additional towns that might have come into existence during the census interval, with the consequence that the projection likewise fails to provide for the possible emergence of more numerous small towns. On the other hand, it is possible that small towns are in fact economically stagnant, and grow with hardly any greater speed than the strictly rural localities.

238. At first it may seem difficult to decide which of the two sets of projections should be preferred, that obtained by the "downward" procedure, or that resulting from the "upward" procedure. But note should be taken of the percentage which each category represents in relation to the combined category from which it was projected.

239. As for the downward procedure, the following percentages are taken from the 1966 census data: Tehran (2,720,000) then contained *10.85* per cent of the country's total population (25,079,000); other cities of 100,000 or more inhabitants (2,947,000) then contained *13.18* per cent of the total population after exclusion of Tehran (22,359,000); towns with 20,000-99,999 inhabitants (2,462,000) contained *12.68* per cent of the total population after exclusion of Tehran and other cities of at least 100,000 (19,412,000); and towns smaller than 20,000 inhabitants (1,665,000) contained *9.82* per cent of the total population after exclusion of Tehran, cities of at least 100,000, and towns of 20,000-99,999 inhabitants (16,950,000); the rural population (15,285,000) constituted the residual.

240. As for the upward procedure, the following percentages are taken from the 1966 census data: The rural population (15,285,000) comprised *60.95* per cent of the country's total population (25,079,000); towns smaller than 20,000 (1,665,000) comprised *17.00* per cent of the country's urban population (9,794,000); towns with 20,000-99,999 inhabitants (2,462,000) comprised *30.29* per cent of the urban population excluding small towns (8,129,000); and cities other than Tehran with 100,000 or more inhabitants (2,947,000) comprised *52.00* per cent of the population of all cities including Tehran (5,667,000); the population of Tehran (2,720,000) constituted the residual.

TABLE 18. COMPOSITION OF THE TOTAL POPULATION OF IRAN BY FIVE CLASSES OF SETTLEMENTS, 1965-1985, AS PROJECTED IN THE "DOWNWARD" PROCEDURE

Mid-year date	Total population	Tehran	Other cities 100,000+	Towns with 20,000–99,999	Towns smaller than 20,000	Rural population
	1. In thousands					
1965	24,549	2,556	2,747	2,352	1,652	15,242
1970	28,358	3,434	3,781	2,945	1,811	16,387
1975	33,152	4,655	5,215	3,686	1,985	17,611
1980	38,769	6,288	7,120	4,550	2,146	18,665
1985	45,050	8,406	9,535	5,492	2,268	19,349
	2. Percentage					
1965	100.0	10.4	11.2	9.6	6.7	62.1
1970	100.0	12.1	13.3	10.4	6.4	57.8
1975	100.0	14.0	15.7	11.1	6.0	53.1
1980	100.0	16.2	18.4	11.7	5.5	48.1
1985	100.0	18.7	21.2	12.2	5.0	43.0

TABLE 19. COMPOSITION OF THE TOTAL POPULATION OF IRAN BY FIVE CLASSES OF SETTLEMENTS, 1965-1985, AS PROJECTED IN THE "UPWARD" PROCEDURE

Mid-year date	Total population	Rural population	Towns smaller than 20,000	Towns with 20,000–99,999	Cities 100,000+ without Tehran	Tehran
	1. In thousands					
1965	24,549	15,228	1,653	2,356	2,750	2,562
1970	28,358	16,459	1,807	2,940	3,759	3,393
1975	33,152	17,859	1,980	3,673	5,142	4,498
1980	38,769	19,222	2,152	4,540	6,958	5,897
1985	45,050	20,493	2,289	5,491	9,212	7,565
	2. Percentage					
1965	100.0	62.0	6.7	9.6	11.2	10.4
1970	100.0	58.0	6.4	10.4	13.3	12.0
1975	100.0	53.9	6.0	11.1	15.5	13.6
1980	100.0	49.6	5.6	11.7	17.9	15.2
1985	100.0	45.5	5.1	12.2	20.4	16.8

241. It will be noted that all the percentages used in the "downward" procedure are rather small, while in the "upward" procedure most of the percentages are rather substantial. On the logistic scale, small percentages rise at accelerating rates, but much less acceleration occurs in percentages at more substantial levels. It is possible, therefore, that more reliance should be placed on the projections arrived at with the "upward" procedure and presented in table 19.

242. As a further check one may compare the present results with those which would have been obtained with the use of simpler methods. The drawbacks of simple methods have been discussed in chapter IV. Nevertheless, within certain limits their use is quite expedient where a population is subdivided into several categories. For instance, the sum of extrapolated percentages for every category will always remain 100 per cent. If constant rates of growth are calculated for each category, on the other hand, the sum of results will exceed the projection of the total population, but an adjustment can be made through prorating, maintaining the projected proportions, but reducing numbers in each category by a constant. The results of the two procedures illustrated in the foregoing and those of the two simple methods obtained for the year 1985 are compared on the next page.

243. The ratio method and constant rates (prorated) produce larger results for small and medium-sized towns than the foregoing procedures. Otherwise, results of the ratio method are generally closer to those of the "upward" procedure, while those of constant rates (prorated) are intermediate between those of the "downward" and "upward" procedures. Each method may be affected by a bias of its own, and no definite conclusion can be reached as to which method produces the "best" results. If no other source of judgement is available, perhaps one might suggest to use an average of the results obtained by the "downward" and "upward" procedures, respectively.

244. This tentative suggestion might be modified in the light of more knowledge of the circumstances prevailing in the urbanization process in Iran. For instance, it might be argued that urbanization occurs either more in response to a "pull" (i.e. the attraction exerted by big

Procedure	*Total population*	*Tehran*	*Other cities 100,000+*	*Towns with 20,000–99,999*	*Towns smaller than 20,000*	*Rural population*
			1. In thousands			
"Downward" procedure	45,050	8,406	9,535	5,492	2,268	19,349
"Upward" procedure	45,050	7,565	9,212	5,491	2,289	20,493
Ratio method	45,050	7,294	8,348	5,834	2,536	21,048
Constant rates:						
(Unprorated)	(47,075)	(8,117)	(9,891)	(5,877)	(2,530)	(20,660)
Prorated	45,050	7,768	9,466	5,624	2,421	19,771
			2. Percentage			
"Downward" procedure	100.0	18.7	21.2	12.2	5.0	43.0
"Upward" procedure	100.0	16.8	20.4	12.2	5.1	45.5
Ratio method	100.0	16.2	18.5	13.0	5.6	46.7
Constant rates	100.0	17.2	21.0	12.5	5.4	43.9

cities) or more in response to a "push" (i.e. the repulsion of the rural and small-town environments). If "pull" is a prevalent factor, the "downward" procedure may be more to the point. If "push" is the dominant phenomenon, then there may seem to be more reason to accept the results of the "upward" procedure. Thus, specific information regarding conditions in Iran may assist in making a choice, in the particular instance. It does not follow that the same choice would be equally pertinent in other countries where conditions may differ.

Chapter VII

SUPPLEMENTARY ESTIMATION OF SEX-AGE COMPOSITION FOR PROJECTED TOTALS OF URBAN AND RURAL POPULATION

A. PRELIMINARY CONSIDERATIONS

Use of supplementary methods

245. Several methods of projecting urban and rural totals have been illustrated in previous chapters. In this chapter, mechanical methods are described for deriving sex-age detail to be used with the projected urban and rural totals. In these methods, an observed age structure in the past or present is adjusted to agree with the projected urban and rural totals calculated by methods previously described. It will have to be recognized that such a procedure is "mechanical" in the sense that it is not responsive to the influence which particular factors may exert on urban and rural age structures.

246. All the methods of projection described in chapters IV to VI lead to projected totals only, whether for the urban and rural population, cities or size classes of communities. The estimated compositions of these totals by sex-age groups are nevertheless of much importance because of their economic and social implications, for they determine to a large extent the available labour force, the formation of households or families and needs arising in the areas of education, employment, housing and so forth. It is therefore useful to estimate in some detail the respective population structures, provided this can be done at least with a tolerable degree of approximation.

247. The demographic causes of variations in urban and rural population structures are complex. They include urban-rural differences in fertility level and trend, to a minor degree also the mortality differences, volumes and time trends in rural-to-urban migration, as well as urban-to-rural return migration, and the sex-age composition of these migratory streams, itself also susceptible to variation in the course of time. These strictly demographic causes are further conditioned by economic, social and cultural background factors, often difficult to identify, and themselves also apt to change as time progresses. Because of the combined effect of these several factors and their accumulation with time, the action of each particular factor cannot easily be identified by analytic means.

248. Where it is possible, or reasonable, to calculate urban and rural population projections with the cohort-component method, the attempt should be made. In that method, the particular demographic factors resulting in the varied sex-age structures are specifically taken into account. It is then also possible to calculate the comparative results which would follow if one or several of the underlying demographic conditions were modified. Such methods are considered in chapter IX. Chapter VIII considers certain other methods yielding directly projections of urban and rural population by groups of sex and age, though in their case the analysis of underlying factors is not so complete.

249. For the use of the mechanical methods described in the present chapter, it will have to be assumed that the factors causing a disparity between urban and rural population structures undergo little change. This could be approximately the case where the relative difference between urban and rural fertility levels remains fairly constant, migratory movements do not fluctuate much, and especially where the greater part of the migrants' residence in urban areas is of a rather temporary character. For in that case the urban population comprises what one may call a "floating population" consisting of a pool of mostly young persons, many of them soon departing to be replaced by other young persons who are again of the same age range. Where migrants tend to take up permanent urban residence, time variations in sex-age structure can be introduced as they advance in age, volumes of migration having fluctuated in the past.

250. As surveyed in chapter II, two prevailing modes of urbanization can be recognized. In Africa and South Asia the rural-to-urban migrants are mostly young men and their duration of urban residence is often rather short. In Latin America, Northern America, Oceania and Western Europe, young women are more numerous than young men among the migrants, and there is the apparent tendency of many migrants to take up permanent urban residence as witnessed by relatively high degrees of urbanization even at advanced ages. Intermediate, or mixed, conditions can be found in some other parts of Europe, in the Soviet Union and apparently also in East Asia. In view of such diversity of actual conditions, the use of the mechanical estimating methods proposed in this chapter may be more satisfactory in some countries than in others.

Adjustment of defective age data for urban and rural projections

251. Since the accuracy of age records is questionable in many censuses—and these data are needed for the supplementary estimates discussed here— it is appropriate to review briefly how the raw census data on sex-age composition of the urban and rural populations might sometimes have to be adjusted. Methods of detecting

inaccuracies in age data and of making rough adjustments with regard to national total populations have already been dealt with in other manuals.[64] It is known that in many censuses significant proportions of small children, notably in the 0 to 4-year age group, are omitted; and furthermore that owing to preferences for particular final digits in age statements, excessive numbers tend to be reported in some age groups and deficient numbers in other age groups.

252. As regards the first defect, namely the under-enumeration of small children, it can usually be assumed that the enumeration of children aged 5 to 9 years is substantially more accurate and that (unless there is information to the contrary) the fertility of women of child-bearing ages may have been about the same in both the recent five-year periods, that when children aged 5 to 9 years were born, and that when those aged 0 to 4 years were born. To correct the 0 to 4 group with reference to the 5 to 9 group, the following steps are then necessary. Numbers of children aged 5 to 9 years are reverse-survived to the period of five to ten years prior to the census, namely when they were born, so as to obtain an estimate of numbers of births in that period.[65] Numbers of women of ages where they might nave been their mothers, e.g. ages 15 to 44 years, are reverse-survived for the middle of that period of births. The ratio of numbers of births to numbers of women, of that period, provides a rough measure of fertility. Assuming that in the most recent five-year period fertility has been the same, numbers of women reverse-survived to the middle of the more recent period can be multiplied by that same measure in order to obtain an estimate of births which occurred within the most recent five years. By forward survival, this number of births can finally be converted into numbers of children (boys and girls) aged 0 to 4 years at the date of the census.

253. As regards the second defect, namely inaccuracy of age statements, an adjustment can be made by applying a smoothing formula to the age data by five-year groups. The particular formula which was suggested in *Manual III*[66] was

$$\Sigma = {}^1/_{16}\,(-S_{-2} + 4\,S_{-1} + 10\,S + 4\,S_1 - S_2),$$

where Σ is the adjusted number of persons in one five-year group, to be computed; S is the reported number of persons in the same five-year group; S_{-2} and S_{-1} are reported numbers in the two preceding five-year groups; and S_1 and S_2 are reported numbers in the two subsequent five-year groups.

254. It must be pointed out, however, that this latter adjustment is not recommended for direct application to sex-age data of the urban and rural population, each taken separately. Since rural-to-urban migration is most intensive in late adolescence or early adulthood, true irregularities of urban and rural age composition are reflected even in the most accurate data: relative bulges at ages 15 to 19 or 20 to 24 in the urban population, and relative deficits at the same ages in the rural population. The effect of applying a smoothing formula directly to the urban and rural populations, each taken separately, would be to diminish considerably those irregularities which are normally to be expected; the consequence may very well be that the smoothed data are even less accurate than the defective data without adjustment. Smoothing of data in the national total population (i.e. the urban and rural populations combined) nevertheless remains justifiable because international migration only seldom produces any marked irregularities in national age structure, and sharp fluctuations in past birth rates (another possible cause of irregularity in age structure) are ordinarily not very likely.

255. Accordingly, to correct age data of the urban and rural population, the adjustments should first be made in the national total population. The relative amounts by which each sex-age group has been adjusted in the national total can then be allocated proportionately in the same sex-age groups of the urban and rural population.[67]

256. After adjustments have been made for incomplete child enumeration and for inaccuracies of age statement, it is advisable to prorate both the adjusted urban and rural populations so as to make them coincide with the original census totals. Given the fact that census totals usually have a certain publicity, it is desirable that the population projections remain consistent with them, so as to avoid possible confusions in the comparison of the results of projections with the basic census data.

B. METHOD OF DIFFERENCE ELIMINATION

Explanation of the method

257. The difference elimination procedure described here is an application of a general matrix solution for adjusting the information in the cells of a matrix in such a way that it conforms to an independent set of horizontal and vertical totals. In the application described here two kinds of information are utilized: (*a*) *base period data* for the sex-age composition of the urban and rural population arranged in matrix form; and (*b*) *projections* of independent totals of population by sex and age (the horizontal totals) and urban and rural population (the vertical totals). From these, a new matrix of projected sex-age composition of the urban and rural population is calculated, which balances both horizontally and vertically, with the projected totals.

258. The method is perhaps best illustrated in a simplified and fictitious example, with a matrix distin-

[64] *Manual II: Methods of Appraisal of Quality of Basic Data for Population Estimates* (United Nations publication, Sales No. 56.XIII.2); and *Manual III: Methods for Population Projections by Sex and Age* (United Nations publication, Sales No. 56.XIII.3).

[65] In forward survival, numbers in each age group are multiplied with the corresponding survival ratios. In reverse-survival, the numbers are divided by the corresponding ratios, thus "bringing to life" those who have died in the interim. With the appropriate ratios, numbers aged 5-9 at a given date can be reverse-survived to numbers aged 0-4 five years previously, and the latter to numbers born within the period of five to ten years ago. For details of procedure, see *Manual III, op. cit.*

[66] *Ibid.*, p. 12.

[67] The implied assumption is, of course, that inaccuracy of age statement has the same proportionate effects in both the urban and rural population, though it can sometimes be expected that ages are reported with somewhat greater accuracy in the urban (usually more literate) population than in the rural population.

TABLE 20. FICTITIOUS EXAMPLE TO ILLUSTRATE THE METHOD OF DIFFERENCE ELIMINATION

Panel A (base period data)

Age	*Urban*	*Rural*	*Total*
0–14.....	100	250	350
15–44.....	150	300	450
45+.....	50	150	200
TOTAL	300	700	1,000

Panel B (projected totals)

Age	*Urban*	*Rural*	*Total*
0–14.....	...	...	500
15–44.....	...	...	600
45+.....	...	...	200
TOTAL	550	750	1,300

Panel C (horizontal prorating)

Age	*Urban*	*Rural*	*Total*
0–14.....	143	357	500
15–44.....	200	400	600
45+.....	50	150	200
TOTAL	393	907	1,300

Panel D (vertical prorating)

Age	*Urban*	*Rural*	*Total*
0–14.....	200	295	495
15–44.....	280	331	611
45+.....	70	124	194
TOTAL	550	750	1,300

Panel E (horizontal prorating)

Age	*Urban*	*Rural*	*Total*
0–14.....	202	298	500
15–44.....	275	325	600
45+.....	72	128	200
TOTAL	549	751	1,300

Panel F (arbitrary adjustment)

Age	*Urban*	*Rural*	*Total*
0–14.....	202	298	500
15–44.....	276	324	600
45+.....	72	128	200
TOTAL	550	750	1,300

guishing only a few group cells. Reference may be made to table 20, in which panel *A* represents the base data, and panel B, the results of the projections (total population by age, and urban and rural totals).

259. As a first step (panel *C*), the figures in each row of panel *A* are prorated in the ratio of the marginal total of panel *B* to the marginal total of panel *A*. Thus, 100 times 500/350 is 143, and so forth. But, when added up vertically, the results in panel *C* do not agree with the vertical totals of panel *B*.

260. As a next step (panel *D*), the figures in each column of panel *C* are prorated in the ratio of marginal totals of panel *B* to marginal totals of panel *C*. For instance, 143 times 550/393 is 200, and so forth. But, when added up horizontally, the results again show some discrepancies from the horizontal totals of panel *B*.

261. The procedure is repeated twice or three times, by prorating alternatingly in the horizontal and vertical directions. In each prorating, the cells of the last matrix are multiplied by a ratio obtained by dividing the marginal totals of the projection in panel *B* by the marginal totals of the last matrix. At each successive step the remaining discrepancies are smaller, and soon they become negligible. When only a few insignificant discrepancies remain—as already happens in the example in panel *E*—these can simply be adjusted by hand. In the end, a matrix is obtained whose marginal totals, both horizontal and vertical, agree perfectly with those of the projections (panel *F* in the example).

262. How often the procedure has to be repeated will depend on the number of significant digits in the figures. In actual practice, three horizontal and three vertical proratings usually suffice. If small discrepancies from the predetermined totals can be tolerated, it is not necessary to carry the procedure to its end.

263. The method is similar to, and yields similar results as, another method which has long been used by the Registrar General's office of England and Wales.[68] The present method is preferred here because it is easier to manipulate on worksheets. Differences in the results of the two methods are virtually negligible.

264. The mathematical properties of the Registrar General's method have been studied,[69] and it can be presumed that the present method has the same properties, at least to a high degree of approximation. For instance, the same results are obtained irrespective of whether the first prorating was done horizontally or vertically. Also, the results are the same whether the method is used repeatedly (e.g. first prorating from data for a date *A* to totals for a date B, and then prorating from the results for date *B* to totals for a date *C*), or directly (prorating at once from date *A* to date *C*).

Application to a projection

265. The method of difference elimination is now applied to a projection of Iran's urban and rural population by a global method, and a projection of Iran's total population by sex-age groups. Original data on

[68] In that method, the increments (gains or losses in each group cell) of each row or column are prorated, each time, in the proportion of the initial data (panel *A*).

[69] D. F. Friedlander, "A technique for estimating a contingency table, given the marginal totals and some supplementary data", *Journal of the Royal Statistical Society* (London), series A (general), vol. 124, part 3, 1961, pp. 412-420. In this method, the modification of the initial data to the final results, measured in terms of the sum of chi-square, is minimized.

TABLE 21A. APPLICATION OF THE METHOD OF DIFFERENCE ELIMINATION TO A PROJECTION OF URBAN AND RURAL POPULATION, AND OF TOTAL POPULATION BY SEX-AGE GROUPS (EXAMPLE OF IRAN): DATA

Sex and age	Census, November 1966			Projection to 1975
	Total	Urban	Rural	
Males				
0–4	2,301	805	1,496	*3,096*
5–9	2,160	776	1,384	*2,464*
10–14	1,609	676	933	*2,114*
15–19	1,068	501	567	*1,790*
20–24	777	398	379	*1,531*
25–29	789	327	462	*1,196*
30–34	864	335	529	*911*
35–39	763	295	468	*750*
40–44	760	280	480	*649*
45–49	483	192	291	*553*
50–54	362	144	218	*467*
55–59	216	80	136	*384*
60–64	342	129	213	*301*
65+	504	178	326	*523*
Females				
0–4	2,142	762	1,380	*3,007*
5–9	1,988	722	1,266	*2,402*
10–14	1,438	612	826	*2,064*
15–19	1,055	452	603	*1,746*
20–24	887	375	512	*1,494*
25–29	848	324	524	*1,166*
30–34	803	301	502	*886*
35–39	670	272	398	*730*
40–44	578	212	366	*634*
45–49	365	154	211	*542*
50–54	382	160	222	*462*
55–59	201	83	118	*385*
60–64	326	126	200	*312*
65+	463	169	294	*592*
ORIGINAL TOTALS, 1966	25,144	9,840	15,304	
PROJECTED TOTALS, 1975		*14,707*	*18,444* [a]	*33,151* [a]

[a] Originally 33,152,000 and 18,445,000. Adjustment by 1,000 was made to make totals agree with the sum of rounded figures for sex-age groups,

the urban and rural population, detailed by sex-age groups, are available from the census taken in November 1966. The method of difference elimination is used to obtain similarly detailed results for 1975. The entire calculation can be carried out on one large worksheet. For reasons of space it is illustrated here in three successive segments (tables 21a, 21b, and 21c).

266. The census age data suffer from large inaccuracies. Probably the enumeration of small children was incomplete, since nearly the same number of children were reported at ages 0 to 4 and 5 to 9. Probably there was also a large heaping on ages such as 30, 40, 50 or 60, as indicated by the irregular progression of numbers in successive age groups. [70] For the purpose of the projection of the total population by sex-age groups, however, the age data were smoothed and a correction was made for the underenumeration of small children. [71]

267. The method of difference elimination can be applied directly to the raw data: since the total population used for reference is smoothed, the prorating procedures have the effect of similarly smoothing the age distributions of the urban and rural populations. In fact, direct smoothing of the original urban and rural age data is inadvisable: there are genuine irregularities in urban and rural sex-age compositions, mainly owing to the age-specific incidence of migration, and these would be caused to vanish if a smoothing formula were applied

[70] Methods of examining the accuracy of census statistics by age have been described in *Manual II: Methods of Appraisal of Quality of Basic Data for Population Estimates* (United Nations publication, Sales No. 1956.XIII.2).

[71] By means of methods described in *Manual III: Methods of Population Projections by Sex and Age* (United Nations publication, Sales No. 1956.XIII.3).

TABLE 21B. APPLICATION OF THE METHOD OF DIFFERENCE ELIMINATION TO A PROJECTION OF URBAN AND RURAL POPULATION, AND OF THE TOTAL POPULATION BY SEX-AGE GROUPS (EXAMPLE OF IRAN): FIRST (HORIZONTAL) AND SECOND (VERTICAL) PRORATING

Sex and age	Horizontal results		Vertical results		Projection to 1975
	Urban	Rural	Urban	Rural	
Males					
0–4	1,083	2,013	1,217	1,851	*3,096*
5–9	885	1,579	994	1,452	*2,464*
10–14	888	1,226	997	1,127	*2,114*
15–19	840	950	944	874	*1,790*
20–24	784	747	881	687	*1,531*
25–29	496	700	557	644	*1,196*
30–34	353	558	397	513	*911*
35–39	290	460	326	423	*750*
40–44	239	410	268	377	*649*
45–49	220	333	247	306	*553*
50–54	186	281	209	258	*467*
55–59	142	242	160	223	*384*
60–64	114	187	128	172	*301*
65+	185	338	208	311	*523*
Females					
0–4	1,070	1,937	1,202	1,781	*3,007*
5–9	872	1,530	979	1,407	*2,402*
10–14	878	1,186	986	1,091	*2,064*
15–19	748	998	840	918	*1,746*
20–24	632	862	710	793	*1,494*
25–29	446	720	501	662	*1,166*
30–34	332	554	373	509	*886*
35–39	296	434	332	399	*730*
40–44	233	401	262	369	*634*
45–49	229	313	257	288	*542*
50–54	194	268	218	246	*462*
55–59	159	226	179	208	*385*
60–64	121	191	136	176	*312*
65+	178	414	200	381	*592*
CALCULATED TOTALS, 1975	13,093	20,058	14,708 [a]	18,446 [a]	
PROJECTED TOTALS, 1975	*14,707*	*18,444*	*14,707*	*18,444*	*33,151*

[a] Discrepancy from projected total due to accidents of rounding,

directly. In this respect, the method of difference elimination offers a distinct advantage. [72]

268. Since the method has already been illustrated in a fictitious example, the procedure involved in tables 21a, 21b and 21c needs no further comment. After two horizontal and two vertical proratings, the results come so close to the predetermined totals that only very slight adjustments remain to be made, requiring no further calculation.

Further uses of this method

269. The method of difference elimination can be useful for many other purposes where cell frequencies are needed to agree with a twofold classification. One such use is to estimate, if there are some data for another date and the marginal totals for the given date, numbers of the population by sex and age and by marital status. [73] Another use is to estimate age distributions for numerous regions of a country, if there are sex-age totals for another date. The method is likewise useful when three or more categories of the population are considered, e.g. the population in different size classes of localities, or the urban and rural populations in each of several regions of a country. One further use of the method is its applicability in the establishment of sex-age estimates for an "urban" population defined differently than in the census.

270. To provide an example and at the same time a test, the case of Japan is taken. Here, the 1960 census

[72] The assumption implicit in this use of the method is that errors of age statement are of equal direction and intensity in the urban and rural populations. If—as may often be—urban age statements are more accurate than the rural, the consequence is an overadjustment of the urban data and an insufficient adjustment of the rural data. These residual errors, however, would usually have only secondary importance.

[73] As illustrated by Friedlander, *op. cit.*

TABLE 21C. APPLICATION OF THE METHOD OF DIFFERENCE ELIMINATION TO A PROJECTION OF URBAN AND RURAL POPULATION, AND OF THE TOTAL POPULATION BY SEX-AGE GROUPS (EXAMPLE OF IRAN): THIRD (HORIZONTAL) PRORATING AND FINAL RESULTS

Sex and age	Horizontal results		Final results [a]		Projection to 1975
	Urban	Rural	Urban	Rural	
Males					
0–4	1,228	1,868	1,231	1,865	*3,096*
5–9	1,001	1,463	1,004	1,460	*2,464*
10–14	992	1,122	994	1,120	*2,114*
15–19	907	883	909	881	*1,790*
20–24	861	670	863	668	*1,531*
25–29	555	641	556	640	*1,196*
30–34	397	514	398	513	*911*
35–39	326	424	327	423	*750*
40–44	270	379	271	378	*649*
45–49	247	306	248	305	*553*
50–54	209	258	210	257	*467*
55–59	160	224	160	224	*384*
60–64	128	173	128	173	*301*
65+	210	313	211	312	*523*
Females					
0–4	1,212	1,795	1,215	1,792	*3,007*
5–9	986	1,416	988	1,414	*2,402*
10–14	980	1,084	982	1,082	*2,064*
15–19	834	912	836	910	*1,746*
20–24	706	788	708	786	*1,494*
25–29	502	664	503	663	*1,166*
30–34	375	511	376	510	*886*
35–39	332	398	333	397	*730*
40–44	263	371	264	370	*634*
45–49	256	286	257	285	*542*
50–54	217	245	218	244	*462*
55–59	178	207	178	207	*385*
60–64	136	176	136	176	*312*
65+	204	388	203	389	*592*
CALCULATED TOTALS, 1975	14,672	18,479	14,707	18,444	*33,151*
PROJECTED TOTALS, 1975	*14,707*	*18,444*	*14,707*	*18,444*	*33,151*

[a] Results of one further (vertical) prorating, not shown here, and final adjustments by hand.

defined as "urban" the population of administrative municipal districts (*shi*), some of them territorially very extensive and including much population which, because of lower densities of settlement, might otherwise be regarded as rural. At the same time, the census determined the population of urban clusters as defined by population size (at least 5,000 inhabitants) and density (at least 4,000 persons per square kilometre within each respective enumeration district), under the term "densely inhabited districts". Thus, the "urban" and "rural" population amounted in 1960 to 59,239,000 and 34,108,000 inhabitants, respectively, the definition of "urban" being rather extensive in that case; and the population within and outside "densely inhabited districts", a rather narrow definition of the "urban" population, amounted to 40,807,000 and 52,540,000 inhabitants, respectively.

271. As shown in table 22, the method of difference elimination leads to a fairly good estimate of the sex-age composition of the "urban" population when defined differently. The errors of estimate are comparatively small. In the particular instance numbers of children and older persons have been somewhat over-estimated for densely inhabited districts, while young adults have been somewhat underestimated. [74] If the sex-age composition of densely inhabited districts had not been ascertained in the census, the estimate could have served as a rough substitute.

272. The method of difference elimination, finally, can be of some help in countries where the sex-age compo-

[74] Under the more intensely "urban" conditions within the narrower confines of densely inhabited districts, migrants of early adult age are more heavily represented than they are in municipal districts which include some population that in other respects perhaps may be classifiable as "rural".

TABLE 22. ESTIMATE OF SEX-AGE COMPOSITION OF D.I.D. (DENSELY INHABITED DISTRICTS) POPULATION FROM DATA ON SEX-AGE COMPOSITION OF "URBAN" AND "RURAL" POPULATION AS DEFINED ADMINISTRATIVELY, JAPAN, 1960, USING THE METHOD OF DIFFERENCE ELIMINATION

Sex and age	*Municipal population (census data)*	*Estimated D.I.D. population* [a]	*D.I.D. population (census data)*	*Error of estimate*
Males				
0–4	2,435	1,635	1,615	+20
5–9	2,708	1,766	1,710	+56
10–14	3,337	2,220	2,168	+52
15–19	3,286	2,394	2,433	−39
20–24	2,959	2,195	2,264	−69
25–29	2,824	2,033	2,070	−37
30–34	2,466	1,723	1,743	−20
35–39	1,774	1,226	1,243	−17
40–44	1,461	1,006	1,007	−1
45–49	1,433	987	995	−8
50–54	1,281	870	873	−3
55–59	1,103	743	737	+6
60–64	856	567	549	+18
65–69	585	330	363	+17
70–74	386	246	228	+18
75–79	205	128	119	+9
80–84	84	52	42	+10
85 and over	26	16	12	+4
Females				
0–4	2,325	1,555	1,535	+20
5–9	2,609	1,705	1,653	+52
10–14	3,226	2,145	2,112	+33
15–19	3,155	2,267	2,293	−26
20–24	2,891	2,081	2,133	−52
25–29	2,809	2,006	2,060	−54
30–34	2,455	1,716	1,756	−40
35–39	2,107	1,456	1,488	−32
40–44	1,758	1,212	1,229	−17
45–49	1,607	1,095	1,098	−3
50–54	1,339	910	910	0
55–59	1,137	764	750	+14
60–64	890	590	582	+8
65–69	660	434	420	+14
70–74	496	322	301	+21
75–79	319	204	186	+18
80–84	173	111	92	+19
85 and over	74	47	40	+7
TOTAL	59,239	40,807	40,807	0

[a] Calculated from "urban" (municipality) and "rural" (other areas) population census data by method of difference elimination.

sitions of the urban and rural population have not yet been ascertained. Data for another country where some of the conditions might be similar can then be used and prorated to the summary data available for the particular country.

273. For instance, the sex-age composition of the total population of Sierra Leone, but not of its urban and rural population, has been obtained in the 1963 census. Relevant data exist, however, in the 1960 census of Ghana for an urban population of 1,551,360 and a rural population of 5,179,460. Both sets of data, those for Ghana and Sierra Leone, however, are heavily affected by age misstatement. But in the case of Sierra Leone a smooth population model has been substituted, and estimates and projections have been made with that model. This makes it possible to prorate the data for Ghana directly to smoothed data for Sierra Leone. In the given example, the data for Ghana are brought into line with Sierra Leone's national sex-age composition as estimated for 1960. For that year, Sierra Leone's urban population is estimated as 250,000, and the rural population as 1,886,000.

TABLE 23. APPLICATION OF THE METHOD OF DIFFERENCE ELIMINATION TO OBTAIN AN ESTIMATE OF THE SEX-AGE COMPOSITION OF THE URBAN AND RURAL POPULATION OF SIERRA LEONE IN 1960 FROM THE URBAN AND RURAL SEX-AGE COMPOSITION OBTAINED IN THE CENSUS OF GHANA IN 1960

Sex and age	Sierra Leone (estimate)	Ghana (census)		Sierra Leone, final adjustment	
		Urban	Rural	Urban	Rural
Males					
0–4	*184,000*	137,460	501,930	19,400	164,600
5–9	*145,000*	97,790	415,940	13,300	131,700
10–14	*125,000*	74,800	282,910	17,900	107,100
15–19	*108,000*	77,190	200,000	15,400	92,600
20–24	*93,000*	88,210	180,130	16,200	76,800
25–29	*80,000*	87,560	193,030	11,500	68,500
30–34	*68,000*	65,190	177,480	9,300	58,700
35–39	*58,000*	48,290	147,650	7,100	50,900
40–44	*49,000*	37,460	129,240	5,400	43,600
45–49	*40,000*	26,440	97,140	4,200	35,800
50–54	*33,000*	19,090	78,170	3,200	29,800
55–59	*26,000*	11,650	48,630	2,000	24,000
60–64	*20,000*	10,240	53,450	1,500	18,500
65+	*31,000*	17,760	95,440	2,300	28,700
Females					
0–4	*182,000*	139,590	514,860	19,000	163,000
5–9	*145,000*	111,510	394,400	15,700	129,300
10–14	*124,000*	83,920	241,030	16,200	107,800
15–19	*108,000*	71,100	192,850	14,800	93,200
20–24	*94,000*	81,850	236,770	12,200	81,800
25–29	*81,000*	68,410	239,780	8,900	72,100
30–34	*69,000*	53,670	193,110	7,400	61,600
35–39	*59,000*	36,340	140,750	5,900	53,100
40–44	*50,000*	28,150	116,930	4,700	45,300
45–49	*42,000*	19,730	75,560	4,200	37,800
50–54	*35,000*	16,840	65,610	3,500	31,500
55–59	*29,000*	9,670	39,470	2,800	26,200
60–64	*23,000*	10,920	44,430	2,200	20,800
65+	*38,000*	20,530	78,770	3,800	34,200
TOTAL, GHANA		1,551,360	5,175,460		
TOTAL, SIERRA LEONE	*2,136,000*			250,000	1,886,000

274. Table 23 shows the original data for Ghana, the marginal totals for Sierra Leone, and the results obtained after two horizontal and vertical proratings, rounded to the nearest hundred. In the absence of the pertinent information, these results may perhaps constitute an acceptable estimate of the sex-age composition of the urban and rural population in Sierra Leone, despite the roughness of the original data for either country, and the likelihood that conditions affecting urbanization are not quite the same in both countries.

