## Population (Human)

In biology, a **population** is all the organisms of the same group or species who live in a particular geographical area and are capable of interbreeding. The area of a sexual population is the area where inter-breeding is possible between any pair within the area and more probable than cross-breeding with individuals from other areas.

In sociology, **population** refers to a collection of humans. Demography is a social science which entails the statistical study of populations. Population, in simpler terms, is the number of people in a city or town, region, country or world; population is usually determined by a process called census (a process of collecting, analyzing, compiling and publishing data).

**Human population** refers to the number of people living in a particular area, from a village to the world as a whole. A secondary **meaning** of **population** is the inhabitants themselves, but in most uses **population means** numbers. ... World **population** grows because births significantly outpace deaths on average ...

## Meaning of "population"

1. Collection of persons alive at a specified point in time who meet certain criteria

Examples:
- The "population of Bangladesh on April 1, 1995,"
- The "population of American black females in the Northeast on June 1, 1900"

**2.** Kind of collectivity that persists through time even though its members are continuously changing through attrition and accession. Thus, "the population of India" may refer to the aggregate of persons who have ever been alive in the area we define as India and possibly even to those yet to be born there. The collectivity persists even though a virtually complete turnover of its members occurs at least once each century.

## Stable Population

The term **stable population** refers to a population with an unchanging (but possibly nonzero) rate of growth and an unchanging age composition (i.e., the population pyramid does not change in shape) as a result of age-specific birth rates and age-specific death rates that have remained constant for a sufficiently long time.

A stable population may or may not have zero population growth. We can have stable populations that are growing, and we can also have stable populations that are declining.

## How can we identify a stable population?

This **stable population** has been defined by the following properties: (a) Constant age distribution; (b) Constant and known mortality; (c) Constant and known fertility. ... (a) Constant age distribution; (b) Constant and known mortality; (e) Constant and known rate of increase.

## Stationary Population

Stationary populations consist of two categories of cohorts, one of which is the birth cohort—all individuals who are born at the same time and thus who survive lockstep forward in time. Members of the birth cohorts comprise the age structure of the population as measured from time since birth. The second category of cohort in stationary populations is the death cohort described by Riffe (2015) and Riffe et al. (2017) whose age index is what they labeled thanatological age, i.e., time until death. Thanatological age equates individuals that share a common terminal state rather than a common origin state.

A **stationary population is** a special example of a **stable population** with a zero growth rate, neither growing nor shrinking in size, and **is** equivalent to a life table **population**. ... By **definition**, **stable populations** have age-specific fertility and mortality rates that remain constant over time.

## What is quasi stable population?

given more general application; a **quasi-stable population**. was defined as a **population** in which fertility hadfor long been constant and the age distribution also remained more or less constant. The concept of **quasi-stable populations** is therefore based on experience, and it was defined as a result .

The stable-population model (with zero population growth) and the quasi-stable population model (similar to the stable-population model but with moderately declining mortality) may also be used to assess DSS population age–sex structures.

## What is the difference between stable and stationary population?

Definition. A **stationary population** is a special example of a **stable population with a** zero growth rate, neither growing nor shrinking in size, and is equivalent to a life table **population**. ... By definition, **stable populations** have age-specific fertility and mortality rates that remain constant over time.

## Demography

Demography is the science of population. The word was coined by a Belgian, AchilleGuillard, who published hisEléments de statistiquehumaine, oudémographiecomparée

(Elements of human statistics or comparative demography) in 1855.1 He defined it as the natural and social history of the human species or the mathematical knowledge of populations, of their general changes, and of their physical, civil, intellectual, and moral condition.

The study of statistics such as births, deaths, income, or the incidence of disease, which illustrate the changing structure of human populations.

Births, deaths and migration are the 'big three' of **demography**, jointly producing population stability or change.

Literally translated from the Greek, *'demography'* means *'descriptionof the people'*. One definition among many: "**Demography** is the study of the size, territorial distribution, and. composition of population, changes therein, and the components of. such changes, which may be identified as natality, mortality, territorial movement (migration), and social mobility (change of status)."

Like most other sciences, demography may be defined narrowly or broadly. **The narrowest sense** is that of "formal demography." Formal demography is concerned with the size, distribution, structure, and change of populations.

**A broader sense includes** additional characteristics of the units. These include ethnic characteristics, social characteristics, and economic characteristics. Ethnic characteristics like race, legal nationality, and mother tongue shade into social characteristics. Other examples of social characteristics are marital and family status, place of birth, literacy, and educational attainment. Economic characteristics include economic activity, employment status, occupation, industry, and income, among others. Other characteristics that might be encompassed are genetic inheritance, intelligence, and health; but the usual sources of demographic data, such as censuses, seldom deal' with these directly. Furthermore, demography may look beyond the basic personal units to such customary social groupings as families and married couples.

## **What Is the Purpose** of Demographics?

Demographics are collected by a variety of venues, and they are most often used to understand a targeted audience or population. For example, in television advertising, marketers use demographics to inform them of who is watching which television programs.

## **What is demography and why is it important**?

**Demography** is the branch of social sciences concerned with the study of human populations, their structure and change (through births, deaths, and migration), and their relationship with the natural environment and with social and economic change.

**Demography** (from prefix *demo-* from Ancient Greekδῆμος*dēmos* meaning "the people", and *-graphy* from γράφω*graphō*, ies "writing, description or measurement") is the statistical study of populations, especially human beings.

Demographic analysis can cover whole societies or groups defined by criteria such as education, nationality, religion, and ethnicity. Educational institutions usually treat demography as a field of sociology, though there are a number of independent demography departments. Based on the demographic research of the earth, earth's population up to the year 2050 and 2100 can be estimated by demographers.

## জনসংখ্যাতত্ত্ব (Demography)

জনসংখ্যাতত্ত্ববলতেমানবজনসংখ্যারসংখ্যাতাত্ত্বিকআলোচনাওগবেষণাশাস্ত্রকেবোঝায়।সাধারণভাবেএইশাস্ত্রেযেকোনোবাস্তবজনসংখ্যা, অর্থাৎস্থানওকালসাপেক্ষেপরিবর্তনশীলযেকোনোজনসমষ্টিরবিশ্লেষণসম্ভব।

## What is the difference between demography and population studies?

**Demography** refers to the hard core analysis of numbers while **population studies** look at the behavioural aspects affecting the reproductive behaviour of people. Fertility, mortality and migration are the three basic aspects which influence the **population** of a particular place.

## What are the main elements of demography?

F**ive** generic aspects of **demography**are- (a) population size, (b) geographic distribution, (c) composition, (d) **components** of change (births, deaths and migration), and (e) determinants of change.

Demography may be defined narrowly or broadly. The narrowest sense is that of "formal demography." Formal demography is concerned with the size, distribution, structure, and change of populations.

A broader sense of demography includes additional characteristics of the units. These include ethnic characteristics, social characteristics, and economic characteristics. Ethnic characteristics like race, legal nationality, and mother tongue shade into social characteristics. Other examples of social characteristics are marital and family status, place of birth, literacy, and educational attainment. Economic characteristics include economic activity, employment status, occupation, industry, and income, among others. Other characteristics that might be encompassed are genetic inheritance, intelligence, and health; but the usual sources of demographic data, such as censuses, seldom deal' with these directly.

Hauser and Duncan regard the field of demography as consisting of a narrow scope —demographic analysis —and a wider scope—population studies. "Demographic analysis is confined to the study of components of population variation and change.

Population studies are concerned not only with population variables but also with relationships between population changes and other variables —social, economic, political, biological, genetic, geographical, and the like. The field of population studies is at least as broad as interest in the 'determinants and consequences of population trends.'

## Demographic Data and their uses

The resulting demographic statistics can then be used to describe the distribution of the population in space, its density and degree of concentration, the fluctuations in its rate of growth, its movements from one area to another, and the force of natality, nuptiality, and mortality within it. These demographic statistics have many and increasingly varied applications. The fields of application include public health; local planning for land use, school and hospital construction, public utilities, etc.; marketing; manpower analysis; family planning programs; land settlement; immigration and emigration policy; and many others. An analysis of current demographic levels and past trends is the necessary first step in the construction of population forecasts that in turn form the underpinning of national plans for economic development and other programs, including explicit population policies in some cases.

## Demographic Models

**Demographic models** are an attempt to represent **demographic** processes in the form of a mathematical function or set of functions relating two or more measurable **demographic** variables.

## Demographic Transition

In demography, **demographic transition** is a phenomenon and theory which refers to the historical shift from high birth rates and high infant death rates in societies with minimal technology, education (especially of women) and economic development, to low birth rates and low death rates in societies with advanced technology, education and economic development, as well as the stages between these two scenarios.

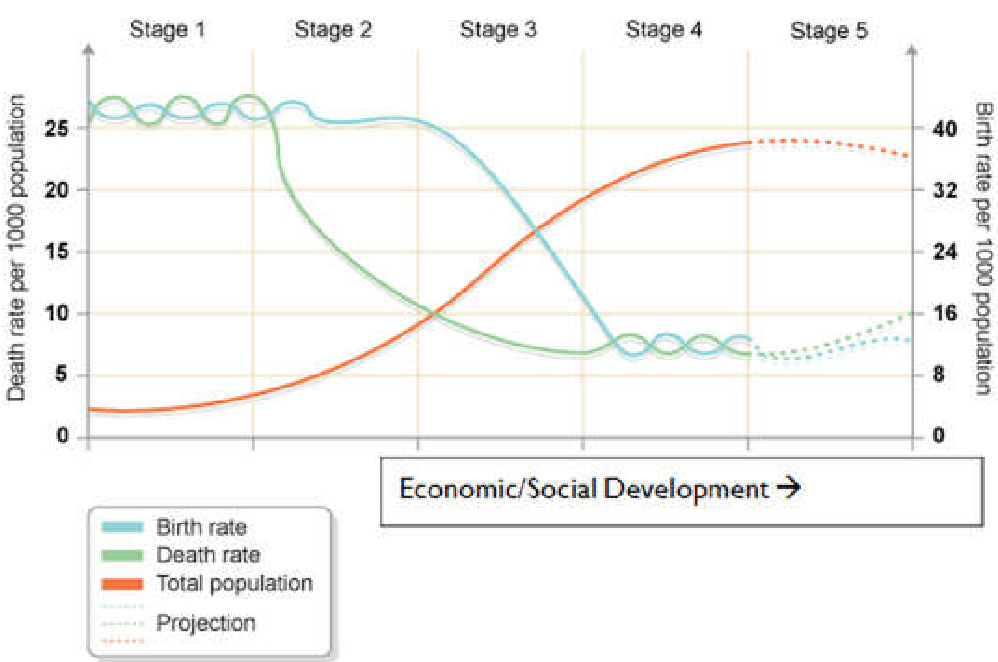
## Demographic Transition Model (DTM)

The **Demographic Transition Model** (DTM) is based on historical population trends of two **demographic** characteristics – birth rate and death rate – to suggest that a country's total population growth rate cycles through stages as that country develops economically.

The "*Demographic Transition*" is a *model* that describes population change over time. It is based on an interpretation begun in 1929 by the American demographer Warren Thompson, of the observed changes, or *transitions*, in birth and death rates in industrialized societies over the past two hundred years or so.

The DTM is a model of population change from a low stable population to a high stable population as a result of a preliminary fall in the death rate from a high level (45/1000 p.a. to around 9/1000 p.a.) to be followed later by a fall in the birth rate. The time-lag between the decline in the two measures of natural population change results in a period when there are far fewer people dying than being born, resulting in a phase of rapid population growth.

The model was developed in the mid 20th century based on repeated observation of similar population growth patterns in countries as their economies developed. Originally identifying 4 stages, a 5th stage was added towards the end of the century, and some demographers suggest there may be a 6th stage. As such it is an evolving model of demographic structure.



**STAGE 1:**

***Death rate:***

Is high (mid 40s/1000 p.a.) due to:

- Poor diet
- Poor sanitation
- Inadequate hygiene
- Lack of medical care

Short life-expectancy

***Birth rate:***

Is high (mid 40s/1000 p.a.) due to:

- High infant mortality
- Lack of contraception
- Children are economic assets (more=better)
- Status value of a large family to fathers

Large families are a social norm

***Total Population***

Total population remains low as births are balanced by deaths so irregular annual 'surpluses' are balanced by irregular annual 'deficits' in years when deaths outnumber births.

**STAGE TWO: (Defined when the DR starts to fall)**

***Death rate:***

Begins to fall due to:

- Improving diet
- Improving living conditions & sanitation
- Advances in hygiene
- Improved medical care

Longer life-expectancy

***Birth rate:***

Remains high

***Total Population***

Total population begins to rise as the frequency of years in which births outnumber deaths increases.

(Note: it is NOT due to 'more births' but to 'fewer deaths' with 'consistent births')

**STAGE THREE (Defined when the BR starts to fall)**

***Death rate:***

Continues to fall

***Birth rate:***

Begins to fall due to:

- More widespread use of reliable contraception
- Children attend school with associated costs
- Increasing status and choice of women
- Increased survival rates of infants

Smaller families become the norm

***Total Population***

Total population rises at its fastest rate at the start of the stage when the surplus of 'births' over 'deaths' is at its maximum. During this phase the rate of increase slows, though the population continues to increase as birth still outnumber deaths.

**STAGE FOUR (Defined when the DR & BR level off)**

***Death rate:***

Levels off around 9/1000 p.a.

***Birth rate:***

Continues to fall with a strong correlation between improving female education and assertiveness and falling fertility.

***Total Population***

The rise in population slows and then levels as birth rate falls to match the existing death rate.

**STAGE FIVE (Defined when the BR slips below the DR)**

***Death rate:***

Death rate increases due to: An ageing population has a higher death rate than a youthful one due to the larger proportion of elderly people reaching the end of their natural lives. There are more elderly people per thousand reaching their extended life expectancy.

***Birth rate:***

Continues to fall with more women choosing a child-free or child-limited lifestyle..

***Total Population***

Total population declines as the death rate of an ageing population rises higher than the still-reducing birth rate.

## Demographic Dividend

Demographic dividend, as defined by the United Nations Population Fund (UNFPA) means, "the economic growth potential that can result from shifts in a population's age structure, mainly when the share of the working-age population (15 to 64) is larger than the non-working-age share of the population (14 and younger, and 65 and older)".[1] In other words, it is "a boost in economic productivity that occurs when there are growing numbers of people in the workforce relative to the number of dependents." UNFPA stated that, "A country with both increasing numbers of young people and declining fertility has the potential to reap a demographic dividend.

Demographic dividend occurs when the proportion of working people in the total population is high because this indicates that more people have the potential to be productive and contribute to growth of the economy.

Due to the dividend between young and old, many argue that there is a great potential for economic gains, which has been termed the "demographic gift".In order for economic growth to occur the younger population must have access to quality education, adequate nutrition and health including access to sexual and reproductive health.

## What is meant by population size?

Population size is simply the number" of units (persons) in the population. **Population size** is the number of individuals in a **population**.

**Population size** (usually denoted *N*) is the number of individual organisms in a population. Population size is directly associated with amount of genetic drift, and is the underlying cause of effects like population bottlenecks and the founder effect. Genetic drift is the major source of decrease of genetic diversity within populations which drives fixation and can potentially lead to speciation events.

**Population size** is the number of individuals in a population. For example, a population ofinsects might consist of 100 individual insects, or many more. Population size influences the chances of a species surviving or going extinct. Generally, very small populations are at greatest risk of extinction. However, the size of a population may be less important than its density.

**Population size**: The total number of people in the group you are trying to study. If you were taking a random sample of people across the U.S., then your **population size** would be about

317 million. Similarly, if you are surveying your company, the **size** of the **population** is the total number of employees.

Four **methods of determining population size** are direct and indirect observations, sampling, and mark-and-recapture studies.

**How do you determine population size?**

**Terms in this set (6)**

1. **Population** Density. The number of individuals in a specific area (pg. ...
2. Direct Observation. The most obvious way to **determine** the **size** of a **population** is to count, one by one.
3. Indirect Observation. ...
4. Mark and Recapture. ...
5. Sampling. ...
6. **Determining Population**.

**Why is it important to know the size of a population?**

Monitoring the **size** and structure of **populations** can also help ecologists manage **populations**—for example, by showing whether conservation efforts are helping an endangered species increase in numbers.

**What total population means?**

**Definition**: For census purposes, the **total population** of the country consists of all persons falling within the scope of the census. In the broadest sense, the **total** may comprise either all usual residents of the country or all persons present in the country at the time of the census.

**Concepts of total population**

In general, however, modern censuses are designed to include the "total population" of an area. This concept is not as simple as may at first appear. There are two ideal types of total population counts, the de facto and the de jure. The former comprises all the people actually present in a given area at a given time. The latter is more ambiguous. It comprises all the people who "belong" to a given' area at a given time by virtue of legal residence, usual residence, or some similar criterion.

In practice, modern censuses call for one of these ideal types with specified modifications, and it is difficult to avoid some mixture of the two approaches.

**What is a Census**?

The United Nations defines a population **census** as the total process of collecting, compiling, and publishing demographic, economic, and social data pertaining to a specific time to all persons in a country or delimited part of a country.

**How is census conducted?**

**Census** data is **taken** by visiting each and every household and gathering particulars by asking questions and filling up **census** forms. The information collected during the process is confidential. In fact, this information is not even accessible to the courts of law.

**What are types of census?**

With that in mind, there are 2 main types of census, namely:

- De facto Population **Census**.
- De jure Population **Census**.

**What is the main purpose of the census?**

A **census** aims to count the entire population of a country, and at the location where each person usually lives. The **census** asks questions of people in homes and group living situations, including how many people live or stay in each home, and the sex, age and race of each person.

**What is the difference between de jure census and de facto census?**

A "**de jure**" **census** tallies people according to their regular or legal residence, whereas a "**de facto**" **census** allocates them to the place where enumerated—normally where they spend the night of the day enumerated. By either method, the reported territorial distribution is according to where people…

**Total number of population censuses conducted in Bangladesh**

First population and housing census was conducted in Bangladesh in 1974
Second population and housing census was conducted in Bangladesh in 1981
Third population and housing census was conducted in Bangladesh in 1991
Fourth population and housing census was conducted in Bangladesh in 2001
Fifth population and housing census was conducted in Bangladesh in 2011.

### Population Density

**Population density** is the average number of individuals in a population per unit of area or volume. For example, a population of 100 insects that live in an area of 100 square meters has a density of 1 insect per square meter. If the same population lives in an area of only 1 square meter, what is its density? Which population is more crowded? How might crowding affect the health of a population?

## Population Distribution

The arrangement or spread of people living in a given area; also, how the population of an area is arranged according to variables such as age, race, or sex.

The arrangement of population geographically as it is spread over a defined area such as community, district, capital city, country, region, etc. ...

Population density just represents the average number of individuals per unit of area or volume. Often, individuals in a population are not spread out evenly. Instead, they may live in clumps or some other pattern. The pattern may reflect characteristics of the species or its environment.

**Population distribution** describes how the individuals are distributed, or spread throughout their habitat.

Population distribution refers to the arrangement of the population in space at a given time, that is, geographically or among various types of residential areas.

### Population structure/Population Pyramid

Structure, in its narrowest sense, is the distribution of the population among its sex and age groupings.

### Population Pyramid

A **population pyramid**, also called **age-sex pyramid** and **age structure diagram**, is a graphical illustration that shows the distribution of various age groups in a population (typically that of a country or region of the world), which normally forms the shape of a pyramid.

It typically consists of two back-to-back bar graphs, with the population plotted on the X-axis and age on the Y-axis, one showing the number of males and one showing females in a particular population in five-year age groups (also called cohorts). Males are conventionally shown on the left and females on the right, and they may be measured by raw number or as a percentage of the total population.

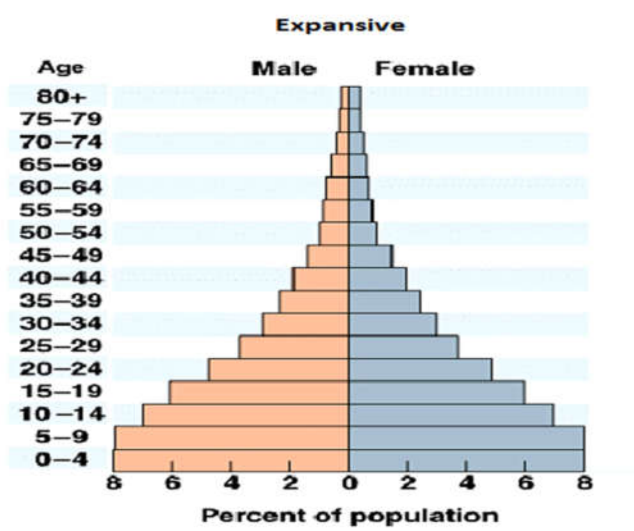
A great deal of information about the population broken down by age and sex can be read from a population pyramid, and this can shed light on the extent of development and other aspects of the population. A population pyramid also tells the council how many people of each age range live in the area. There tends to be more females than males in the older age groups, due to females' longer life expectancy.