Additional considerations

275. Several advantages in the use of the method of difference elimination have been noted. It is applicable not only in the projection of the urban and rural population, but also in the calibration of urban and rural sex-age data to smoothed data of the total population, and in the estimation of sex-age composition for "urban" and "rural" populations defined differently than at the census, or even belonging to another country. The question remains whether, in a projection, the adjustments obtained by this method are plausible in terms of the dynamics of the growth components.

276. The differences between urban and rural sex-age structures stem mainly from urban-rural differences in fertility and from net rural-urban migration. As compared with the rural, the urban population pyramid has usually a somewhat narrower base (because of lower urban fertility), and "bulges" about the ages at which most migrants arrive in the cities and towns. The method of difference elimination preserves these peculiarities in the urban and rural population structures, in so far as they remain compatible with projected changes in the sex-age composition of the total population. In other words, implicit in such projections are the rough assump-

tions that the urban-rural fertility difference will remain unchanged, and that migration, both in its relative magnitude and in its composition by sex and age groups, will continue to have similar effects as in the past.

277. It can be demonstrated that quite similar results are often obtained whether the urban and rural populations are projected globally and the age composition estimated with the present method, or whether the urban and rural populations are each projected with the cohort-survival method. For in the latter method it will usually also have to be assumed that fertility differences between urban and rural areas tend to persist, and that the relative volume and composition of the migratory stream, with its dominance of young adults, will remain similar to that for which a relevant estimate can be made, i.e. according to past experience. The method of difference elimination simulates the combined effects of those fertility differences and sex-age compositions at the base date, without analysing and applying them in any specific detail. Therefore, there may sometimes be little difference in the results of both types of projections, except that the global projection leaves the analytic detail unspecified.

278. Under more special circumstances, where the inherent conditions are expected to undergo some change or where past fluctuations are implicit in the initial age structure, the global method with difference elimination can become less adequate. For instance, a fertility decline might be foreseen for urban areas, but not yet for rural areas, with consequent widening in the urban-rural difference. Or the tempo of urbanisation, especially its migratory component, might be expected to accelerate or to slow down with consequent intensification or diminution of the effects of migration upon the urban and rural age structures. Where such considerations are important a cohort-survival projection is of course preferable.

A shorter method

279. The method of difference elimination discussed in the foregoing may sometimes appear more cumbersome than is warranted by the approximate nature of the forecasts. A shorter method is therefore also to be recommended in which, however, the differences in age group totals are not entirely eliminated. Among the many uses which have been made of the shorter method one may cite a demographic study undertaken jointly by the United Nations and the Government of the Philippines. [75]

280. The base data for the projection were those obtained in household surveys around 1957, including separate data by sex and age for the urban and rural population. The total population was projected by groups of sex and age for five-yearly intervals up to 1977. Percentages of rural population were projected in a trend parallel to a projected trend in the percentage of labour force engaged in agriculture. The expected future sizes of urban and rural population were then derived from the projection of total population, applying these percentages.

281. To obtain sex and age detail for future urban and rural population, the following steps were taken. First, the percentage distributions by sex-age groups in 1957 were calculated separately for the total, urban and rural population. Next, ratios were computed for the percentages in the urban and rural population by sex and age, relative to the percentages in the total population. These steps are illustrated in table 24.

282. These ratios were then maintained, as "correction factors" so to speak, to adjust any projected percentage sex and age distributions of the total population so as to yield corresponding distributions for the urban and rural populations, respectively. [76] The projected total population had the following percentages in different sex-age groups (table 25). Multiplication of the percentages in table 25 by the urban and rural "correction factors" of the last two columns of table 24, led to the following percentage sex and age distributions for the projected urban and rural population (table 26). These, in turn, were then applied to projected actual numbers of urban and rural population so as to obtain the absolute numbers to be estimated. [77]

C. ESTIMATING SEX-AGE GROUPS WITH THE USE OF THE LOGISTIC TABLE

282. Levels or degrees of urbanization can be measured separately for each sex-age group of the national popution, in terms of urban residence ratios specific by sex and age (see chapter II, second section). For reasons discussed in chapter III, third section, it is useful to transform these sex-age-specific percentage levels to a logistic scale. For, as argued, the flexibility of a percentage is under varied constraints, depending on whether the percentage is at an intermediate or extreme level. Here again the particular parameters entering into the calculation of a logistic curve are immaterial, hence the simple curve tabulated in annex I can serve as reference also for the purpose of estimating sex-age composition.

283. Table 27 shows urban percentages of the population of Iran in 1966, specific by groups of sex and age. Thus, children were urbanized to an extent of 35 to 36 per cent, while at adult ages the percentage fluctuated about 40, reaching peaks among adolescents and young adults, and also among women about the age of 50. Comparatively high percentages of urbanization appear among males aged 15 to 19 and those aged 20 to 24. It is not unlikely that many young men of rural origin spend their period of military service at urban duty stations.

[75] *Population Growth and Manpower in the Philippines*, a joint study by the United Nations and the Government of the Philippines (United Nations publication, Sales No. 61.XIII.2).

[76] The majority of the initial population was still rural, hence the rural correction factors differ less from unity than the urban correction factors. With time, an increasing proportion of the population will be urban, but the present method makes no provision for the effect of shift in weights on the correction factors.

[77] With this procedure, the totals of urban and rural population within each sex-age group do not exactly agree with the projected total population, although the discrepancies are generally trivial. The sum of the urban and rural population may therefore be accepted as a modified projection of total population, or an adjustment may be made in the urban and rural figures.

TABLE 24. SEX-AGE DISTRIBUTIONS OF THE TOTAL POPULATION OF THE PHILIPPINES AND OF URBAN AND RURAL POPULATION, 1957 (DATA FROM 1956 AND 1957 PSSH ROUNDS, REFERRING TO PRIVATE HOUSEHOLD POPULATION)

Sex and age (years) (1)	*Per cent distribution by sex and age*			*Ratio, col. 3 ÷ col. 2* [a]	*Ratio, col. 4 ÷ col. 2* [b]
	Total population (2)	*Urban population* (3)	*Rural population* (4)	(5)	(6)
Both sexes, all ages	*100.00*	*100.00*	*100.00*	*1.000*	*1.000*
Males					
0–4	9.32	8.94	9.53	.959	1.023
5–9	7.29	6.91	7.50	.948	1.029
10–14	6.58	6.36	6.70	.967	1.018
15–19	5.12	5.17	5.08	1.010	.992
20–24	4.10	4.19	4.05	1.022	.988
25–34	5.89	6.10	5.78	1.036	.981
35–44	4.80	4.79	4.81	.998	1.002
45–54	3.39	3.43	3.36	1.012	.991
55–64	1.85	1.70	1.94	.919	1.049
65 and over	1.57	1.34	1.70	.854	1.083
Females					
0–4	8.97	8.79	9.07	.980	1.011
5–9	7.04	6.76	7.18	.960	1.020
10–14	6.26	6.07	6.36	.970	1.016
15–19	5.32	6.01	4.93	1.130	.927
20–24	4.47	4.91	4.23	1.098	.946
25–34	6.51	6.98	6.26	1.072	.962
35–44	4.98	4.97	4.98	.998	1.000
45–54	3.28	3.30	3.27	1.006	.997
55–64	1.73	1.73	1.73	1.000	1.000
65 and over	1.54	1.55	1.54	1.006	1.000

[a] This will be considered as the urban "correction factor".

[b] This will be considered as the rural "correction factor".

TABLE 25. PERCENTAGE SEX-AGE COMPOSITION OF THE TOTAL POPULATION OF THE PHILIPPINES AS PROJECTED FROM 1957 TO 1977

Sex and age (years)	*1957*	*1962*	*1967*	*1972*	*1977*
Males					
0–4	9.32	9.46	9.57	9.59	9.58
5–9	7.29	7.48	7.60	7.70	7.74
10–14	6.58	6.17	6.21	6.36	6.43
15–19	5.12	5.57	5.19	5.27	5.31
20–24	4.10	4.28	4.63	4.30	4.36
25–34	5.89	6.08	6.37	6.74	6.70
35–44	4.80	4.27	4.00	4.11	4.29
45–54	3.39	3.38	3.12	2.77	2.60
55–64	1.85	1.89	2.00	2.00	1.85
65 and over	1.57	1.38	1.25	1.23	1.27
Females					
0–4	8.97	9.22	9.32	9.34	9.31
5–9	7.04	7.22	7.41	7.51	7.55
10–14	6.26	5.95	6.07	6.21	6.27
15–19	5.32	5.29	4.99	5.07	5.18
20–24	4.47	4.45	4.40	4.14	4.21
25–34	6.51	6.66	6.75	6.67	6.41
35–44	4.98	4.62	4.42	4.51	4.56
45–54	3.28	3.43	3.31	3.06	2.93
55–64	1.73	1.81	2.03	2.11	2.05
65 and over	1.54	1.40	1.28	1.29	1.40

TABLE 26. PROJECTION OF SEX-AGE DISTRIBUTION OF URBAN AND RURAL POPULATION OF THE PHILIPPINES, 1957-1977
(Percentage)

Sex and age (years)	1957		1962		1967		1972		1977	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Both sexes, all ages ...	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*	*100.00*
Males										
0–4	8.94	9.53	9.07	9.67	9.18	9.78	9.20	9.80	9.19	9.79
5–9	6.91	7.50	7.09	7.69	7.21	7.81	7.30	7.92	7.34	7.96
10–14	6.36	6.70	5.97	6.28	6.09	6.40	6.15	6.47	6.22	6.54
15–19	5.17	5.08	5.62	5.53	5.25	5.16	5.33	5.24	5.37	5.28
20–24	4.19	4.05	4.37	4.23	4.73	4.57	4.40	4.25	4.46	4.31
25–34	6.10	5.78	6.29	5.97	6.59	6.25	6.98	6.61	6.93	6.57
35–44	4.79	4.81	4.26	4.28	4.00	4.01	4.11	4.11	4.29	4.29
45–54	3.43	3.36	3.42	3.35	3.16	3.09	2.80	2.74	2.63	2.58
55–64	1.70	1.94	1.73	1.98	1.83	2.10	1.84	2.10	1.70	1.94
65 and over	1.34	1.70	1.17	1.49	1.06	1.35	1.05	1.33	1.08	1.37
Females										
0–4	8.79	9.07	9.04	9.32	9.14	9.42	9.16	9.44	9.13	9.41
5–9	6.76	7.18	6.93	7.38	7.12	7.57	7.22	7.67	7.25	7.71
10–14	6.07	6.36	5.76	6.05	5.88	6.17	6.02	6.31	6.08	6.37
15–19	6.01	4.93	5.98	4.92	5.64	4.64	5.74	4.72	5.85	4.81
20–24	4.91	4.23	4.89	4.21	4.83	4.16	4.55	3.92	4.63	3.98
25–34	6.98	6.26	7.14	6.40	7.23	6.49	7.15	6.41	6.87	6.16
35–44	4.97	4.98	4.61	4.62	4.41	4.42	4.50	4.51	4.55	4.56
45–54	3.30	3.27	3.44	3.42	3.33	3.30	3.08	3.05	2.95	2.92
55–64	1.72	1.73	1.81	1.81	1.29	2.03	2.12	2.11	2.05	2.05
65 and over	1.55	1.54	1.41	1.40	1.29	1.28	1.30	1.29	1.41	1.40

TABLE 27. CALCULATION OF SEX-AGE SPECIFIC URBAN RESIDENCE RATIOS, AND OF CORRESPONDING LOGISTIC LEVELS, FROM 1966 CENSUS DATA FOR IRAN

Sex and age	Population		Per cent urban	Logistic level	Same, smoothed
	Total	Urban			
Both sexes	*25,144*	*9,840*	*39.1*	*−44*	*−44*
Males	*12,998*	*5,116*	*39.4*	*−43*	...
0–4	2,301	805	35.0	−62	−60
5–9	2,160	776	35.9	−58	−58
10–14.....	1,609	676	42.0	−32	−32
15–19.....	1,068	501	46.9	−12	−12
20–24.....	777	398	51.2	+5	+5
25–29.....	789	327	41.4	−34	−25
30–34.....	864	335	38.8	−46	−42
35–39.....	763	295	38.7	−46	−49
40–44.....	760	280	36.8	−54	−47
45–49.....	483	192	39.8	−41	−45
50–54.....	362	144	39.8	−41	−45
55–59.....	216	80	37.0	−53	−48
60–64.....	342	129	37.7	−50	−55
65 and over	504	178	35.3	−61	−61
Females	*12,146*	*4,724*	*38.9*	*−45*	...
0–4	2,142	762	35.6	−59	−60
5–9	1,988	722	36.3	−56	−58
10–14.....	1,438	612	42.6	−30	−30
15–19.....	1,055	452	42.8	−29	−29
20–24.....	887	375	42.3	−31	−31
25–29.....	848	324	38.2	−48	−43
30–34.....	803	301	37.5	−51	−46
35–39.....	670	272	40.6	−38	−48
40–44.....	578	212	36.7	−55	−41
45–49.....	365	154	42.8	−29	−39
50–54.....	382	160	41.9	−33	−32
55–59.....	201	83	41.3	−35	−38
60–64.....	326	126	38.7	−46	−45
65 and over	463	169	36.5	−55	−55

TABLE 28. PROJECTION OF LOGISTIC LEVEL, URBAN RESIDENCE RATIOS AND ACTUAL NUMBERS OF URBAN POPULATION TO 1975, IN CONFORMITY WITH PROJECTED POPULATION OF IRAN BY SEX-AGE GROUPS, AND URBAN TOTAL

Sex and age	Logistic level		Per cent urban 1975	Population, 1975		
	1966	1975		Total	Urban	Urban, prorated
Both sexes	−44	−22	44.6	*33,151*	*14,949*	*14,707*
Males	...	...	...	*16,729*	*7,647*	*7,524*
0–4	−60	−38	40.6	3,096	1,257	1,237
5–9	−58	−36	41.1	2,464	1,013	997
10–14	−32	−10	47.5	2,114	1,004	988
15–19	−12	+10	52.5	1,790	940	925
20–24	+5	+27	56.7	1,531	868	854
25–29	−25	−3	49.3	1,196	590	580
30–34	−42	−20	45.0	911	410	403
35–39	−49	−27	43.3	750	325	320
40–44	−47	−25	43.8	649	284	279
45–49	−45	−23	44.3	553	245	241
50–54	−45	−23	44.3	467	207	204
55–59	−48	−26	43.5	384	167	164
60–64	−55	−33	41.8	301	126	124
65 and over	−61	−39	40.4	523	211	208
Females	...	...	...	*16,422*	*7,302*	*7,183*
0–4	−60	−38	40.6	3,007	1,221	1,201
5–9	−58	−36	41.1	2,402	987	971
10–14	−30	−8	48.0	2,064	991	975
15–19	−29	−7	48.3	1,746	843	829
20–24	−31	−9	47.8	1,494	714	702
25–29	−43	−21	44.8	1,166	522	514
30–34	−46	−24	44.0	886	390	384
35–39	−48	−26	43.5	730	318	313
40–44	−41	−19	45.3	634	287	282
45–49	−39	−17	45.7	542	248	244
50–54	−32	−10	47.5	462	219	215
55–59	−38	−16	46.0	385	177	174
60–64	−45	−23	44.3	312	138	136
65 and over	−55	−33	41.8	592	247	243

284. With reference to the table in annex I, these specific urban residence ratios can be transformed to the logistic levels also shown in table 27. Some incongruities emerge at middle and advanced adult ages, and these are most pronounced among women where the logistic level fluctuates from −51 at ages 30 to 34 to −38 at ages 35 to 39, back to −55 at ages 40 to 44, and again to −29 at ages 45 to 49. It is unlikely that in actual fact women of adjacent five-year age groups would be urbanized to such an unequal extent. Most likely, these fluctuations are due to unequal accuracy in age statements for urban women as compared with those for rural women. To counteract this effect, the logistic levels were smoothed for age groups between 25 and 64 years of age, using a three-term moving average. Another slight modification, also in the last column of table 27, was made by introducing the arbitrary assumption that at ages 0 to 4 and 5 to 9 boys and girls may be urbanized to the same extent. [78]

285. These smoothed logistic levels of urbanization were entered in the first column of table 28. In a previous projection of urban and rural totals, the percentage urban in Iran was estimated to rise from 39.1 per cent at the 1966 census to 44.6 per cent in 1975. By reference to the logistic table in annex I it can be seen that this corresponds to a rise along the logistic curve of 22 points (from a value of −44 to −22). For purposes of the projection it will be assumed that the *increase* in logistic level of each sex-age group was the same as the *increase* in logistic level previously projected for the total population, i.e. 22 points as shown in the second column of table 28. The corresponding percentage levels (as read from the logistic table in annex I) are shown in the third column. These percentages are then applied to the projection of the total population to 1975, already calculated by sex-age groups. The results add up to an urban population of 14,949,000, which is more than the figure of 14,707,000 already projected. In the last column, therefore, the figures for each sex-age group are prorated so as to coincide with the latter total. (The rural population, by sex and age, can then be obtained

[78] This adjustment is debatable. In Latin America, for instance, small girls are more often taken by their migrant mothers to the towns, whereas small boys are more often left in the countryside, as can be borne out by analysis of census data.

TABLE 29. CALCULATION OF SEX-AGE SPECIFIC URBAN RESIDENCE RATIOS AND OF CORRESPONDING LOGISTIC LEVELS FROM 1950 CENSUS DATA FOR BRAZIL

Sex and age	Population		Per cent urban	Logistic level
	Total	Urban		
Both sexes	*51,946*	*18,684*	*35.97*	*−57.7*
Males	*25,886*	*8,971*	*34.66*	*−63.4*
0–4	4,276	1,273	30.05	−84.5
5–9	3,561	1,026	28.81	−90.5
10–14	3,165	976	30.84	−80.8
15–19	2,645	922	34.86	−62.5
20–24	2,384	901	37.79	−49.8
25–29	2,030	779	38.37	−47.4
30–39	3,146	1,225	38.94	−45.0
40–49	2,246	892	39.72	−41.7
50–59	1,361	543	39.90	−40.9
60–69	729	288	39.51	−42.6
70 and over [a]	383	146	38.12	−48.4
Females	*26,060*	*9,713*	*37.27*	*−52.1*
0–4	4,135	1,256	30.37	−83.0
5–9	3,455	1,027	29.73	−86.0
10–14	3,144	1,047	33.30	−69.5
15–19	2,858	1,093	38.24	−47.9
20–24	2,607	1,069	41.00	−36.4
25–29	2,102	877	41.72	−33.4
30–39	3,140	1,342	42.74	−29.2
40–49	2,119	936	44.17	−23.4
50–59	1,290	589	45.66	−17.3
60–69	723	347	47.99	−8.0
70 and over [a]	487	230	47.23	−11.1

[a] Includes persons of unknown age.

by subtracting estimated numbers in sex-age groups of the urban population from those already projected for the total population.)

286. The reader may wish to compare these results with the ones which had been obtained in the preceding chapter, in table 21c, by means of the method of difference elimination. It will be noted that the results do not differ greatly. Part of the difference in results may be attributable to the smoothing of the logistic levels, as done in table 28. At any rate, census age statements have been rather inaccurate, hence the estimates are rather uncertain, and it would be futile to argue which of the two sets of results are likely to be the more accurate ones. It will be noted that less calculating work is involved when the logistic table is used than in the method of difference elimination.

287. To give an idea of the possible errors of such a calculation, tables 29 and 30 present the results of the same type of procedure for Brazil. The calculation for 1960 proceeds from the census of 1950 and results are compared with corresponding data of the 1960 census. For the calculation it is assumed that only the sex-age composition of the total population is known for 1960, as well as the totals of urban and rural population. Since the age declarations are probably somewhat more accurate in Brazil than in Iran, percentages have been calculated with an additional decimal, and logistic levels have been interpolated to the nearest tenth of each interval in the table in annex I, but no smoothing was done among those levels.

288. The comparison of the projection with the 1960 census result is carried out in the last three columns of table 30. For males and females alike, the following observations can be made. The projection results in an underestimation of the population aged 0 to 14 years, an over-estimation of numbers aged 15 to 29 years, an underestimation of the population aged 30 to 39 years, an over-estimation at ages 40 to 69 and a nearly correct estimation at ages 70 and over. Evidently the comparative urbanization levels did not, in actual fact, remain the same between the two censuses, 1950 and 1960.

289. The underestimation in projected numbers of children suggests that the relative fertility level of the urban population (as compared with the rural population) was higher in the 1950-1960 period than in a period preceding 1950. The over-estimation in projected numbers of young adults, aged 15 to 29, suggests that the intensity of rural-to-urban migration was less during 1950-1960 than during years preceding 1950. The alternation between over-estimates and underestimates, as we proceed through the entire range of ages, may even suggest that the intensity of urbanization trends could have fluctuated cyclically over extended periods of the past. Of course, the effects of variations in fertility differences and migration trends cannot be disentangled in such an analysis, and alternative interpretations are pos-

TABLE 30. PROJECTION OF LOGISTIC LEVEL, URBAN RESIDENCE RATIO, AND ACTUAL NUMBERS OF URBAN POPULATION IN 1960, AND COMPARISON WITH 1960 CENSUS DATA FOR BRAZIL

Sex and age	Logistic level 1960	Per cent urban 1960	Population, 1960			
			Total as per census	Urban projected	Urban as per census	Error in projection
Both sexes	*−14.6*	*46.36*	*70,033*	*32,467*	*32,469*	*−2*
Males	...	...	*35,010*	*15,677*	*15,620*	*+57*
0–4	−41.4	39.80	5,712	2,273	2,370	−97
5–9	−47.4	38.37	5,159	1,980	2,108	−128
10–14	−37.7	40.69	4,287	1,744	1,784	−40
15–19	−19.4	45.17	3,446	1,557	1,447	+110
20–24	−6.7	48.33	2,964	1,433	1,354	+79
25–29	−4.3	48.93	2,522	1,234	1,214	+20
30–39	−1.9	49.53	4,210	2,085	2,104	−19
40–49	+1.4	50.40	3,052	1,538	1,458	+80
50–59	+2.2	50.55	1,951	986	952	+34
60–69	+0.5	50.12	1,124	563	543	+20
70 and over [a]	−5.3	48.68	583	284	286	−2
Females	...	...	*35,023*	*16,790*	*16,849*	*−59*
0–4	−39.9	40.16	5,484	2,202	2,329	−127
5–9	−42.9	39.44	5,002	1,973	2,118	−145
10–14	−25.6	43.63	4,287	1,870	1,907	−37
15–19	−4.8	48.80	3,697	1,804	1,724	+80
20–24	+6.7	51.67	3,197	1,652	1,596	+56
25–29	+9.7	52.27	2,687	1,404	1,395	+9
30–39	+13.9	53.47	4,210	2,251	2,277	−26
40–49	+19.7	54.91	2,907	1,596	1,527	+69
50–59	+25.8	56.41	1,835	1,035	1,000	+35
60–69	+35.1	58.69	1,061	623	596	+27
70 and over [a]	+32.0	57.93	656	380	380	0

[a] Includes persons of unknown age.

sible: both urban fertility and migration may have fluctuated in the course of time.

290. As was noted in chapter II, the mode of urbanization in Latin America is characterized by higher urbanization levels of women as compared with men, and rising urbanization levels with advancing age. Accordingly, one may assume that in Brazil a large proportion of rural-to-urban migrants settle in the urban areas indefinitely. If sex-age specific urban residence ratios are affected by fluctuations from past trends, it is probable that the same fluctuations will reappear at ages ten years more advanced at each of the successive decennial censuses. In so far as this may have to be expected, the mechanical methods proposed in both parts of the present chapter have only limited validity. The case of Brazil will be further investigated in the next chapter.

291. The improved estimation of sex and age groups in a projected urban and rural population depends, however, on additional statistical information. In the absence of sufficient information, it would be difficult to make better estimates than those possible with the procedures of both parts of the present chapter.

Chapter VIII

MIXED PROJECTION METHODS

292. As explained in the Introduction, the methods of projecting urban and rural populations can be of four types, namely:

(*a*) Global methods (using neither sex-age groups of the population nor the component trends);

(*b*) Composite methods (using sex-age groups of the population, but not the component trends);

(*c*) Crude component methods (using component trends, but not the sex-age groups of the population); and

(*d*) Cohort-survival methods (using both the sex-age groups of the population and the component trends).

293. Chapters IV, V and VI dealt with global methods, while chapter VII illustrates how age groups can be estimated for globally projected urban and rural populations. Chapter IX deals with cohort-component methods. The present chapter is concerned with methods of the above types (*b*) and (*c*), i.e. methods which are detailed in one respect, but not in another. Type (*c*) will be dealt with in the first section, while the rest of the chapter is concerned with methods of type (*b*).

294. Crude component methods present an advantage over global methods only in so far as they can show to what extent urban and rural population growth is apt to be affected by births, deaths and migration, respectively. This leads to the possibility of varying the assumptions concerning these growth components. Otherwise, this type of method has little to commend it, nor does it lead to estimates of urban and rural sex-age structures.

295. The composite methods, on the other hand, produce directly projections of urban and rural population by groups of sex and age. In a sense, therefore, they are almost as useful as the cohort-survival methods, but they lack flexibility because no clear distinction can be made between the effects of fertility, mortality and migration, respectively (and area reclassification where this is relevant). However, their use depends on the availability of relevant and comparable statistics from two successive censuses.

Crude components methods

296. In special circumstances it may be commendable to project urban and rural populations on the basis of crude birth, death and migration rates. Those should be projections over short periods only, since no attention is given to changes in the crude vital rates which may eventually result from the modification of age structures. Because of this limitation, the crude component methods present little advantage over methods discussed in preceding chapters. Their use depends on the availability of accurate statistics on births and deaths occurring in urban and rural areas, respectively.

297. In at least one instance, nevertheless, this method has been used with good effect. [79] In Jamaica the statistics on births and deaths are accurate, and successive censuses provide comparable data on parish of birth of migrants, permitting calculation of migratory balances for the intercensal time interval. The most significant distinction between parishes is made when the "metropolitan" parishes of Kingston and St. Andrew, containing the sprawling capital city, are singled out because the remaining parishes are mostly rural.

298. Aside from internal migration between the metropolitan and the rural parishes, it was necessary also to calculate balances of international migration, as there has been a considerable outward movement of Jamaicans. Statistics on international migration are deficient, but the net movement can be calculated by means of intercensal balancing equations, once the components of natural increase and internal migration have been determined. The Jamaican census data are accurate and detailed enough for such a purpose.

299. The particular data situation made it advantageous to calculate presumable future trends in natural increase, internal migration and international migration as continuations from past trends for the metropolitan area of Kingston and St. Andrew and for the remaining parishes. A projection of this type is interesting because one can deduce from it how much of the expected local population growth may be due to natural increase, how much to the internal migratory balance and how much to the external balance. In the given instance, the calculation was also made of the population resulting in the metropolitan parishes if internal migration were to end suddenly. Other assumptions might also be varied in order to study the respective consequences.

300. There may be other countries or cities where the statistical data situation is similar so that this type of calculation becomes relevant. But it would seem unwise to carry such a calculation over a period longer than, say, ten years. With time, age structures vary, and these variations will have effects on vital rates and migration which this simple method does not make it possible to calculate.

[79] G. W. Roberts, "Provisional assessment of growth of the Kingston-St.Andrew area, 1960-70", *Social and Economic Studies*, University of the West Indies (Kingston, Jamaica), December 1963, pp. 432-441.

TABLE 31A. PROJECTION OF IRAN'S URBAN AND RURAL POPULATION ACCORDING TO AGE GROUPS: CALCULATION OF SEX-AGE SPECIFIC URBAN RESIDENCE RATIOS FROM IRANIAN CENSUS DATA OF 1956 AND 1966

Sex and age [a]	1956 population (thousands)		Per cent urban in 1956	1966 population (thousands)		Per cent urban in 1966
	Total	Urban		Total	Urban	
Both sexes	*18,950*	*5,958*	*31.4*	*25,143*	*9,840*	*39.1*
Males	*9,644*	*3,077*	*31.9*	*12,994*	*5,116*	*39.4*
0–4	1,684	471	28.0	2,301	805	35.9
5–9	1,419	426	30.0	2,160	776	35.9
10–14	975	332	34.1	1,609	676	42.0
15–19	710	267	37.6	1,068	501	46.9
20–24	699	289	41.3	777	398	51.2
25–29 [b]	737	244	33.1	845	352	41.7
30–34	704	216	30.7	808	310	38.4
35–39	578	179	31.0	812	304	37.4
40–44	479	150	31.3	711	271	38.1
45–49	403	127	31.5	484	191	39.5
50–54	339	106	31.3	361	145	40.2
55–59	292	89	30.5	300	114	38.0
60–64	232	69	29.7	254	95	37.4
65 and over	393	112	28.5	504	178	35.3
Females	*9,306*	*2,881*	*31.0*	*12,149*	*4,724*	*38.9*
0–4	1,664	454	27.3	2,142	762	35.6
5–9	1,404	415	29.6	1,988	722	36.3
10–14	848	297	35.0	1,438	612	42.6
15–19	710	255	35.9	1,055	452	42.8
20–24	798	267	33.5	887	375	42.3
25–29 [b]	780	233	29.9	869	334	38.4
30–34	683	202	29.6	782	291	37.2
35–39	507	151	29.6	680	261	38.4
40–44	384	125	32.6	568	223	39.3
45–49	374	125	33.1	418	174	41.6
50–54	330	109	33.0	329	140	42.6
55–59	263	82	31.2	281	114	40.6
60–64	201	62	30.8	246	95	38.6
65 and over	360	104	28.9	463	169	36.5

[a] Excluding population of unknown age.

[b] Age groups from 25 to 29 upward obtained by halving the corresponding ten-year age groups by means of Newton's formula.

COMPOSITE METHOD EMPLOYING URBAN RESIDENCE RATIOS FOR FIXED SEX-AGE GROUPS

301. In this method, it is considered that the propensity of the national population to reside in urban areas varies by groups of sex and age. An exception will have to be made for children at those ages where they would normally reside with their mothers, but this complication will be disregarded at first. From the data of two successive censuses, sex-age specific urban residence ratios can be calculated. It can then be assumed that in future periods the rise in these ratios, as inferred from the two censuses, will continue at the same tempo.

302. The residence ratios are best expressed as percentages in each national sex-age group residing in urban areas. Because of the considerations first introduced in chapter II, second section, and also used in part B of chapter VII, the "tempo" of rise in these ratios (expressed as percentages) will be measured on the logistic scale. The reader will recall that there are varying constraints on the rise in a percentage, depending on whether this is at a low, intermediate or high level, and the logistic scale takes this fact into account.

303. Tables 31a, 31b and 31c illustrate the procedure involved with the use of 1956 and 1966 census data for Iran. In this connexion, it is pointed out that some modifications were made in the published census data. The data for 1956 have been published by five-year age groups up to age 25, and by ten-year groups for ages 25 to 34, 35 to 44, and so forth. To obtain estimates by five-year groups, the ten-year groups were halved with the use of Newton's formula. [80] To maintain comparability, age groups 25 to 29, 30 to 34 and so forth up to

[80] $f_{na} = 1/2\ [f_n + 1/8\ (f_{n-1} - f_{n+1})]$, where f_{na} is the number in the first half of the given ten-year group, to be computed; f_n is the given number in the entire ten-year group; and f_{n-1} and f_{n+1} are numbers in the preceding and following ten-year groups.

TABLE 31B. PROJECTION OF IRAN'S URBAN AND RURAL POPULATION ACCORDING TO AGE GROUPS: DERIVATION OF LOGISTIC LEVELS OF URBAN RESIDENCE RATIOS IN 1956 AND 1966, AND PROJECTION OF THESE LEVELS TO MID-YEAR 1975

Sex and age	Logistic level		Ten-year rise in level	8.62-year rise in level	Level projected to mid-year 1975
	Census 1956	Census 1966			
Both sexes	...	...	...	...	...
Males	...	...	...	...	...
0–4	−94	−62	32	28	−34
5–9	−85	−58	27	23	−35
10–14	−66	−32	34	29	−3
15–19	−51	−12	39	34	+22
20–24	−35	+5	40	34	+39
25–29	−70	−34	36	31	−3
30–34	−81	−47	34	29	−18
35–39	−80	−51	29	25	−26
40–44	−78	−49	29	25	−24
45–49	−78	−43	35	30	−13
50–54	−79	−40	39	34	−6
55–59	−82	−49	33	28	−21
60–64	−86	−52	34	29	−18
65 and over	−92	−61	31	27	−30
Females	...	...	...	...	...
0–4	−98	−59	39	34	−25
5–9	−87	−56	31	27	−29
10–14	−62	−30	32	28	−2
15–19	−58	−29	29	25	+4
20–24	−69	−31	38	33	+2
25–29	−85	−47	38	33	−14
30–34	−87	−52	35	30	−22
35–39	−87	−47	40	34	−13
40–44	−73	−43	30	26	−17
45–49	−70	−34	36	31	−3
50–54	−71	−30	41	35	+5
55–59	−79	−38	41	35	−3
60–64	−81	−46	35	30	−16
65 and over	−90	−55	35	30	−25

age 65 were recalculated for the 1966 census by forming ten-year groups and halving them according to the same formula; the noted fluctuations among adjacent five-year groups were thereby mostly eliminated.

304. Table 31a presents the data of the censuses held in November 1956 and in November 1966 and the corresponding urban residence ratios. These ratios correspond to levels in the logistic curve of annex I and the logistic levels are entered in the first two columns of table 31b. Differences between them indicate the "tempo" at which rises have occurred during the exact ten years of the census interval. These rises are then multiplied by 0.862, to correspond to the 8.62-year interval between the census of November 1966 and the date of mid-year 1975. Added to the levels of November 1966, they indicate levels to be expected in 1975. In table 31c, the logistic levels projected to 1975 are converted to the corresponding percentages (see annex I). The country's total population, projected by sex-age groups to 1975, is then multiplied with these percentages to yield projected numbers of urban population, by sex and age. The corresponding rural population is then obtained by subtraction of the urban from the projected total.