A **population pyramid**, also called an **age pyramid** or **age** picture is a graphical illustration that shows the distribution of various **age** groups in a **population** (typically that of a country or region of the world), which forms the shape of a **pyramid** when the **population** is growing.

**Types of Population Pyramid**

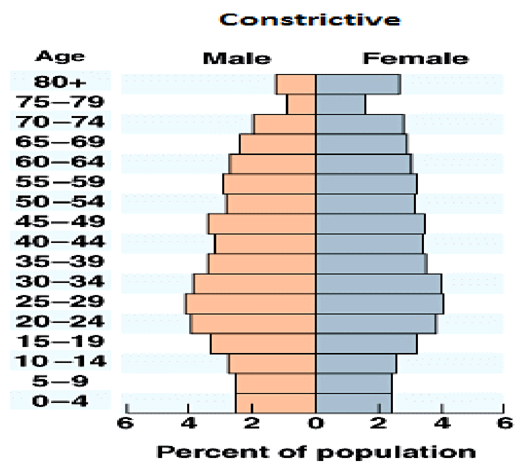
There are **three types of population pyramids**: expansive, constrictive, and stationary. Expansive **population pyramids** depict **populations** that have a larger percentage of people in younger age groups. **Populations** with this shape usually have high fertility rates with lower life expectancies.

**The Three Basic Shapes of Population Pyramids**



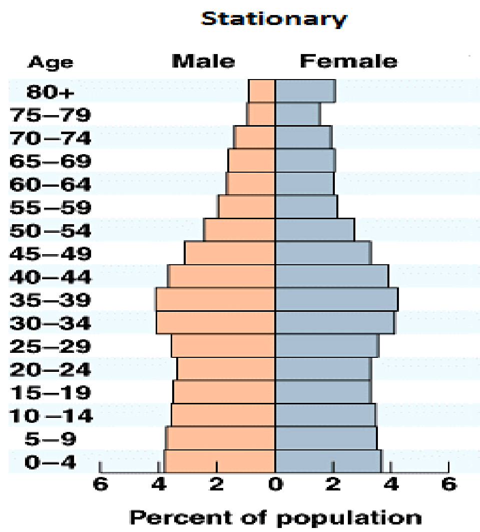
**Expansive**

Expansive population pyramids are used to describe populations that are young and growing. They are often characterized by their typical 'pyramid' shape, which has a broad base and narrow top. Expansive population pyramids show a larger percentage of the population in the younger age cohorts, usually with each age cohort smaller in size than the one below it. These types of populations are typically representative of developing nations, whose populations often have high fertility rates and lower than average life expectancies.




**Constrictive**

Constrictive population pyramids are used to describe populations that are elderly and shrinking. Constrictive pyramids can often look like beehives and typically have an inverted shape with the graph tapering in at the bottom. Constrictive pyramids have smaller percentages of people in the younger age cohorts and are typically characteristic of countries with higher levels of social and economic development, where access to quality education and health care is available to a large portion of the population.




**Stationary**

Stationary, or near stationary, population pyramids are used to describe populations that are not growing. They are characterized by their rectangular shape, displaying somewhat equal percentages across age cohorts that taper off toward the top. These pyramids are often characteristic of developed nations, where birth rates are low and overall quality of life is high.

EXPANSIVE population pyramids show larger numbers or percentages of the population in the younger age groups. These types of pyramids are usually found in populations with very large fertility rates and lower than average life expectancies. The age-sex distributions of many Third World countries would probably display expansive population pyramids.

CONSTRICTIVE population pyramids display lower numbers or percentages of younger people. The age-sex distributions of the United States fall into this type of pyramid.

STATIONARY or near-stationary population pyramids display somewhat equal numbers or percentages for almost all age groups. Of course, smaller figures are still to be expected at the oldest age groups. The age-sex distributions of some European countries, especially Scandinavian ones, will tend to fall into this category.

## Population Composition

**Population composition** is the description of the characteristics of a group of people in terms of factors such as their age, sex, marital status, education, occupation, and relationship to the head of household. Of these, the age and sex **composition** of any **population** are most widely used.

## Population change

Change is the growth or decline of the total population or of one of its structural units. The components of change in total population are births, deaths, and migrations.

## Components of change

The components of change in total population are births, deaths, and migrations. In analyzing change in structure, however, we have to include the transition from one group to another. In the case of age, this is expressed as a simple function of time.

## Usual residence in population census

The technical **definition of usual residence** refers to the address at which a person lives or intends to live for six months or more. ... In 2016, under the new enumeration method, **usual** address information was no longer collected during the non-private dwelling enumeration process.

The general principle is, "usual place of residence is, ordinarily, the place a person regards as his home. As a rule, it will be the place where he usually sleeps." The first two paragraphs defined the census date (12:01 a.m. on April 1), specified that babies born after that time should be omitted, whereas persons dying after that time should be included, and stated that persons moving in after April 1 for permanent residence should be enumerated unless they had already been enumerated in the enumeration district (ED) whence they came. Members of the household temporarily absent on vacation, visiting, on business, or in a general hospital were to have been counted, as were boarders or lodgers who usually slept in the housing unit.

Each person has one and only one place of usual residence, defined as the place where the person lives at the time of the census and has been there for some time and intends to stay there for some time. A threshold (দ্বার, সীমা) of 12 months is recommended in applying the usual residence definition and 2 alternative criteria are provided for implementing this threshold: either, the place at which the person has lived continuously for most of the last 12 months (not including temporary absences) or intends to live for at least 6 months; or, the place at which the person has lived for at least the last 12 months (not including temporary absences) or intends to live for at least 12 months.

**Time reference in population census**

A **reference period** is the time **period** for which statistical results are collected or calculated and to which, as a result, these values **refer**. ... Some data, like **population** variables, relate to one specific time, a **reference** time point (e.g. a specific day, **population** on the 1st of January).

As noted by the United Nations, one of the essential featuresof a population census is simultaneity (একযোগে). A national census shouldnot be taken by a crew of enumerators that moves from onedistrict to another as it completes its work; nor, in general,should the enumeration begin on different dates in differentparts of the country. Occasionally, however, exceptionalstarting dates may be justified by such considerations as grossvariations in climate or the annual dispersal (ছত্রভঙ্গ) of nomads (যাযাবর) toisolated grazing (চারণ) grounds. The census of Alaska was conductedas of October 1, 1929 and 1939, when that of conterminous (বিতর্কিত)United States was taken as of the following April 1. Theobject was to avoid canvassing in Alaska during the springthaw (গলা, গলান).

**Completeness of coverage**

As has been brought out already, countries exclude from their censuses certain relatively small classes of population on the basis of the type of census being taken — de jure, de facto, or some modification of one of these. Other exclusions are on ground of feasibility —cost, danger to census personnel, or considerations of national security. Finally, some persons will inadvertently (অসাবধানতাবসত) be omitted from the population as defined and others will be counted twice. Omissions by design then will be discussed separately from the net underenumeration(or overenumeration) that always occurs to some extent in counting a sizeable population.

**Deliberate (ইচ্ছাকৃত) Exclusion of Territory or Group**

It is not unusual for various population subgroups to be excluded from a census for one reason or another. In some countries, for example, either the indigenous or nonindigenous populationmay be omitted from the census count, or the two may be enumerated at different times. Some examples are as follows:

| | Census | |
|---|---|---|
| Country | Date | Exclusion |
| Madagascar ... | 1956 | Africans |
| Malawi ... | 1961 | Africans not employed in European money economy |
| Mauritania ... | 1956 | Africans |
| Zambia ... | 1963 | Non-Africans (enumerated in 1961) |
| Southern Rhodesia... | 1962 | Non-Africans (enumerated in 1961) |
| New Guinea (Australian | 1961 | Indigenous population |

| | | |
|---|---|---|
| Trust Territory) ... | | |
| Papua ... | 1961 | Indigenous population |
| New Hebrides ... | 1957 | Indigenous population |

In addition to tribal jungle areas, censuses may omit parts of the country that are under the control of alien (বিদেশী) enemies or of insurgents. These are essentially temporary arrangements and rarely occur in practice because the usual action is to postpone the entire census.

Attempts have also been made to estimate the population of the excluded territory or groups, and the more credible estimates are cited in the U.N. Demographic Yearbooks. The sources vary from sample surveys, projections from past counts, reports of tribal or village chiefs, and aerial photographs, down to guesses by officials, missionaries, or explorers.

**Unintentional Exclusions—Underenumeration**

In many countries the public probably has an exaggerated (ক্ষতিকারক)notion (ধারণা) of the accuracy of the census count. As Deming has pointed out, it also has an exaggerated notion of the accuracy needed.This is not to say that, for most countries, there is not now a need to improve the accuracy of the census count and of the postcensal estimates of total population. Even in the countries of Northwestern Europe with a long history of census taking and registration, occasional measures of accuracy are desirable even though there may be considerable confidence that coverage errors are minimal.

The more sophisticated users of census data have long been aware that even the size of the population of a given area is not exact to the last person. The reader who has followed this discussion of the definition of population size will appreciate some of the uncertainties and the opportunities for omission or duplication. Some familiarity with field surveys will confirm the fact that it is not possible to make the count for a fair-sized area with absolute accuracy.

According to Hauser and Duncan, "The degree of accuracy required in data is a relative thing and a function of the use to which the data are put." Truesdell, Mauldin, and Depoidhave also discussed this issue.
Although there is some danger of duplicate counting and there have been historical instances of deliberate padding (সংযুক্ত করা, adding/repetitive), the major danger is that of underenumeration. Most measures of the accuracy of census totals have been confined to net rather than to gross error. When we consider that a person may be counted but listed at, or allocated to, the incorrect geographic subdivision, the magnitude of gross errors assumes more importance.

Attempts to measure the accuracy of census counts are a relatively modern development. For a long time, indeed, most census officials were smug (স্মার্ট, ফিটফাট) and defensive about the official figures on population size. As statisticians acquired experience through scientific sample surveys of households, they realized that many of the types of errors encountered there would also occur in a "complete" census.

**Sources of Error in figure on Population Size**

The sources or types of errors in figures on population size can be classified from several different standpoints. First, we may distinguish population size as given by universal population registers, censuses, sample surveys, and "independent" estimates. Next, within each of these major sources, we can examine the nature and causes of error.

**In population registers.** — Here there are, to begin with, errors in the register from failures to report births, deaths, and changes of residence or failure to record these events properly even when they are reported. Then, when counts are made for a specific date, there may be processing errorsarising from the personnel or the machines. The accuracy ofthe register may be checked against a census count, which is itself an imperfect standard. Errors are also reflected in "books of the missing" that are maintained in Sweden and other countries—lists of registered persons who can no longer be located. Having many persons remain in the register past the age of 100 would indicate failures to remove many decedents (বিচ্ছিন্ন) and emigrants. Errors of omission in the civil register in South Korea are apparent when many children try to enter school for the first time, and there is no record of them in the register.

**In population censuses.** — Here the errors may be attributable to the design of the census (lack of simultaneity, inadequate instructions, missing or erroneous maps), the field operations (enumerators, field office editors, etc.) the respondents, loss of schedules in shipment, central office operations, tabulation equipment, right down to the typing and printing of the final tables.Errors are sometimes deliberate, but more often they arise from carelessness, lack of understanding of the procedures, or lack of knowledge of the facts. It has also been found helpful in measuring faulty omissions or faulty inclusions to distinguish omission (or duplication, etc.) of entire households from omission (or erroneous inclusion) of persons within properly included households. The section on "Methods of Evaluating Census Coverage" and the references cited in that section, go into some of these types of error in more detail. See also the more general discussion of sources of error on pages 185 to 197 of Depoid's article and in Zarkovich's book.

**In sample surveys.** — Population size as measured in national sample surveys or samples of the population of particular areas is affected by all the kinds of errors to which censuses are subject and in addition, to sampling error and sampling bias. The nature and measurement of sampling errors are the subject of a very extensive literature. A brief list is given below.

Where there are relatively accurate postcensals independent estimates of population, the sample survey results may be inflated (স্ফীত) to these population controls, rather than being simply inflated by the sampling ratio or ratios. In this case, the total population will not be subject to sampling error, although it will be affected by errors in the last census total and in the postcensal components of change. This step leads us to the next subsection.

**In independent population estimates.** — The types and methods of construction of population estimates are described in detail in later chapters of this book. What needs to be noted here, however, is that errors in all the base data from which population estimates are derived contribute to errors in the resulting estimates.

**Methods of Evaluating Census Coverage.** — Let us concentrate now on the accuracy of published figures on population size in complete censuses, since these are the most important and have been the object of most of the research. Most measures are of national totals; relatively few are available for geographic subdivisions. Although the present discussion concentrates mainly on the accuracy of the total count and not on that of population subgroups or characteristics, some ofthe most effective methods of measurement require the use of statistics by age and sex.

A number of publications classify the methods that have been used.The present classification focuses more narrowly on the accuracy of census figures on population size. We will discuss:

(1) Reenumeration
(2) Comparison of successive censuses
(3) Internal consistency within a single census
(4) Check against independent aggregates
    (a) Universal population register
    (b) Partial register
(5) Matching against individual records
    (a) Successive censuses
    (b) Periodic sample survey
    (c) Independent records
(6) Postenumeration sample survey
(7) Combinations of these

**Reenumeration.** — A complete repetition of the canvass does yield two-counts that can be compared, but a national reenumeration would never be undertaken unless the government were convinced that the first count was unacceptable. Hence, it would not ordinarily be made public. The 1937 census of the U.S.S.R. was rejected, and a new census was taken in 1939. Also, the 1962 census of Nigeria was declared invalid and repeated in 1963. Political as well as statistical factors were involved in both cases, however.

Some partial reenumerations have been conducted in American censuses, usually before final certification but occasionally after the final census figures had been published. In such comparisons, allowance should be made for the lapse of time between the two counts.

**Comparison of successive censuses.** — The relative completeness of two censuses is frequently estimated by starting with the first count, computing the expected population at the second date, and comparing it with the second count. The expected population is computed by some variety of the inflow-outflow method (or the "balancing equation," as it is often called). Here it is necessary to measure or estimate the intercensal population change; and the accuracy of the measure of relative completeness obviously depends upon the accuracy of the measure of change.

Some ways of computing the expected population are the following:

(1) Adding births, subtracting deaths, adding immigrants, and subtracting emigrants.
(2) Estimating the survivors by applying life-table survival rates to the population at the first census, distributed by age and sex, and taking account of registered or estimated births and net immigration.
(3) An iterative method that requires age-sex distributions for two or more censuses and previous estimates of net enumeration error for some age groups (say of children from birth statistics).In practice, survivors of recent births have also been employed in this method. There is a basic hypothesis that the pattern of net undercounts or overcounts by age and sex is similar from one census to the next.
(4) A method of reconstructing births from age statistics in a series of censuses, establishing a "true" series of births,and then reconstructing the census populations.
(5) An evaluation of the intercensal growth rate for reasonableness.

**Internal consistency within a single census.**— Various testsare used to examine the reported age-sex structure. In some of these tests, it is necessary to assume that fertility and mortality rates have long been constant. Relative net undercounts inparticular age-sex groups can then be inferred. Characterizations of the accuracy of the size of the total population is mostly qualitative, although estimated gross deficits in particular groups (young children, males of military age, etc.)may be also imputed to some extent to the total population.This approach may involve applications of stable, or quasistable, population theory.

**Check against independent aggregates.** — Although, as has been stated, censuses are often used for periodic updating of universal population registers, there have been occasions when population size as given in the register has been used to measure the accuracy of the census count. For example, the 1960 census of Aruba in the Netherlands Antilles was stated to be about 4 percent too low in comparison with the population register.

**Matching against individual records.-**One advantage of this and the following method is that they yield measures of gross differences (erroneous omissions and inclusions) rather than of net differences only. Moreover, the matching of names from the census against those in another file can be used to generate a list of names that is more complete than either source taken alone.

A sample of names from the preceding census may be checked against the names of the census being investigated. This procedure was part of the coverage check for the 1960 Census of Population in the United States.34 One of the great difficulties in this procedure is the tracing of movers over a period of years. Furthermore, since names may be changed or inconsistently reported and since more than one person may have the same name, there are often uncertainties as to whether a pair of names has been matched. Rules have to be set up to define a match and a probable match. An unmatched person is not necessarily a missed person. The 1960 census report just referred to contains several different estimates of net underenumeration based on alternative assumptions.

**Postenumeration sample surveys.** — In general, these checks involve (1) reenumerating designated sample segments or enumeration districts and (2) reenumerating the persons in a sample of previoiusly enumerated households.

**Comparisons of successive censuses**. — Estimates of relative completeness of enumeration based on the comparison of successive censuses are one of the ways.

## Population Growth

### Population Growth

**Population growth** is the increase in the number of individuals in a population.

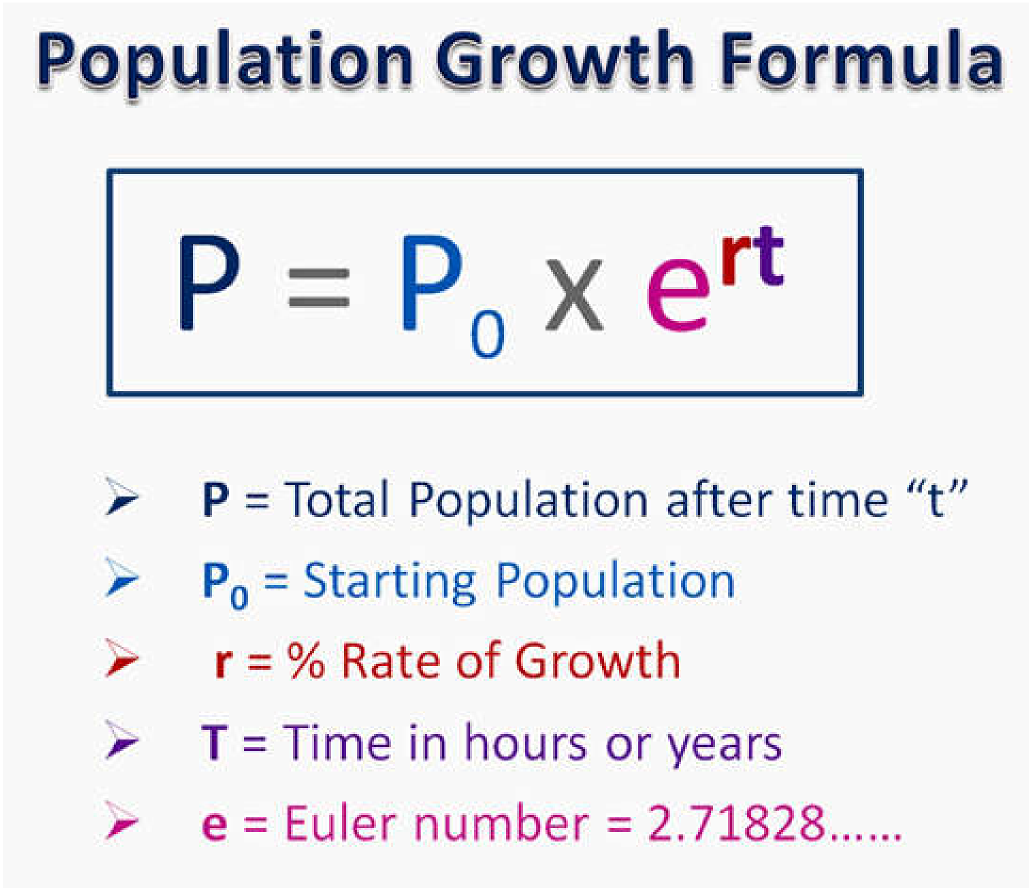
### What is population growth explain it?

**Population growth** refers to change in the size of a **population**—which can be positive or negative—over time, depending on the balance of births and deaths. ... Relative **growth** is usually expressed as a rate or a percentage; for example, in 2000 the rate of global **population growth** was 1.4 percent (or 14 per 1,000).