305. It will be noted that the levels or percentages projected to 1975 are affected by considerable fluctuations. These may in part be due to inaccuracies in the original sex-age data, but to a large extent they may also reflect the effects of past fluctuations in urban birth rates (relative to the rural rates), in migration, or both. Since the effects of true fluctuations move up in age as time progresses, the method of projection is partly at fault. On the other hand, the comparatively high levels of urbanization among persons aged 15 to 24, especially males, are likely to reproduce themselves also at the same ages in the future: it is highly likely that much of the urban residence of such young persons has only a temporary character, and while many return sooner or later to rural localities, they tend to be replaced by other young persons, again of the same ages.

306. The reader may wish to compare the projection in table 31c with projections of the Iranian urban popu-

TABLE 31c. PROJECTION OF IRAN'S URBAN AND RURAL POPULATION ACCORDING TO AGE GROUPS: PROJECTED LOGISTIC LEVELS, URBAN RESIDENCE RATIOS AND NUMBERS OF TOTAL, URBAN AND RURAL POPULATION, MID-YEAR 1975

Sex and age	Logistic level	Per cent urban	Population (thousands)		
			Total	Urban	Rural
Both sexes	...	...	*33,040*	*15,651*	*17,479*
Males	...	...	*16,729*	*7,885*	*8,844*
0–4	−34	41.6	3,096	1,288	1,808
5–9	−35	41.3	2,464	1,018	1,446
10–14	−3	49.3	2,114	1,042	1,072
15–19	+22	55.5	1,790	993	797
20–24	+39	59.6	1,531	912	619
25–29	−3	49.3	1,196	590	606
30–34	−18	45.5	911	415	496
35–39	−26	43.5	750	326	424
40–44	−24	44.0	649	286	363
45–49	−13	46.8	553	259	294
50–54	−6	48.5	467	226	241
55–59	−21	44.8	384	172	212
60–64	−18	45.5	301	137	164
65 and over	−30	42.6	523	223	300
Females	...	...	*16,311*	*7,676*	*8,635*
0–4	−25	43.8	3,007	1,317	1,690
5–9	−29	42.8	2,402	1,028	1,374
10–14	−2	49.5	2,064	1,022	1,042
15–19	+4	51.0	1,746	890	856
20–24	+2	50.5	1,494	754	740
25–29	−14	46.5	1,166	542	624
30–34	−22	44.5	886	394	492
35–39	−13	46.8	730	342	388
40–44	−17	45.8	634	290	344
45–49	−3	49.5	542	267	275
50–54	+5	51.2	462	237	225
55–59	−3	49.3	385	190	195
60–64	−16	46.0	312	144	168
65 and over	−25	43.8	592	259	333

lation by sex and age groups presented in the two proceding chapters, in tables 21c and 28. Whereas the methods differ, the results do not differ very greatly. Which of the three projections is the "best" cannot be ascertained until a new census is taken.

COMPOSITE METHOD EMPLOYING URBAN RESIDENCE RATIOS BY COHORT [81]

307. In the foregoing example, urban residence ratios specific by age group were projected to rise, but they were assumed to remain applicable to the same age groups also in the future. The population of persons of the same age at different dates, however, does not comprise the same individuals because, with time, a population of given individuals advances in age. The method can, however, be modified so that persons of the same cohort are followed whose ages advance by the same number of years as the time interval of the calculation. Persons of the same cohort may become urbanized to an increasing extent, as time passes, if more of them migrate from rural to urban areas than from urban to rural, also if localities in which some of them reside become reclassified from rural to urban. This method of calculation is slightly more laborious than that of the foregoing example, and will presently be illustrated.

308. The question arises, of course, whether projections by cohort are more pertinent than those with age-specific rates of urbanization. The answer depends on the degree of permanence of urban residence once a migrant has entered the urban area. As was discussed in chapter II, the process of urbanization has varying features in different parts of the world. By and large, the settlement of rural migrants in urban areas tends to be of longer duration, or greater permanence in Latin America and in the more developed regions, than in many parts of Africa and Asia. In Africa and Asia young men typically migrate temporarily or seasonally

[81] By "cohort" we understand a group of persons born in the same period of time and advancing in age as time progresses.

TABLE 32A. PROJECTION OF BRAZIL'S URBAN AND RURAL POPULATION ACCORDING TO AGE GROUPS: CALCULATION OF SEX-AGE SPECIFIC URBAN RESIDENCE RATIOS FROM BRAZILIAN CENSUS DATA OF 1950 AND 1960

Sex and age	1950 population (thousands)		Per cent urban in 1950	1960 population (thousands)		Per cent urban in 1960
	Total	Urban		Total	Urban	
Both sexes	*51,944*	*18,784*	*36.16*	*70,033*	*32,470*	*46.36*
Males	*25,884*	*8,971*	*34.66*	*35,010*	*15,621*	*44.62*
0–4	4,236	1,273	30.05	5,712	2,370	41.49
5–9	3,561	1,026	28.81	5,159	2,108	40.86
10–14	3,165	976	30.84	4,287	1,784	41.61
15–19	2,645	922	34.86	3,446	1,447	41.99
20–24	2,384	901	34.79	2,964	1,354	45.68
25–29	2,030	779	38.37	2,522	1,214	48.14
30–34 [a]	1,702	662	38.89	2,257	1,121	49.67
35–39	1,444	563	38.99	1,953	982	50.28
40–44	1,235	489	39.35	1,667	801	48.05
45–49	1,011	403	39.86	1,385	657	47.44
50–54	775	309	39.87	1,096	533	48.63
55–59	584	234	40.07	855	419	49.01
60–64	426	169	39.67	648	313	48.30
65–69	303	119	39.27	476	232	48.74
70 and over [b]	383	146	38.12	583	286	49.06
Females	*26,060*	*9,813*	*37.66*	*35,023*	*16,849*	*48.11*
0–4	4,135	1,256	30.37	5,484	2,329	42.47
5–9	3,455	1,027	29.73	5,002	2,118	42.34
10–14	3,144	1,047	33.30	4,287	1,907	44.48
15–19	2,858	1,093	38.24	3,697	1,724	46.63
20–24	2,607	1,069	41.00	3,197	1,596	49.92
25–29	2,102	877	41.72	2,687	1,395	51.92
30–34 [a]	1,732	734	42.38	2,291	1,230	53.69
35–39	1,408	608	43.18	1,919	1,047	54.56
40–44	1,175	515	43.83	1,602	843	52.62
45–49	944	421	44.60	1,305	684	52.41
50–54	732	331	45.22	1,033	557	53.92
55–59	558	258	46.24	802	443	55.24
60–64	412	196	47.57	604	337	55.79
65–69	311	151	48.55	457	259	56.67
70 and over [b]	487	230	47.23	656	380	57.93

[a] Age groups from 30 to 34 upward obtained by halving the corresponding ten-year age groups by means of Newton's formula.

[b] Including persons of unknown age.

to urban areas in search of cash income needed by their families who remain in the rural areas. Usually they return to their rural residences when sufficient cash has been accumulated. Hence, fixed age calculations may be more appropriate for many countries in Africa and Asia where migrations are often temporary, while cohort calculations may be more appropriate for other areas where migration (or the lack of it) is more often a permanent experience which depends on the particular circumstances existing during the young adult ages of each individual cohort. Such occurrences as economic depressions may permanently curb urban migration in the contemporary cohort of young adults, while wars or economic prosperity in the cities at another date may swell the tide of urban migration in another cohort of young adults. Once having reached middle age, there is rather less chance that a change in the residence pattern of a cohort will occur. By middle age, persons in these areas are more or less permanently committed to urban or rural occupations and urban or rural life styles. [82]

309. Data on urban and rural population by groups of sex and age are now available from three Brazilian censuses, those of 1950, 1960 and 1970. This circumstance makes it possible to submit the projection methods to a test. In what follows, two composite projections of the urban population of Brazil are made, both based on the same data of the 1950 and 1960 censuses, and the results of both for the year 1970 will then be compared with census data for 1970 in order to ascertain which of

[82] There is, however, a strong indication that nearly everywhere rural widowed women tend to migrate to urban places. See "Urban-rural differences in the marital status composition of the population" (ESA/P/WP.51).

TABLE 32B. PROJECTION OF BRAZIL'S URBAN AND RURAL POPULATION ACCORDING TO AGE GROUPS: DERIVATION OF LOGISTIC LEVELS OF URBAN RESIDENCE RATIOS IN 1950 AND 1960, AND PROJECTIONS OF THESE LEVELS TO 1970

Sex and age	Percentage urban		Logistic level			
	1950	1960	1950	1960	Rise in level	1970 projected
Both sexes	*36.16*	*46.36*	...	...	...	...
Males	*34.66*	*44.62*	...	...	...	...
0–4	30.05	41.49	−84.5	−34.4	+50.1	+15.7
5–9	28.81	40.86	−90.5	−37.0	+53.5	+16.5
10–14	30.84	41.61	−80.8	−33.9	+46.9	+13.0
15–19	34.86	41.99	−62.5	−32.3	+30.2	−2.1
20–24	34.79	45.68	−62.8	−17.3	+45.5	+28.2
25–29	38.37	48.14	−47.4	−7.4	+40.0	+32.6
30–34	38.89	49.67	−45.2	−1.3	+43.9	+42.6
35–39	38.99	50.28	−44.8	+1.1	+45.9	+47.0
40–44	39.35	48.05	−43.3	−7.8	+35.5	+27.7
45–49	39.86	47.44	−41.1	−10.2	+30.9	+20.7
50–54	39.87	48.63	−41.1	−5.5	+35.6	+30.1
55–59	40.07	49.01	−40.3	−4.0	+36.3	+32.3
60–64	39.67	48.30	−41.9	−6.8	+35.1	+28.3
65–69	39.27	48.74	−43.6	−5.0	+38.6	+33.6
70 and over	38.12	49.06	−48.4	−3.8	+44.6	+40.8
Females	*37.66*	*48.11*	...	...	...	...
0–4	30.37	42.47	−83.0	−30.4	+52.6	+22.6
5–9	29.73	42.34	−86.0	−30.9	+55.1	+24.2
10–14	33.30	44.48	−69.5	−22.2	+47.3	+25.1
15–19	38.24	46.63	−47.9	−13.5	+34.4	+20.9
20–24	41.00	49.92	−36.4	−0.3	+36.1	+35.8
25–29	41.72	51.92	−33.4	+7.7	+41.1	+48.8
30–34	42.38	53.69	−30.7	+14.8	+45.5	+60.3
35–39	43.18	54.56	−27.4	+18.3	+45.7	+64.0
40–44	43.83	52.62	−24.8	+10.5	+35.3	+45.8
45–49	44.60	52.41	−21.7	+9.6	+31.3	+40.9
50–54	45.22	53.92	−19.2	+15.7	+34.9	+50.6
55–59	46.24	55.24	−15.1	+21.0	+36.1	+57.1
60–64	47.57	55.79	−9.7	+23.3	+33.0	+56.3
65–69	48.55	56.67	−5.8	+26.8	+32.6	+59.4
70 and over	47.23	57.93	−11.1	+32.0	+43.1	+75.1

the two methods has yielded the more accurate results. The first projection is made according to fixed age groups, and the second according to cohorts.

310. The Brazilian census data are by five-year age group up to age 29, and then by ten-year groups such as 30 to 39, 40 to 49 and so forth. Again, Newton's formula [83] is used to halve the ten-year groups and estimate the population in each five-year group.

311. The projection by specific age groups is taken up first, and it is illustrated in tables 32a, 32b and 32c. Little explanation is needed because the same method was used in the projection for Iran, in tables 31a, 31b and 31c. The Brazilian case is simpler because both the first census interval (1950-1960) and the postcensal period (1960-1970) comprise exactly ten years.

312. If the procedure is to be carried out by identical cohorts—and not by fixed age groups—a complication arises because the same individuals are of different age at different dates. How this can be overcome is illustrated in table 33a, part of which is a rearrangement of table 32b. Three sets of age groups apply to the same individuals according to the three dates, 1950, 1960 and 1970. [84] The logistic levels for 1950 and 1960 are the same as those of table 32b, but they have now been placed in those lines where the age groups apply at the particular date. Thus, the logistic urbanization level of males aged 0 to 4 in 1950 was −84.5 in that year. And for the same cohort, i.e. males aged 10 to 14 in 1960, the level in 1960 was −33.9, this being an advance by +50.6 for the identical cohort, as followed through time while their age advances.

313. The assumption of the projection by cohorts is that rises in each cohort's urbanization level which occurred during 1950-1960 may occur again in the same

[83] See foot-note 80.

[84] A simpler method of presentation would be to identify cohorts according to the years in which they were born. For instance, those aged 15-19 in 1950, 25-29 in 1960 and 35-39 in 1970 have originated from births which occurred during 1930-1935, etc.

TABLE 32C. PROJECTION OF BRAZIL'S URBAN AND RURAL POPULATION ACCORDING TO AGE GROUPS: PROJECTED LOGISTIC LEVELS, URBAN RESIDENCE RATIOS AND NUMBERS OF TOTAL, URBAN AND RURAL POPULATION, 1970

Sex and age	Logistic level	Per cent urban	1970 population (thousands)		
			Total [a]	Urban	Rural
Both sexes	...	...	*93,204*	*53,282*	*39,922*
Males	...	...	*46,330*	*25,668*	*20,662*
0–4	+15.7	53.92	7,020	3,785	3,235
5–9	+16.5	54.12	6,730	3,642	3,088
10–14	+13.0	53.25	5,850	3,115	2,735
15–19	−2.1	49.48	4,934	2,441	2,493
20–24	+28.2	57.00	4,063	2,316	1,747
25–29	+32.6	58.08	3,202	1,860	1,342
30–34 [b]	+42.6	60.49	2,857	1,728	1,129
35–39	+47.0	61.54	2,460	1,514	946
40–44	+27.7	56.88	2,209	1,256	953
45–49	+20.7	55.00	1,879	1,033	846
50–54	+30.1	57.47	1,510	868	642
55–59	+32.3	58.01	1,193	692	501
60–64	+28.3	57.03	894	510	384
65–69	+33.6	58.32	656	383	273
70 and over [c]	+40.8	60.06	874	525	349
Females	...	...	*46,874*	*27,614*	*19,260*
0–4	+22.6	55.63	6,879	3,808	3,071
5–9	+24.2	56.02	6,571	3,681	2,890
10–14	+25.1	56.24	5,816	3,271	2,545
15–19	+20.9	55.21	5,270	2,910	2,360
20–24	+35.8	58.86	4,359	2,566	1,793
25–29	+48.8	61.96	3,344	2,072	1,272
30–34 [b]	+60.3	64.63	2,963	1,915	1,048
35–39	+64.0	65.48	2,502	1,638	864
40–44	+45.8	61.25	2,179	1,335	844
45–49	+40.9	60.08	1,828	1,098	730
50–54	+50.6	62.39	1,482	925	557
55–59	+57.1	63.90	1,170	748	422
60–64	+56.3	63.71	869	554	315
65–69	+59.4	64.43	649	418	231
70 and over [c]	+75.1	67.94	993	675	318

[a] Census results (for totals only).

[b] Age groups from 30 to 34 upward obtained by halving the corresponding ten-year age groups by means of Newton's formula.

[c] Including persons of unknown age.

age groups (i.e. in the cohort born ten years more recently, hence ten years younger) during 1960-1970. In table 33a, the assumed 1960-1970 rises in logistic level are the same as those observed in 1950-1960, except that they are moved up by ten years. For example in the 1945-1950 cohort, next to the last column of table 33a, the 1960-1970 difference of 63.5 was assumed to be equal to the 1950-1960 difference for the 1935-1940 cohort (shown in the previous column), since those two cohorts were the same age at dates ten years apart. The 1960-1970 rises are then added to the levels ascertained for each cohort in 1960 so as to arrive at projected levels in 1970 when each cohort is again ten years older. The procedure is completed in table 33b, where the logistic levels are converted to percentage levels with the use of the table in annex I, and the resulting percentages are applied to the census data on sex-age composition of the total population in 1970.

314. Two observations must be made, however, one trivial and the other rather important. It will be noted that calculations are carried out up to a terminal age group of 70 years and over. Individuals of such ages at each given date were aged 60 years and over at a date ten years previously. To be exact, the calculation should have been carried out in terms of rises of logistic levels from a combined age group 60 years and over at one date (i.e. the sum of those aged 60 to 64, 65 to 69 and 70 and over) to a terminal group of 70 years and over at the next date. This was not done here mainly for reasons of simplicity, and because the resulting error is unlikely to be very significant.

315. More important, it will be noted that this method of projection cannot be applied to individuals aged 0 to 4 and 5 to 9 years in 1970, because none of them had been born as yet in 1960, and there are no usable national

TABLE 33A. PROJECTION OF BRAZIL'S URBAN AND RURAL POPULATION ACCORDING TO COHORTS: LOGISTIC LEVELS OF URBAN RESIDENCE RATIOS IN 1950 AND 1960, DIFFERENCES, AND PROJECTIONS OF LEVELS TO 1970

Year of birth	Sex and age: Age in 1950	Age in 1960	Age in 1970	Logistic level: 1950	1960	Rise in level: 1950-1960 [a]	1960-1970 [b]	1970, projected [c]
Both sexes	...	...	...	...	...	...	...	...
Males	...	...	...	...	...	...	...	...
1965–1970	...	...	0–4	...	...	...	...	...
1960–1965	...	...	5–9	...	...	...	...	...
1955–1960	...	0–4	10–14	...	−34.4	...	+50.6	+16.2
1950–1955	...	5–9	15–19	...	−37.0	...	+58.2	+21.2
1945–1950	0–4	10–14	20–24	−84.5	−33.9	+50.6	+63.5	+29.6
1940–1945	5–9	15–19	25–29	−90.5	−32.3	+58.2	+55.1	+22.8
1935–1940	10–14	20–24	30–34	−80.8	−17.3	+63.5	+61.5	+44.2
1930–1935	15–19	25–29	35–39	−62.5	− 7.4	+55.1	+48.5	+41.1
1925–1930	20–24	30–34	40–44	−62.8	− 1.3	+61.5	+37.4	+36.1
1920–1925	25–29	35–39	45–49	−47.4	+ 1.1	+48.5	+34.6	+35.7
1915–1920	30–34	40–44	50–54	−45.2	− 7.8	+37.4	+37.8	+30.0
1910–1915	35–39	45–49	55–59	−44.8	−10.2	+34.6	+37.1	+26.9
1905–1910	40–44	50–54	60–64	−43.3	− 5.5	+37.8	+34.3	+28.8
1900–1905	45–49	55–59	65–69	−41.1	− 4.0	+37.1	+35.3	+31.3
1895–1900	50–54	60–64	70+	−41.1	− 6.8	+34.3	+38.1	+31.3 [d]
1890–1895	55–59	65–69	...	−40.3	− 5.0	+35.3	...	...
1885–1890	60–64	70+	...	−41.9	− 3.8	+38.1	...	...
Females	...	...	...	...	...	...	...	...
1965–1970	...	...	0–4	...	...	...	...	...
1960–1965	...	...	5–9	...	...	...	...	...
1955–1960	...	0–4	10–14	...	−30.4	...	+60.8	+30.4
1950–1955	...	5–9	15–19	...	−30.9	...	+62.5	+31.6
1945–1950	0–4	10–14	20–24	−83.0	−22.2	+60.8	+69.2	+47.0
1940–1945	5–9	15–19	25–29	−86.0	−13.5	+62.5	+55.6	+42.1
1935–1940	10–14	20–24	30–34	−69.5	− 0.3	+69.2	+51.2	+50.9
1930–1935	15–19	25–29	35–39	−47.9	+ 7.7	+55.6	+51.7	+59.4
1925–1930	20–24	30–34	40–44	−36.4	+14.8	+51.2	+41.2	+56.0
1920–1925	25–29	35–39	45–49	−33.4	+18.3	+51.7	+37.0	+55.3
1915–1920	30–34	40–44	50–54	−30.7	+10.5	+41.2	+40.5	+51.0
1910–1915	35–39	45–49	55–59	−27.4	+ 9.6	+37.0	+42.7	+52.3
1905–1910	40–44	50–54	60–64	−24.8	+15.7	+40.5	+42.5	+58.2
1900–1905	45–49	55–59	65–69	−21.7	+21.0	+42.7	+41.9	+62.9
1895–1900	50–54	60–64	70+	−19.2	+23.3	+42.5	+41.7	+65.0 [d]
1890–1895	55–59	65–69	...	−15.1	+26.8	+41.9	...	...
1885–1890	60–64	70+	...	− 9.7	+32.0	+41.7	...	...

[a] Observed rise.
[b] Assumed rise.
[c] Assumed rise added to level observed in 1960.
[d] For simplicity, the assumed rise is added to level of 60 to 64-year age group observed in 1960.

statistics on births in Brazil. [85] For these groups, therefore, special calculations had to be made, which are explained below.

316. The assumption was made that urban levels of child-woman ratios, relative to rural levels, would be similar in 1970 to what they were in 1950 and 1960. This is to say, very roughly, that the ratio of fertility in urban areas relative to fertility in the whole country would remain about the same. [86] The following ratios were defined:

Children (males and females separately) aged 0 to 4 years per woman aged 20 to 39 years; and

[85] The matter would be different in a country with good birth registration statistics, where urban and rural birth cohorts of precensal and postcensal periods can be compared with eventual survivors aged 0 to 4 and 5 to 9 years in the urban and rural areas.

[86] The assumption is not exact because child-woman ratios, however defined, do not measure fertility accurately. Some of the children have died, and rates of infant and child mortality may differ between urban areas and the rest of the country. More important, not all children necessarily reside with their mothers. Detailed observations lead to the impression that some women who have migrated from rural to urban areas tend to leave some of their children under the care of rural relatives; this seems to be more often the case with boys than with girls, and more often with bigger children (aged 5 to 9) than with small children (aged 0 to 4). This possibly interesting topic, however, has so far been little investigated.

TABLE 33B. PROJECTION OF BRAZIL'S URBAN AND RURAL POPULATION ACCORDING TO COHORT: PROJECTED LOGISTIC LEVELS, URBAN RESIDENCE RATIOS AND NUMBERS OF TOTAL, URBAN AND RURAL POPULATION, 1970

Year of birth	Sex and age in 1970	Logistic level	Per cent urban	Population (thousands)		
				Total [a]	Urban	Rural
Both sexes	...	...	...	*93,204*	*51,616*	*41,588*
Males	...	...	...	*46,330*	*24,882*	*22,448*
1965–1970	0–4	...	46.72 [b]	7,020	3,280	3,940
1960–1965	5–9	...	45.11 [b]	6,730	3,036	3,694
1955–1960	10–14	+16.2	54.05	5,850	3,162	2,688
1950–1955	15–19	+21.2	55.28	4,934	2,728	2,206
1945–1950	20–24	+29.6	57.35	4,063	2,330	1,733
1940–1945	25–29	+22.8	55.68	3,202	1,783	1,419
1935–1940	30–34	+44.2	60.87	2,857	1,739	1,118
1930–1935	35–39	+41.1	60.13	2,460	1,479	981
1925–1930	40–44	+36.1	58.93	2,209	1,302	907
1920–1925	45–49	+35.7	58.83	1,879	1,105	774
1915–1920	50–54	+30.0	57.44	1,510	867	643
1910–1915	55–59	+26.9	56.68	1,193	676	517
1905–1910	60–64	+28.8	57.15	894	511	383
1900–1905	65–69	+31.3	57.76	656	379	277
Up to 1900	70 and over	+31.3	57.76	874	505	369
Females	...	...	...	*46,874*	*26,734*	*20,140*
1965–1970	0–4	...	47.52 [b]	6,879	3,269	3,610
1960–1965	5–9	...	46.65 [b]	6,571	3,065	3,506
1955–1960	10–14	+30.4	57.54	5,816	3,347	2,469
1950–1955	15–19	+31.6	57.83	5,270	3,048	2,222
1945–1950	20–24	+47.0	61.54	4,359	2,683	1,676
1940–1945	25–29	+42.1	60.37	3,344	2,019	1,325
1935–1940	30–34	+50.9	62.46	2,963	1,851	1,112
1930–1935	35–39	+59.4	64.43	2,502	1,612	890
1925–1930	40–44	+56.0	63.65	2,179	1,387	792
1920–1925	45–49	+55.3	63.48	1,828	1,160	668
1915–1920	50–54	+51.0	62.48	1,482	926	556
1910–1915	55–59	+52.3	62.78	1,170	735	435
1905–1910	60–64	+58.2	64.15	869	557	312
1900–1905	65–69	+62.9	65.23	649	423	226
Up to 1900	70 and over	+65.0	65.70	993	652	341

[a] Census results; age groups from 30 to 34 upward obtained by halving the corresponding ten-year age groups by means of Newton's formula.
[b] For method of calculation, see text.

Children (males and females separately) aged 5 to 9 years per woman aged 25 to 44 years. [87]

317. Actually the calculations were carried out in terms of relative urban residence ratios. The urban residence ratios of children (separately for males and females, and for 0 to 4 and 5 to 9 age groups) were calculated, and also the average of urban residence ratios of women who might be their mothers (aged 20 to 39 and 25 to 44). Then a ratio between the residence ratios of the children and their mothers was calculated. This was done in respect of data for 1950, and again in respect of data for 1960. It was then assumed that in 1970 the ratio between residence ratios might be an average [88] of those in 1950 and 1960. The urban residence ratios of women aged 20 to 39 or 25 to 44 have already been projected to 1970, and by applying the assumed ratios between residence ratios the urban residence ratios for children (males and females, 0 to 4 and 5 to 9) were obtained. These are entered in the appropriate place in table 33b. [89]

[87] True, the mothers of such children may in some instances be either younger or older than the age range selected for women, but in the majority of instances they would be of such ages. The calculation might be further refined by assigning weights to numbers of women of different ages according to the comparative likelihood that they might be mothers of children aged either 0 to 4 or 5 to 9 years. But such refinement would be of interest only if there were more detailed information about possible trends and age patterns in urban and rural fertility, which is not the case in the present example.

[88] It was assumed that, in the case of ratios, the appropriate average should be the geometric mean; actually, an artihmetic mean might have sufficed, and results would have been nearly the same.

[89] Take, for example, the case of males in the age group 0 to 4. From table 32a it can be calculated that the arithmetic average of the urban residence ratios (URR), i.e. the percentage urban, for women aged 20 to 39 is 42.07 in 1950 and 52.52 in 1960. For the males aged 0 to 4 it is 30.05 in 1950 and 41.49 in 1960. The ratio of the ratios, i.e. the ratio of the URR's of the children over the mothers, $\left(\frac{30.05}{42.07} \text{ in 1950 and } \frac{41.49}{52.52} \text{ in 1960}\right)$ equals .7143 in 1950 and .7900 in 1960.

(Continued on next page.)

Residence ratio of:	1950		1960	
	Male children	Female children	Male children	Female children
Children aged 0 to 4	30.05	30.37	41.49	42.47
Women aged 20 to 39 [a]	42.07	42.07	52.52	52.52
Ratio between residence ratios	0.7143	0.7219	0.7900	0.8086
Children aged 5 to 9	28.81	29.73	40.86	42.34
Women aged 25 to 44 [a]	42.78	42.78	53.20	53.20
Ratio between residence ratios	0.6734	0.6950	0.7680	0.7959

[a] Arithmetic mean of residence ratios in the corresponding five-year age groups.

318. This auxiliary calculation is interesting for its own sake, because it indicates, however roughly, that relative urban fertility (i.e. relative to fertility in the whole country) evidently underwent some change between 1950 and 1960, with implications for 1970 which, in the absence of the new census, would have been difficult to foresee. For this reason, the detail is presented below.

319. For children aged 0 to 4, the ratio between children's and women's residence ratios in 1950 was 0.7143 for boys and 0.7219 for girls; by 1960, these ratios had risen to 0.7900 and 0.8086, respectively. There was a similar rise in the ratio between children's and women's residence ratios in respect of children aged 5 to 9. Aside from the varying frequency with which migrant women may leave their children with rural relatives and variations in infant mortality, this rising tendency, from 1950 to 1960, reflects a rise in urban fertility relative to the fertility level of the whole country. The calculation presents an opportunity to make varied assumptions. Urban fertility (relative to that of the entire country) may be assumed to rise even further until 1970; it may be assumed to decline again by 1970, possibly below the 1950 level; and it may be assumed to reach a level in 1970 which is intermediate between the levels of 1950 and 1960. Actually, this latter assumption was made to arrive at the results presented in table 33b.

320. Two projections of Brazil's urban population in 1970 have now been presented, one in terms of fixed age groups (table 32c), the other in terms of cohorts (table 33b). Both were calculated in relation to 1970 census data on sex-age composition of the total national population. Actually, however, 1970 census data detailed by sex and age are also available separately for the urban and rural population. It is possible, therefore, to compare the projections with actual data for 1970, and to indicate which of the two projections has been more accurate. The comparison is carried out in table 34.

321. Discrepancies between the projections and actual observations are indicated in the last two columns of table 34. It will be noted that both projections have erred considerably with respect to children aged 0 to 4 and 5 to 9 in 1970. The projection by fixed age groups, because of an apparent urban fertility rise between 1950 and 1960, implies a continuous urban fertility rise until 1970, and therefore over-estimates urban children in 1970, especially the children aged 0 to 4. The projection by cohorts assumes that during 1960-1965 and 1965-1970, fertility would be at levels averaging those of 1940-1945 and 1950-1955, and those of 1945-1950 and 1955-1960. In this projection, urban children aged 0 to 4 in 1970 were slightly underestimated, and those aged 5 to 9 in 1970 were considerably underestimated. It becomes evident that in actual fact, urban fertility relative to the fertility of the whole country continued to rise during 1960-1965 (hence the large underestimate of children aged 5 to 9), but declined significantly during 1965-1970 (hence the smaller underestimate of children aged 0 to 4). But this trend would have been difficult to foresee in a projection when the 1970 census data were not yet available. [90]

322. Past the age of 10 years in 1970, with a few exceptions, the errors in the projection by cohorts are markedly smaller than the errors in the projection according to fixed age groups. It is worth while to consider the distribution of errors according to sex and age and to reflect on their possible causes. [91] On the whole it appears that the cohort method is the more reliable of the two, though actual events will always deviate more or less from any projection. Rural-to-urban migration and rural-to-urban area reclassification may at times gather momentum and ebb off at other times, and the selection of migrants by sex and age may vary as time progresses.

Migration-survival method as applied to the rural population

323. The method now to be described resembles the cohort-survival method in so far as use is made of a type of ratio similar to "survival ratios". But survival ratios, as used in the cohort-survival method, indicate only the progressive decimation of each cohort as a result of deaths; as regards the consequences of migration and of rural-to-urban area reclassification, separate

(Continued)
The geometric mean of these $= \sqrt{(.7143)(.7900)} = .751199$. Then the arithmetic mean of URR's for women aged 20 to 39 in 1970 can be calculated from table 32b to be 62.20. The ratios of ratios are then set equal to each other $\left(\frac{\text{URR, males 0 to 4,1970}}{.6220} = .751199\right)$ and the solution of 46.72 per cent urban is posted as the first figure of the second column in table 33b.

[90] The trend cannot be measured accurately because of possible changes in infant mortality and in the completeness of enumeration of small children (defective in most censuses).

[91] Another source of error difficult to evaluate is the inaccurate reporting of age at each census; the accuracy of age reporting may also vary from one census to another.

TABLE 34. BRAZIL'S URBAN POPULATION BY SEX AND AGE ACCORDING TO THE CENSUS OF 1970 AND ACCORDING TO TWO PROJECTIONS

Year of birth	Sex and age in 1970	Urban population, 1970 (thousands)			Error of projection (thousands)	
			Projected by		Projection by	
		Census	Age groups	Cohorts	Age groups	Cohorts
Both sexes		*52,098*	*53,282*	*51,616*	*+1,184*	*−482*
Males		*25,213*	*25,668*	*24,882*	*+455*	*−331*
1965–1970	0–4	3,449	3,785	3,280	+336	−169
1960–1965	5–9	3,489	3,642	3,036	+153	−453
1955–1960	10–14	3,130	3,115	3,162	−15	+32
1950–1955	15–19	2,668	2,441	2,728	−227	+60
1945–1950	20–24	2,273	2,316	2,330	+43	−43
1940–1945	25–29	1,795	1,860	1,783	+65	−12
1935–1940	30–34 [a]	1,650	1,728	1,739	+78	+89
1930–1935	35–39	1,470	1,514	1,479	+44	+9
1925–1930	40–44	1,297	1,256	1,302	−41	+5
1920–1925	45–49	1,098	1,033	1,105	−65	+7
1915–1920	50–54	858	868	867	+10	+9
1910–1915	55–59	668	692	676	+24	+8
1905–1910	60–64	500	510	511	+10	+11
1900–1905	65–69	372	383	379	+11	+7
Up to 1900	70 and over [b]	496	525	505	+29	+9
Females		*26,885*	*27,614*	*26,734*	*+729*	*−151*
1965–1970	0–4	3,388	3,808	3,269	+420	−119
1960–1965	5–9	3,437	3,681	3,065	+244	−372
1955–1960	10–14	3,227	3,271	3,347	+44	+120
1950–1955	15–19	3,081	2,910	3,048	−171	−33
1945–1950	20–24	2,586	2,566	2,683	−20	+97
1940–1945	25–29	2,010	2,072	2,019	+62	+9
1935–1940	30–34 [a]	1,826	1,915	1,851	+89	+25
1930–1935	35–39	1,564	1,638	1,612	+74	+48
1925–1930	40–44	1,360	1,335	1,387	−25	+27
1920–1925	45–49	1,143	1,098	1,160	−45	+17
1915–1920	50–54	923	925	926	+2	+3
1910–1915	55–59	732	748	735	+16	+3
1905–1910	60–64	551	554	557	+3	+6
1900–1905	65–69	417	418	423	+1	+6
Up to 1900	70 and over [b]	640	675	652	+35	+12

[a] Age groups from 30 to 34 upward obtained by halving the corresponding 10-year age groups by means of Newton's formula.

[b] Including persons of unknown age.

calculations would have to be made in the cohort-survival method. In the method now presented, the "migration-survival ratios" incorporate the combined consequences of mortality, net rural-to-urban migration and rural-to-urban reclassification of areas without considering their several effects separately.

324. As may be recalled from chapter IV, third section, constant rates of change in the rural population have a somewhat wider applicability than constant rates of change of urban population. There may be many situations in which such an assumption produces satisfactory results. What is true of the entire rural population is also valid for individual rural population cohorts. While advancing in age, each cohort tends to be depleted by the combined action of mortality and net transfers (migratory or by classification) to the urban category, and it is at least conceivable that the combined rates of depletion remain approximately the same in the course of time.

325. Table 35 presents the results of such an assumption with respect to the rural population of Brazil. From numbers in identical rural cohorts in 1950 and 1960, migration-survival ratios for the 1950-1960 period are obtained by division of numbers for 1960 by numbers for 1950. The migration-survival ratios are then moved up by ten years to apply to the same age-intervals again in the 1960-1970 period. Multiplication of numbers in each cohort in 1960 by the rearranged migration-survival ratios then yields a projection of the rural population by sex-age groups for 1970. Again, age groups 0 to 4 and 5 to 9 require a separate calculation, the numbers of births in the time interval being unknown. In the present instance, that calculation has been performed as follows.

326. Ratios were calculated between numbers of children aged 0 to 4 (males and females) and numbers of women aged 20 to 39, both in 1950 and in 1960; and, for the same dates, ratios of children aged 5 to 9 (males,

TABLE 35. PROJECTION OF BRAZIL'S RURAL POPULATION WITH THE MIGRATION-SURVIVAL METHOD

Sex and age			Rural population (thousands)		Migration-survival ratios		Projected rural population, 1970
Age in 1950	Age in 1960	Age in 1970	1950	1960	1950-1960	1960-1970	
Both sexes			*33,159*	*37,563*			*41,452*
Males			*16,912*	*19,389*			*21,526*
...	...	0–4	...	...	...	...	3,546 [a]
...	...	5–9	...	...	...	...	3,109 [a]
...	0–4	10–14	...	3,342	...	0.845	2,824
...	5–9	15–19	...	3,051	...	0.789	2,407
0–4	10–14	20–24	2,963	2,503	0.845	0.735	1,840
5–9	15–19	25–29	2,535	1,999	0.789	0.759	1,517
10–14	20–24	30–34	2,189	1,610	0.735	0.766	1,233
15–19	25–29	35–39	1,723	1,308	0.759	0.776	1,015
20–24	30–34	40–44	1,483	1,136	0.766	0.833	946
25–29	35–39	45–49	1,251	971	0.776	0.826	802
30–34	40–44	50–54	1,040	866	0.833	0.755	654
35–39	45–49	55–59	881	728	0.826	0.717	522
40–44	50–54	60–64	746	563	0.755	0.751	423
45–49	55–59	65–69	608	436	0.717	0.697	304
50–54	60–64	70+	466	335	0.751	0.438 [c]	384
55–59	65–69	...	350	244	0.697	...	...
60+ [b]	70+	...	678	297	0.438 [c]	...	...
Females			*16,247*	*18,174*			*19,926*
...	...	0–4	...	...			3,396 [a]
...	...	5–9	...	...	...	...	2,957 [a]
...	0–4	10–14	...	3,155	...	0.827	2,609
...	5–9	15–19	...	2,884	...	0.813	2,345
0–4	10–14	20–24	2,879	2,380	0.827	0.763	1,816
5–9	15–19	25–29	2,428	1,973	0.813	0.732	1,444
10–14	20–24	30–34	2,097	1,601	0.763	0.690	1,105
15–19	25–29	35–39	1,765	1,292	0.732	0.712	920
20–24	30–34	40–44	1,538	1,061	0.690	0.761	807
25–29	35–39	45–49	1,225	872	0.712	0.776	677
30–34	40–44	50–54	998	759	0.761	0.721	547
35–39	45–49	55–59	800	621	0.776	0.686	426
40–44	50–54	60–64	660	476	0.721	0.666	317
45–49	55–59	65–69	523	359	0.686	0.660	237
50–54	60–64	70+	401	267	0.666	0.436 [c]	323
55–59	65–69	...	300	198	0.660	...	...
60+ [b]	70+	...	633	276	0.436 [c]	...	...

[a] For method of calculation, see text.

[b] i.e. 60 to 64, 65 to 69, 70 and over and persons of unknown age. Ratio from combined ages 60 and over to ages 70 and over.

females) to numbers of women aged 25 to 44. The average of ratios for 1950 and 1960 rsepectively were then assumed to apply in 1970. Since numbers of women of ages when they might be mothers of young children have already been projected, corresponding numbers of children can be obtained by multiplying the projected numbers of women of the relevant age groups with these average ratios. [92]

327. If either a projection or census data of the total population by sex-age groups in 1970 exist, subtraction of projected numbers in the rural population produces a corresponding forecast for the sex-age composition of the urban population. In table 36, the projection for the rural population and the implied projection for the urban population are compared with the Brazilian census results of 1970. Reference to table 34 suggests that the results of the present projection (by migration-survival ratios in the rural population) are no worse than those obtained previously by the composite method using levels of urban residence ratios by fixed age groups; but they are perhaps less accurate than most of the results obtained previously by the composite method using urban residence ratios by cohort.

328. More in particular, the following errors appear to be involved. Rural fertility has been considerably underestimated for 1960-1965 and appreciably also for 1965-1970, and a change may also have occurred in the

[92] Alternative assumptions might have been made, implying either a rise or a fall in rural fertility between 1960 and 1970.

TABLE 36. BRAZIL'S TOTAL URBAN AND RURAL POPULATION BY SEX AND AGE IN 1970 ACCORDING TO CENSUS, AND RURAL POPULATION AS PROJECTED BY MEANS OF MIGRATION-SURVIVAL RATIOS

Sex and age	Population according to 1970 census (in thousands)			Projected population (in thousands)		Error in projected urban population
	Total	Urban	Rural	Urban [a]	Rural	
Both sexes	*93,205*	*52,098*	*41,107*	*51,753*	*41,452*	*+345*
Males	*46,331*	*25,213*	*21,118*	*24,805*	*21,526*	*+408*
0–4	7,020	3,449	3,571	3,474	3,546	−25
5–9	6,730	3,489	3,241	3,621	3,109	−132
10–14	5,850	3,130	2,720	3,026	2,824	+104
15–19	4,934	2,668	2,266	2,527	2,407	+141
20–24	4,063	2,273	1,790	2,223	1,840	+50
25–29	3,202	1,795	1,407	1,685	1,517	+110
30–34 [b]	2,857	1,650	1,207	1,624	1,233	+26
35–39	2,460	1,470	990	1,445	1,015	+25
40–44	2,209	1,297	912	1,263	946	+34
45–49	1,879	1,098	781	1,077	802	+21
50–54	1,510	858	652	856	654	+2
55–59	1,193	668	525	671	522	−3
60–64	894	500	394	471	423	+29
65–69	656	372	284	352	304	+20
70 and over [c]	874	496	378	490	384	+6
Females	*46,874*	*26,885*	*19,989*	*26,948*	*19,926*	*−63*
0–4	6,879	3,388	3,491	3,483	3,396	−95
5–9	6,571	3,437	3,134	3,614	2,957	−177
10–14	5,816	3,227	2,589	3,207	2,609	+20
15–19	5,270	3,081	2,189	2,925	2,345	+156
20–24	4,359	2,586	1,773	2,543	1,816	+43
25–29	3,344	2,010	1,334	1,900	1,444	+110
30–34 [b]	2,963	1,826	1,137	1,858	1,105	−32
35–39	2,502	1,564	938	1,582	920	−18
40–44	2,179	1,360	819	1,372	807	−12
45–49	1,828	1,143	685	1,151	677	−8
50–54	1,482	923	559	935	547	−12
55–59	1,170	732	438	744	426	−12
60–64	869	551	318	552	317	−1
65–69	649	417	232	412	237	+5
70 and over [c]	993	640	353	670	323	−30

[a] The "projected" urban population is obtained by subtracting the projected rural population from the total population enumerated at the census.

[b] Age groups from 30 to 34 upward obtained by halving the corresponding 10-year age groups by means of Newton's formula.

[c] Including persons of unknown age.

relative frequency (impossible to calculate) with which migrant mothers leave either their sons or their daughters under the care of rural relatives. Rural-to-urban migration of young persons has been underestimated, which seems in actual fact to have intensified during 1960-1970, especially at the ages 15 to 19 and 25 to 29.[93] At most ages past 30, male rural-to-urban migration has been underestimated slightly, and female rural-to-urban migration has been over-estimated slightly. The inferences are, however, debatable, partly owing to the influence of additional factors (e.g. area reclassification and urban-rural differences in mortality), and partly owing to possible errors in census enumeration and age reporting. Perhaps the original age data should have been subjected to some smoothing before being used in the calculation of migration-survival ratios.

[93] That the apparent underestimate in the intervening 20 to 24 age group of females was less is probably a somewhat complex consequence of variations in the accuracy of age statements from one census to another.

Chapter IX

COHORT-SURVIVAL METHOD

329. In this chapter, projections of urban and rural population are developed in such a way that 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 of the results of modification in any one of these factors are possible only if the projections are calculated on the basis of such detail. In short, the cohort-survival method is indispensable for such a purpose.

330. It is recognized, however, that without recourse to electronic computers the calculations cannot be carried to a high degree of precision. As has been explained in chapter II, more than one demographic event can occur to the same individual within any given time period, hence fertility, mortality and migration (also reclassification) are partly interdependent functions whose precise interaction, moment by moment of time, would have to be simulated in a computer model. In calculations with desk equipment, the interaction of the several factors must be artificially simplified. As will be shown, it is most convenient to begin with mortality, making use of the continuous life-table function. Next, it is advisable to measure and project the action of rural-to-urban population transfers as already affected by mortality intervening within the period of the calculation. Finally, it is practical to deal with an imperfect measurement of fertility, as ascertained for the end of each period after the intervening effects of mortality and population transfers. The rates of transfer and the rates of fertility, both as calculated for past periods and as projected, lack precision, but the consequences of such imperfect measurement upon the projection are only of small importance since the method of measurement, for the past as well as the future, remains the same.

33. Because of the space needed for exposition, a variety of possible results is illustrated in this chapter for one case only, namely Brazil. More cases might have been worked out, including countries with more detailed and accurate statistics, and others whose data are less detailed and less accurate, but the essential methods would have been nearly the same also in other examples. Such detailed projections of urban and rural population have been carried out in a number of countries with excellent statistics, but a full exposition of all data used and all procedures involved has rarely if ever been published. The reason is simple. Usually many experimental calculations are needed and many auxiliary estimates must be constructed, especially if the method is a fairly refined one. The complete description of all these operations would require an undue amount of space. But although a full description of methods can be space-consuming, it does not follow that the methods are mathematically complicated. With adaptations as needed, these methods can be used for the projection of urban and rural populations also in countries with less detailed or less accurate statistics, although actually this has been done very seldom.

332. In the case of Brazil, selected for this chapter, it is to be noted that there exist no comprehensive statistics on births and deaths. Such statistics would be valuable for a projection, particularly if births and deaths were registered separately in urban and rural areas and if those areas were not affected by reclassification. But even some of the most accurate vital statistics systems distinguish these vital events only by place of occurrence, rather than by place of usual residence. Because of the urban location of many hospitals, births and deaths to rural residents may often occur within an urban area, thus falsifying somewhat the statistics for purposes of a projection of the urban and rural resident population. Nor can there be any continuous series of birth and death statistics, except within constant administrative boundaries.

333. On the other hand, the case of Brazil has the advantage that censuses have been taken every ten years; that the definition of "urban" localities, while geographically flexible, has remained the same;[94] and that the accuracy of age reporting is at least tolerable. In countries where these conditions are not met, various adjustments to data and auxiliary estimates would first have to be made, requiring a lengthy description.[95]

334. In judging these projections, it should also be borne in mind that the case of Brazil may be fairly typical of Latin America, but not of other parts of the world. As noted in chapter II, in Latin America a majority of the rural-to-urban migrants are female, and many former

[94] In the Brazilian censuses, localities are defined as "urban" if they constitute urban and suburban zones of administrative centres of *municipios* or districts. The geographical boundaries of these "zones" are flexible and apparently undergo much expansion from one census to another.

[95] The estimation and adjustment of basic data for a population projection has been discussed in *Manual III: Methods for Population Projections by Sex and Age* (United Nations publication, Sales No. 56.XIII.3).

migrants reside in the cities indefinitely. In these respects, urbanization in Africa or Asia has quite different characteristics. Similar calculating methods may be used for projections in other countries, but the comparison of results would lead to quite different conclusions.

335. The present chapter is organized in three parts. In part A, it is shown how the detailed estimates and assumptions underlying the projections have been derived. Part B then describes the calculation procedures for one particular combination of assumptions, which will be referred to as the "standard projection". In part C, finally, the results of the "standard projection" are compared with those of eight "variant projections", each of which differs from the "standard" in one or another single respect. Many possible refinements of calculation have been omitted in order to facilitate a fairly simple exposition.

A. DERIVATION OF BASIC DATA AND ESTIMATES

Sex-age composition

336. In chapter VIII, the Brazilian census data on sex-age composition of the urban and rural population were accepted without adjustment. For the most part, the age statements are tolerably, but not highly, accurate. In one respect, however, it is necessary to introduce a modification for the present purpose. As in the censuses of many countries, the enumeration of small children, aged 0 to 4 years, has been rather incomplete in the Brazilian censuses. To avoid inconsistency with levels of fertility estimated for past periods and to be assumed in the projection and in the consequent trends of the child population, it was found necessary in this chapter to modify the numbers of children aged 0 to 4 years on the approximate assumption that only 95 per cent of such children were enumerated in urban areas, and only 90 per cent in rural areas. [96]

Mortality

337. In order to project urban and rural mortality, it is necessary as a minimum to have a recent estimation of the level of mortality in the total population as expressed in the expectation of life at birth. Methods have been described in a previous manual permitting the estimation of mortality level, given only some data on age composition and the rate of growth of the total population. [97] These methods are now applied to available data for Brazil for several past dates, and the estimated expectations of life in the total population will be presently shown. The methods described in the previous manual provide only approximate estimations. However, where mortality is rather low, even an inaccurate estimate of the more exact level will not cause any large error in the corresponding population projections. For this reason, it was considered sufficient to estimate mortality in Brazil only rather roughly. The urban and rural expectations of life through the 1965-1970 period shown below were derived by arbitrary estimation from the life expectations of the total population. The following considerations were observed:

(*a*) Rural expectation of life was assumed to be lower than the urban expectation. Advanced economic and social conditions are found, for instance, in Brazil's south, much of whose population is urban. In Brazil's north, much of whose population is rural, conditions are still comparatively backward. With the lack of pertinent detailed statistics, it is a matter of conjecture by how much urban expectation of life may exceed the rural, and it is at least conceivable that the difference may now be of the order of five years.

(*b*) For the purpose of the projection, it was assumed that both the rural and urban expectations of life would rise according to the United Nations sequence of model life tables. [98]

(*c*) The life expectancy of the total population was assumed to be the approximate average of the urban and rural rates.

Date	*Expectation of life at birth (years)*		
	Total population [a]	*Urban population*	*Rural population*
1950–1955	53.2	55.0	50.0
1955–1960	55.7	57.6	52.5
1960–1965	58.3	60.4	55.0
1965–1970	60.8	63.2	57.6
1970–1975		65.8	60.4
1975–1980		68.2	63.2
1980–1985		70.2	65.8
1985–1990		71.7	68.2
1990–1995		73.0	70.2
1995–2000		73.9	71.7

[a] Estimates according to *World Population Prospects as Assessed in 1968* (United Nations publication, Sales No. 72.XIII.4).

Rural-to-urban population transfers, by sex and age

338. In the calculation of rural-to-urban population transfers, which follows, the distinction between urban and rural mortality will be dropped for the sake of simplicity. True, a more refined calculation might be carried out in which urban and rural mortality levels are distinguished, but the presentation of such a detailed procedure would require much space. Furthermore, since age statements are not highly accurate, errors of calculation due to inaccurate age statement are likely to be larger than those due to the lack of distinction between urban and rural mortality. Finally, where mortality is fairly low, errors in calculated numbers of the population due to an inaccurate estimation of the mortality level, at the most, are quite slight (except perhaps in earliest childhood and at advanced ages).

[96] How this rough estimate was arrived at is explained further on, in paragraph 371, in connexion with estimation of fertility trends. The correction introduced here consists in multiplying numbers of urban children aged 0 to 4 by 100/95 or 1.0526, and of rural children by 100/90 or 1.1111. This correction has also been taken into account in the ensuing calculations of apparent survival ratios and rural-to-urban population transfers.

[97] *Manual IV: Methods of Estimating Basic Demographic Measures from Incomplete Data* (United Nations publication, Sales No. 67.XIII.2).

[98] Five-year survival ratios in the successive model tables are reproduced in annex II.

TABLE 37. APPARENT DECENNIAL SURVIVAL RATIOS IN TOTAL POPULATION AND HYPOTHETICAL SURVIVAL OF RURAL POPULATION, 1960–1970, AGES 10 AND OVER (AGES AS OF 1970)

Sex, and age as of 1970	Census data on total population (thousands)		Apparent intercensals survival ratio, 1960-1970	Rural population (thousands)	
	1960	1970		As of 1960 (census)	Hypothetical survivors in 1970 [a]
Males					
10–14	6,208 [b]	5,850	0.9423	3,713 [b]	3,499
15–19	5,159	4,934	0.9564	3,051	2,918
20–24	4,287	4,063	0.9477	2,503	2,372
25–29	3,446	3,202	0.9292	1,999	1,857
30–34	2,964	2,857	0.9639	1,610	1,552
35–39	2,522	2,460	0.9754	1,308	1,276
40–44	2,257	2,209	0.9787	1,136	1,112
45–39	1,953	1,897	0.9621	971	934
50–54	1,667	1,510	0.9058	866	784
55–59	1,385	1,193	0.8614	728	627
60–64	1,096	894	0.8157	563	459
65–69	855	656	0.7673	436	335
70 and over	1,707 [c]	874	0.5120	876 [c]	449
Females					
10–14	5,958 [b]	5,816	0.9762	3,506 [b]	3,423
15–19	5,002	5,270	1.0536 [d]	2,884	3,039
20–24	4,287	4,359	1.0168 [d]	2,380	2,420
25–29	3,697	3,344	0.9045	1,973	1,785
30–34	3,197	2,963	0.9268	1,601	1,484
35–39	2,687	2,502	0.9311	1,292	1,203
40–44	2,291	2,179	0.9511	1,061	1,009
45–49	1,919	1,828	0.9526	872	831
50–54	1,602	1,482	0.9251	759	702
55–59	1,305	1,170	0.8966	621	557
60–64	1,033	869	0.8412	476	400
65–69	802	649	0.8092	359	291
70 and over	1,717 [c]	993	0.5783	741 [c]	429

[a] Obtained by multiplying each sex-age group (according to the 1960 census) with the corresponding apparent survival ratio obtained from the intercensal comparison of the total population.

[b] i.e. aged 0 to 4 in 1960. Figure corrected for assumed incomplete census enumeration of small children.

[c] i.e. sum of those aged 60 to 64, 65 to 69 and 70 and over in 1960.

[d] A "survival ratio" greater than unity is in theory impossible, but age misstatements can produce an "apparent" ratio greater than unity (see text). For the same reason, calculated "survival ratios" at ages 25 to 29 and 30 to 34 are probably too low.

339. Two assumptions are made in the following calculation of rural-to-urban population transfers: namely, that the effects of age misstatement are the same in the rural and urban populations; and that for practical purposes mortality conditions, and hence the survival ratios, were also the same in the rural and urban populations. Both assumptions are admittedly inaccurate, but since the calculations can at best only be approximate, the resulting errors are probably not of much importance.[99] Furthermore, a smoothing procedure will be applied at the end of the calculation which, it can be presumed, eliminates at least some of the errors resulting in the calculation. Some international migration also occurred during recent decades, which is disregarded here, the balance having been small as compared with the size of Brazil's population.

340. The first few steps of the calculation are illustrated in table 37. In the first column, data of the 1960 census concerning the total population are arranged according to ages 10 years and higher, i.e. ages which those population groups, if surviving, were to attain by 1970. As can be expected, with two exceptions, smaller numbers were actually enumerated in 1970 because at least some persons in each age group had died in the time interval. The exceptions are females aged 15 to 19 and 20 to 24 in 1970 (or 5 to 9 and 10 to 14 in 1960), either because too few were enumerated in 1960, around the ages of 10 years, or too many in 1970 around the ages of 20 years; the latter is more likely to have been the case, as there is reason to believe that some young women prefer to report an age between 15 and 25 years rather than an age below 15 or above 25, with the consequence that women

[99] Age reporting is probably more accurate in the urban than in the rural population. Mortality is probably higher in the rural than in the urban population. The effects of resulting errors in the calculation are complex and cannot be easily assessed.

TABLE 38. HYPOTHETICAL SURVIVORS OF RURAL POPULATION IN 1970, RURAL POPULATION ENUMERATED IN 1970 AND APPARENT NET RURAL-TO-URBAN POPULATION TRANSFERS OF 1960-1970 (NUMBERS AND PERCENTAGES OF CALCULATED RURAL SURVIVORS)

Sex, and age as of 1970	Rural population, 1970 (thousands)		Apparent net transfers, 1960-1970		
	Hypothetical survivors	Actually enumerated	Numbers (in thousands)	Transfer rate (i.e. per cent of hypothetical rural survivors)	Rate of non-transfer (i.e. 100 minus transfer rate)
Males					
10–14	3,499	2,720	779	22.3	77.7
15–19	2,918	2,266	652	22.3	77.7
20–24	2,372	1,790	582	24.5	75.5
25–29	1,857	1,407	450	24.2	75.8
30–34	1,552	1,207	345	22.2	77.8
35–39	1,276	990	286	22.4	77.6
40–44	1,112	912	200	18.0	82.0
45–49	934	791	143	15.3	84.7
50–54	784	652	132	16.8	83.2
55–59	627	525	102	16.3	83.7
60–64	459	394	65	14.2	85.8
65–69	335	284	51	15.2	84.8
70 and over	449	378	71	15.8	84.2
Females					
10–14	3,423	2,589	834	24.4	75.6
15–19	3,039	2,189	850	28.0	72.0
20–24	2,420	1,773	647	26.7	73.3
25–29	1,785	1,334	451	25.3	74.7
30–34	1,484	1,137	347	23.4	76.6
35–39	1,203	938	265	22.0	78.0
40–44	1,009	819	190	18.8	81.2
45–49	831	685	146	17.6	82.4
50–54	702	559	143	20.4	79.6
55–59	557	438	119	21.4	78.6
60–64	400	318	82	20.5	79.5
65–69	291	232	59	20.3	79.7
70 and over	429	353	76	17.7	82.3

were over-reported within those particular age groups and under-reported in adjacent groups (10 to 14, or 25 to 29). No exact determination can be made, but if it can be assumed that age misstatements in urban and rural areas had a similar tendency, part of the error of calculation is cancelled out in the subsequent procedures (see further on).

341. Continuing with the calculation illustrated in table 37, we obtain in the third column the "apparent" intercensal survival ratios as a result of dividing the numbers in each sex-age group obtained at the 1970 census by the numbers aged ten years less at the 1960 census (who, if surviving, would by 1970 have attained the same ages). If international migration had been negligible and age reporting at each census had been accurate, the sequence of survival ratios would permit a detailed calculation of mortality conditions and the construction of a life table. Actually, because of inaccuracies in the data, this is not quite the case. The "apparent" survival ratios are partly false, but it will be assumed that the distortions are proportionately the same in the total as well as in the rural population. On this rough assumption, we can now apply those "apparent" survival ratios to the rural population enumerated in 1960 to result in hypothetical numbers of survivors of that rural population by 1970, as is done in the last two columns of table 37.

342. The last column of table 37 is re-entered as the first column of table 37, where the calculation continues. Of course, fewer individuals than those which survived are to be expected as still residing in rural areas by 1970, owing to the intervening rural-to-urban transfers of population, whether as a consequence of migration or area reclassification. In fact, as can be seen from a comparison of the first two columns in table 38, fewer rural inhabitants were enumerated at all ages in rural areas at the 1970 census, and the difference between hypothetical rural survivors and actually enumerated rural population can be attributed to population transfers, provided the net errors of calculation are not too severe.

343. The net transfers which appear in the third column of table 38 do not include persons who may have been involved in transfers during 1960-1970 but have died before 1970. More accurately speaking, those are net transfers during the period of those persons only who also survived. This manner of calculation is necessary for the eventual purposes of the projection where also

TABLE 39. INTERPOLATION OF DECENNIAL RURAL-TO-URBAN TRANSFER RATES, 1960-1970, FOR FIVE-YEAR PERIODS

Sex, and age at the end of each period	Decennial rate of non-transfer (per 100 of rural population)	Log. of same (add. 2)	Interpolation of log.	Same, smoothed [a]	Quinquennial rate	
					Non-transfer	Transfer
Males						
5–9	...	...	.9452	.9452 [b]	88.1	11.9
10–14	77.7	1.8904	.9452	.9452	88.1	11.9
15–19	77.7	1.8904	.9452	.9421	87.5	12.5
20–24	75.5	1.8779	.9327	.9394	87.0	13.0
25–29	75.8	1.8797	.9470	.9427	87.6	12.4
30–34	77.8	1.8910	.9440	.9452	88.1	11.9
35–39	77.6	1.8899	.9459	.9509	89.3	10.7
40–44	82.0	1.9138	.9679	.9604	91.3	8.7
45–49	84.7	1.9279	.9600	.9620	91.6	8.4
50–54	83.2	1.9201	.9601	.9607	91.4	8.6
55–59	83.7	1.9227	.9626	.9640	92.0	8.0
60–64	85.8	1.9335	.9709	.9655	92.4	7.6
65–69	84.8	1.9284	.9575	.9634	91.9	8.1
70 and over	84.2	1.9253	.9678	.9634 [c]	91.9	8.1
Females						
5–9	...	...	.9392	.9392 [b]	86.9	13.1
10–14	75.6	1.8785	.9393	.9340	85.9	14.1
15–19	72.0	1.8573	.9180	.9306	85.2	14.8
20–24	73.3	1.8651	.9471	.9346	86.0	14.0
25–29	74.7	1.8733	.9262	.9394	87.0	13.0
30–34	76.6	1.8842	.9580	.9441	87.9	12.1
35–39	78.0	1.8921	.9341	.9504	89.2	10.8
40–44	81.2	1.9096	.9755	.9564	90.4	9.6
45–49	82.4	1.9159	.9405	9542	90.0	10.0
50–54	79.6	1.9009	.9604	.9491	88.9	11.1
55–59	78.6	1.8954	.9350	.9490	88.9	11.1
60–64	79.5	1.9004	.9654	.9505	89.2	10.8
65–69	79.7	1.9015	.9361	.9467	88.4	11.6
70 and over	82.3	1.9154	.9793	.9467 [c]	88.4	11.6

[a] Smoothed by formula $^1/_4(a_{-1} + 2a_0 + a_{+1})$, where a_0 is the unsmoothed number in the given age group, and a_{-1} and a_{+1} are the unsmoothed numbers in the preceding and subsequent age groups.

[b] Assumed same as unsmoothed number.

[c] Assumed same as smoothed number at ages 65 to 69.

first the effects of mortality are calculated, and then the effects of transfer (migration and reclassification) among those who survive (see section B of this chapter).

344. The transfer rates shown in the fourth column of table 38 are calculated as percentages relative to calculated numbers of hypothetical survivors; those are the proportionate deductions which will have to be made in a projection of the rural population according to survival rates. When these rates are subtracted from 100 per cent, complementary rates, or rates of non-transfer, are obtained, which appear in the last column of table 38.

345. These rates, it will be recalled, have been obtained for the decennial time interval between the censuses of 1960 and 1970. Projections, on the other hand, are usually calculated by five-year time periods. The operations necessary to transform rates for ten-year periods into rates for five-year periods are illustrated in table 39. Logarithms are used here for convenience, although this is not strictly necessary. The calculation begins with the decennial rates of non-transfer, as obtained in table 38. In the second column of table 39, these rates are converted into logarithms to which the amount of 2 is added for convenience of calculation.

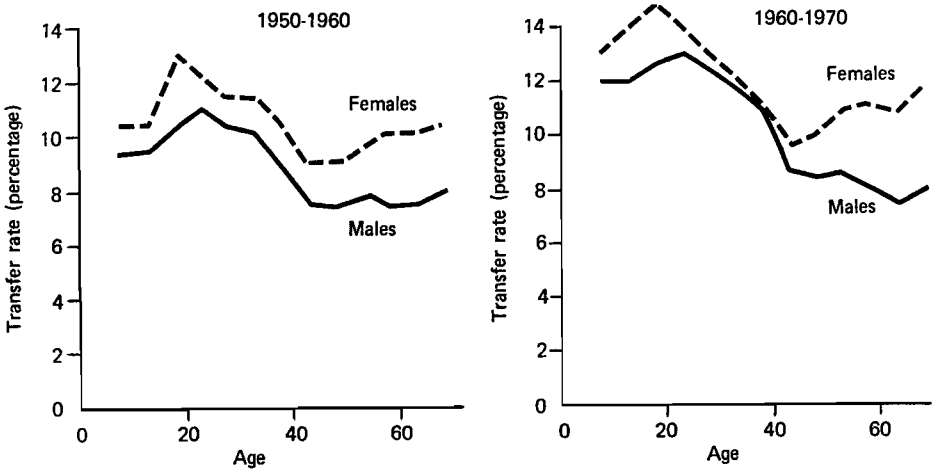
346. It will be recalled that the decennial survival ratios were for persons passing through two successive five-year age groups. Thus, persons aged 0 to 4 years in 1960 were affected by certain quinquennial rates (still to be determined) to bring them to ages 5 to 9 years in 1965, and then by certain other quinquennial rates to bring them to ages 10 to 14 years in 1970. Thus, the decennial non-transfer rate for those aged initially 0 to 4 and finally 10 to 14 are the product of a quinquennial rate for persons passing from ages 0 to 4 to 5 to 9, and another quinquennial rate for persons passing from ages 5 to 9 to 10 to 14; and similarly for all other age groups. In addition, it is to be noted that the next decennial rate, bringing individuals from ages 5 to 9 to eventual ages 15 to 19, is the product of quinquennial rates for persons passing from 5 to 9 to 10 to 14 and rates for persons passing from 10 to 14 to 15 to 19. Consequently, among adjacent age cohorts, decennial rates each time contain one common multiplier, in this instance the

TABLE 40. COMPARISON OF QUINQUENNIAL TRANSFER RATES CALCULATED FROM DATA FOR THE 1960–1970 PERIOD WITH THOSE SIMILARLY CALCULATED FOR THE 1950-1960 PERIOD (RATES PER 100 OF THE RURAL POPULATION)

Age at end of each period	*Quinquennial transfer rates calculated from 1950-1960 data*		*Quinquennial transfer rates calculated from 1960-1970 data*	
	Males	*Females*	*Males*	*Females*
5–9	9.3	11.4	11.9	13.1
10–14	9.5	11.6	11.9	14.1
15–19	10.5	13.1	12.5	14.8
20–24	11.1	12.5	13.0	14.0
25–29	10.4	11.6	12.4	13.0
30–34	10.1	11.5	11.9	12.1
35–39	9.0	10.6	10.7	10.8
40–44	7.5	8.9	8.7	9.6
45–49	7.5	8.9	8.4	10.0
50–54	7.9	9.7	8.6	11.1
55–59	7.6	10.1	8.0	11.1
60–64	7.4	10.2	7.6	10.8
65–69	8.0	10.3	8.1	11.6
70 and over	8.0	10.3	8.1	11.6

FIGURE III

Comparison of quinquennial transfer rates by sex and age as calculated from data for 1950-1960 and 1960-1970 (ages at the end of a five-year period)



quinquennial rate for persons passing from 5 to 9 to 10 to 14.[100]

347. Since in the logarithmic scale the successive multiplications are represented by successive additions, the interpolation can be performed very easily, as will be seen in the comparison between the second and third columns of table 39. Somewhat arbitrarily, the first quinquennial rate (for persons passing from 0 to 4 to 5 to 9) is taken as the square root (i.e. one-half of the logarithm) of the corresponding decennial rate. The first quinquennial rate in the third column is then subtracted from the 10 to 14 age group figure in the second column to obtain the second quinquennial rate in the third column, and so on. Thus, one-half of 1.8904 equals 0.9452 for males aged 5 to 9. Successive subtractions then yield a sequence of logarithms for quinquennial rates, admittedly seesawing to some extent partly as a result of errors of calculation due to inaccurate age statements.[101] The zigzags are eliminated after the smoothing procedure which is carried out in the next column according to a simple formula (see table footnote *a*). The resulting logarithms are then converted into the corresponding quinquennial non-transfer rates, and these, after subtraction from 100 per cent, yield the quinquennial transfer rates appearing in the last column of table 39.

[100] Among the adjacent age groups, however, survival from 5 to 9 to 10 to 14 occurs in different time periods. To simplify, it is here assumed that mortality in both periods was the same. The error of calculation due to this simplification is trivial.

[101] If the rates themselves had been used in the calculation instead of their logarithms, successive divisions would have had to be made instead of successive subtractions.

348. The foregoing calculation is for the intercensal period of 1960-1970. To gain some judgement regarding the possible validity of the results, the same calculation has also been carried out for the 1950-1960 period. The details of calculation are not shown here to save space, but the procedure has been the same. A comparison of the results of calculations for both periods appears in table 40 and in figure. III. The following observations can be made.

349. In both periods, female transfer rates at all ages exceeded the male transfer rates, female rates reaching a peak in the group passing from ages 10 to 14 to ages 15 to 19, whereas the male peak occurs in the group passing from ages 15 to 19 to ages 20 to 24. Both males and females reach minimal transfer rates about the age of 40 years, but the rates of females rise again with advancing age.[102] For both sexes and all age groups the rates were higher in 1960-1970 than in 1950-1960. Some change of detailed pattern also seems to have occurred. For instance, in the more recent period the transfer rates for males aged between 30 and 40 years almost attained the levels for females at the same ages. Nevertheless, in view of the general consistency of the results obtained for both periods, the calculated transfer rates appear to be adequate for use in a projection.