### How do we measure population growth?

Net reproductive rate (r) is calculated as: r = (births-deaths)/**population** size or to get in percentage terms, just multiply by 100. the**population** is so much bigger, many more individuals are added. If a **population** grows by a constant percentage per year, this eventually adds up to what we call exponential **growth**.

Population growth means an increase in the number of people that reside in a country, state, county, or city. To determine whether there has been population growth, the following formula is used: (birth rate + immigration) - (death rate + emigration).




**The Net Reproductive Rate**

The net reproductive rate (r) is the percentage growth after accounting for births and deaths. In the example above, the population reproductive rate is 0.5%/yr.

Net reproductive rate (r) is calculated as: r = (births-deaths)/population size or to get in percentage terms, just multiply by 100.

Suppose we came back many years later, the net reproductive rate was still the same, but now the population had grown to 1,000,000. How many new individuals would be added each year now? Simply multiply the population by the reproductive rate:

1,000,000 x 0.05 (which is 0.5%) = 50,000

This means that now 50,000 new individuals are added in one year!! The net reproductive rate is the same as before, but because the population is so much bigger, many more individuals are added.

**Change in Population**

Think about the town where you live. How long have you lived there? Do you know how much that town has grown since you've been there? If you determine the overall amount the population has changed in the entire time you've been there, this only tells you the change in population size. However, this doesn't really help you think about annual growth or predict future growth for your town. To do this, you need to know the population growth rate.

The **population growth rate** expresses the change in population size as a factor of time. Typically, both for human and non-human populations, we want to know the average annual growth rate. This gives us more information than stating the exact population growth for the entire time period, and allows us to better predict future years of growth or decline for the population.

## What are the components of population growth?

## Components of population growth

$$P_t = P_0 + (B - D) + (I - E)$$

$P_t$= Population at time *t*
$P_0$= Population at time *0*
$B - D$ =**Natural increase**(Births – Deaths)
$I - E$ =**Net migration** (Immigration – Emigration) ;( arrivals – departures)

**Formula for Population Change**

The standard formula for calculating growth rate is:

*Gr*= *N* / *t*

Here, *Gr* is the growth rate expressed as a number of individuals. *N* is the total change in population size for the entire time period, also expressed as a number of individuals. *t* is time, usually expressed in number of years. Of course, for really quickly growing populations, it might also be expressed in months or some other unit of time. The formula is calculated the same way regardless of the unit of time used.

In order to calculate the overall growth rate, you first have to figure out *N*. This is done by subtracting the initial population (or P1) from the current population, or the population at the end of the time period you are using (or P2). Therefore:

*N*= P2 - P1

Now, let's take a look at few examples that put this formula into practice.

**Example One**

You are looking into the history of your town, and you'd like to know exactly how much the population has grown since 1980. Town records have kept track of the overall population each year. The current population for 2017 is 300,000 people. Back in 1980, the population was only 150,000 people.

First, you need to determine *N*, the overall change in population size since 1980:

*N*= 300,000 - 150,000

So, the total change in population size since 1980 is 150,000 people.

Next, you need to determine the number of years by subtracting the end year from the start year:

2017 - 1980 = 37

So, t=37

*Gr= 150,000/ 37*

**Natural increase** and **population growth**

N**atural increase** is the difference between the numbers **of** births and deaths in a **population**; the **rate of natural increase** is the difference between the birthrate and the death **rate**.

**Measuring Population Change**

• If past trends in population growth can be expressed in a mathematical model, there would be a solid justification for making projections on the basis of that model.
• Demographers developed an array of models to measure population growth; four of these models are usually utilized.

¬*Arithmetic (Linear),*
¬*Geometric,*
¬*Exponential, and*
¬*Logistic.*

**What is population growth rate?**

The "**population growth rate**" is the **rate** at which the number of individuals in a**population** increases in a given time period, expressed as a fraction of the initial **population**.

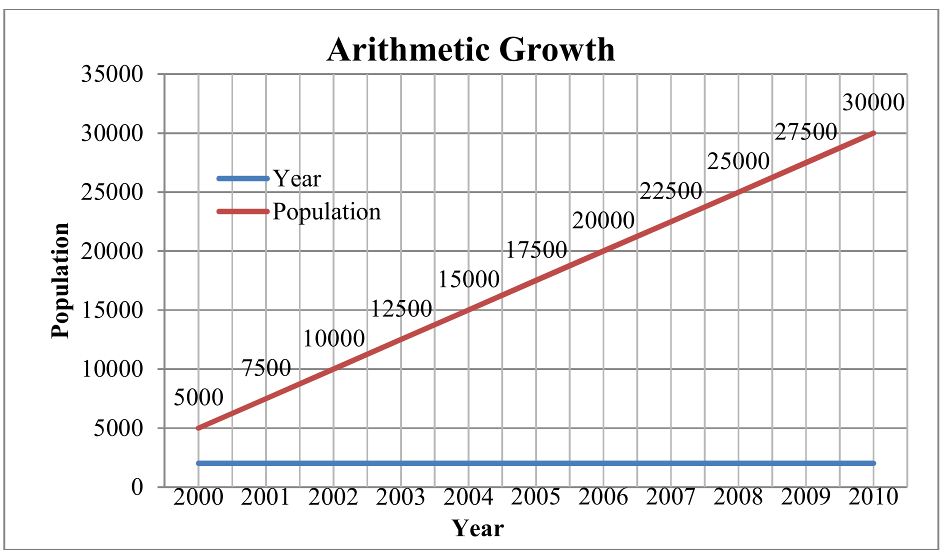
**What is arithmetic population growth?**

**Arithmetic growth** refers to the situation where a **population** increases by a constant number of persons (or other objects) in each period being analysed. It is a type of **growth in** which the **rate** of **growth** is constant and **increase in growth** occurs **in arithmetic** progression 2, 4, 6, 8, 10, 12. ...

**Arithmetic Change/Arithmetic Growth**

• A population growing arithmetically would increase by a constant number of people in each period.
• If a population of 5000 grows by 100 annually, its size over successive years will be: 5100, 5200, 5300, . . .
• Hence, the growth rate can be calculated by the following formula:
• (100/5000 = 0.02 or 2 per cent).
• Arithmetic growth is the same as the 'simple interest', whereby interest is paid only on the initial sum deposited, the principal, rather than on accumulating savings.
• Five percent simple interest on $100 merely returns a constant $5 interest every year.
• Hence, arithmetic change produces a linear trend in population growth – following a straight line rather than a curve.

**Arithmetic Growth**




The arithmetic growth rate is expressed by the following equation:

$$r = \left(\frac{P_t - P_0}{t}\right) \div P_0 \times 100$$

where $P_0$ means population at the start, e.g. year zero

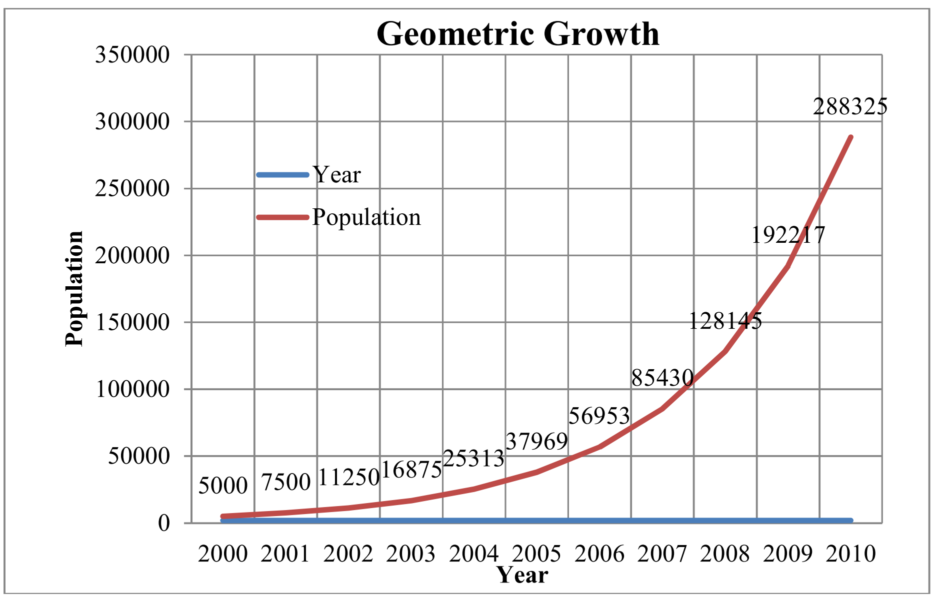
$P_t$ means population at the end, e.g. after $t$ years

$t$ means number of intervals (e.g. years) between $P_0$ and $P_t$.

**Geometric Change/ Geometric Growth**

• Geometric population growth is the same as the growth of a bank balance receiving compound interest.
• According to this, the interest is calculated each year with reference to the *principal plus previous interest payments*, thereby yielding a far greater return over time than simple interest.
• The geometric growth rate in demography is calculated using the 'compound interest formula'.
• Under arithmetic growth, successive population totals differ from one another by a constant amount.
• Under geometric growth they differ by a constant ratio.
• In other words, the population totals for successive years form a geometric progression in which the ratio of adjacent totals remains constant.
• However, in reality population change may occur almost continuously – not just at yearly intervals.
• Recognition of this led to a focus on exponential growth, which more accurately describes the continuous and cumulative nature of population growth.

**Geometric Growth**




• A geometric series is one in which the population increases or decreases at the same rate during each unit of time, usually a year.
• If this constant rate of change is represented by *r* and the initial population is represented by $P_0$, then after *t* years the final population is given by the following equation:

$$P_t = P_0(1 + r)^r$$

where $P_0$ means population at the start, e.g. year zero
$P_t$ means population at the end, e.g. after $t$ years
$r$ means annual growth rate.