The separate effects of rural-to-urban area reclassification and migration

350. The foregoing calculations comprise net transfers of population from rural to urban areas which can occur for two distinct reasons: the reclassification as urban of areas previously designated as rural; and the physical migration from areas designated at the time as rural to areas designated at the time as urban. Some interaction between the two phenomena exists, since presumably the reclassified areas also have experienced much recent immigration. For the purpose of the projections it is important to consider these two processes separately, for only then can variations be introduced in the assumptions with respect to reclassification, migration or both. The contribution made by net migration as such to urban and rural population change is also a subject of separate interest.[103]

351. The Brazilian census data provide no direct clue for the distinction of transfers caused by reclassification from those caused by migration. Rough estimates can nevertheless be attempted if there is sufficient ground for two assumptions, both of them somewhat plausible. First, since much of the net migration is caused by the search for employment, affecting especially adolescents and young adults, it can be assumed that past a certain age, when most persons are rather committed to their existing livelihood and residence, net migration becomes slight if not negligible; since it was observed that the net transfer rates reach a minimum about the age of 40, one may assume, very roughly, that rural-to-urban transfers past the age of 40 years are mostly the consequence of area reclassification. Secondly, as regards the reclassified areas themselves, it may perhaps be reasonable to assume, in the case of Brazil, that the sex-age composition of their population resembles that of the population which has already been urban during the same time.[104] This is a very hazardous assumption whose possible validity must first be tested. The following analysis does not prove the correctness of such an assumption, but it shows that it may be at least tenable.

352. As shown in table 40 and figure III, when calculated relatively to the rural population, transfer rates of ageing females rise until they exceed considerably those of ageing males. The matter becomes quite different, however, when the transfer rates are calculated relatively to the urban population, in which case they might be termed "rates of accretion", in view of the fact that the transferred population is added to that of urban areas.

353. The calculation of these urban accretion rates, based on the quinquennial rural transfer rates arrived at in table 40, is shown in the first three columns of table 41. It is assumed that quinquennial transfer rates on the basis of 1960-1970 data are also applicable to the 1965-1970 period. Multiplying these rates with the rural population of 1970 in each age group, we obtain estimated amounts of transfer during that quinquennium. Dividing these amounts by the urban population of 1970 in each age group, we obtain the corresponding urban accretion rates. To save space, the detailed steps of the calculation for 1955-1960 are not presented, but the resulting urban accretion rates of 1955-1960 are shown in the last column for comparison with those of 1965-1970. The results for both periods are also shown in figure IV on page 90.

354. Though rural transfer rates rose from 1950-1960 to 1960-1970 (figure III), urban accretion rates fell because of the faster growth of urban population as compared with the rural. The pattern of urban accretion rates remained similar in these respects: female accretion rates exceeded the male only at early ages, whereas between the ages of 20 and 40 years male rates exceeded the female (slightly in 1955-1960, and more considerably

[102] In this connexion, it should be noted that the calculation implies equal mortality levels in urban and rural areas. It is possible, however, that urban females of mature and advanced ages had significantly lower mortality than the corresponding rural females, and that this circumstance may have affected the results of the calculation. However, as shown further on, another explanation can be found for this observation, which may be of greater significance.

[103] Only the balance, or net migration, is considered here, which in turn results from the difference between in-movements and out-movements. Very detailed statistics, found in rather few countries, would be needed to assess the composition and trend of movements in either direction separately. The question may be of some importance in countries where suburban population continues to be classified as "rural", as there may be at certain ages a net movement from cities to the suburbs; and also in African and Asian countries, where a good deal of urbanization is caused by the influx of short-term residents who, after some period of time, generally return again to their rural places of origin. In the case of Brazil, as already noted, the boundaries of "urban" areas are flexible and can include expanding zones having, as defined, a "suburban" character. Hence the large importance of area reclassification in the case of Brazil.

[104] Depending on the type of flexibility of the definition of urban areas, quite different assumptions may have to be made in other countries. As discussed in chapter II, sex-age compositions of localities in Japan vary systematically with the size of the localities; and in the United States, the structures of suburban populations differ greatly from the populations of cities within their administrative boundaries.

TABLE 41. CALCULATION OF QUINQUENNIAL URBAN ACCRETION RATES FOR 1965–1970, AND COMPARISON WITH SIMILARLY CALCULATED RATES FOR 1955-1960

Sex and age at end of each period	*Rural net transfer rate, 1960-1970* [a]	*Rural population 1970 (thousands)*	*Estimated amount of transfer, 1965-1970 (thousands)*	*Urban population 1970 (thousands)*	*Urban accretion rate (percentage)*	
					1965-1970	*1955-1960* [b]
Males						
5–9	11.9	3,241	386	3,489	11.1	13.5
10–14	11.9	2,720	324	3,130	10.4	13.3
15–19	12.5	2,266	283	2,668	10.6	14.5
20–24	13.0	1,790	233	2,273	10.3	13.2
25–29	12.4	1,407	174	1,759	9.9	11.2
30–34	11.9	1,207	144	1,650	8.7	10.3
35–39	10.7	990	106	1,470	7.2	8.9
40–44	8.7	912	79	1,297	6.1	8.1
45–49	8.4	791	66	1,098	6.0	8.4
50–54	8.6	652	56	858	6.5	8.3
55–59	8.0	525	42	668	6.3	7.9
60–64	7.6	394	30	500	6.0	8.0
65–69	8.1	284	23	372	6.2	8.6
70 and over	8.1	378	31	496	6.3	8.4
Total, 40 and over			327	5,289	6.2	8.2
Females						
5–9	13.1	3,134	411	3,437	12.0	15.5
10–14	14.1	2,589	365	3,227	11.3	14.5
15–19	14.8	2,189	324	3,081	10.5	15.0
20–23	14.0	1,773	248	2,586	9.6	12.5
25–29	13.0	1,334	173	2,010	8.6	10.8
30–34	12.1	1,137	138	1,826	7.6	9.9
35–39	10.8	938	101	1,564	6.5	8.8
40–44	9.6	819	79	1,360	5.8	8.1
45–49	10.0	685	68	1,143	5.9	8.0
50–54	11.1	559	62	923	6.7	8.3
55–59	11.1	438	49	732	6.7	8.1
60–64	10.8	318	34	551	6.2	8.0
65–69	11.6	232	27	417	6.5	7.7
70 and over	11.6	353	41	640	6.4	7.4
Total, 40 and over			360	5,766	6.2	8.0
Both sexes						
Sum, 40 and over			687	11,055	6.2	8.1

[a] Taken from table 40, per 100 of the rural population.

[b] Calculated by the same procedure as the rates for 1965-1970.

in 1965-1970). Past the age of 40 years, the rates for either sex fluctuated about the same values, without any trend, namely about 8.1 per cent in 1955-1960, and about 6.2 per cent in 1965-1970. The fluctuations past the age of 40 years may be due as much, if not more, to the effects of inaccurate age statements upon the calculation (with advancing age the accuracy of age reporting deteriorates), as they may have been due to any significant difference between the sex-age composition of the urban population and that of the population which became reclassified as urban. The two assumptions which have been made—namely that past the age of 40 years migratory balances may be negligible, and that the reclassified population may resemble that which is already urban—though not proven, are significantly strengthened. While admittedly debatable, these assumptions will now be used to distinguish the two types of population transfer, that due to reclassification and that due to migration.

355. As assumed, past the age of 40 all transfers are now ascribed to reclassification, hence net migration rates of significance can be calculated only up to the age of 40 years. The assumption now takes the form that urban accretion rates due to reclassification are the same at all ages, below 40 and above 40 years; namely, as calculated in table 41, 6.2 per cent in the 1965-1970 period, and 8.1 per cent in the 1955-1960 period. Since the population at risk of net migration is the rural one, migration rates need to be calculated relative to the rural population. The calculation pertains only to ages below 40 years and is shown in table 42. First, from the size of sex-age groups in the urban population and the

FIGURE IV

Comparison of quinquennial urban accretion rates by sex and age as calculated for the periods 1950-1960 and 1960-1970 (ages at the end of each five-year period) and assumed applicable in 1955-1960 and 1965-1970

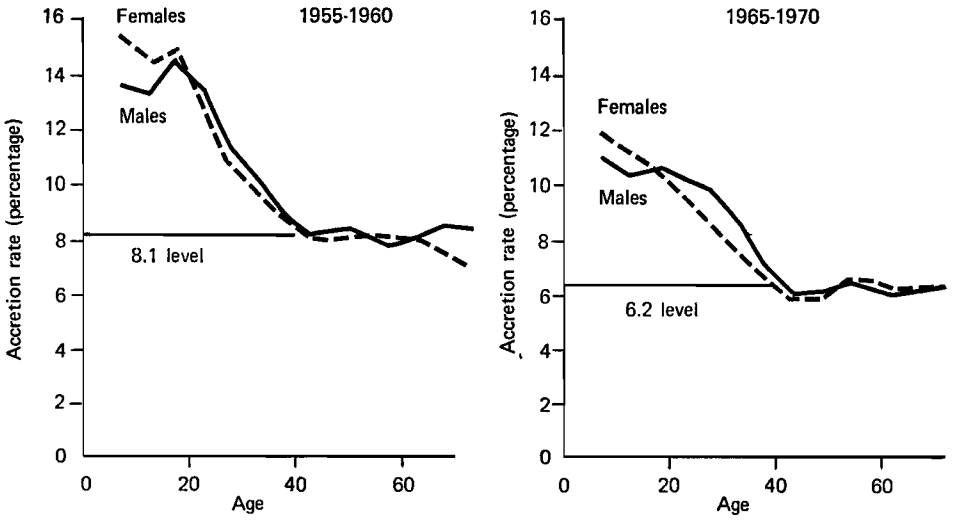


TABLE 42. CALCULATION OF QUINQUENNIAL NET RURAL-TO-URBAN MIGRATION RATES, 1965-1970, AND COMPARISON WITH SIMILARLY CALCULATED RATES FOR 1955-1960

Sex, and age at end of each period	*Urban population, 1970*	*Amount of reclassified population, 1965-1970* [a]	*Amount of transferred population, 1965-1970* [b]	*Amount of net migration, 1965-1970*	*Rural population, 1970*	*Net migration rate (per 100 of the rural population)*	
						1965-1970	*1955-1960* [c]
Males							
5-9	3,489	216	386	170	3,241	5.2	3.7
10-14	3,130	194	324	130	2,720	4.8	3.7
15-19	2,668	165	283	118	2,266	5.2	4.7
20-24	2,273	141	233	92	1,790	5.1	4.3
25-29	1,759	109	174	65	1,407	4.6	2.9
30-34	1,650	102	144	42	1,207	3.5	1.5
35-39	1,470	91	106	15	990	1.5	0.7
Females							
5-9	3,437	213	411	198	3,134	6.3	5.4
10-14	3,227	200	365	165	2,589	6.4	5.1
15-19	3,081	191	324	133	2,189	6.1	6.0
20-24	2,586	160	248	88	1,773	5.0	4.4
25-29	2,010	125	173	48	1,334	3.6	2.9
30-34	1,826	113	138	25	1,137	2.2	2.1
35-39	1,564	97	101	4	928	0.4	0.8

[a] Assuming an urban accretion of 6.2 per cent due to reclassification (for 1955-1960, the urban accretion due to reclassification is estimated as 8.1 per cent).

[b] Taken from table 40.

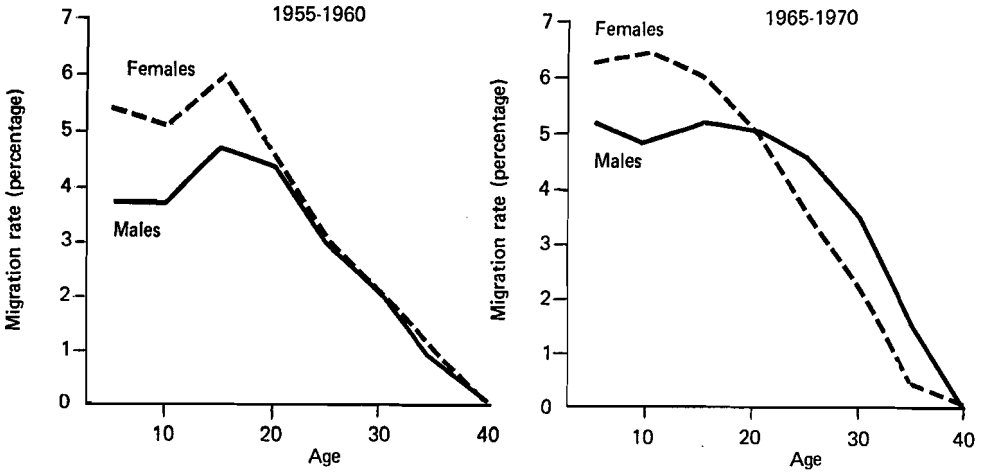
[c] Calculated by the same procedure as the rates for the 1965-1970 period.

reclassification accretion rate ascertained for ages above 40, the amount of population reclassified in a five-year period is calculated for ages below 40 years. When this amount, in each sex-age group, is subtracted from estimated amounts of transfer, the estimated amount of net migration is obtained. And when this is related to the size of the rural population, in each sex-age group, net migration rates are ascertained. The calculation is illustrated for the 1965-1970 period, and for the sake of comparison results of the same procedure for the 1955-1960 period are presented in the last column. The calculated migration rates are plotted also in figure V.

356. First it will be noted that the reclassification rates are surprisingly high and the migration rates surprisingly low in comparison with the combined transfer rates. The explanation of this circumstance consists in the likelihood that much migration occurs in the direction of areas which are about to be or have recently been reclassified in the period of observation. This must be so, not only owing to the present assumption that the sex-age structure in reclassified areas is apt to resemble that in areas already urban; but also because much migration occurs to precisely those areas—surroundings of growing big cities and new emerging towns—which have the

FIGURE V

Comparison of quinquennial rural-to-urban migration rates by sex and age as assumed applicable in the periods 1955-1960 and 1965-1970 (ages at the end of each five-year period)



greatest likelihood of becoming reclassified. In fact, there may even be a significant outward migration from established urban centres to the areas in process of reclassification. If, in a special projection, an arbitrary assumption is to be made that no additional areas will be reclassified in the future, a large part of the urbanization process will be missed owing to considerable migration to new areas of an urban type which, on such an assumption, would remain classified as rural.

357. Of course, the foregoing calculation can contain large errors. Whereas at advanced ages the population structure of reclassified areas may indeed resemble that of areas already urban, it is far from certain whether this is also the case at early ages. Fertility rates, for instance, may differ between established urban areas and areas in process of reclassification, and conceivably they may be higher in the latter areas (which are not yet so congested, perhaps). In such a case, the reclassification may comprise a larger number of children than have here been calculated, with the consequence that the presently estimated migration rates for children are somewhat too large. However, in the absence of pertinent detailed information no further tests can be made. It would be difficult to improve upon the present calculation with the limited information at hand.

Fertility

358. It will be noted that in the foregoing, mortality was considered first, and rural-to-urban transfers were calculated thereafter in relation to age groups at the end of each period, so that transferred persons who had died in the period were no longer included. The difficulty of estimates of deaths occurring to the transferred population itself (whether reclassified or migrants) is thereby obviated. For similar reasons, the calculation of fertility is postponed to the end to avoid the complexity of separate calculation of the fertility of migrants or fertility of the population in reclassified areas (each of which may differ from both the urban and rural fertility, to an extent difficult to ascertain).[105] The same order of calculations—mortality first, migration and reclassification second, and fertility last—will also be maintained in the population projections.

359. Any calculation of fertility generally relates the number of children born in a period (boys and girls) to numbers of women of reproductive ages during the period of time when those births occurred. The calculation is usually detailed by age-specific fertility rates of women in each of the age groups from 15 to 19 to 45 to 49. One prerequisite is to estimate the mean number of women in each age group during the period under consideration, defined here as the arithmetic average between numbers of such women at the beginning and numbers at the end of the period.[106] The numbers at the end of each period, of course, are already reduced by intervening rates of infant and childhood mortality, and augmented (in the urban population) or reduced (in the rural population) by intervening rates of population transfer. The fertility estimate for the rural population then excludes, and that for the urban population includes, that of women in process of transfer from rural to urban areas. Separate calculation of the fertility of migrant or reclassified urban women is therefore unnecessary. One of the questions often mentioned in the projection of urban population is an insufficiency of knowledge concerning the fertility of migrants. In our present calculations, however, the fertility of the urban population includes at any time, past or future, the fertility of previous rural-to-urban migrants so that

[105] There is a further separate effect, also disregarded here, of migrant mothers leaving some of their children under the care of their rural relatives.

[106] It is a simplification to use the arithmetic mean, since it is not believed that population growth in each period occurs at an arithmetic rate. The survival ratios from birth to ages 0 to 4 during five-year periods, taken from model life tables, likewise refer to an annual arithmetic average of children born. It can therefore be considered that the "errors" in calculating from arithmetic means (of number of women and of births) are mostly cancelled out in the calculated fertility rates.

at each projection date the urban fertility likewise includes that of recent in-migrants.[107]

360. An important consideration to take into account, however, pertains to the accuracy with which children aged 0 to 4 years may have been enumerated. In the censuses of most countries a more or less significant proportion of small children tend to be omitted, and there is reason to suspect that the enumeration of small children was also deficient in the censuses of Brazil.[108] This consideration makes it advisable to estimate fertility levels and trends over periods longer than the five years preceding the census.

361. The relationship between women's age-specific fertility rates and the gross reproduction rate (GRR for short) also needs to be elucidated. Given a set of age-specific fertility rates covering the reproductive age span of women, one can calculate the average number of births a woman may ultimately undergo as she passes through all these consecutive age groups. To ascertain the rate at which female generations replace each other, the GRR is expressed in terms of the number of girls born.[109] In most countries with good statistics, about 105 boys are born per 100 girls born, hence the GRR is the sum of age-specific fertility rates multiplied by $\frac{100}{205}$ or, approximately, 0.4878. For the purposes of a projection, it is a frequent practice to calculate the past and conjecture the future trend of fertility in terms of GRR. The detailed calculation can therefore be confined to the ascertainment of the number of girls born; the number of boys born may then be obtained by multiplying the combined number of girls by 1.05.[110]

362. The projection in terms of the GRR is simplified if, instead of explicit age-specific fertility rates, a set of comparative rates only are considered, i.e. the so-called "age pattern of fertility", or the percentage contributions made by each age-specific rate to their sum, which is the GRR (after multiplication by 0.4878). By applying these percentages to numbers of women in the corresponding age groups, a "weighted sum" of women of reproductive age is obtained; this "weighted sum" of women can then be multiplied directly by the GRR to calculate the corresponding number of girls born, and then by 1.05 to obtain corresponding numbers of boys born. One assumption of the projection, then, consists of the "age pattern of fertility", conveniently expressed in percentage terms.

363. Depending on the fertility age pattern, the same number of births can result from different gross reproduction rates. Usually, women of earlier reproductive ages are more numerous than those of later reproductive ages. If the fertility age pattern gives much weight to the younger groups of reproductive women, therefore, a lower GRR suffices to produce the same number of births as would result if the age pattern gave more weight to older age groups of reproductive women, and if these were somewhat less numerous. If it is important to measure the reproductivity of women as such, then much accuracy is also needed in the estimation of the fertility age pattern.

364. In a population projection, however, the levels and trends in numbers of births only are required, whatever the detailed age pattern of fertility or the precise level of GRR might be. An inaccurately estimated fertility age pattern, then, does not introduce any appreciable errors in the corresponding projection of the child population. Both the level of GRR in past periods and that projected to future periods may (with an inaccurate age pattern) be either over-estimated or underestimated, but the error of estimation is largely cancelled out in terms of the projected numbers of births.

365. The age pattern of fertility may differ significantly between urban and rural areas, and each of the two patterns may change with time in different ways. If there are sufficient statistical data, it is desirable to estimate both fertility age patterns with some degree of accuracy, perhaps also to make separate assumptions of future changes in both the urban and rural patterns. If he has access to the requisite statistics, the user of this manual may refine the calculations as he sees fit. But since the present example is largely confined to an illustration of basic methods, while statistical data for Brazil are not so refined, and simplicity is preferable, only one uniform fertility age pattern will be assumed for both urban and rural areas, and it will be kept constant also in future periods. This age pattern was arrived at partly through analogy with other countries where conditions might have been similar, in a population projection for Brazil recently calculated by the United Nations.[111] It is represented by the figures below, but no claim is made that these figures reflect the actual Brazilian fertility pattern with any degree of accuracy.

Age of women (years)	*Percentage contribution to GRR*
15–19	7
20–24	23
25–29	25
30–34	21
35–39	14
40–44	8
45–49	2
TOTAL	100

366. To estimate fertility in past periods in the absence of suitable birth registration statistics, the procedure of population projection must now be reversed. Numbers

[107] If migration should intensify or diminish considerably and the fertility of migrants differs noticeably from that of non-migrants, the average level of urban fertility (migrants and non-migrants) may thereby be affected.

[108] As already mentioned, for the purpose of the projection the numbers of children aged 0 to 4 years had to be modified, taking into account an estimate of the probable degree of completeness of their enumeration.

[109] The net reproduction rate, or NRR, equals the GRR multiplied by the probability of survival to the mean age of reproductivity. It indicates the rate at which successive generations of women tend to replace each other.

[110] Slightly different ratios between numbers of boys and girls born have also been observed, for instance in the Caribbean region, but there is no evidence that the ratio in Brazil may differ from 1.05 to any significant extent.

[111] *World Population Prospects as Assessed in 1968* (United Nations publication, Sales No. 72.XIII.4).

TABLE 43A. REVERSE-SURVIVAL OF NUMBERS OF CHILDREN AND REPRODUCTIVE WOMEN FROM BRAZILIAN CENSUS DATA FOR THE URBAN POPULATION IN 1970, AND ESTIMATION OF URBAN GROSS REPRODUCTION RATE IN 1965–1970 AND 1960–1965

Sex and age	*Fertility age pattern*	*1970 urban population (census)*	*Survival ratio ($^{o}e_{o}$ = 63.2)*	*1965 urban population (estimate)*	*Survival ratio ($^{o}e_{o}$ = 60.4)*	*1960 urban population (estimate)*
Boys						
(to be born)		...	(0.9262)	(3,724)	(0.9070)	(3,939
0–4		3,449 [a]	0.9765	3,573	0.9708	
5–9		3,489				
Girls						
(to be born)		...	(0.9380)	(3,612)	(0.9208)	(3,812)
0–4		3,388 [a]	0.9791	3,510	0.9731	
5–9		3,437				
Women						
15–19	0.07	3,081	0.9891	2,614	0.9865	2,065
20–24	0.23	2,586	0.9869	2,037	0.9893	1,882
25–29	0.25	2,010	0.9858	1,852	0.9826	1,617
30–34	0.21	1,826	0.9842	1,589	0.9811	1,413
35–39	0.14	1,564	0.9814	1,386	0.9783	1,197
40–44	0.08	1,360	0.9759	1,171	0.9727	982
45–49	0.02	1,143	0.9668	955	0.9631	797
50–54		923	0.9529	768		
55–59		732				
Weighted sum	1.00	2,047		1,755		1,540
				1965-1970		*1960-1965*
Births of period				7,336		7,751
Mean weighted sum of women				1,901		1,648
Births per woman				3.86		4.70
Gross reproduction rate [b]				1.88		2.29

[a] Uncorrected figure, as provided in the census.

[b] Births per woman times 0.4878.

of children are projected backward to arrive at numbers of births in past periods; numbers of reproductive women are projected backward to those ages when they might have given birth; and a relationship is established between the two sets of numbers so as to estimate the level of GRR. Use is made of model life table survival ratios corresponding to the levels of mortality already indicated near the beginning of this chapter. But whereas in a projection into the future, numbers in each age group are multiplied by corresponding survival ratios, in a projection into the past, numbers of each age group are divided by the survival ratios, as a result of which additional individuals, who had died in the period are, so to speak, brought back to life. The procedure is often referred to as "reverse survival". The steps of the calculation are illustrated in tables 43a and 43b for the urban and rural populations, respectively.

367. In the first step, numbers of the 1970 census are divided by survival ratios from model life tables as tabulated in annex II, but each time situated one line above, to obtain numbers in the preceding age group who might have been alive in 1965. Thus, in table 43a, the 3,489,000 urban boys aged 5 to 9 in 1970 when divided by 0.9765, indicate that there might have been 3,573,000 boys of the same generation aged 0 to 4 years in 1965; and similarly with other age groups. The first survival ratio is shown in parenthesis to indicate that this is the ratio of survival from births occurring during a five-year period to the eventual age group 0 to 4 at the end of those five years. Thus, in the same table, the 3,449,000 urban boys aged 0 to 4 in 1970, by virtue of a survival ratio of 0.9262, may have resulted from a generation of 3,724,000 births which occurred in the period from 1965 to 1970. By the same procedure, estimated numbers of the population in 1965 are reverse-survived to yield estimated numbers of births during 1960-1965 and numbers of women in 1960.

368. In the next step, numbers of women in each of the age groups from 15 to 19 to 45 to 49 are multiplied with the proportions contributed to their gross reproductivity according to the assumed fertility age pattern, yielding the weighted sums of 2,047,000 in 1970, 1,755,000 in 1965 and 1,540,000 in 1960 in the case of the urban population.

369. In the final step, births of each period are related to the mean of weighted sums of women of the same period. As calculated for the urban population, during 1965-1970, 3,724,000 boys and 3,612,000 girls were born, giving a sum of 7,336,000 births. These are related to a weighted sum of 1,901,000 women, being the arithmetic mean of 2,047,000 in 1970 and 1,755,000 in 1965. Division shows that during the period there were 3.86 births per woman, or a gross reproduction rate of 1.88

TABLE 43B. REVERSE-SURVIVAL OF NUMBERS OF CHILDREN AND REPRODUCTIVE WOMEN FROM BRAZILIAN CENSUS DATA FOR THE RURAL POPULATION IN 1970, AND ESTIMATION OF RURAL GROSS REPRODUCTION RATE IN 1965-1970 AND 1960–1965

Sex and age	*Fertility age pattern*	*1970 rural population (census)*	*Survival ratio ($^{o}e_{o}$ = 57.6)*	*1965 rural population (estimate)*	*Survival ratio ($^{o}e_{o}$ = 55.0)*	*1960 rural population (estimate)*
Boys						
(to be born)		...	(0.8877)	(4,023)	(0.8703)	(3,860)
0–4		3,571 [a]	0.9648	3,359		
5–9		3,241				
Girls						
(to be born)		...	(0.9036)	(3,863)	(0.8882)	(3,649)
0–4		3,491 [a]	0.9669	3,241		
5–9		3,134				
Women						
15–19	0.07	2,189	0.9838	1,802	0.9809	1,389
20–24	0.23	1,773	0.9807	1,362	0.9771	1,188
25–29	0.25	1,334	0,9792	1,161	0.9756	983
30–34	0.21	1,137	0.9777	959	0.9739	863
35–39	0.14	938	0.9749	840	0.9710	728
40–44	0.08	819	0.9691	707	0.9650	604
45–49	0.02	685	0.9589	583	0.9543	486
50–54		559	0.9433	464		
55–59		438				
Weighted sum	1.00	1,344		1,117		939

	1965-1970	*1960-1965*
Births of period	7,886	7,509
Mean weighted sum of women	1,230	1,028
Births per woman	6.41	7.30
Gross reproduction rate [b]	3.13	3.56

[a] Uncorrected figure, as provided in the census.

[b] Births per woman times 0,4878.

(assuming that of all births a proportion of 0.4878 were those of girls).

370. The same calculations were performed for the rural population of 1970 (table 43b) as well as for the urban and rural populations in earlier periods on the basis of earlier census data (not shown here to save space). Thus, from census data of 1960 urban and rural GRR's were calculated for 1955-1960 and 1950-1955; and from census data of 1950, for 1945-1950 and 1940-1945.

371. As the provisional result of all these calculations, the following time series of urban and rural GRR were obtained:

	GRR	
Period	*Urban*	*Rural*
1940–1945	1.84	3.46
1945–1950	1.84	3.22
1950–1955	2.22	3.66
1955–1960	2.05	3.19
1960–1965	2.29	3.56
1965–1970	1.88	3.13

When these series are plotted on a graph, it is noted that there are zigzags with comparatively low figures in 1945-1950, 1955-1960 and 1965-1970, i.e. in those periods for which births had been reverse-survived from census data for the age group 0 to 4 years. Since it is to be suspected that in each of the censuses the enumeration of this age group was incomplete, an estimate has to be made by how much the low figures of 1945-1950, 1955-1960 and 1965-1970 have to be raised so that, as a result, a fairly continuous time trend is obtained for both the urban and rural series of GRR. It was found that this is approximately the case when the assumption is made that the censuses enumerated only 95 per cent of such children in urban areas and 90 per cent in rural areas. For when the corresponding figures are raised in such proportions, we obtain the following, fairly continuous series.[112]

	GRR	
Period	*Urban*	*Rural*
1940–1945	1.84	3.46
1945–1950	1.94	3.58
1950–1955	2.22	3.66
1955–1960	2.16	3.45
1960–1965	2.29	3.56
1965–1970	1.98	3.48

The number of children aged 0 to 4 years in each of the censuses was accordingly modified, as already indicated at the beginning of this chapter (see paragraph 336).

372. Considering the estimated trend of rising GRR during 1940-1955 and falling GRR in more recent years, it is somewhat probable that urban fertility may decline fairly consistently in coming years, and that a rural fertil-

[112] These estimates, because of their uncertainty, are deliberately rough. Actually, the smoothest trends in GRR result if it is assumed that in both urban and rural areas about 88 per cent of children aged 0 to 4 years had been enumerated.

ity decrease, gradual at first but gathering speed with time, may also come under way. Assumptions of future trends in GRR will be made accordingly.

B. STANDARD PROJECTION

Assumptions

373. In the preceding part of the chapter, trends of mortality, rural-to-urban population transfer and fertility have been examined, leading to some plausible basic estimates and assumptions. A detailed assessment of the "most probable" future population prospects in Brazil may have to depend on various other evaluations concerning the nation's economic and social development and the popular propagation of fertility regulation practices, which perhaps only the national experts can make. Without such pretension, some selected assumptions are here combined to serve as the basis for a standard projection, i.e. a projection which, with the admittedly limited information at hand, may appear to have some degree of likelihood that actual future population trends may in fact approximate it. The set of assumptions is recapitulated below:

1. The sex-age data of the census of 1960 were accepted as given, except for a modification in the 0 to 4 year age group for which census enumeration had probably been incomplete.
2. For future periods five-year survival ratios will be assumed according to the set of United Nations model life tables in annex II, selected according to the following expectations of life at birth:

	Model life table to be selected according to expectation of life at birth (years)	
Period	*Urban areas*	*Rural areas*
1970–1975	65.8	60.4
1975–1980	68.2	63.2
1980–1985	70.2	65.8
1985–1990	71.7	68.2
1990–1995	73.0	70.2
1995–2000	73.9	71.7

3. It will be assumed that the quinquennial rural-to-urban transfer rates, which have been calculated from data of the 1960-1970 period, will remain constant in all future periods of the projection. According to age at the end of each five-year period, the transfer rates (in per cent) are the following:

	Quinquennial transfer rate (per 100 of the rural population)	
Age group	*Males*	*Females*
5–9	11.9	13.1
10–14	11.9	14.1
15–19	12.5	14.8
20–24	13.0	14.0
25–29	12.4	13.0
30–34	11.9	12.1
35–39	10.7	10.8
40–44	8.7	9.6
45–49	8.4	10.0
50–54	8.6	11.1
55–59	8.0	11.1
60–64	7.6	10.8
65–69	8.1	11.6
70 and over	8.1	11.6

In the standard projection no distinction will be made between transfers due to migration and those due to the reclassification of areas.

4. Seemingly plausible future trends in urban and rural gross reproduction rates have been conjectured, somewhat arbitrarily, for the purpose of the standard projection. It is assumed that the GRR of urban areas, near 2.0 in 1970, may decrease linearly to a level of 1.2 by the year 2000; and that the GRR of rural areas, near 3.5 in 1970, may decrease with gradually increasing momentum to reach about 1.6 by the year 2000. For the intervening periods of the projection, the levels of urban and rural GRR would then be as follows:

	Assumed GRR	
Period	*Urban areas*	*Rural areas*
1970–1975	1.88	3.35
1975–1980	1.74	3.15
1980–1985	1.62	2.90
1985–1990	1.50	2.60
1990–1995	1.38	2.25
1995–2000	1.26	1.85

374. For simplicity and owing to the lack of more detailed information, a uniform age pattern of fertility is maintained, indicated by the following percentage contributions by individual age groups to GRR:

Age of women	*Contribution to GRR*
15–19	7
20–24	23
25–29	25
30–34	21
35–39	14
40–44	8
45–49	2
Sum	100

Manner of calculation

375. To calculate the actual projection, three different worksheets have to be used concurrently, the beginning parts of which are shown in tables 44a, 44b and 44c. In one worksheet, the rural population is calculated; in the other, the urban population, and in the third, the numbers of births. To facilitate ready recognition of different columns of figures, the analyst carrying out the calculation is advised to use pencils of different colours.

376. Beginning with the first column in table 44a (rural population) we note that the numbers "to be born" are not yet determined and will be calculated in the third worksheet. The survival ratios of the next column are those of the appropriate model life table, including the special survival ratios from births to ages 0 to 4, and the ratio assumed to apply for survival from ages 65 and over to ages 70 and over. Multiplication of figures of the first two columns results in estimated survivors at the end of the five-year period, shown in the third column and, because of advancing age, placed one line beneath. Thus, the 3,968,000 males aged 0 to 4 years in 1970, if surviving at the rate of 0.9708, result in 3,852,000 males aged 5 to 9 years in 1975; and so forth. The transfer rates of the next column are now multiplied with corresponding

TABLE 44A. STANDARD PROJECTION OF URBAN AND RURAL POPULATION FOR BRAZIL (PART OF WORKSHEET IN WHICH RURAL POPULATION IS CALCULATED)

Sex and age	Rural population 1970	Survival ratio ($^{o}e_{o}$ = 60.4)	Survivors 1975	Transfer rate (per cent)	Transferred population	Rural population 1975
Both sexes	*41,891*					*44,367*
Males	*21,514*					*22,863*
(to be born)	(4,862) [a]	(0.9070) [b]				(4,809) [c]
0–4	3,968	0.9708				4.410 [d]
5–9	3,241	0.9909	3,852	11.9	−458	3,394
10–14	2,720	0.9900	3,212	11.9	−382	2,830
15–19	2,266	0.9848	2,693	12.5	−337	2,356
20–24	1,790	0.9819	2,232	13.0	−290	1,942
25–29	1,407	0.9811	1,758	12.4	−218	1,540
30–34	1,207	0.9792	1,380	11.9	−164	1,216
35–39	990	0.9746	1,182	10.7	−126	1,056
40–44	912	0.9658	965	8.7	−84	881
45–49	791	0.9516	881	8.4	−74	807
50–54	652	0.9306	753	8.6	−65	688
55–59	525	0.8985	607	8.0	−49	558
60–64	394	0.8502	472	7.6	−36	436
65–69	284	(0.6816) [e]	335	8.1	−27	308
70 and over	378		451	8.1	−37	414
Females	*20,377*					*21,504*
(to be born)	(4,630) [a]	(0.9208) [b]				(4,580) [c]
0–4	3,879	0.9731				4,263 [d]
5–9	3,134	0.9914	3,775	13.1	−495	3,280
10–14	2,589	0.9906	3,107	14.1	−438	2,669
15–19	2,189	0.9865	2,565	14.8	−380	2,185
20–24	1,773	0.9839	2,159	14.0	−302	1,857
25–29	1,334	0.9826	1,744	13.0	−227	1,517
30–34	1,137	0.9811	1,311	12.1	−159	1,152
35–39	938	0.9783	1,116	10.8	−121	995
40–44	819	0.9727	918	9.6	−88	830
45–49	685	0.9631	797	10.0	−80	717
50–54	559	0.9482	660	11.1	−73	587
55–59	438	0.9238	530	11.1	−59	471
60–64	318	0.8825	405	10.8	−44	361
65–69	232	(0.7197) [e]	281	11.6	−33	248
70 and over	353		421	11.6	−49	372

[a] To be born during 1970-1975; see table 44c.

[b] Survival ratio from a five-year period of births to ages 0 to 4.

[c] To be born during 1975-1980.

[d] Determined after calculation of number of births.

[e] Assumed survival ratio from ages 65 and over to ages 70 and over; actually, the survival ratio from ages 70 to 74 to ages 75 to 79 according to model life table.

numbers of survivors in 1975 to result in estimated numbers of transferred population (whether owing to to migration or reclassification) at the same date. Thus, if 3,852,000 male survivors aged 5 to 9 are subject to transfer to urban areas at the rate of 11.9 per cent, then the rural population will lose 458,000 males aged 5 to 9 years; and similarly with other age groups. When the transferred population is subtracted from calculated survivors, finally, we arrive at the projected numbers of the rural population for 1975, shown in the last column. At this stage of the calculation, numbers aged 0 to 4 years are still missing because the births of the preceding period remain to be calculated.

377. Proceeding to table 44b (urban population), we note that the mode of calculation is essentially the same, except as regards the transferred population. This latter category is simply copied from table 44a (rural population), where the transfers were calculated in relation to numbers of rural survivors. The same numbers are now added to urban survivors of each age group, resulting in the projected numbers which appear in the last column. Again, as in table 44a, numbers of births and survivors to ages 0 to 4 are still missing.

378. Table 44c, finally, shows how the births of intervening periods are calculated. Numbers of women of reproductive age at the various dates are copied from the

TABLE 44B. STANDARD PROJECTION OF URBAN AND RURAL POPULATION FOR BRAZIL (PART OF WORKSHEET IN WHICH URBAN POPULATION IS CALCULATED

Sex and age	*Urban population 1970*	*Survival ratio ($^{\circ}e_o$ = 65.8)*	*Survivors 1975*	*Transferred population*	*Urban population 1975*
Both sexes	*51,872*				*64,379*
Males	*24,966*				*31,304*
(to be born)	(4,583) [a]	(0.9438) [b]			(5,300) [c]
0–4	3,631	0.9818			4,325 [d]
5–9	3,489	0.9937	3,565	458	4,023
10–14	3,130	0.9928	3,467	382	3,849
15–19	2,668	0.9893	3,107	337	3,444
20–24	2,273	0.9873	2,639	290	2,929
25–29	1,795	0.9866	2,244	218	2,462
30–24	1,650	0.9849	1,771	164	1,935
35–39	1,470	0.9808	1,625	126	1,751
40–44	1,297	0.9728	1,442	84	1,526
45–49	1,098	0.9596	1,262	74	1,336
50–54	858	0.9400	1,054	65	1,119
55–59	668	0.9098	807	49	856
60–64	500	0.8639	608	36	644
65–69	372	(0.7012) [a]	432	27	459
70–74	496		609	37	646
Females	*26,906*				*33,075*
(to be born)	(4,365) [a]	(0.9535) [b]			(5,048) [c]
0–4	3,566	0.9844			4,162 [d]
5–9	3,437	0.9948	3,510	495	4,005
10–14	3,227	0.9941	3,419	438	3,857
15–19	3,081	0.9914	3,208	380	3,588
20–24	2,586	0.9896	3,055	302	3,357
25–29	2,010	0.9884	2,559	227	2,786
30–34	1,826	0.9868	1,987	159	2,146
35–39	1,564	0.9841	1,802	121	1,923
40–44	1,360	0.9788	1,539	88	1,627
45–49	1,143	0.9700	1,331	80	1,411
50–54	923	0.9570	1,109	73	1,182
55–59	732	0.9351	883	59	942
60–64	551	0.8971	684	44	728
65–69	417	0.7422) [e]	494	33	527
70 and over	640		785	49	834

[a] To be born during 1970-1975; see table 44c.

[b] Survival ratio from a five-year period of births to ages 0 to 4.

[c] To be born during 1975-1980.

[d] Determined after calculation of number of births.

[e] Assumed survival ratio from ages 65 and over to ages 70 and over. Actually the survival ratio from ages 70 to 74 to ages 75 to 79 according to model life table.

worksheets on rural and urban population for the beginning and the end of each period. Multiplication with the coefficients describing the fertility age pattern and addition of the products results in the weighted sums shown below those numbers. The weighted sums are then averaged for each period to represent reproductive women during the periods for which births are to be calculated. Multiplication of these mean weighted sums with the GRR assumed for the same period directly yields the projected numbers of girls to be born; and multiplication of the latter by 1.05 yields the corresponding numbers of boys. The calculation for both segments of the population, urban and rural, proceeds in the same fashion. In table 44c, the worksheet is extended for another time interval up to 1970, but the projected numbers of reproductive women are not available until the calculations of tables 44a and 44b are likewise extended. The numbers of births calculated in this fashion are then inserted in the appropriate places in tables 44a and 44b and multiplied with the corresponding survival ratios to yield numbers of eventual survivors at ages 0 to 4.

Presentation of results for 1970-2000

379. The projection, as described, has been calculated by repeating the same procedure in each successive five-year period up to the year 2000. Projected numbers of the urban and rural population by sex and age, at time intervals of five years, are shown in tables 45a and

TABLE 44C. STANDARD PROJECTION OF URBAN AND RURAL POPULATION FOR BRAZIL (PART OF WORKSHEET IN WHICH BIRTHS ARE CALCULATED)

	Fertility age pattern	*1970*	*1970-1975*	*1975*	*1975-1980*	*1980*
		Rural population				
Women						
15–19	0.07	2,189		2,185		2,257
20–24	0.23	1,773		1,857		1,858
25–29	0.25	1,334		1,517		1,595
30–34	0.21	1,137		1,152		1,314
35–39	0.14	938		995		1,012
40–44	0.08	819		830		882
45–49	0.02	685		717		729
Weighted sum	1.00	1,344		1,421		1,487
Mean of period			1,382		1,454	
GRR			3.35		3.15	
Girls born [a]			4,630		4,580	
Boys born [a]			4,862		4,809	
		Urban population				
Women						
15–19	0.07	3,081		3,588		4,232
20–24	0.23	2,586		3,357		3,868
25–29	0.25	2,010		2,786		3,568
30–34	0.21	1,826		2,146		2,942
35–39	0.14	1,564		1,923		2,245
40–44	0.08	1,360		1,627		1,991
45–49	0.02	1,143		1,411		1,678
Weighted sum	1.00	2,047		2,598		3,203
Mean of period			2,322		2,901	
GRR			1.88		1.74	
Girls born [b]			4,365		5,048	
Boys born [b]			4,583		5,300	

[a] To be entered in table 44a. [b] To be entered in table 44b.

45b. It will be seen that the combination of assumptions adopted for the standard projection causes the urban population to increase from 52 million in 1970 to 143 million in 2000, while the rural population, 42 million in 1970, would grow at a decreasing rate reaching a maximum of about 50 million around 1995, and diminish slowly thereafter. Mainly because of declining fertility rates, the age structures of both the urban and the rural population will be modified. For instance, in the urban population numbers of small children will merely double between 1970 and 2000, while numbers at the most advanced ages will increase fivefold; in the rural population between 1985 and 2000 numbers below the age of 15 would diminish, while at subsequent ages numbers would continue to increase. Because of the greater intensity of female rates of rural-to-urban population transfer, the urban population at all dates from 1970 to 2000 maintains a relative surplus of females over males of almost two million, whereas in the rural population there continues to be a relative deficit of females of nearly the same magnitude.

380. Table 46 summarizes some further results of the projection. It can be seen, for instance, that the level of urbanization is projected to rise from 55.6 per cent in 1970 to 74.1 per cent in 2000. Shifts in the age compositions of the urban and rural populations are also indicated. At all dates of the projection, the rural population is more youthful and has smaller proportions of middle-aged and elderly persons than does the urban population. In both populations, the projection implies decreases in the proportions of children and increases in the proportion of the middle-aged and elderly. As projected, the age composition of the rural population in the year 2000 may resemble that of the urban population in the year 1970. Finally, an appreciable surplus of women is maintained in the urban population, and a surplus of men in the rural, throughout the projection period.

The components of change

381. From the worksheets used in the calculation of the projections, it is possible to deduce the components of demographic change in the total, urban and rural population. The following sequence of calculations is involved.

382. First, the amounts of population growth can be deduced for each time interval of the projection by subtracting the population total at the end from that of the beginning of each period.

TABLE 45A. STANDARD PROJECTION FOR THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; URBAN POPULATION, BY SEX AND AGE, AT FIVE-YEAR TIME INTERVALS

Sex and age	*1970*	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*
Both sexes	*52,458*	*64,379*	*77,791*	*92,765*	*108,891*	*125,790*	*143,044*
Males	*25,395*	*31,304*	*37,925*	*45,398*	*53,469*	*61,951*	*70,630*
0–4	3,631	4,325	5,077	5,796	6,397	6,872	7,213
5–9	3,489	4,023	4,779	5,550	6,271	6,858	7,302
10–14	3,130	3,849	4,403	5,210	5,992	6,710	7,278
15–19	2,668	3,444	4,177	4,751	5,606	6,398	7,113
20–24	2,273	2,929	3,716	4,466	5,061	5,959	6,762
25–29	1,795	2,462	3,136	3,936	4,700	5,313	6,247
30–34	1,650	1,935	2,615	3,307	4,116	4,892	5,518
35–39	1,470	1,751	2,039	2,729	3,434	4,248	5,032
40–44	1,297	1,526	1,725	2,101	2,797	3,509	4,324
45–49	1,098	1,336	1,561	1,765	2,140	2,838	3,552
50–54	858	1,119	1,353	1,574	1,781	2,153	2,847
55–59	668	856	1,108	1,336	1,551	1,758	2,123
60–64	500	644	821	1,060	1,278	1,484	1,687
65–69	372	459	590	753	971	1,173	1,363
70 and over	496	646	825	1,064	1,374	1,786	2,269
Females	*27,063*	*33,075*	*39,866*	*47,367*	*5,5422*	*63,839*	*72,414*
0–4	3,566	4,162	4,876	5,558	6,128	6,579	6,902
5–9	3,437	4,005	4,664	5,393	6,073	6,624	7,040
10–14	3,227	3,857	4,449	5,160	5,899	6,571	7,101
15–19	3,081	3,588	4,232	4,846	5,605	6,352	7,018
20–24	2,586	3,357	3,868	4,525	5,159	5,956	6,712
25–29	2,010	2,786	3,568	4,084	4,753	5,403	6,231
30–34	1,826	2,146	2,942	3,734	4,254	4,932	5,594
35–39	1,564	1,923	2,245	3,056	3,855	4,378	5,062
40–44	1,360	1,627	1,991	2,315	3,136	3,938	4,461
45–49	1,143	1,411	1,678	2,044	2,369	3,196	3,998
50–54	923	1,182	1,450	1,715	2,082	2,406	3,233
55–59	732	942	1,198	1,462	1,724	2,087	2,407
60–64	551	728	933	1,181	1,437	1,691	2,044
65–69	417	527	695	888	1,121	1,363	1,603
70 and over	640	834	1,077	1,406	1,827	2,363	3,008
Males per 100 females	93.8	94.6	95.1	95.8	96.5	97.0	97.5

383. Secondly, the number of births can be roughly ascertained for each time period, as calculated in the projection worksheet (table 44c), subject to a correction which will presently be discussed.

384. Thirdly, the numbers of rural-to-urban transfers (ages 5 and over) can be added up for each period from the corresponding worksheet (table 44a), again subject to further corrections.

385. Then the amount of natural increase can be calculated as the difference between the amount of population growth and the amount of rural-to-urban transfer. And finally the number of deaths can be derived as the difference between births and natural increase. All these amounts—growth, natural increase, births, deaths and transfers— can be transformed into crude rates by dividing one-fifth the numbers of each five-year period by the mean population (total, urban, rural) of the period, for simplicity taken as the arithmetic mean between the population at the period's beginning and that at its end.

386. Complications arise from several sources, but these can be dealt with by fairly easy adjustments. The births of small children to transferred (migrant or reclassified) women at the end of any five-year period may have occurred before the transfer (e.g. before migration), and therefore still in the rural area; or after the transfer, and therefore already in the urban area. The transferred population itself must have been slightly more numerous than the survivors of the transfer calculated in the worksheets because some individuals, alive at the time of the transfer (or migration), may have died subsequent to that transfer, yet within the same five-year period. A precise calculation of all the quantities involved would be feasible only in a simulation model for an electronic computer, and this cannot be considered in the present context. But the complicating instances (e.g. migrants who died or children born to women before migration) are relatively not very numerous, hence a few rough adjustments will suffice. In this connexion, it will be assumed that each five-year period's transferred population, on an average, spent one-half of that period in the rural area and the other half in the urban area.

387. To correct the number of births occurring in rural areas, the calculations of births (worksheet, see

TABLE 45B. STANDARD PROJECTION FOR THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; RURAL POPULATION, BY SEX AND AGE, AT FIVE-YEAR TIME INTERVALS

Sex and age	*1970*	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*
Both sexes	*41,902*	*44,340*	*46,620*	*48,495*	*49,795*	*50,367*	*49,973*
Males	*21,525*	*22,836*	*24,062*	*25,082*	*25,811*	*26,171*	*26,040*
0–4	3,968	4,410	4,454	4,362	4,153	3,832	3,342
5–9	3,241	3,394	3,794	3,853	3,792	3,625	3,354
10–14	2,720	2,830	2,967	3,321	3,377	3,328	3,186
15–19	2,266	2,356	2,455	2,578	2,888	2,942	2,902
20–24	1,790	1,942	2,024	2,113	2,224	2,496	2,547
25–29	1,407	1,540	1,675	1,750	1,832	1,933	2,174
30–34	1,207	1,216	1,335	1,456	1,525	1,601	1,692
35–39	990	1,056	1,066	1,174	1,284	1,348	1,418
40–44	912	881	943	955	1,055	1,156	1,216
45–49	791	807	782	840	854	945	1,039
50–54	652	688	705	685	739	754	837
55–59	525	558	592	610	595	645	661
60–64	394	436	467	498	516	505	552
65–69	284	308	344	370	398	415	410
70 and over	378	414	459	517	579	646	710
Females	*20,377*	*21,504*	*22,558*	*23,413*	*23,984*	*24,196*	*23,933*
0–4	3,879	4,263	4,296	4,197	3,989	3,674	3,202
5–9	3,134	3,280	3,627	3,675	3,608	3,440	3,176
10–14	2,589	2,669	2,799	3,099	3,145	3,091	2,949
15–19	2,189	2,185	2,257	2,370	2,628	2,671	2,628
20–24	1,773	1,857	1,858	1,925	2,025	2,249	2,289
25–29	1,334	1,517	1,595	1,600	1,662	1,751	1,948
30–34	1,137	1,152	1,314	1,385	1,393	1,450	1,530
35–39	938	995	1,012	1,157	1,222	1,232	1,284
40–44	819	830	882	900	1,031	1,092	1,103
45–49	685	717	729	777	795	913	968
50–54	559	587	616	629	672	689	793
55–59	438	471	497	525	537	576	592
60–64	318	361	391	415	441	452	486
65–69	232	248	284	310	331	354	364
70 and over	353	372	401	449	505	562	621
Males per 100 females	105.6	106.2	106.7	107.1	107.6	108.2	108.8

table 44c) are repeated by substituting, for the end of each period, the numbers of women surviving from the rural population (i.e. numbers prior to their reduction by transfer) to obtain numbers of rural births which would have occurred if there had been no transfer at all (third column in table 44a). Then the difference between the results of the two calculations of births is halved so as to represent those numbers of births still occurring in the rural area among the women transferred to the urban population within the same period. This number is added to the original calculation of rural births and subtracted from the original calculation of urban births.

388. The amount of correction for the number of births is also added to the first results of the calculation of rural-urban transfers since children of transferred women still born in the rural area were presumably (at least for the most part) also transferred. A further adjustment remains to be made in calculated numbers of transfers to take account of additional transfers of persons followed, within the same period, also by the deaths of those same persons. A rough calculation utilizing figures in the worksheets (table 44a or 44b) indicates that an adequate correction is made if it is estimated that the actual transfers (including persons who died shortly thereafter) were about one per cent more numerous than the surviving transferred population originally calculated in the projection.[113] In individual circumstances, the reader may wish to apply other correction techniques not described here.

389. These corrections apply in the urban and rural population only. The total population is unaffected, since no assumption has been made with regard to international migration. Table 47 shows the amounts involved in the components of population change, and table 48 shows the corresponding rates (per 1,000 of the mean population of each period).

390. From table 47 it can be deduced that the growth in total population will be by slowly increasing amounts

[113] This would imply a crude death rate among migrants of 2 per 1,000 per year, which is possible considering that most migrants are young adults. However, the reclassified population might well have a somewhat higher crude death rate.

TABLE 46. STANDARD PROJECTION FOR THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; SELECTED RESULTS

	1970	1975	1980	1985	1990	1995	2000
				Population (thousands)			
Total population	*94,360*	*108,719*	*124,411*	*141,260*	*158,686*	*176,157*	*193,017*
Urban population	52,458	64,379	77,791	92,765	108,891	125,790	143,044
Rural population	41,902	44,340	46,620	48,495	49,795	50,367	49,973
Percentage urban	55.6	59.2	62.5	65.7	68.6	71.4	74.1
				Percentage age composition of the urban population (both sexes)			
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	13.2	12.8	12.2	11.5	10.7	9.9
5–14	25.3	24.4	23.5	23.0	22.3	21.3	20.1
15–24	20.2	20.7	20.6	20.0	19.7	19.6	19.3
25–44	24.7	25.1	26.0	27.2	28.5	29.1	29.7
45–64	12.3	12.8	13.0	13.1	13.2	14.0	15.3
65 and over	3.7	3.8	4.1	4.4	4.9	5.3	5.8
				Percentage age composition of the rural population (both sexes)			
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	19.5	18.8	17.6	16.4	14.9	13.1
5–14	27.9	27.4	28.3	28.8	28.0	26.8	25.3
15–24	19.1	18.8	18.4	18.5	19.6	20.6	20.7
25–44	20.9	20.7	21.1	21.4	22.1	23.0	24.7
45–64	10.4	10.4	10.3	10.3	10.3	10.9	11.9
65 and over	3.0	3.0	3.2	3.4	3.6	3.9	4.2
				Males per 100 females in the population (all ages)			
Total population	*98.9*	*99.2*	*99.3*	*99.6*	*99.8*	*100.1*	*100.3*
Urban population	93.8	94.6	95.1	95.8	96.5	97.0	97.5
Rural population	105.6	106.2	106.7	107.1	107.6	*108.2*	*108.8*

until about 1990, and then by slowly decreasing amounts. Likewise, numbers of births will rise to a maximum about 1990 and then slowly diminish. The numbers of deaths in the total population will decrease somewhat to reach a minimum about 1985, and then begin to increase, mainly as a result of changes in age structure.

391. The urban population will grow by increasing amounts to the end of the century. Of the amount of growth, 45 per cent will be due to rural-to-urban transfers in 1970-1975, and 55 per cent to natural increase. By 1995-2000, 36 per cent of the urban growth will be caused by transfers, and 64 per cent by natural increase.

392. Growth of the rural population will slow down and give way to a slight decrease by the century's end. The natural increase of the rural population would attain its largest amount in 1975-1980 and thereafter it would diminish. Two-thirds of the natural increase are offset by rural-to-urban population transfer in 1970-1975, and at the century's end the net transfer will exceed the rural natural increase.

393. Other inferences can be deduced from table 48, showing the components of population change in terms of crude rates.

394. The entire country's population growth will occur at diminishing rates, from a rate of 28.4 per 1,000 in 1970-1975, to one of 18.3 per 1,000 in 1995-2000. Both the national birth rates and death rates will diminish, but the projected decline in the birth rate will be more rapid than that in the death rate, which is already quite low.

395. The urban birth rate may decline from 29.4 to 21.0 per 1,000 in the projection period, and the rural birth rate, from 45.7 to 27.7 per 1,000. The urban death rate may fall from 6.8 to 4.6 per 1,000, and the rural death rate from 9.6 to 4.4. Population transfers will make a decreasing contribution to the urban population because of its rapid growth, as compared with the much slower growth of the rural population whence the transfers come. In the rural population, the assumption of the projection has the effect that the net transfer rates stays at an almost constant level.

C. VARIANT PROJECTIONS

Population projections as part of systems analysis

396. The availability of several alternative population projections detailed by urban and rural areas (if not also in other respects: sex, age, marital status, economic activity, level of education and so on, can make a valuable contribution to decision-making processes concerned with the adoption of one or another course of action in fields of economic, social, cultural or administrative policy, regional and physical planning and so forth. It is to be noted that for such purposes the absolute magnitudes reached in the population projections are only of

TABLE 47. STANDARD PROJECTION FOR THE URBAN AND RURAL POPULATION OF BRAZIL, 1970–2000. AMOUNTS OF GROWTH, NATURAL INCREASE, BIRTHS, DEATHS AND NET POPULATION TRANSFERS IN TOTAL, URBAN AND RURAL POPULATION, BY FIVE-YEAR PERIODS

Quantity	*1970-1975*	*1975-1980*	*1980-1985*	*1985-1990*	*1990-1995*	*1995-2000*
			Total population			
Growth	14,397	15,665	16,849	17,426	17,471	16,860
Natural increase	14,397	15,665	16,849	17,426	17,471	16,860
Births	18,440	19,737	20,717	21,277	21,439	21,041
Deaths	4,043	4,072	3,868	3,851	3,968	4,181
Net transfer	0	0	0	0	0	0
			Urban population			
Growth	11,921	13,412	14,974	16,126	16,899	17,254
Natural increase	6,609	7,908	9,095	10,037	10,680	11,025
Births	8,584	9,992	11,350	12,491	13,413	14,090
Deaths	1,975	2,183	2,255	2,454	2,733	3,065
Net transfer	5,312	5,603	5,879	6,089	6,219	6,229
			Rural population			
Growth	2,476	2,253	1,875	1,300	572	−394
Natural increase	7,788	7,856	7,754	7,389	6,791	5,835
Births	9,856	9,745	9,367	8,786	8,026	6,951
Deaths	2,068	1,889	1,613	1,397	1,235	1,116
Net transfer	−5,312	−5,603	−5,879	−6,089	−6,219	−6,229

TABLE 48. STANDARD PROJECTION FOR THE URBAN AND RURAL POPULATION OF BRAZIL, 1970–2000. RATES OF GROWTH, NATURAL INCREASE, BIRTHS, DEATHS AND NET POPULATION TRANSFERS IN TOTAL, URBAN AND RURAL POPULATION, BY FIVE-YEAR PERIODS, PER 1,000 INHABITANTS

Rate	*1970-1975*	*1975-1980*	*1980-1985*	*1985-1990*	*1990-1995*	*1995-2000*
			Total population			
Growth	28.4	26.9	25.4	23.2	20.9	18.3
Natural increase	28.4	26.9	25.4	23.2	20.9	18.3
Births	36.3	33.9	31.2	28.4	25.6	22.8
Deaths	8.0	7.0	5.8	5.1	4.7	4.5
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
			Urban population			
Growth	40.8	37.7	35.1	32.0	28.8	25.7
Natural increase	22.6	22.0	21.3	19.9	18.2	16.4
Births	29.4	28.1	26.6	24.8	22.9	21.0
Deaths	6.8	6.1	5.3	4.9	4.7	4.6
Net transfer	18.2	15.8	13.8	12.1	10.6	9.3
			Rural population			
Growth	11.5	9.9	7.9	5.3	2.3	−1.6
Natural increase	36.1	34.5	32.6	30.1	27.1	23.3
Births	45.7	42.8	39.4	35.8	32.0	27.7
Deaths	9.6	8.3	6.8	5.7	4.9	4.4
Net transfer	−24.6	−24.6	−24.7	−24.8	−24.8	−24.8

secondary importance. *Comparisons* have to be made among alternative projections, hence what is really important is that the *differences* between the results of such projections, their direction and magnitude, are valid enough. The forecasting value of the projections in this context is not of particular relevance. The assembly of several alternative projections for comparative purposes, preferably projections in which one basic assumption is varied at a time, constitutes what is called a *scenario*.

397. In this discussion it is necessary at once to point at the great complexity of background factors underlying a *scenario* for policy decisions. True, specific fiscal measures, programmes in housing, public health, education, employment and so on, each can have effects on one if not several of the population trend components (fertility, mortality, migration and reclassification), and the calculated interaction of the demographic components with the dynamics of the evolving age structure results in population projections relevant to these considerations. However, each of the various lines of policy also affect economic, social, cultural and other conditions, requirements and trends, and these also interact among each other quite apart from their interaction with population trends. The population trends themselves have further consequences on economic, social, fiscal, housing and other conditions. To take account of the entire interplay of multiple factors and their multiple interactions, a complex model may have to be built for computer simulation. A large amount of specific information is needed for the construction of such a model, including absolute magnitudes, trends and the presumed interactions (correlations, regressions) within any pair of the component trends. Because of its complexity, such an interactive model is referred to as a *system*.

398. Systems analysis is an important tool for reasoning where the eventual effects of any particular line of action are far from obvious. There can be multiple feedbacks leading to eventual results which are rather different from those expected as the seemingly more direct outcome. Depending on likely further repercussions within the system, a given line of action may even prove to be eventually self-defeating. In the opposite case, where desirable eventual effects can become much larger than those immediately following the action, the particular measures taken can have a catalytic effect. Without implying that such consequences will necessarily result in any given instance, reasoning as in the following two examples is at least conceivable.

399. A programme to increase the urban housing supply could actually have the unintended consequence of increasing the housing shortage and producing also some other undesirable effects. The subsidized housing project can encourage an increased fertility among the resident families. Rural-to-urban migration can be stimulated as more potential migrants entertain an expectation that their urban housing might be facilitated by the project. The demand for broader welfare measures may increase and the urban government may have to make the corresponding concessions. Again, more migrants may be attracted to the city, increasing also overhead charges concerning transport, sewage, schools, security services and so forth, without a commensurate increase in the tax-paying capacity of the urban population. Rising expenditures may drain the municipal budget, and some of the expected services including that of subsidized housing may then have to be cut back. The initial action in its eventual results may thus defeat its own purpose and others as well. [114]

400. To vary the example, an argument like the following may also be conceivable. To relieve unemployment in a depressed area, an industrial estate may be established at public cost, including the provision of some infrastructure (e.g. a power supply, improved transport facilities, a training institute enabling adolescents to acquire economic skills or some other projects). Fiscal measures (subsidies, tax relief) may then be taken to attract an initial group of entrepreneurs who establish some local industries. Once the initial project is launched, additional enterprises may be attracted without further public expenditure because of their complementarity with industries already established, and benefiting also from a labour supply whose skills have been improved. The incomes generated create demands for additional local services, and the economic activities in the area may then multiply and diversify. The new industries may include the processing of agricultural products raised in the vicinity and contribute to the prosperity of the farmers. Not only is a high level of employment achieved within the area, but skilled workers are also attracted from other areas. The eventual outcome may be a prosperous town and rural hinterland capable of supporting a large tax revenue, far in excess of the public expenditure involved in the initial project which, so to speak, merely primed the pump. With such eventual results, the initial action can be said to have been catalytic. [115]

401. Even though a line of public action need not be expected to have extreme (self-defeating or catalytic) effects, it is evident that a full appreciation of all its important consequences, including perhaps many favourable or unfavourable side-effects, depends on a consideration of a complex interplay among numerous factors.

402. In passing, it may be mentioned that even the demographic factors can have effects upon each other. Motivation to reduce family size may be increased when infant and child mortality reaches a low level. Migrants may have a lower fertility than persons remaining in their places of residence. Migration can become a major cause for the urban reclassification of hitherto rural areas; and so forth.

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[114] Another argument of this type has been illustrated in a computerized system in Jay W. Forrester, *Urban Dynamics* (The M.I.T. Press, Cambridge, Mass., 1969). Forrester arrives at the pessimistic conclusion that self-defeat may be inherent in most social measures. "In a situation where coincident symptoms appear to be causes, a person acts to dispel the symptoms. But the underlying causes remain. The treatment is either ineffective or detrimental. With a high degree of confidence, we can say that the intuitive solutions to the problems of complex social systems will be wrong most of the time" (*Ibid.*, p. 110).

[115] This line of reasoning, more optimistic than Forrester's conclusion (see the preceding foot-note), is implicit in the presently evolving theories of regional planning, especially in the concepts of satellite towns, growth poles, service centres and so forth.

403. The complex computer models used for an analysis of the response of an entire system of factors to any given line or amplitude of policy action require, aside from mathematical and programming skill, a large amount of research into the possible interrelation between any two factors. The apparent interplay between two factors can only seldom be observed in isolation because in actual experience there would usually be a further interference by additional factors which cannot be controlled as they might be in a laboratory experiment. Many points of detail will probably remain debatable. Nevertheless, the exercise can lead to much valuable insight. For instance, there is the possibility that short-run consequences may differ from those in the long run, and decisions may have to be formulated accordingly. A given line of action, aimed at short-run effects, may then have to be followed by suitably timed corrective action in the longer run to neutralize or counteract eventual undesirable side effects.

The present purpose

404. The methods presented in this manual are primarily intended for relatively short- to medium-term usage, such as periods from ten to thirty years. The methods presented in chapters IV to VIII have been in the nature of simple forecasts rather than models.[116] Forecasts are calculated on the assumption that some reasonable continuation or modification of an observed past trend will assert itself also in the near future. Simple forecasts may serve well where reasonably dependable results are required for immediate practical purposes, as past trends are likely to change only gradually, barring catastrophic developments.

405. Projections calculated on the basis of specified assumptions for a small number of trend components have the advantage of permitting an evaluation of what the comparative consequences might be if one or another of the component assumptions has to be modified. The reasons why they have to be modified, under the influence of what development in the total situation and to what extent remain unexplained. The choice of modifications in the specific assumptions is left as a mere matter of judgement, preferably judgement based on some experience through past studies of the manner in which demographic phenomena may respond to changing conditions or may be influenced by specific measures. This subject matter lies outside the scope of this manual.[117]

406. In the sections which follow, the attempt has been made to develop a population model limited to demographic factors only and permitting the insertion of arbitrary changes in the component assumptions. Subject to judgements of detail developed by other means, the simple model also facilitates some manipulation and permits at least some limited conclusions. With enough knowledge, detailed assumptions might be delineated which can be believed to reflect with some degree of realism the situations which various quite conceivable developments may give rise to. The simple model may sometimes suffice to indicate the desirability of particular instruments of economic, social, administrative and sometimes also population policy. The accuracy of such a model may be sufficient to indicate the direction as well as the magnitude of the impact to be expected if certain elements of the given situation are permitted to change. The simple model reflecting variability in demographic factors only can also be regarded as a subsystem suitable for integration into a wider system, in which the interplay of other, non-demographic factors is included.

407. The authors of this manual are not thoroughly familiar with the relevant economic, social, administrative and other circumstances in Brazil, nor have they been able to consult with the respective national experts. The calculations, furthermore, are carried out with simple calculating equipment and without the use of computers. The aim of comparing the standard projection (reviewed in the preceding section) with each of several variants is strictly *methodological*, namely to show what differences in results are obtained if only one or another of the demographic assumptions in the standard projection is varied. It is not implied that any one of the calculated variants has a likelihood of approximating the as yet unknown future course of events, and some of the modified assumptions are quite frankly unrealistic, as can at once be recognized.

408. The following variant projections will be considered:

Variant I: it is assumed—quite unrealistically—that urban and rural populations grow by natural increase only, and that there are no rural-to-urban population transfers;

Variant II: it is assumed that there will occur no rural-to-urban area reclassifications, i.e. urban and rural areas will remain the same, although migratory transfers will occur between the two sets of areas;

Variant III: it is assumed that rural-to-urban population transfers will occur at the lower rates calculated for the 1950-1960 period, rather than at the rates of the 1960-1970 period assumed in the standard projection;

Variant IV: it is assumed that rural-to-urban population transfers will occur with similar intensity as in the standard projection, but with a different incidence by sex and age; the particular (unrealistic) assumption made is that transfers of males will occur at the rates originally assumed for females, and transfers of females at the rates originally assumed for males;

Variant V: it is assumed that mortality will not improve, but will remain constantly at the levels estimated for 1970;

Variant VI: it is assumed that fertility will not decrease, but will remain constantly at the levels estimated for 1970;

Variant VII: as compared with the standard projection, it is assumed that urban fertility will decline more rapidly and rural fertility less rapidly;

Variant VIII: as compared with the standard projection, it is assumed that urban fertility will decline less rapidly and rural fertility more rapidly.

[116] For a discussion of the differences between forecasts and models, see the introduction to this manual.

[117] It is reviewed at length, for instance, in *The Determinants and Consequences of Population Trends* (United Nations publication, Sales No. E.71.XIII.5).