Geometric growth rate is expressed by the following equation:

$$r = \sqrt[t]{\frac{P_t}{P_0}} - 1$$

or

$$\log(1+r) = \frac{\log(\frac{P_t}{P_0})}{t}$$

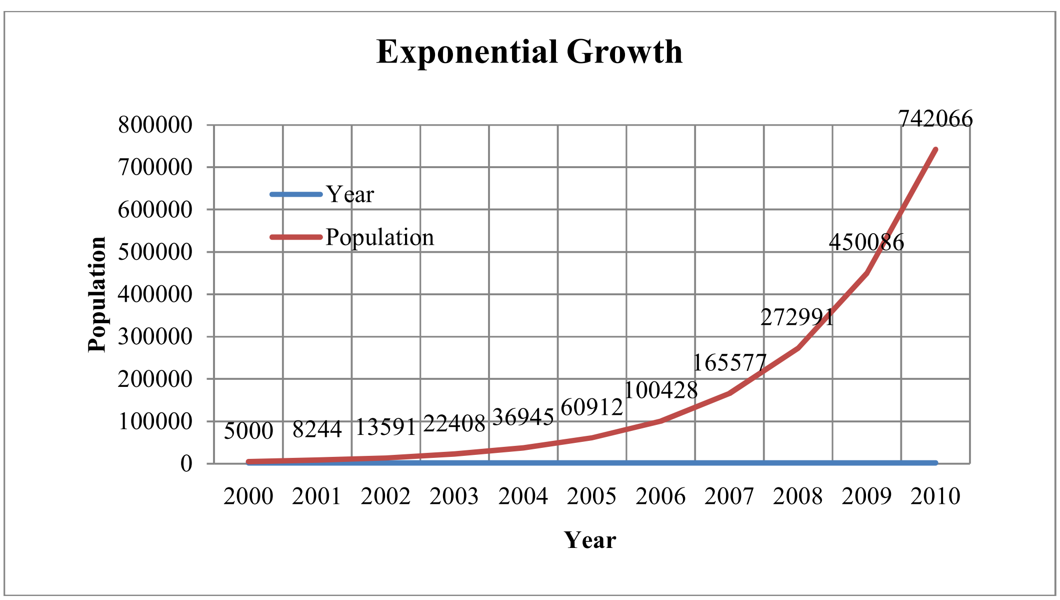
**Doubling Time for Geometric Growth**

$$t = \frac{log2}{log(1+r)}$$

**Exponential Change/ExponentialGrowth**

• Exponential growth refers to the situation where growth compounds continuously – at every instant of time.
• Accordingly, it is sometimes called "instantaneous growth."
• In fact, geometric growth can be regarded as a special case of exponential growth, because population growth according to this model occurs at intervals much longer than an instant.
• The shorter the interval over which increments occur, the faster the population increases – just as the balance in a bank account with daily interest rate grows more quickly than one with yearly interest.

**ExponentialGrowth**



• The exponential change can be expressed by the following equation:

$$P_t = P_0 e^{rt}$$

where $P_0$ means population at the start, e.g. year zero
$P_t$ means population at the end, e.g. after $t$ years
$r$ means annual growth rate
$ln$ means natural logarithm.
$e$ is a constant (2.718280.

• Hence, the annual exponential growth rate can be derived from the equation above as follows:

$$e^{rt} = \frac{P_t}{P_0}$$

• Then,

$$r = \frac{ln\left(\frac{P_t}{P_0}\right)}{t}$$

• **Example:** • If the population of Egypt increased from 48 million in 1986 to 60 million in 1996, calculate the annual growth rate in the intercensal period using the exponential growth rate.

• Calculate the growth rate using the geometric method and compare the results.

**Doubling Time for Exponential Growth**

• It is often of interest to know the time required for a population to double in size if a given annual rate of increase were to continue.
• This interest reflects the problems confronting many rapidly growing countries, especially the economically underdeveloped ones.
• For this purpose, we must return to the equation of the exponential growth: $P_t = P_0 e^{rt}$.
• where $t$ is the length of the interval in years and $P_t$ is the population at the end of the interval.

• We want to find the number of years it will take for $P_t$ to equal $2P_0$. $2P_0 = P_0 e^{rt}$
• In this equation, we know the values of $P_0$: and $r$, so that the missing value is time $t$ for
$2 = e^{rt}$
$ln2 = rt$
$t = \frac{ln2}{r}$

**Example:**

• If the annual growth rate of the population of Cuba between 2005 and 2010 was 1.35%, calculate the time required for the Cuban population to double.

$$t = \frac{0.693417}{0.0135}$$
$t = 51.4$years.

• Doubling time cannot be used to project future population size, because it assumes a constant growth over decades, whereas growth rates change.
• Nonetheless, calculating doubling time helps sketch how fast a population is growing at the present time.

• **Assignments**:

• Calculate the rate of population change in your country or a country of your choice between the last two censuses using the geometric and exponential growth rates
• Calculate the doubling time of the population.
• Comment on the results.

## Logistic Change/Logistic Growth

• **Logistic** population **growth** occurs when the **growth** rate decreases as the population reaches carrying capacity. Carrying capacity is the maximum number of individuals in a population that the environment can support. ... When the population approaches carrying capacity, its **growth** rate will start to slow.
• Recognition that populations *cannot* grow indefinitely has led to interest in other mathematical approaches to representing population growth and defining its upper limit.
• One of the best known is the logistic curve.
• The model assumes an upper limit to thenumber of population a country or a region can maintain.
• Fitting a logistic model for population growth requires more data than just population trends in the past.

A **logistic function** or **logistic curve** is a common S-shaped curve (sigmoid curve) with equation

$$f(x) = \frac{L}{1+e^{-k(x-x_0)}}$$

where

$x_0$= the $x$ value of the sigmoid's midpoint,
$L$ = the curve's maximum value,
$k$ = the logistic growth rate or steepness of the curve.

For values of $x$ in the domain of real numbers from $-\infty$ to $+\infty$, the S-curve shown on the right is obtained, with the graph of $f$ approaching $L$ as $x$ approaches $+\infty$and approaching zero as $x$ approaches$-\infty$ .

## World population growth through history

| World population | When? | How long? |
|---|---|---|
| 1 billion | 1800 | All of human history |
| 2 billion | 1930 | 130 years |
| 3 billion | 1960 | 30 years |
| 4 billion | 1975 | 15 years |
| 5 billion | 1987 | 12 years |
| 6 billion | 1999 | 12 years |
| 7 billion | 2013 | 14 years |
| … | … | … |

*Source*: McFalls 2007: 25

# How has world population growth changed over time?

### World population from 10,000 BC to today

The chart shows the increasing number of people living on our planet over the last 12,000 years. A mind-boggling change: The world population today that is 1,860-times the size of what it was 12 millennia ago when the world population was around 4 million – half of the current population of London.

What is striking about this chart is of course that almost all of this growth happened just very recently. Historical demographers estimate that around the year 1800 the world population was only around 1 billion people. This implies that on average the population grew very slowly over this long time from 10,000 BCE to 1700 (by 0.04% annually). After 1800 this changed fundamentally: The world population was around 1 billion in the year 1800 and increased 7-fold since then.

Around 108 billion people have ever lived on our planet. This means that today's population size makes up 6.5% of the total number of people ever born.[2]

For the long period from the appearance of modern Homo sapiens up to the starting point of this chart in 10,000 BCE it is estimated that the total world population was often well under one million.[3]

In this period our species was often seriously threatened by extinction.[4]

### *How has the world population growth rate changed?*

In terms of recent developments, the data from the UN Population Division provides consistent and comparable estimates (and projections) within and across countries and time, over the last century. This data starts from estimates for 1950, and is updated periodically to reflect changes in fertility, mortality and international migration.

In the section above we looked at the absolute change in the global population over time. But what about the *rate* of population growth?

**The global population growth rate peaked long ago**. The chart shows that global population growth reached a peak in 1962 and 1963 with an annual growth rate of 2.2%; but since then, world population growth has halved.

For the last half-century we have lived in a world in which the population growth rate has been declining. The UN projects that this decline will continue in the coming decades.

A common question we're asked is: i**s the global population growing exponentially**? The answer is no. For population growth to be exponential, the growth *rate* would have be the same over time (e.g. 2% growth every year). In absolute terms, this would result in an exponential increase in the number of people. That's because we'd be multiplying an ever-larger number of people by the same 2%. 2% of the population this year would be larger than 2% last year, and so on; this means the population would grow exponentially.

But, as we see in this chart, since the 1960s the growth rate has been falling. This means the world population is not growing exponentially – for decades now, growth has been more similar to a linear trend.

***The absolute annual change of the population***

The previous section looked at the growth *rate*. This visualization here shows the annual global population increase from 1950 to today and the projection until the end of this century.

The absolute increase of the population per year has peaked in the late 1980s at over 90 million additional people each year. But it stayed high until recently. From now on the UN expects the annual increase to decline by around 1 million every year.

***How long did it take for the world population to double?***

The visualization shows how strongly the growth rate of the world population changed over time. In the past the population grew slowly: it took nearly seven centuries for the population to double from 0.25 billion (in the early 9th century) to 0.5 billion in the middle of the 16th century. As the growth rate slowly climbed, the population doubling time fell but remained in the order of centuries into the first half of the 20th century. Things sped up considerably in the middle of the 20th century.

The fastest doubling of the world population happened between 1950 and 1987: a doubling from 2.5 to 5 billion people in *just 37 years* — the population doubled within a little more than one generation. This period was marked by a peak population growth of 2.1% in 1962.

Since then, population growth has been slowing, and along with it the doubling time. In this visualisation we have used the UN projections to show how the doubling time is projected to change until the end of this century. By 2100, it will once again have taken approximately 100 years for the population to double to a predicted 10.8 billion.

**Population growth by world region**

Two hundred years ago the world population was just over one billion. Since then the number of people on the planet grew more than 7-fold to 7.7 billion in 2019. How is the world population distributed across regions and how did it change over this period of rapid global growth?

In this visualization we see historical population estimates by region from 1820 through to today. These estimates are published by the History Database of the Global Environment (HYDE) and the United Nations Population Division from 1950 onwards.

Most people always lived in Asia: Today it is 60% two hundred years ago it was 68%. If you want to see the relative distribution across the world regions in more detail you can switch to the relative view.

The world region that saw the fastest population growth over last two centuries was North America. The population grew 31-fold. Latin America saw the second largest increase (28-fold). Over the same period the population Europe of increased 3-fold, in Africa 14-fold, and in Asia 6-fold.

The distribution of the world population is expected to change significantly over the 21st century.

# Population growth by country

**What are the most populous countries in the world?**

Over the last century, the world has seen rapid population growth. But how are populations distributed across the world? Which countries have the most people?

In the map we see the estimated population of each country in 2019. To see how this has changed since 1800, you can use the ‘play’ button and timeline in the bottom-left of the chart. By clicking on any country you can also see how its population has evolved over this period.