TABLE 49. VARIANT I AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Variant I		
		1980	1990	2000	1980	1990	2000
		Population (thousands)					
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*125,572*	*163,499*	*202,887*
Urban population	52,458	77,791	108,891	143,044	66,221	81,339	95,758
Rural population	41,902	46,620	49,795	49,973	59,351	82,160	107,129
Percentage urban	55.6	62.5	68.6	74.1	52.7	49.7	47.2
	Percentage age composition of the urban population (both sexes)						
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	13.2	11.5	9.6
5–14	25.3	23.5	22.3	20.1	22.7	21.9	19.4
15–24	20.2	20.6	19.7	19.3	19.8	18.4	18.5
25–44	24.7	26.0	28.5	29.7	26.3	28.5	28.9
45–64	12.3	13.0	13.2	15.3	13.7	14.4	16.9
65 and over	3.7	4.1	4.9	5.8	4.3	5.4	6.7
	Percentage age composition of the rural population (both sexes)						
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	18.3	16.5	13.2
5–14	27.9	28.3	28.0	25.3	28.1	27.8	25.8
15–24	19.1	18.4	19.6	20.7	19.3	20.1	21.1
25–44	20.9	21.1	22.1	24.7	21.4	22.9	25.5
45–64	10.4	10.3	10.3	11.9	9.8	9.5	10.8
65 and over	3.0	3.2	3.6	4.2	3.1	3.3	3.6
	Males per 100 females in the population (all ages)						
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.3*	*99.9*	*100.5*
Urban population	93.8	95.1	96.5	97.5	95.4	96.9	98.0
Rural population	105.6	106.7	107.6	108.8	104.0	103.1	102.8

TABLE 50. VARIANT I AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant I		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
	Total population					
Growth	27.6	24.3	19.6	28.6	26.4	21.6
Natural increase	27.6	24.3	19.6	28.6	26.4	21.6
Births	35.1	29.8	24.2	36.2	32.1	26.3
Deaths	7.5	5.5	4.6	7.6	5.7	4.7
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
	Urban population					
Growth	39.3	33.6	27.3	23.3	20.3	16.4
Natural increase	22.3	20.6	17.3	23.3	20.3	16.4
Births	28.7	25.7	21.9	29.8	25.5	21.4
Deaths	6.4	5.1	4.6	6.5	5.2	5.0
Net transfer	17.0	13.0	10.0	0.0	0.0	0.0
	Rural population					
Growth	10.7	6.6	0.4	34.7	32.4	26.5
Natural increase	35.3	31.4	25.2	34.7	32.4	26.5
Births	44.3	37.6	29.8	43.6	38.5	30.9
Deaths	9.0	6.3	4.6	8.9	6.1	4.4
Net transfer	−24.6	−24.8	−24.8	0.0	0.0	0.0

409. For each variant, summary tables of results will be presented, making comparisons with some of the figures already shown in tables 46 and 48 of the preceding section for the standard projection.

Variant I: No rural-to-urban population transfers

410. This variant differs from the standard projection in so far as it is assumed that no rural-to-urban population transfers would occur from 1970 onward. Both the urban and rural populations would grow independently of each other according to rates of natural increase The assumption is obviously unrealistic since in actual fact the urbanization trend can hardly come to an abrupt end. But comparison of results of this variant with those of the standard projection permits an appraisal of the extent to which the growth in urban, rural and total population tends to be modified by migration and reclassification. The comparison is made in tables 49 and 50.

411. As can be seen in table 49, under this variant the total population of Brazil may grow to 203 million by the year 2000, rather than 193 million as in the standard projection. This additional population growth would be the consequence of more women remaining in the rural areas where their fertility is at a higher level. Another consequence would be a more rapid population growth in rural areas than in urban areas, because in the rural areas the rate of natural increase also is higher. In fact, under this assumption the level of urbanization would decline, from 55.6 per cent in 1970 to 47.2 per cent in 2000.

412. Surprisingly, despite the greatly modified amounts of growth in urban, rural and total population, under this variant, the age compositions of urban and rural population will resemble closely those calculated in the standard projection. Ageing of the population, as measured by the percentage aged 65 years and over, would be slightly more rapid in the urban population in the absence of migration and reclassification and slightly slower in the rural population. It is evident that the fertility and mortality trends assumed both in the standard projection and in this variant have far greater effect on age composition than the combined effects of migration and area reclassification. There would however be a marked effect on sex composition, especially in the rural population. In the standard projection, because more females than males are involved in the population transfer, the rural sex ratio would rise from 105.6 in 1970 to 108.8 in 2000, whereas in variant I it would diminish to 102.8 in 2000.

413. As shown in table 50, the assumption of no rural-to-urban transfers would have the effect of a more rapid decline of the rate of natural increase in urban areas and a slower decline in rural areas. Because of the greater proportion of rural in total population, the rate of natural increase in the combined total population would be significantly higher under this variant than according to the standard projection.

Variant II: No reclassification

414. In this variant it is assumed that rural-to-urban migration would continue at the same rates as in the standard projection, but that no reclassification of areas would occur. In the calculation, net migration rates are used as determined in table 42, for the 1965-1970 period. Theoretically, this projection should result in future population estimates within and outside those areas which in 1970 were classified as "urban". The projection does not take into account those aspects of the urbanization process which result in new areas settled under urban residential densities. Furthermore, since probably much migration of rural origin is actually directed at areas in process of reclassification, rather than at areas already classified as "urban", only a diminishing proportion of the combined rural-to-urban migratory flows is reflected in this variant. The assumption that the migration pattern to areas already classified as urban in 1970 will remain constant is also debatable. With the geographic expansion of existing urban agglomerations, a redistribution of population between the "old" urban centre and the "new" urban periphery occurs in actuality, and it is possible that eventually, owing to increasing suburbanization, a negative migratory balance develops within the "old" city cores, more persons moving from the city centres into suburbs than new migrants moving into the central parts of the city. Despite these possible incongruities in the assumption, the calculation is worth while because it permits comparisons to be made both with the standard projection and with variant I.

415. Table 51 again shows the surprising result that urban and rural age compositions are little affected by rural-to-urban migration, although they are responsive to the fertility and mortality changes assumed in both variant II and the standard projection. Another surprising result is that, with the apparently prevailing tempo of net rural-to-urban migration, the urban population grows only slightly faster than the rural population, bringing the urbanization level from 55.6 per cent in 1970 to only 57.7 per cent in 2000. As shown in table 52, the "net transfer" rates due to migration to established urban areas only are comparatively slight, whereas rates of natural increase differ appreciably between urban and rural areas. The reader may also wish to compare tables 51 and 52 with tables 49 and 50 (variant I), the difference of results being due to the effects of reclassification, as well as the inclusion of migration occurring from rural places to new areas in process of being reclassified.

Variant III: Lower rates of rural-to-urban population transfers

416. Since it is uncertain whether rural-to-urban population transfers will continue to occur at the rates calculated (in section A of this chapter) for the 1950-1970 period, a variant is here introduced to show the effects of a lower intensity of such movements, as calculated for the 1950-1960 period (also shown in section A). By the same token, higher rates of rural-to-urban population transfers might also have been assumed, in which case the comparison of results with the standard projection would lead to the opposite observations. Other assumptions might also have been made, such as a change in transfer rates in the course of time.

TABLE 51. VARIANT II AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Variant II		
		1980	1990	2000	1980	1990	2000
		Population (thousands)					
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*125,317*	*161,863*	*199,107*
Urban population	52,458	77,791	108,891	143,044	70,104	91,496	114,973
Rural population	41,902	46,620	49,795	49,973	55,213	70,367	84,134
Percentage urban	55.6	62.5	68.6	74.1	55.9	56.5	57.7
		Percentage age composition of the urban population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	13.0	11.6	9.9
5–14	25.3	23.5	22.3	20.1	23.5	22.6	20.4
15–24	20.2	20.6	19.7	19.3	20.5	19.7	19.6
25–44	24.7	26.0	28.5	29.7	26.0	28.4	29.5
45–64	12.3	13.0	13.2	15.3	12.9	13.0	14.9
65 and over	3.7	4.1	4.9	5.8	4.1	4.7	5.7
		Percentage age composition of the rural population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	18.5	16.2	12.8
5–14	27.9	28.3	28.0	25.3	27.5	27.2	24.7
15–24	19.1	18.4	19.6	20.7	18.5	19.0	20.2
25–44	20.9	21.1	22.1	24.7	21.6	22.8	25.0
45–64	10.4	10.3	10.3	11.9	10.5	10.9	12.7
65 and over	3.0	3.2	3.6	4.2	3.3	3.9	4.6
		Males per 100 females in the population (all ages)					
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.5*	*100.0*	*100.5*
Urban population	93.8	95.1	96.5	97.5	95.7	97.1	98.2
Rural population	105.6	106.7	107.6	108.8	104.5	103.9	103.6

TABLE 52. VARIANT II AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant II		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
	Total population					
Growth	27.6	24.3	19.6	28.3	25.6	20.7
Natural increase	27.6	24.3	19.6	28.3	25.6	20.7
Births	35.1	29.8	24.2	35.8	31.2	25.4
Deaths	7.5	5.5	4.6	7.5	5.6	4.7
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
	Urban population					
Growth	39.3	33.6	27.3	28.9	26.6	22.8
Natural increase	22.3	20.6	17.3	23.1	20.9	17.5
Births	28.7	25.7	21.9	29.4	26.0	22.0
Deaths	6.4	5.1	4.6	6.3	5.1	4.5
Net transfer	17.0	13.0	10.0	5.8	5.7	5.3
	Rural population					
Growth	10.7	6.6	0.4	27.5	24.2	17.9
Natural increase	35.3	31.4	25.2	34.9	31.5	25.0
Births	44.3	37.6	29.8	43.9	37.9	29.9
Deaths	9.0	6.2	4.6	9.0	6.4	4.9
Net transfer	−24.6	−24.8	−24.8	−7.4	−7.3	−7.1

TABLE 53. VARIANT III AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Varant III		
		1980	1990	2000	1980	1990	2000
		Population (thousands)					
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*124,779*	*159,315*	*194,119*
Urban population	52,458	77,791	108,891	143,044	76,589	106,078	138,724
Rural population	41,902	46,620	49,795	49,973	48,190	53,237	55,395
Percentage urban	55.6	62.5	68.6	74.1	61.4	66.6	71.5
		Percentage age composition of the urban population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	12.8	11.5	9.9
5–14	25.3	23.5	22.3	20.1	23.5	22.1	20.0
15–24	20.2	20.6	19.7	19.3	20.4	19.6	19.2
25–44	24.7	26.0	28.5	29.7	26.1	28.5	29.7
45–64	12.3	13.6	13.2	15.3	13.1	13.3	15.4
65 and over	3.7	4.1	4.9	5.8	4.1	4.9	5.8
		Percentage age composition of the rural population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	18.6	16.3	13.0
5–14	27.9	28.3	28.0	25.3	28.5	28.0	25.5
15–24	19.1	18.4	19.6	20.7	18.7	20.0	21.0
25–44	20.9	21.1	22.1	24.7	21.0	22.2	25.1
45–64	10.4	10.3	10.3	11.9	10.1	10.0	11.5
65 and over	3.0	3.2	3.6	4.2	3.1	3.5	3.9
		Males per 100 females in the population (all ages)					
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.7*	*100.3*	*100.6*
Urban population	93.8	95.1	96.5	97.5	95.3	96.1	96.9
Rural population	105.6	106.7	107.6	108.8	107.3	109.0	110.5

TABLE 54. VARIANT III AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant III		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
	Total population					
Growth	27.6	24.3	19.6	27.9	24.4	19.7
Natural increase	27.6	24.3	19.6	27.9	24.4	19.7
Births	35.1	29.8	24.2	35.2	30.0	24.4
Deaths	7.5	5.5	4.6	7.3	5.5	4.6
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
	Urban population					
Growth	39.3	33.6	27.5	37.7	32.5	26.8
Natural increase	22.3	20.6	17.3	22.8	20.6	17.2
Births	28.7	25.7	21.9	28.9	25.7	21.9
Deaths	6.4	5.1	4.6	6.1	5.1	4.7
Net transfer	17.0	13.0	10.0	14.9	11.9	9.6
	Rural population					
Growth	10.7	6.6	0.4	14.0	10.0	4.0
Natural increase	35.3	31.4	25.2	35.1	31.2	25.3
Births	44.3	37.6	29.8	44.0	37.5	29.9
Deaths	9.0	6.2	4.6	8.9	6.3	4.5
Net transfer	−24.6	−24.8	−24.8	−21.1	−21.2	−21.3

417. As can be seen in table 53, transfer rates lower than those of the standard projection would cause a somewhat smaller increase in urban and larger increase in rural population, but the effect on age structures would be almost negligible. As can be deduced from table 54, the rates of growth in urban population would only be slightly less rapid, whereas the growth in rural population would be appreciably more rapid. Rates of natural increase would be scarcely affected.

Variant IV: Transfers involving more males and fewer females

418. In this variant, the unrealistic assumption is made that, beginning in 1970, the rates of transfer for males will be those calculated for females in the preceding period, and those for females will be those previously calculated for males.

419. As shown in table 55, the effects of this varied assumption on population growth will be quite slight. Since more females remain in rural areas, where fertility is higher, the rural population will grow somewhat more rapidly, and the urban population somewhat more slowly, than in the standard projection. By the end of the century, the proportion of children will be slightly higher in rural areas and slightly lower in urban areas. The sex ratios in the two sets of areas would, however, be significantly altered. Beginning about 1985, a male surplus would develop in urban areas and a female surplus in rural areas, reversing the situation observed in 1970.

420. As appears in table 56, rates of growth and natural increase would not be significantly modified in the urban population, but would be noticeably higher in the smaller population of rural areas.

Variant V: Constant mortality

421. For the purpose of this variant, it has been assumed that both urban and rural mortality will remain at the levels estimated for 1970, typified by expectations of life at birth of 64.5 years in urban areas and 59.0 years in rural areas. An abrupt halt of progress in public health is, of course, not a realistic assumption, though it is reasonable to foresee the possibility that actual future progress may be somewhat slower or even somewhat more rapid than assumed in the standard projection. The purpose of this variant is to permit an inference of the possible effects of different mortality trends on the resulting population.

422. As of 1970, mortality in Brazil is estimated at such a low level that the gain in additional lives saved by further progress in health will no longer be exceedingly large. As can be seen in table 57, the mortality decline assumed in the standard projection will result in an additional population of 13 million inhabitants in 2000, when the national population may total 193 million, instead of the 180 million in the event of constant mortality. As compared with variant V, the standard projection results in an eventual urban population that is 9 million larger, and a rural population that is larger by 4 million. The eventual level of urbanization, however, would be virtually the same.

423. Some modification of age structure is implied in the mortality declines foreseen in the standard projection. As compared with variant V, the eventual urban and rural populations of the standard projection have somewhat lower proportions of adults between the ages of 25 and 64, and somewhat higher proportions of either children or aged persons. The increase in the latter proportions is due to the fact that the largest decreases are possible in the specific death rates in infancy and early childhood, and at relatively advanced ages: at intermediate ages, death risks are already so low that mortality reductions no longer result in any large increase in the number of survivors.

424. As can be inferred from table 58, while birth rates decline (as assumed in both projections), death rates in both the urban and rural population under constant mortality would have a tendency to rise because the decline in fertility modifies the age structure.

Variant VI: Constant fertility

425. It is not probable that fertility levels as high as they were estimated for the 1960-1970 period will long continue in Brazil. Urban fertility has already declined far below the rural level, and the general level of fertility has recently been decreasing at least in Brazil's south. As has been the experience of other countries in their process of economic and social development, it is naturally to be expected that within the coming thirty years fertility in Brazil will undergo a substantial decline, both in urban and in rural areas. One particular form of this assumption has been incorporated in the standard projection, implying a linear decline in urban fertility and a first gradual but then accelerating decline in rural fertility. But the future course of events cannot be estimated with such exactitude, and many alternative developments are entirely possible. The comparison of variant VI with the standard projection permits an appreciation of the amount of population changes due to the particular fertility assumption of the standard. The assumption in variant VI is that the gross reproduction rate (GRR) in urban areas will remain at the level of 2.0, and in the rural areas at 3.5. As can be seen in table 59, a very large reduction of population growth is implied in the assumptions of the standard projection. If fertility were to remain at the pre-1970 levels, the national population would grow to 234 million by the year 2000, whereas in the standard the total population then attains 193 million, which is 41 million less. As compared with constant fertility, the standard projection results by 2000 in an urban population that is 27 million smaller and a rural population about 14 million smaller. The level ot urbanization, however, advances with almost the same speed in both projections.

426. Also shown in table 59, changes in age composition in both urban and rural areas which might occur from 1970 to 2000 are much more pronounced in the standard projection (declining fertility) than in variant VI. Substantially smaller proportions of the population will be children and appreciably larger proportions will be in advanced ages if fertility declines than if it remains constant. *(Text continues on p. 115.)*

TABLE 55. VARIANT IV AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Variant IV		
		1980	1990	2000	1980	1990	2000
		Population (thousands)					
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*124,614*	*158,563*	*193,269*
Urban population	52,458	77,791	108,891	143,044	77,830	107,965	141,673
Rural population	41,902	46,620	49,795	48,973	46,784	50,598	51,596
Percentage urban	55.6	62.5	68.6	74.1	62.5	68.1	73.3
		Percentage age composition of the urban population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	12.7	11.2	9.7
5–14	25.3	23.5	22.3	20.1	23.5	22.2	19.9
15–24	20.2	20.6	19.7	19.3	20.6	19.9	19.4
25–44	24.7	26.0	28.5	29.7	26.1	28.4	30.0
45–64	12.3	13.0	13.2	15.3	13.0	13.4	15.2
65 and over	3.7	4.1	4.9	5.8	4.1	4.9	5.8
		Percentage age composition of the rural population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	19.0	17.0	13.8
5–14	27.9	28.3	28.0	25.3	28.2	28.2	26.0
15–24	19.1	18.4	19.6	20.7	18.3	19.3	20.6
25–44	20.9	21.1	22.1	24.7	21.0	21.7	24.0
45–64	10.4	10.3	10.3	11.9	10.2	10.2	11.5
65 and over	3.0	3.2	3.6	4.2	3.2	3.6	4.1
		Males per 100 females in the population (all ages)					
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.5*	*100.5*	*100.8*
Urban population	93.8	95.1	96.5	97.5	98.3	101.3	102.2
Rural population	105.6	106.7	107.6	108.8	101.4	98.8	97.1

TABLE 56. VARIANT IV AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970–2000. COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant IV		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
	Total population					
Growth	27.6	24.3	19.6	27.8	24.1	19.8
Natural increase	27.6	24.3	19.6	27.8	24.1	19.8
Births	35.1	29.8	24.2	35.2	29.9	24.4
Deaths	7.5	5.5	4.6	7.4	5.8	4.6
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
	Urban population					
Growth	39.3	33.6	27.3	39.3	32.7	27.1
Natural increase	22.3	20.6	17.3	22.3	19.6	16.9
Births	28.7	25.7	21.9	28.6	25.1	21.5
Deaths	6.4	5.1	4.6	6.3	5.6	4.6
Net transfer	17.0	13.0	10.0	17.0	13.1	10.3
	Rural population					
Growth	10.7	6.6	0.4	11.0	7.8	1.9
Natural increase	35.3	31.4	25.2	35.7	32.5	26.7
Births	44.3	37.6	29.8	44.6	38.8	31.4
Deaths	9.0	6.2	4.6	8.9	6.2	4.6
Net transfer	−24.6	−24.8	−24.8	−24.7	−24.7	−24.8

TABLE 57. VARIANT V AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Variant V		
		1980	1990	2000	1980	1990	2000
			Population (thousands)				
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*123,108*	*152,991*	*180,095*
Urban population	52,458	77,791	108,891	143,044	77,119	105,446	134,333
Rural population	41,902	46,620	49,795	49,973	45,989	47,545	45,762
Percentage urban	55.6	62.5	68.6	74.1	62.6	68.9	74.6
			Percentage age composition of the urban population (both sexes)				
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	12.6	11.3	9.7
5–14	25.3	23.5	22.3	20.1	23.5	21.9	19.7
15–24	20.2	20.6	19.7	19.3	20.7	19.9	19.3
25–44	24.7	26.0	28.5	29.7	26.3	28.9	30.4
45–64	12.3	13.0	13.2	15.3	13.0	13.3	15.6
65 and over	3.7	4.1	4.9	5.8	4.0	4.7	5.4
			Percentage age composition of the rural population (both sexes)				
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	18.4	15.8	12.6
5–14	27.9	28.3	28.0	25.3	28.3	27.5	24.6
15–24	19.1	18.4	19.6	20.7	18.6	20.1	20.9
25–44	20.9	21.1	22.1	24.7	21.2	22.7	25.8
45–64	10.4	10.3	10.3	11.9	10.3	10.5	12.2
65 and over	3.0	3.2	3.6	4.2	3.2	3.5	3.9
			Males per 100 females in the population (all ages)				
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.4*	*99.6*	*99.8*
Urban population	93.8	95.1	96.5	97.5	95.3	96.3	97.0
Rural population	105.6	106.7	107.6	108.8	106.6	107.4	108.3

TABLE 58. VARIANT V AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970–2000; COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant V		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
		Total population				
Growth	27.6	24.3	19.6	26.6	21.7	16.3
Natural increase	27.6	24.3	19.6	26.6	21.7	16.3
Births	35.1	29.8	24.2	35.2	30.1	24.7
Deaths	7.5	5.5	4.6	8.6	8.4	8.4
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
		Urban population				
Growth	39.3	33.6	27.3	38.4	31.2	24.2
Natural increase	22.3	20.6	17.3	21.5	18.4	14.5
Births	28.7	25.7	21.9	28.8	26.0	22.3
Deaths	6.4	5.1	4.6	7.3	7.5	7.8
Net transfer	17.0	13.0	10.0	16.9	12.8	9.7
		Rural population				
Growth	10.7	6.6	0.4	9.3	3.3	−3.8
Natural increase	35.3	31.4	25.2	33.9	28.0	20.9
Births	44.3	37.6	29.8	44.5	38.1	30.7
Deaths	9.0	6.2	4.6	10.5	10.1	9.8
Net transfer	−24.6	−24.8	−24.8	−24.6	−24.7	−24.7

TABLE 59. VARIANT VI AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Variant VI		
		1980	1990	2000	1980	1990	2000
		Population (thousands)					
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*127,788*	*173,486*	*234,231*
Urban population	52,458	77,791	108,891	143,044	79,863	118,339	170,030
Rural population	41,902	46,620	49,795	49,973	47,925	55,147	64,201
Percentage urban	55.6	62.5	68.6	74.1	62.5	68.2	72.6
		Percentage age composition of the urban population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	14.3	14.2	13.8
5–14	25.3	23.5	22.3	20.1	23.6	24.3	23.8
15–24	20.2	20.6	19.7	19.3	20.0	18.7	19.2
25–44	24.7	26.0	28.5	29.7	25.4	26.2	25.4
45–64	12.3	13.0	13.2	15.3	12.6	12.1	12.9
65 and over	3.7	4.1	4.9	5.8	4.0	4.5	4.8
		Percentage age composition of the rural population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	20.3	19.9	20.2
5–14	27.9	28.3	28.0	25.3	28.2	29.3	29.0
15–24	19.1	18.4	19.6	20.7	17.9	18.2	18.8
25–44	20.9	21.1	22.1	24.7	20.5	20.0	19.6
45–64	10.4	10.3	10.3	11.9	10.0	9.3	9.2
65 and over	3.0	3.2	3.6	4.2	3.1	3.3	3.3
		Males per 100 females in the population (all ages)					
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.4*	*100.2*	*101.0*
Urban population	93.8	95.1	96.5	97.5	95.4	97.0	98.4
Rural population	105.6	106.7	107.6	108.8	106.6	107.4	108.3

TABLE 60. VARIANT VI AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant VI		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
	Total population					
Growth	27.6	24.3	19.6	30.3	30.5	30.0
Natural increase	27.6	24.3	19.6	30.3	30.5	30.0
Births	35.1	29.8	24.2	37.9	36.0	34.3
Deaths	7.5	5.5	4.6	7.6	5.5	4.4
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
	Urban population					
Growth	39.3	33.6	27.3	41.9	39.2	36.1
Natural increase	22.3	20.6	17.3	24.9	26.2	25.9
Births	28.7	25.7	21.9	31.5	31.3	30.2
Deaths	6.4	5.1	4.6	6.5	5.0	4.3
Net transfer	17.0	13.0	10.0	16.9	13.0	10.2
	Rural population					
Growth	10.7	6.6	0.4	13.4	14.0	15.2
Natural increase	35.3	31.4	25.2	38.0	38.7	39.7
Births	44.3	37.6	29.8	47.1	45.0	44.2
Deaths	9.0	6.2	4.6	9.1	6.3	4.5
Net transfer	−24.6	−24.8	−24.8	−24.6	−24.7	−24.5

TABLE 61. VARIANT VII AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970–2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Variant VII		
		1980	1990	2000	1980	1990	2000
		Population (thousands)					
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*123,270*	*152,927*	*184,313*
Urban population	52,458	77,791	108,891	143,044	75,874	100,515	128,493
Rural population	41,902	46,620	49,795	49,973	47,396	52,412	55,820
Percentage urban	55.6	62.5	68.6	74.1	61.6	65.7	69.7
		Percentage age composition of the urban population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	11.3	8.3	8.4
5–14	25.3	23.5	22.3	20.1	23.4	20.4	16.6
15–24	20.2	20.6	19.7	19.3	21.1	20.8	18.8
25–44	24.7	26.0	28.5	29.7	26.7	30.9	32.7
45–64	12.3	13.0	13.2	15.3	13.3	14.3	17.0
65 and over	3.7	4.1	4.9	5.8	4.2	5.3	6.4
		Percentage age composition of the rural population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	19.6	18.0	15.9
5–24	27.9	28.3	28.0	25.3	28.3	28.8	27.1
15–24	19.1	18.4	19.6	20.7	18.1	18.9	20.1
25–44	20.9	21.1	22.1	24.7	20.7	21.0	22.4
45–64	10.4	10.3	10.3	11.9	10.1	9.8	10.6
65 and over	3.0	3.2	3.6	4.2	3.1	3.5	3.8
		Males per 100 females in the population (all ages)					
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.3*	*99.7*	*100.1*
Urban population	93.8	95.1	96.5	97.5	94.9	95.8	96.7
Rural population	105.6	106.7	107.6	108.8	106.6	107.0	108.6

TABLE 62. VARIANT VII AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant VII		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
	Total population					
Growth	27.6	24.3	19.6	26.7	21.5	18.7
Natural increase	27.6	24.3	19.6	26.7	21.5	18.7
Births	35.1	29.8	24.2	34.2	27.1	23.5
Deaths	7.5	5.5	4.6	7.5	5.5	4.8
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
	Urban population					
Growth	39.3	33.6	27.3	36.8	28.1	24.5
Natural increase	22.3	20.6	17.3	19.5	14.0	12.7
Births	28.7	25.7	21.9	25.9	19.2	17.6
Deaths	6.4	5.1	4.6	6.4	5.1	4.9
Net transfer	17.0	13.0	10.0	17.3	14.0	11.8
	Rural population					
Growth	10.7	6.6	0.4	12.3	10.0	6.3
Natural increase	35.3	31.4	25.2	36.9	34.8	31.1
Births	44.3	37.6	29.8	46.0	41.0	35.7
Deaths	9.0	6.2	4.6	9.1	6.3	4.6
Net transfer	−24.6	−24.8	−24.8	−24.6	−24.7	−24.8

TABLE 63. VARIANT VIII AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF SELECTED RESULTS

	Base data 1970	Standard projection			Variant VIII		
		1980	1990	2000	1980	1990	2000
			Population (thousands)				
Total population	*94,360*	*124,411*	*158,686*	*193,017*	*124,470*	*160,022*	*198,125*
Urban population	52,458	77,791	108,891	143,044	78,628	112,232	151,434
Rural population	41,902	46,620	49,795	49,973	45,842	47,790	46,691
Percentage urban	55.6	62.5	68.6	74.1	63.2	70.1	76.4
		Percentage age composition of the urban population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	13.7	12.8	11.5	9.9	13.5	12.7	11.5
5–14	25.3	23.5	22.3	20.1	23.5	23.0	21.4
15–24	20.2	20.6	19.7	19.3	20.3	19.2	19.1
25–44	24.7	26.0	28.5	29.7	25.8	27.7	28.1
45–64	12.3	13.0	13.2	15.3	12.8	12.8	14.5
65 and over	3.7	4.1	4.9	5.8	4.1	4.7	5.4
		Percentage age composition of the rural population (both sexes)					
All ages	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
0–4	18.7	18.8	16.4	13.1	17.9	15.4	12.2
5–14	27.9	28.3	28.0	25.3	28.3	26.9	23.9
15–24	19.1	18.4	19.6	20.7	18.7	20.1	20.5
25–44	20.9	21.1	22.1	24.7	21.4	23.0	26.2
45–64	10.4	10.3	10.3	11.9	10.4	10.8	12.7
65 and over	3.0	3.2	3.6	4.2	3.2	3.8	4.5
		Males per 100 females in the population (all ages)					
Total population	*98.9*	*99.3*	*99.8*	*100.3*	*99.3*	*99.9*	*100.4*
Urban population	93.8	95.1	96.5	97.5	95.2	96.7	98.0
Rural population	105.6	106.7	107.6	108.8	106.7	107.7	108.9

TABLE 64. VARIANT VIII AND STANDARD PROJECTION OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF RATES OF GROWTH AND THEIR COMPONENTS

Rate	Standard projection			Variant VIII		
	1970-1980	1980-1990	1990-2000	1970-1980	1980-1990	1990-2000
		Total population				
Growth	27.6	24.3	19.6	27.6	25.1	21.3
Natural increase	27.6	24.3	19.6	27.6	25.1	21.3
Births	35.1	29.8	24.2	35.1	30.5	25.9
Deaths	7.5	5.5	4.6	7.5	5.5	4.6
Net transfer	0.0	0.0	0.0	0.0	0.0	0.0
		Urban population				
Growth	39.3	33.6	27.3	40.3	35.5	29.9
Natural increase	22.3	20.6	17.3	23.5	23.2	20.9
Births	28.7	25.7	21.9	30.0	28.2	25.4
Deaths	6.4	5.1	4.6	6.5	5.1	4.5
Net transfer	17.0	13.0	10.0	16.8	12.3	9.0
		Rural population				
Growth	10.7	6.6	0.4	9.0	4.2	−2.3
Natural increase	35.3	31.4	25.2	33.7	28.9	22.4
Births	44.3	37.6	29.8	42.5	35.1	27.3
Deaths	9.0	6.2	4.6	8.9	6.2	4.8
Net transfer	−24.6	−24.8	−24.8	−24.7	−24.8	−24.8

Period	Standard projection		Variant VII		Variant VIII	
	Urban	Rural	Urban	Rural	Urban	Rural
1970–1975	1.88	3.35	1.75	3.45	1.92	3.25
1975–1980	1.74	3.15	1.50	3.35	1.86	2.95
1980–1985	1.62	2.90	1.25	3.20	1.78	2.65
1985–1990	1.50	2.60	1.00	3.00	1.70	2.30
1990–1995	1.38	2.25	1.00	2.75	1.62	1.95
1995–2000	1.26	1.85	1.00	2.45	1.54	1.65

427. As can be seen in table 60, the assumption of constant fertility (but declining mortality) has the effect of gradually rising crude birth rates, both in urban and rural areas, because of modifications in the population's age structure.

Variants VII and VIII: Varied assumptions of fertility decline in both urban and rural areas

428. Whereas it is most probable that fertility will decline in both the urban and rural areas of Brazil, it remains realistic to assume that the decline may be either slow or rapid, and that the tempo of decline may differ between urban and rural areas. While in all the preceding variants, I to VI, there is some degree of unrealism, variants VII and VIII, showing alternative assumptions for future fertility trends, may be regarded as somewhat realistic. For it is to be admitted that, among all the assumptions, that of the future fertility trend is still affected by great uncertainties.

429. As compared with the standard projection, variant VII assumes a more rapid decline in urban fertility and a less rapid decline in rural fertility, whereas in variant VIII the opposite combination is made. In particular, the assumptions are as shown in the table above, in terms of the gross reproduction rate (GRR).

430. Since the urban population is of greater and increasing weight in the national total, the trend in urban fertility has more effect on national population growth than does the trend in rural fertility. For this reason, variant VII (rapidly declining urban fertility, slowly declining rural fertility) results in a smaller national total population, and variant VIII (with the opposite assumptions) in a larger national total, than does the standard projection (see tables 61 and 63). As can be expected, the level of urbanization rises less rapidly under variant VII and more rapidly under variant VIII. Age structures are considerably affected by the assumed fertility trends. Tables 62 and 64 permit comparisons of the corresponding growth rates, reflecting for instance the different speeds with which crude birth rates might decline.

Relative effects of different demographic assumptions

431. As was pointed out at the beginning of this section, the several variants represent the effects of arbitrarily selected demographic assumptions without regard to whether such changes could actually occur or, if they did, whether they would be the result of specific economic, social or administrative programmes. The comparison is of methodological interest, but does not constitute a *scenario*. If the alternative results of a *scenario* were to be surveyed, it would be necessary to select one or a few characteristic findings and compare the results of all projections in those particular respects. For the sake of illustration, a few over-all comparisons of the present projections are shown in tables 65 and 66. The eight variants have been separated into two groups, since variants I to IV differ in respect of assumed population transfers, whereas variants V to VIII differ in assumed mortality and fertility trends.

TABLE 65. STANDARD PROJECTION, AND EIGHT VARIANTS, OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; INHABITANTS IN 2000 PER 100 INHABITANTS IN 1970, IN THE TOTAL, URBAN AND RURAL POPULATION

Projection	Total population	Urban population	Rural population
Standard	205	273	119
Variant I	215	183	256
Variant II	211	219	201
Variant III	206	264	132
Variant IV	205	270	123
Variant V	191	256	109
Variant VI	248	324	153
Variant VII	195	245	133
Variant VIII	210	289	111

432. As appears in table 65, the growth in total population, from 1970 to 2000, varies rather little, although the rural-to-urban transfers assumed may vary greatly. On the other hand, constant mortality (variant V) and especially constant fertility (variant VI) have a large effect on total population growth. The growth in urban and rural population depends considerably on assumed population transfers (none assumed in variant I) or at least on assumed reclassification of areas (none assumed in variant II), but little on modified assumptions concerning transfers. Constant mortality and especially constant fertility have large effects on the growth of both urban and rural populations.

433. An element of age structure is reviewed in table 66. It will be noted that varied assumptions concerning population transfers (variants I to IV) have surprisingly little effect on resulting urban and rural age structures (as measured here by the proportion of the population aged less than 25 years). The effect of varied mortality on age structure (variant V) is also rather slight. Both the urban and rural age structures, however, are greatly influenced by the particular assumptions made in respect of fertility (variants VI to VIII).