Here we see that the top five most populous countries are:

(1) China (1.42 billion)

(2) India (1.37 billion)

(3) United States (329 million)

(4) Indonesia (269 million)

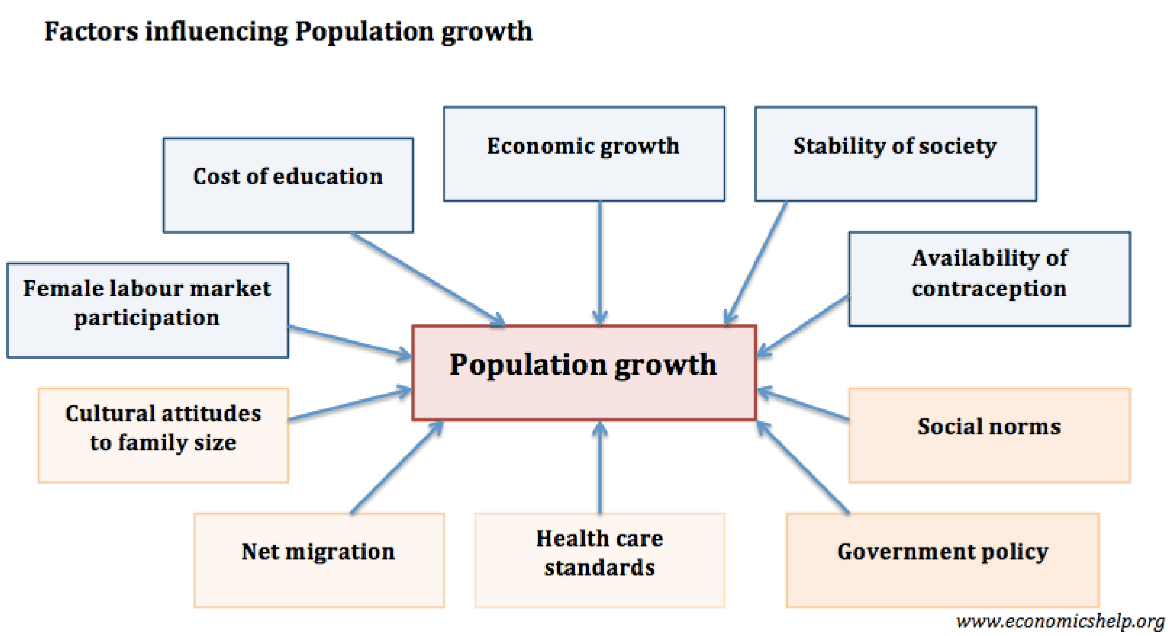
(5) Brazil (212 million)

For several centuries, China has been the world's most populous country. But not for long: it's expected that India will overtake China within the next decade.

## Factors that affect population size and growth

*Explain the main factors which affect population size and growth?*

Population growth is determined by fertility rates (the number of children per adult) –fatality rates. Birth rates and mortality rates are, in turn, determined by a combination of factors. Often economic growth and economic development have led to a decline in population growth, but there are no hard and fast rules and other factors, such as availability of family planning, social expectations and government intervention can play an important role.




**Factors influencing population growth**

- **Economic development**. Countries who are in the early stages of economic development tend to have higher rates of population growth. In agriculturally based societies, children are seen as potential income earners. From an early age, they can help with household tasks and collecting the harvest. Also, in societies without state pensions, parents often want more children to act as an insurance for their old age. It is expected children will look after parents in old age. Because child mortality rates are often higher, therefore there is a need to have more children to ensure the parents have sufficient children to look after them in old age.

- **Education**. In developed countries, education is usually compulsory until the age of 16. As education becomes compulsory, children are no longer economic assets – but economic costs. In the US, it is estimated a child can cost approx $230,000 by the time they leave college. Therefore, the cost of bringing up children provides an incentive to reduce family size.
- **Quality of children**. Gary Becker produced a paper in 1973 with H.Gregg Lewis which stated that parents choose the number of children based on a marginal cost and marginal benefit analysis. In developed countries with high rates of return from education, parents have an incentive to have a lower number of children and spend more on their education – to give their children not just standard education but a relatively better education than others. To be able to give children the best start in life, it necessitates smaller families. Becker noted rising real GDP per capita was generally consistent with smaller families.
- **Welfare payments/State pensions**. A generous state pension scheme means couples don't need to have children to provide an effective retirement support when they are old. Family sizes in developing countries are higher because children are viewed as 'insurance' to look after them in old age. In modern societies, this is not necessary and birth rates fall as a result.
- **Social and cultural factors**. India and China (before one family policy) had strong social attachments to having large families. In the developed world, smaller families are the norm.
- **Availability of family planning**. Increased availability of contraception can enable women to limit family size closer to the desired level. In the developing world, the availability of contraception is more limited, and this can lead to unplanned pregnancies and more rapid population growth. In Africa in 2015, it was estimated that only 33% of women had access to contraception. Increasing rates would play a role in limiting population growth. (link)
- **Female labour market participation**. In developing economies, female education and social mobility are often lower. In societies where women gain a better education, there is a greater desire to put work over starting a family. In the developed world, women have often chosen to get married later and delay having children (or not at all) because they prefer to work and concentrate on their career.
- **Death rates** – Level of medical provision. Often death rates are reduced before a slowdown in birth rates, causing a boom in the population size at a certain point in a country's economic development. In the nineteenth and early twentieth century, there was a rapid improvement in medical treatments which helped to deal with many fatal diseases. Death rates fell and life expectancy increased.
- **Immigration levels.** Some countries biggest drivers of population growth come from net migration. In the UK from 2000 to 2013, around 50% of net population growth came from net international migration. Countries like Japan with very strict immigration laws have seen a stagnation in the population.
- **Historical factors/war**. In the post-war period, western countries saw a 'boom' in population, as couples reunited at the end of the Second World War began having families. The 'baby-boomer' period indicates population growth can be influenced by historical events and a combination of factors which caused a delay in having children until the war ended.

# Population Distribution-Geographic Areas

## Population Distribution

Population distribution is the arrangement of the population on a certain area in accordance with conditions and requirements of the society. Population distribution over a territory is described by the population density which is calculated by the rate between the numbers of people on an area to the total population. The unit of population density is persons/km$^2$.

The arrangement or spread of people living in a given area; also, how the population of an area is arranged according to variables such as age, race, or sex.

The arrangement of population geographically as it is spread over a defined area such as community, district, capital city, country, region, etc. ...

Population density just represents the average number of individuals per unit of area or volume. Often, individuals in a population are not spread out evenly. Instead, they may live in clumps or some other pattern. The pattern may reflect characteristics of the species or its environment.

**Population distribution** describes how the individuals are distributed, or spread throughout their habitat.

Population distribution refers to the arrangement of the population in space at a given time, that is, geographically or among various types of residential areas.

**What are the 3 types of population distribution?**

**Three** basic **types of population distribution** within a regional range are (from top to bottom) uniform, random, and clumped (ছত্রভঙ্গ).
Individuals may be **distributed** in a **uniform**, **random, or clumped** pattern. **Uniform** means that the population is evenly spaced, **random** indicates **random** spacing, and **clumped** means that the population is **distributed** in clusters.

**What is an example of population distribution?**

Three patterns of **distribution** in **populations** of organisms: A **population** may have a uniform, random, or clumped **distribution**. Territorial birds, such as penguins, tend to have uniform **distribution**. Plants with wind-dispersed seeds, such as dandelions, are usually distributed randomly.

ADMINISTRATIVE OR POLITICAL AREAS

**Administrative regions** are the territorial units which a country is divided in. There is normally an administration with some government functions and powers connected to **administrative regions**. The jurisdiction (এখতিয়ার, অধিক্ষেত্র, আইনগতঅধিকার, বিচারব্যবস্থা) of an **administrative** area normally covers the total area inside its borders.
Political areas are not ordinarily created or delineated (plotted, decorated, portrayed - বর্ণিত/অঙ্কিত) by a country's central statistical agency or its census office but instead are established by national constitutions, laws, decrees (ফরমান, আদেশ), regulations, or charters (সনদ, দলিল, রাজশাসনপত্র). In some countries, the primary political subdivisions are empowered to create secondary and tertiary subdivisions.

**Bangladesh** is divided into eight major administrative divisions (Bengali: বিভাগBibhag). Each division is named after the major city within its jurisdiction that serves as the administrative capital of that division:

- Barishal (বরিশাল *Barishal*)
- Chittagong (চট্টগ্রাম *Chittagong*)
- Dhaka (ঢাকা *Dhaka*)
- Mymensingh (ময়মনসিংহ *Mymensingh*)
- Khulna (খুলনা *Khulna*)
- Rajshahi (রাজশাহী *Rajshahi*)
- Rangpur (রংপুর *Rangpur*)
- Sylhet (সিলেট *Sylhet*)

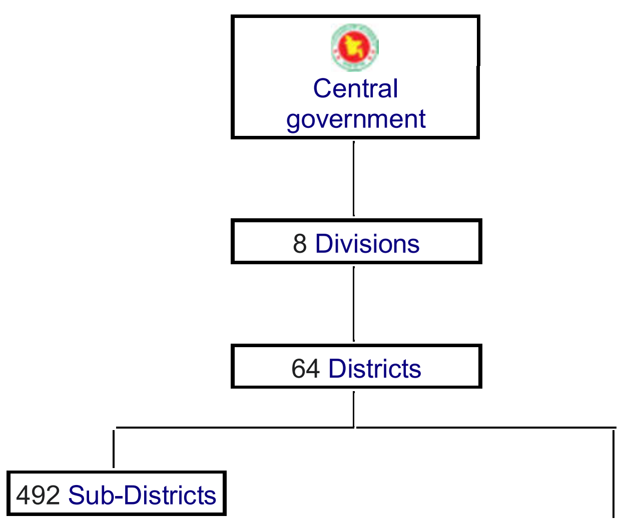
**Sub-Districts:** 492 (Upazila)

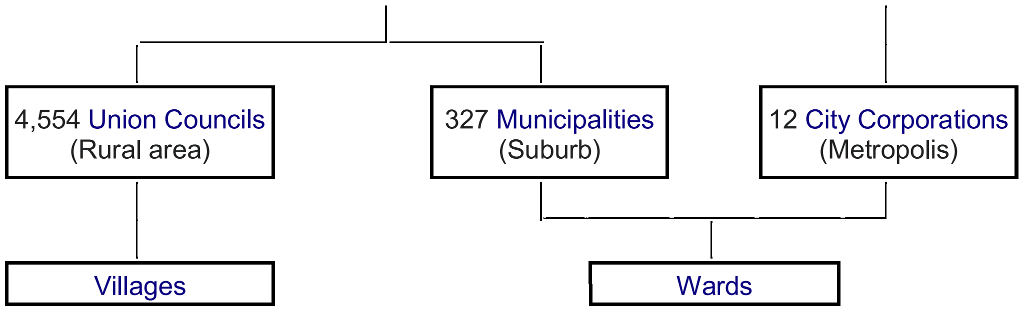
**Districts:** 64

**Divisions:** 8

**City Corporations:** 12

The diagram below outlines the five tiers of government in Bangladesh.