TABLE 66. STANDARD PROJECTION, AND EIGHT VARIANTS, OF THE URBAN AND RURAL POPULATION OF BRAZIL, 1970-2000; COMPARISON OF PERCENTAGES OF POPULATION AGED UNDER 25 YEARS

Projection	*Urban population*				*Rural population*			
	1970	*1980*	*1990*	*2000*	*1970*	*1980*	*1990*	*2000*
Standard	60.2	56.9	53.5	49.3	65.7	65.5	64.0	59.1
Variant I	60.2	55.7	51.8	47.5	65.7	65.7	64.4	60.1
Variant II	60.2	57.0	53.9	49.9	65.7	64.5	62.4	57.7
Variant III	60.2	56.7	53.2	49.1	65.7	65.8	64.3	59.5
Variant IV	60.2	56.8	53.3	49.0	65.7	65.5	64.5	60.4
Variant V	60.2	56.8	53.1	48.7	65.7	65.3	63.4	58.1
Variant VI	60.2	57.9	57.2	56.8	65.7	66.4	67.4	68.0
Variant VII	60.2	55.8	49.5	43.8	65.7	66.0	65.7	63.1
Variant VIII	60.2	57.3	54.9	52.0	65.7	64.9	62.4	56.6

ANNEX I

Table of logistic curve $100 \frac{U_t}{T_t} = \frac{100 e^{dt}}{1 + e^{dt}}$ for values of 100dt from -480 to 480

Note: The logistic transformation column is equivalent to an abstract "table year" of time at which the corresponding percentage urban would be expected to occur. The value of $100dt$ is defined as the table year (assuming the year zero at the point where 50 per cent of the population is urban, and also that the difference between the exponential rates of urban and rural growth equals one per cent a year).

The value of $100 \frac{U_t}{T_t}$ is defined as the percentage urban in the total population at the given moment of time, and presented under the heading "percentage urban". For more explanations, see the penultimate section in chapter III and the penultimate section in chapter V.

Table year	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*
−480	0.8163	−445	1.1544	−410	1.6302	−375	2.2977
−479	0.8244	−444	1.1658	−409	1.6464	−374	2.3203
−478	0.8326	−443	1.1774	−408	1.6626	−373	2.3431
−477	0.8409	−442	1.1891	−407	1.6791	−372	2.3661
−476	0.8493	−441	1.2009	−406	1.6957	−371	2.3893
−475	0.8577	−440	1.2128	−405	1.7124	−370	2.4127
−474	0.8663	−439	1.2249	−404	1.7293	−369	2.4364
−473	0.8749	−438	1.2370	−403	1.7464	−368	2.4602
−472	0.8836	−437	1.2493	−402	1.7636	−367	2.4844
−471	0.8924	−436	1.2617	−401	1.7810	−366	2.5087
−470	0.9013	−435	1.2742	−400	1.7986	−365	2.5333
−469	0.9103	−434	1.2869	−399	1.8164	−364	2.5581
−468	0.9194	−433	1.2996	−398	1.8343	−363	2.5831
−467	0.9285	−432	1.3125	−397	1.8524	−362	2.6084
−466	0.9378	−431	1.3255	−396	1.8707	−361	2.6339
−465	0.9471	−430	1.3387	−395	1.8891	−360	2.6597
−464	0.9565	−429	1.3520	−394	1.9077	−359	2.6857
−463	0.9661	−428	1.3654	−393	1.9265	−358	2.7120
−462	0.9757	−427	1.3789	−392	1.9455	−357	2.7385
−461	0.9854	−426	1.3926	−391	1.9647	−356	2.7652
−460	0.9952	−425	1.4064	−390	1.9842	−355	2.7923
−459	1.0051	−424	1.4203	−389	2.0036	−354	2.8195
−458	1.0151	−423	1.4344	−388	2.0233	−353	2.8471
−457	1.0252	−422	1.4486	−387	2.0432	−352	2.8748
−456	1.0354	−421	1.4629	−386	2.0633	−351	2.9029
−455	1.0457	−420	1.4774	−385	2.0836	−350	2.9312
−454	1.0561	−419	1.4920	−384	2.1041	−349	2.9598
−453	1.0666	−418	1.5068	−383	2.1248	−348	2.9887
−452	1.0772	−417	1.5217	−382	2.1457	−347	3.0178
−451	1.0879	−416	1.5368	−381	2.1668	−346	3.0472
−450	1.0987	−415	1.5520	−380	2.1881	−345	3.0769
−449	1.1096	−414	1.5673	−379	2.2096	−344	3.1068
−448	1.1206	−413	1.5828	−378	2.2313	−343	3.1371
−447	1.1318	−412	1.5985	−377	2.2533	−342	3.1676
−446	1.1430	−411	1.6143	−376	2.2754	−341	3.1984

Table year	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*
−340	3.2295	−285	5.4681	−230	9.1123	−175	14.8047
−339	3.2609	−284	5.5201	−229	9.1955	−174	14.9313
−338	3.2926	−283	5.5724	−228	9.2793	−173	15.0588
−337	3.3246	−282	5.6253	−227	9.3638	−172	15.1871
−336	3.3569	−281	5.6786	−226	9.4490	−171	15.3164
−335	3.3895	−280	5.7324	−225	9.5349	−170	15.4465
−334	3.4224	−279	5.7867	−224	9.6216	−169	15.5776
−333	3.4556	−278	5.8415	−223	9.7089	−168	15.7095
−332	3.4891	−277	5.8967	−222	9.7969	−167	15.8424
−331	3.5230	−276	5.9524	−221	9.8856	−166	15.9762
−330	3.5571	−275	6.0087	−220	9.9750	−165	16.1109
−329	3.5916	−274	6.0654	−219	10.0652	−164	16.2465
−328	3.6264	−273	6.1226	−218	10.1561	−163	16.3830
−327	3.6615	−272	6.1803	−217	10.2477	−162	16.5205
−326	3.6969	−271	6.2386	−216	10.3400	−161	16.6589
−325	3.7327	−270	6.2973	−215	10.4331	−160	16.7982
−324	3.7688	−269	6.3566	−214	10.5269	−159	16.9384
−323	3.8051	−268	6.4164	−213	10.6215	−158	17.0795
−322	3.8420	−267	6.4767	−212	10.7168	−157	17.2216
−321	3.8791	−266	6.5375	−211	10.8129	−156	17.3647
−320	3.9166	−265	6.5989	−210	10.9097	−155	17.5086
−319	3.9544	−264	6.6608	−209	11.0073	−154	17.6535
−318	3.9925	−263	6.7232	−208	11.1056	−153	17.7994
−317	4.0310	−262	6.7862	−207	11.2047	−152	17.9462
−316	4.0699	−261	6.8498	−206	11.3036	−151	18.0939
−315	4.1091	−260	6.9138	−205	11.4052	−150	18.2426
−314	4.1487	−259	6.9785	−204	11.5067	−149	18.3922
−313	4.1889	−258	7.0437	−203	11.6089	−148	18.5427
−312	4.2290	−257	7.1094	−202	11.7119	−147	18.6943
−311	4.2697	−256	7.1758	−201	11.8157	−146	18.8467
−310	4.3107	−255	7.2426	−200	11.9203	−145	19.0002
−309	4.3522	−254	7.3101	−199	12.0257	−144	19.1545
−308	4.3940	−253	7.3782	−198	12.1319	−143	19.3099
−307	4.4362	−252	7.4468	−197	12.2389	−142	19.4662
−306	4.4788	−251	7.5160	−196	12.3467	−141	19.6234
−305	4.5217	−250	7.5858	−195	12.4553	−140	19.7816
−304	4.5651	−249	7.6562	−194	12.5648	−139	19.9408
−303	4.6089	−248	7.7272	−193	12.6751	−138	20.1009
−302	4.6530	−247	7.7988	−192	12.7862	−137	20.2620
−301	4.6976	−246	7.8710	−191	12.8981	−136	20.4240
−300	4.7426	−245	7.9439	−190	13.0108	−135	20.5870
−299	4.7880	−244	8.0173	−189	13.1244	−134	20.7510
−298	4.8338	−243	8.0913	−188	13.2389	−133	20.9159
−297	4.8800	−242	8.1660	−187	13.3542	−132	21.0818
−296	4.9266	−241	8.2413	−186	13.4703	−131	21.2487
−295	4.9737	−240	8.3173	−185	13.5873	−130	21.4165
−294	5.0211	−239	8.3938	−184	13.7051	−129	21.5853
−293	5.0690	−238	8.4710	−183	13.8238	−128	21.7550
−292	5.1174	−237	8.5489	−182	13.9434	−127	21.9257
−291	5.1661	−236	8.6274	−181	14.0638	−126	22.0974
−290	5.2154	−235	8.7066	−180	14.1851	−125	22.2700
−289	5.2650	−234	8.7864	−179	14.3073	−124	22.4436
−288	5.3151	−233	8.8669	−178	14.4303	−123	22.6181
−287	5.3657	−232	8.9480	−177	14.5542	−122	22.7936
−286	5.4167	−231	9.0298	−176	14.6790	−121	22.9701

ANNEX I *(continued)*

Table year	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*
−120	23.1475	− 65	34.2990	− 10	47.5021	45	61.0639
−119	23.3259	− 64	34.5247	− 9	47.7515	46	61.3014
−118	23.5052	− 63	34.7511	− 8	48.0011	47	61.5384
−117	23.6855	− 62	34.9781	− 7	48.2507	48	61.7748
−116	23.8667	− 61	35.2059	− 6	48.5005	49	62.0106
−115	24.0489	− 60	35.4344	− 5	48.7503	50	62.2459
−114	24.2320	− 59	35.6635	− 4	49.0001	51	62.4806
−113	24.4161	− 58	35.8933	− 3	49.2501	52	62.7148
−112	24.6011	− 57	36.1237	− 2	49.5000	53	62.9483
−111	24.7871	− 56	36.3547	− 1	49.7500	54	63.1812
−110	24.9740	− 55	36.5864	0	50.0000	55	63.4136
−109	25.1618	− 54	36.8188	1	50.2500	56	63.6453
−108	25.3506	− 53	37.0517	2	50.5000	57	63.8763
−107	25.5402	− 52	37.2852	3	50.7499	58	64.1067
−106	25.7309	− 51	37.5194	4	50.9999	59	64.3365
−105	25.9225	− 50	37.7541	5	51.2497	60	64.5656
−104	26.1150	− 49	37.9894	6	51.4995	61	64.7941
−103	26.3084	− 48	38.2252	7	51.7493	62	65.0219
−102	26.5027	− 47	38.4616	8	51.9989	63	65.2489
−101	26.6980	− 46	38.6986	9	52.2485	64	65.4753
−100	26.8451	− 45	38.9361	10	52.4979	65	65.7010
− 99	27.0912	− 44	39.1741	11	52.7472	66	65.9260
− 98	27.2892	− 43	39.4126	12	52.9964	67	66.1503
− 97	27.4880	− 42	39.6517	13	53.2454	68	66.3739
− 96	27.6878	− 41	39.8912	14	53.4943	69	66.5967
− 95	27.8885	− 40	40.1321	15	53.7430	70	66.8188
− 94	28.0900	− 39	40.3717	16	53.9915	71	67.0401
− 93	28.2925	− 38	40.6127	17	54.2398	72	67.2607
− 92	28.4958	− 37	40.8541	18	54.4879	73	67.4805
− 91	28.7000	− 36	41.0960	19	54.7358	74	67.6996
− 90	28.9050	− 35	41.3382	20	54.9834	75	67.9179
− 89	29.1110	− 34	41.5809	21	55.2308	76	68.1354
− 88	29.3178	− 33	41.8241	22	55.4779	77	68.3521
− 87	29.5254	− 32	42.0676	23	55.7248	78	68.5680
− 86	29.7339	− 31	42.3115	24	55.9714	79	68.7831
− 85	29.9433	− 30	42.5557	25	56.2176	80	68.9974
− 84	30.1535	− 29	42.8004	26	56.4636	81	69.2110
− 83	30.3645	− 28	43.0454	27	56.7093	82	69.4236
− 82	30.5764	− 27	43.2907	28	56.9546	83	69.6355
− 81	30.7890	− 26	43.5364	29	57.1996	84	69.8465
− 80	31.0026	− 25	43.7824	30	57.4443	85	70.0567
− 79	31.2169	− 24	44.0286	31	57.6885	86	70.2661
− 78	31.4320	− 23	44.2752	32	57.9324	87	70.4746
− 77	31.6479	− 22	44.5221	33	58.1759	88	70.6822
− 76	31.8646	− 21	44.7692	34	58.4191	89	70.8890
− 75	32.0821	− 20	45.0166	35	58.6618	90	71.0950
− 74	32.3004	− 19	45.2642	36	58.9040	91	71.3000
− 73	32.5195	− 18	45.5121	37	59.1459	92	71.5042
− 72	32.7393	− 17	45.7602	38	59.3873	93	71.7075
− 71	32.9599	− 16	46.0085	39	59.6283	94	71.9100
− 70	33.1812	− 15	46.2570	40	59.8688	95	72.1115
− 69	33.4033	− 14	46.5057	41	60.1088	96	72.3122
− 68	33.6261	− 13	46.7546	42	60.3483	97	72.5120
− 67	33.8497	− 12	47.0036	43	60.5874	98	72.7108
− 66	34.0740	− 11	47.2528	44	60.8259	99	72.9088

ANNEX I *(continued)*

Table year	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*
100	73.1059	155	82.4914	210	89.0903	265	93.4011
101	73.3020	156	82.6353	211	89.1871	266	93.4625
102	73.4973	157	82.7784	212	89.2832	267	93.5233
103	73.6916	158	82.9205	213	89.3785	268	93.5836
104	73.8850	159	83.0616	214	89.4731	269	93.6434
105	74.0775	160	83.2018	215	89.5669	270	93.7027
106	74.2691	161	83.3411	216	89.6600	271	93.7614
107	74.4598	162	83.4795	217	89.7523	272	93.8197
108	74.6494	163	83.6170	218	89.8439	273	93.8774
109	74.8382	164	83.7535	219	89.9348	274	93.9346
110	75.0260	165	83.8891	220	90.0250	275	93.9913
111	75.2129	166	84.0238	221	90.1144	276	94.0476
112	75.3989	167	84.1576	222	90.2031	277	94.1033
113	75.5839	168	84.2905	223	90.2911	278	94.1585
114	75.7680	169	84.4224	224	90.3784	279	94.2133
115	75.9511	170	84.5535	225	90.4651	280	94.2676
116	76.1333	171	84.6836	226	90.5510	281	94.3214
117	76.3145	172	84.8129	227	90.6362	282	94.3747
118	76.4948	173	84.9412	228	90.7207	283	94.4276
119	76.6741	174	85.0687	229	90.8045	284	94.4799
120	76.8525	175	85.1953	230	90.8877	285	94.5319
121	77.0299	176	85.3210	231	90.9702	286	94.5833
122	77.2064	177	85.4458	232	91.0520	287	94.6343
123	77.3819	178	85.5697	233	91.1331	288	94.6849
124	77.5564	179	85.6927	234	91.2136	289	94.7350
125	77.7300	180	85.8149	235	91.2934	290	94.7846
126	77.9026	181	85.9362	236	91.3726	291	94.8339
127	78.0743	182	86.0566	237	91.4511	292	94.8826
128	78.2450	183	86.1762	238	91.5290	293	94.9310
129	78.4147	184	86.2949	239	91.6062	294	94.9789
130	78.5835	185	86.4127	240	91.6827	295	95.0263
131	78.7513	186	86.5297	241	91.7587	296	95.0734
132	78.9182	187	86.6458	242	91.8340	297	95.1200
133	79.0841	188	86.7611	243	91.9087	298	95.1662
134	79.2490	189	86.8756	244	91.9827	299	95.2120
135	79.4130	190	86.9892	245	92.0561	300	95.2574
136	79.5760	191	87.1019	246	92.1290	301	95.3024
137	79.7380	192	87.2138	247	92.2012	302	95.3470
138	79.8991	193	87.3249	248	92.2728	303	95.3911
139	80.0592	194	87.4352	249	92.3438	304	95.4349
140	80.2184	195	87.5447	250	92.4142	305	95.4783
141	80.3766	196	87.6533	251	92.4840	306	95.5212
142	80.5338	197	87.7611	252	92.5532	307	95.5638
143	80.6901	198	87.8681	253	92.6218	308	95.6060
144	80.8455	199	87.9743	254	92.6899	309	95.6478
145	80.9998	200	88.0797	255	92.7574	310	95.6863
146	81.1533	201	88.1843	256	92.8242	311	95.7303
147	81.3057	202	88.2881	257	92.8906	312	95.7710
148	81.4573	203	88.3911	258	92.9563	313	95.8111
149	81.6078	204	88.4933	259	93.0215	314	95.8513
150	81.7574	205	88.5948	260	93.0862	315	95.8909
151	81.9061	206	88.6954	261	93.1502	316	95.9301
152	82.0538	207	88.7953	262	93.2138	317	95.9690
153	82.2006	208	88.8944	263	93.2768	318	96.0075
154	82.3465	209	88.9927	264	93.3392	319	96.0456

ANNEX I *(concluded)*

Table year	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*	*Table year*	*Percentage urban*
320	96.0834	360	97.3403	400	98.2014	440	98.7872
321	96.1209	361	97.3661	401	98.2190	441	98.7991
322	96.1580	362	97.3916	402	98.2364	442	98.8109
323	96.1948	363	97.4169	403	98.2536	443	98.8226
324	96.2312	364	97.4419	404	98.2707	444	98.8342
325	96.2673	365	97.4667	405	98.2876	445	98.8456
326	96.3031	366	97.4913	406	98.3043	446	98.8570
327	96.3385	367	97.5156	407	98.3209	447	98.8682
328	96.3736	368	97.5398	408	98.3374	448	98.8794
329	96.4084	369	97.5636	409	98.3536	449	98.8904
330	96.4429	370	97.5873	410	98.3698	450	98.9013
331	96.4770	371	97.6107	411	98.3857	451	98.9121
332	96.5109	372	97.6339	412	98.4015	452	98.9228
333	96.5444	373	97.6569	413	98.4172	453	89.9334
334	96.5776	374	97.6797	414	98.4327	454	98.9439
335	96.6105	375	97.7023	415	98.4480	455	98.9543
336	96.6431	376	97.7246	416	98.4632	456	98.9646
337	96.6754	377	97.7467	417	98.4783	457	98.9748
338	96.7074	378	97.7687	418	98.4932	458	98.9849
339	96.7391	379	97.7904	419	98.5080	459	98.9949
340	96.7705	380	97.8119	420	98.5226	460	99.0048
341	96.8016	381	97.8332	421	98.5371	461	99.0146
342	96.8324	382	97.8543	422	98.5514	462	99.0243
343	96.8629	383	97.8752	423	98.5656	463	99.0339
344	96.8932	384	97.8959	424	98.5797	464	99.0435
345	96.9231	385	97.9164	425	98.5936	465	99.0529
346	96.9528	386	97.9367	426	98.6074	466	99.0622
347	96.9822	387	97.9568	427	98.6211	467	99.0715
348	97.0113	388	97.9767	428	98.6346	468	99.0806
349	97.0402	389	97.9964	429	98.6480	469	99.0897
350	97.0688	390	98.0158	430	98.6613	470	99.0987
351	97.0971	391	98.0353	431	98.6745	471	99.1076
352	97.1252	392	98.0545	432	98.6875	472	99.1164
353	97.1529	393	98.0735	433	98.7004	473	99.1251
354	97.1805	394	98.0923	434	98.7131	474	99.1337
355	97.2077	395	98.1109	435	98.7258	475	99.1423
356	97.2348	396	98.1293	436	98.7383	476	99.1507
357	97.2615	397	98.1476	437	98.7507	477	99.1591
358	97.2880	398	98.1657	438	98.7630	478	99.1674
359	97.3143	399	98.1836	439	98.7751	479	99.1756

ANNEX II

Table of survival ratios (P_x) of model life tables for five-year age groups and five-year intervals of time

Note: This and related tables were originally published in *Manual III: Methods for Population Projections by Sex and Age* [a] to serve as estimates of mortality conditions applicable in population projections calculated by the cohort-component method. In particular, an annual gain of 0.5 years in expectation of life at birth was assumed wherever the expectation is less than 55 years. When an expectation of 55 years is attained, the model assumption implies a slight acceleration in gains until the expectation approaches 65 years. Thereupon, the rate of gain slows down and becomes slight when the expectation has risen substantially higher than 70 years. These assumptions were based on observed world-wide averages at about mid century.

The table is arranged by five-year intervals of time. Survival ratios for other time intervals can be calculated from the table by interpolation. Interpolations may also be made to serve in assumptions of either a slower or a more rapid decline in mortality.

[a] United Nations publication, Sales No. 56.XIII.3.

SURVIVAL RATIOS (P_x) OF MODEL LIFE TABLES FOR FIVE-YEAR AGE GROUPS AND

Sex and age (percentage) in years	*Level 0 ($^{o}e_0$ = 20)*	*Level 5 ($^{o}e_0$ = 22.5)*	*Level 10 ($^{o}e_0$ = 25)*	*Level 15 ($^{o}e_0$ = 27.5)*	*Level 20 ($^{o}e_0$ = 30)*	*Level 25 ($^{o}e_0$ = 32.5)*	*Level 30 ($^{o}e_0$ = 35)*	*Level 35 ($^{o}e_0$ = 37.5*	*Level 40 ($^{o}e_0$ = 40)*	*Level 45 ($^{o}e_0$ = 42.5)*	*Level 50 ($^{o}e_0$ = 45)*	*Level 55 ($^{o}e_0$ = 47.5)*
Males												
(Births) [b]	(0.6092)	(0.6334)	(0.6622)	(0.6853)	(0.7058)	(0.7248)	(0.7440)	(0.7626)	(0.7789)	(0.7950)	(0.8107)	(0.8256)
0–4	0.7666	0.7953	0.8200	0.8405	0.8577	0.8731	0.8868	0.8993	0.9098	0.9198	0.9287	0.9369
5–9	0.9269	0.9359	0.9436	0.9501	0.9556	0.9606	0.9651	0.9691	0.9725	0.9757	0.9785	0.9811
10–14	0.9383	0.9444	0.9498	0.9547	0.9590	0.9629	0.9666	0.9700	0.9729	0.9758	0.9783	0.9806
15–19	0.9234	0.9291	0.9346	0.9399	0.9444	0.9487	0.9532	0.9574	0.9612	0.9648	0.9681	0.9712
20–24	0.9073	0.9141	0.9207	0.9271	0.9326	0.9379	0.9434	0.9484	0.9530	0.9574	0.9615	0.9653
25–29	0.8906	0.8999	0.9088	0.9171	0.9245	0.9313	0.9381	0.9440	0.9494	0.9545	0.9592	0.9634
30–34	0.8675	0.8805	0.8925	0.9036	0.9130	0.9218	0.9301	0.9373	0.9437	0.9496	0.9551	0.9599
35–39	0.8357	0.8533	0.8692	0.8836	0.8957	0.9068	0.9170	0.9258	0.9336	0.9408	0.9473	0.9529
40–44	0.7976	0.8198	0.8395	0.8572	0.8722	0.8857	0.8980	0.9085	0.9180	0.9267	0.9342	0.9408
45–49	0.7603	0.7850	0.8072	0.8271	0.8440	0.8594	0.8734	0.8854	0.8964	0.9062	0.9150	0.9226
50–54	0.7219	0.7469	0.7698	0.7907	0.8086	0.8251	0.8406	0.8542	0.8664	0.8776	0.8877	0.8965
55–59	0.6776	0.7011	0.7233	0.7443	0.7626	0.7798	0.7964	0.8113	0.8249	0.8375	0.8488	0.8587
60–64	0.6221	0.6428	0.6633	0.6833	0.7011	0.7182	0.7355	0.7514	0.7660	0.7798	0.7924	0.8037
65–69	0.5395	0.5582	0.5772	0.5963	0.6139	0.6312	0.6492	0.6660	0.6820	0.6972	0.7116	0.7246
70–74	0.4303	0.4478	0.4660	0.4847	0.5023	0.5202	0.5386	0.5561	0.5732	0.5896	0.6054	0.6199
75–79	0.3044	0.3207	0.3381	0.3559	0.3724	0.3900	0.4083	0.4258	0.4430	0.4595	0.4757	0.4906
(80+) [c]	(0.1095)	(0.1280)	(0.1483)	(0.1678)	(0.1850)	(0.2023)	(0.2195)	(0.2355)	(0.2502)	(0.2640)	(0.2768)	(0.2882)
Females												
(Births) [b]	(0.6290)	(0.6558)	(0.6801)	(0.7024)	(0.7242)	(0.7447)	(0.7627)	(0.7802)	(0.7969)	(0.8135)	(0.8292)	(0.8443)
0–4	0.7637	0.7932	0.8179	0.8387	0.8570	0.8732	0.8870	0.8996	0.9105	0.9209	0.9300	0.9384
5–9	0.9212	0.9309	0.9392	0.9462	0.9524	0.9579	0.9627	0.9670	0.9707	0.9742	0.9773	0.9801
10–14	0.9301	0.9370	0.9432	0.9487	0.9539	0.9586	0.9628	0.9666	0.9701	0.9734	0.9764	0.9792
15–19	0.9146	0.9209	0.9271	0.9330	0.9390	0.9446	0.9495	0.9541	0.9587	0.9631	0.9671	0.9709
20–24	0.8965	0.9041	0.9115	0.9186	0.9259	0.9327	0.9387	0.9442	0.9500	0.9555	0.9606	0.9651
25–29	0.8779	0.8884	0.8983	0.9076	0.9165	0.9249	0.9322	0.9388	0.9456	0.9520	0.9577	0.9628
30–34	0.8581	0.8720	0.8849	0.8967	0.9077	0.9178	0.9265	0.9342	0.9419	0.9490	0.9550	0.9604
35–39	0.8390	0.8563	0.8719	0.8861	0.8989	0.9106	0.9204	0.9289	0.9372	0.9448	0.9513	0.9570
40–44	0.8203	0.8400	0.8576	0.8734	0.8875	0.9003	0.9110	0.9202	0.9290	0.9369	0.9439	0.9500
45–49	0.7965	0.8175	0.8364	0.8533	0.8686	0.8825	0.8942	0.9043	0.9140	0.9229	0.9304	0.9373
50–54	0.7663	0.7872	0.8064	0.8241	0.8407	0.8560	0.8688	0.8800	0.8910	0.9012	0.9098	0.9178
55–59	0.7238	0.7437	0.7626	0.7805	0.7981	0.8145	0.8285	0.8411	0.8538	0.8655	0.8761	0.8859
60–64	0.6627	0.6811	0.6993	0.7171	0.7355	0.7530	0.7682	0.7822	0.7967	0.8104	0.8230	0.8348
65–69	0.5782	0.5952	0.6125	0.6300	0.6487	0.6668	0.6830	0.6983	0.7145	0.7299	0.7443	0.7578
70–74	0.4636	0.4799	0.4970	0.5143	0.5330	0.5519	0.5689	0.5853	0.6029	0.6197	0.6358	0.6511
75–79	0.3275	0.3431	0.3600	0.3772	0.3959	0.4156	0.4331	0.4500	0.4687	0.4867	0.5040	0.5206
(80+) [c]	(0.1320)	(0.1508)	(0.1694)	(0.1878)	(0.2066)	(0.2251)	(0.2409)	(0.2556)	(0.2708)	(0.2850)	(0.2979)	(0.3099)

SOURCE: *Manual III: Methods for Population Projections by Sex and Age* (United Nations publication, Sales No. 56.XIII.3), pp. 80-81.

[a] Equivalent values of $^{o}e_0$ shown in parentheses refer to expectation of life at birth, for both sexes, in years.

[b] A ratio of survival from births occurring in the course of a five-year period to age group 0 to 4 by the end of the period.

[c] Ratio of survival from terminal age group 80 and over to terminal age group 85 and over.

FIVE-YEAR INTERVALS OF TIME; MORTALITY LEVEL (OR TIME REFERENCE IN YEARS) [a]

Level 60 (${}^{o}e_0$ = 50)	*Level 65* (${}^{o}e_0$ = 52.5)	*Level 70* (${}^{o}e_0$ = 55)	*Level 75* (${}^{o}e_0$ = 57.6)	*Level 80* (${}^{o}e_0$ = 60.4)	*Level 85* (${}^{o}e_0$ = 63.2)	*Level 90* (${}^{o}e_0$ = 65.8)	*Level 95* ${}^{o}e_0$ = 68.2)	*Level 100* (${}^{o}e_0$ = 70.2)	*Level 105* (${}^{o}e_0$ = 71.7)	*Level 110* (${}^{o}e_0$ = 73.0)	*Level 115* (${}^{o}e_0$ = 73.9)	*Sex and age (percentage) in years)*
												Males
(0.8406)	(0.8557)	(0.8703)	(0.8877)	(0.9070)	(0.9262)	(0.9438)	(0.9580)	(0.9678)	(0.9744)	(0.9788)	(0.9817)	.....(Births)
0.9445	0.9518	0.9584	0.9648	0.9708	0.9765	0.9818	0.9867	0.9908	0.9936	0.9954	0.9966	 0–4
0.9834	0.9856	0.9876	0.9893	0.9909	0.9924	0.9937	0.9949	0.9963	0.9974	0.9982	0.9986	 5–9
0.9827	0.9848	0.9867	0.9884	0.9900	0.9914	0.9928	0.9941	0.9955	0.9968	0.9977	0.9982	 10–14
0.9741	0.9772	0.9798	0.9824	0.9848	0.9871	0.9893	0.9913	0.9935	0.9953	0.9965	0.9974	 15–19
0.9688	0.9725	0.9758	0.9789	0.9819	0.9847	0.9873	0.9898	0.9924	0.9944	0.9957	0.9966	 20–24
0.9673	0.9712	0.9748	0.9781	0.9811	0.9840	0.9866	0.9891	0.9916	0.9935	0.9948	0.9956	 25–29
0.9644	0.9686	0.9725	0.9760	0.9792	0.9822	0.9849	0.9874	0.9897	0.9917	0.9930	0.9939	 30–34
0.9580	0.9628	0.9671	0.9711	0.9746	0.9779	0.9808	0.9835	0.9860	0.9881	0.9897	0.9907	 35–39
0.9467	0.9523	0.9575	0.9617	0.9658	0.9696	0.9728	0.9759	0.9786	0.9812	0.9835	0.9851	 40–44
0.9294	0.9359	0.9419	0.9469	0.9516	0.9558	0.9596	0.9632	0.9664	0.9696	0.9727	0.9752	 45–49
0.9045	0.9121	0.9189	0.9250	0.9306	0.9356	0.9400	0.9441	0.9481	0.9521	0.9558	0.9594	 50–54
0.8678	0.8767	0.8847	0.8919	0.8985	0.9044	0.9098	0.9148	0.9198	0.9249	0.9296	0.9341	 55–59
0.8141	0.8244	0.8338	0.8423	0.8502	0.8573	0.8639	0.8702	0.8765	0.8830	0.8890	0.8945	 60–64
0.7367	0.7487	0.7598	0.7698	0.7794	0.7881	0.7963	0.8042	0.8119	0.8197	0.8269	0.8335	 65–69
0.6334	0.6469	0.6594	0.6708	0.6816	0.6917	0.7012	0.7012	0.7192	0.7283	0.7372	0.7454	 70–74
0.5049	0.5193	0.5326	0.5449	0.5566	0.5675	0.5779	0.5878	0.5976	0.6072	0.6176	0.6280	 75–79
(0.2988)	(0.3091)	(0.3186)	(0.3272)	(0.3352)	(0.3426)	(0.3493)	(0.3556)	(0.3613)	(0.3666)	(0.3721)	(0.3775)	..... (80+)
												Females
(0.8594)	(0.8739)	(0.8882)	(0.9036)	(0.9208)	(0.9380)	(0.9535)	(0.9660)	(0.9744)	(0.9801)	(0.9838)	(0.9864)	.....(Births)
0.9463	0.9537	0.9607	0.9669	0.9731	0.9791	0.9844	0.9892	0.9925	0.9948	0.9963	0.9973	 0–4
0.9828	0.9852	0.9874	0.9895	0.9914	0.9932	0.9948	0.9962	0.9972	0.9981	0.9986	0.9990	 5–9
0.9819	0.9843	0.9865	0.9886	0.9906	0.9925	0.9941	0.9956	0.9967	0.9976	0.9982	0.9987	 10–14
0.9745	0.9778	0.9809	0.9838	0.9865	0.9891	0.9914	0.9935	0.9952	0.9965	0.9974	0.9980	 15–19
0.9694	0.9735	0.9771	0.9807	0.9839	0.9869	0.9896	0.9920	0.9940	0.9956	0.9966	0.9973	 20–24
0.9674	0.9718	0.9756	0.9792	0.9826	0.9858	0.9884	0.9909	0.9929	0.9945	0.9956	0.9963	 25–29
0.9654	0.9700	0.9739	0.9777	0.9811	0.9842	0.9868	0.9893	0.9913	0.9929	0.9941	0.9948	 30–34
0.9622	0.9669	0.9710	0.9749	0.9783	0.9814	0.9841	0.9866	0.9886	0.9903	0.9915	0.9923	 35–39
0.9556	0.9606	0.9650	0.9691	0.9727	0.9759	0.9788	0.9814	0.9835	0.9853	0.9868	0.9879	 40–44
0.9437	0.9493	0.9543	0.9589	0.9631	0.9668	0.9700	0.9731	0.9754	0.9775	0.9792	0.9806	 45–49
0.9252	0.9318	0.9377	0.9433	0.9482	0.9529	0.9570	0.9609	0.9637	0.9661	0.9680	0.9695	 50–54
0.8949	0.9030	0.9104	0.9175	0.9238	0.9298	0.9351	0.9402	0.9437	0.9466	0.9491	0.9510	 55–59
0.8459	0.8559	0.8653	0.8743	0.8825	0.8903	0.8971	0.9036	0.9083	0.9122	0.9161	0.9196	 60–64
0.7710	0.7832	0.7948	0.8059	0.8162	0.8259	0.8345	0.8429	0.8490	0.8549	0.8609	0.8668	 65–69
0.6662	0.6804	0.6940	0.7073	0.7197	0.7316	0.7422	0.7525	0.7602	0.7677	0.7764	0.7852	 70–74
0.5369	0.5523	0.5672	0.5819	0.5955	0.6088	0.6207	0.6323	0.6410	0.6498	0.6592	0.6697	 75–79
(0.3211)	(0.3313)	(0.3406)	(0.3495)	(0.3576)	(0.3652)	(0.3719)	(0.3781)	(0.3828)	(0.3869)	(0.3913)	(0.3957)	..... (80+)

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