Primary Divisions. — The generic (জাতিগত, বর্গীয়, জাতিবাচক) names of the major civil divisions are given in several of the U.N. *Demographic Yearbooks* — most recently the 1971 *Yearbook.* The generic names appear in English and French, and often in the national language as well. The most common names in English for the primary areas are district, province, island, department, parish, state, and region.

It is fairly common for the capital city to constitute a primary division in its own right and often with a distinctive name. Examples are Nairobi District in Kenya, the Distrito Federal in Mexico, Brazil, and Venezuela, the District of Columbia in the U.S.A., the Capital Federal in Argentina, Asuncion in Paraguay, Seoul Special City in the Republic of Korea, Ulan Bator (Mongolia), Manila (P.I.), Damascus (Syria),Tirane (Albania), Copenhagen, Greater Athens, Budapest, Stockholm, Warsaw, Bucharest, and the Australian Capital Territory. In a few countries, some of the larger cities are also primary political divisions, (e.g., in Morocco, United Arab Republic, Trinidad and Tobago, Cambodia, Taiwan, Bulgaria, Hungary, Poland, and Romania).

Countries that have been settled relatively recently or countries that contain large areas of virtually uninhabited land or land inhabited mainly by aborigines may have a different kind of primary subdivision that has a distinctive generic name and a rudimentary political character. Examples are the Frontier Districts of the United Arab Republic, some of the Territories of Canada and Australia, the Federal Territories of Venezuela, and some of the Union Territories of India.

Secondary and Tertiary Divisions. — The intermediate or secondary political divisions also have a wide variety of names. These include county, district, and commune. Some small countries have only primary divisions. Some large countries have three or more levels. Examples of tertiary divisions are the townships in the United States, the *myun* and *eup* in Korea, and the *hsiang* and *chen* in Taiwan. For different administrative functions, a province, state, etc., may be divided into more than one set of political areas. The census of Canada shows, for the Province of Ontario, figures for both counties and electoral districts. In other census publications, such alternative administrative divisions may be ignored.

Municipalities. —It is difficult to find a universal, precise term for the type of political area discussed in this subsection. The ideal type is the city; but smaller types of municipalities such as towns and villages are also included. (Incidentally, in Puerto Rico, a *municipio* is the equivalent of a county in mainland United States.) In some countries, these areas could be described as incorporated places or localities. In some countries, again, these municipalities are located within secondary or tertiary divisions; but, in other countries, they are simply those territorial divisions that are administratively recognized as having an urban character.

The larger municipalities are frequently subdivided for administrative purposes into such areas as boroughs or wards (Britain and some of its former colonies), *arrondissements* (France), *ku* (Japan and Korea), and *chu* (China, Taiwan).These subdivisions of cities, in turn, may be divided into precincts (United States), *chun* (China, Taiwan), or *dong*(Korea). In China and Korea, even a fifth level exists —the *lin* and *ban,* respectively —for which "urban neighborhood" is as close as one could come in English. These smaller types of administrative areas are ordinarily not used for the presentation of official demographic statistics, but they are sometimes used as units in sample surveys.

## Uses and Limitations of Statistics on the Distribution of the Population

**Uses.** —Statistics on the distribution of the population among political areas are useful for many purposes. For example, they may be used to meet legal requirements for determining the apportionment of representation in legislative bodies; they are needed for studies of internal migration and population distribution in relation to social, economic, and other administrative planning; and they provide base data for the computation of subnational vital statistics rates and for preparing local population estimates and projections.

**Limitations.** —A limitation of these political areas from the standpoint of the analysis of population distribution, and even from that of planning, is the fact that the boundaries may be rather arbitrary and may not consider physiographic, economic, or social factors. Moreover, the areas officially designated as cities may not correspond very well to the actual physical city in terms of population settlement or to the functional economic unit. Furthermore, in some countries the smallest type of political areas does not provide adequate geographic detail for ecological studies or city planning. Therefore, various types of statistical and functional areas have been defined, in census offices and elsewhere, to meet these needs. These may represent groups or subdivisions of the political areas, or they may disregard them altogether.

## STATISTICAL AREAS

For many purposes, data are needed for areas other than those recognized as political entities by law. Nonpolitical areas in common use for statistical purposes include both combinations and subdivisions of political areas. The most general objective in delineating (বর্ণনামূলক/অঙ্কিত করা) such statistical areas is to attain relative homogeneity within the area; and, depending on the particular purpose of the delineation (চিত্র), the homogeneity sought may be with respect to geographic, demographic, economic, social, historical, or cultural characteristics. Also, groups of noncontiguous areas meeting specified criteria, such as all the urban areas within a State, are frequently used in presentation and analysis of population data.

**International Recommendations and National Practices of Statistical Areas**

There are several types of such statistical areas; for example, regions or functional economic areas; metropolitan areas, urban agglomerations (সমষ্টি, সমাগম), or conurbations (সংমিশ্রণ); localities; and urban census tracts (which are small subdivisions of cities and their adjacent area).

**Regions or Functional Economic Areas.** —The terminology for this kind of geographic area is not too well standardized, but as used here, a "region" means a large area. It ordinarily means something more, however, namely some kind of functional economic area or a cultural area. A region may represent a grouping of a country's primary divisions (states or provinces) or a grouping of secondary or tertiary divisions that cuts across the boundaries of the primary divisions. (There are, of course, also international regions, which are either combinations of whole countries or which cut across national boundaries.) Among the factors on which regions are delineated are physiography, climate, type of soil, type of farming, culture, and economic levels and organizations. The cultural and economic factors include ethnic or linguistic differences, type of economy, and level of living. The objective may be homogeneous regions —with minimal differences within regions and maximal differences among regions —or relatively self-contained regions where a large city or urban complex is economically dominant over a hinterland (আন্তঃদেশ, পশ্চাদভূমি). Some delineations may be based on statistical manipulations of a large number of indexes, for example, by factor analysis. The regions defined and used by geographers, anthropologists, etc., are somewhat more likely than those defined by demographers and statisticians to ignore political areas altogether. The latter users have to be more concerned with the units for which their data are readily available and to use such units as building-blocks in constructing regions. There may be also a hierarchy of regions; the simplest type consists of the region and the subregion.

**Large Urban Agglomerations (সমষ্টি, সমাগম).** — The concept of an urban agglomeration is defined by the United Nations as follows:" A large locality of a country (i.e., a city or a town) is often part of an urban agglomeration, which comprises the city or town proper and also the suburban fringe or thickly settled territory lying outside of, but adjacent to, its boundaries. The urban agglomeration is, therefore, not identical with the locality but is an additional geographic unit which includes more than one locality.

**Localities (স্থান, বসতি).** — A "locality" is a distinct population cluster (inhabited (জনবসতি) place, settlement, population nucleus, etc.) of which the inhabitants live in closely adjacent structures. The locality usually has a commonly recognized name, but it may be named or delineated for purposes of the census. Localities are not necessarily the same as the smallest civil divisions of a country.

Localities, places, or settlements may be incorporated or unincorporated; thus, it is only the latter, or the sum of the two types, that is not provided for by the conventional statistics on political areas. The problem of delineating an unincorporated locality is similar to that of delineating a large urban agglomeration; but, with the shift to the lower end of the scale, the areas required often cannot be approximated by combining several political areas since small localities are often part of the smallest type of political area. Just how small the smallest delineated locality should be for purposes of studying population distribution is rather arbitrary in countries where there is a size continuum (ধারাবাহিকতা) from the largest agglomeration down to the isolated dwelling unit. In view of the considerable work required for such delineations, 200 inhabitants seems about as low a minimum as is reasonable. In countries where there is essentially no scattered rural population but all rural families live in a village or hamlet, the answer is automatically provided by the settlement pattern.

**Urban Census Tracts.** —The urban census tract is a statistical subdivision of a relatively large city, especially delineated for purposes of showing the internal distribution of population within the city and the characteristics of the inhabitants of the tract as compared with those of other tracts. Once their boundaries are established, not only census data but also other kinds of data, such as vital and health records, can be assembled for these areas. In Far Eastern countries and others where there are well-established small administrative units within cities, such special statistical subdivisions are unnecessary. So far, the census tract is not a very widespread type of statistical area. Originating in the United States *(q.v.),* it has so far been taken over only in Canada.

**Standard Metropolitan Statistical Areas.** —The responsibility for the definition of standard metropolitan statistical areas (SMSA's) is lodged in the Office of Statistical Standards of the U.S. Bureau of the Budget.

*1970 criteria.*— The criteria used in the 1970 Census publications are sufficiently important to be quoted in full with the omission of footnotes, which clarify a few technical points.

"The definition of an individual standard metropolitan statistical area involves two considerations; first, a city or cities of specified population to constitute the central city and to identity the county in which it is located as the central county; and, second, economic and social relationships with contiguous (সংলগ্ন, পাশাপাশি) counties which are metropolitan in character, so that the periphery (পরিধি) of the specific metropolitan area may be determined. Standard metropolitan statistical areas may cross State lines, if this is necessary in order to include qualified contiguous counties.

*Population Criteria*

"1. Each standard metropolitan statistical area must include at least:

> *"(a)* One city with 50,000 or more inhabitants, or
>
> *"(b)* Two cities having contiguous boundaries and constituting, for general economic and social purposes, a single community with a combined population of at least 50,000, the smaller of which must have a population of at least 15,000.

"2. If two or more adjacent counties each have a city of 50,000 inhabitants or more (or twin cities under 1 *(b))* and the cities are within 20 miles of each other (city limits to city limits), they will be included in the same area unless there is definite evidence that the two cities are not economically and socially integrated.

*Criteria of Metropolitan Character*

'The criteria of metropolitan character relate primarily to the attributes of the county as a place of work or as a home for a concentration of nonagricultural workers. Specifically, these criteria are:

"3. At least 75 percent of the labor force of the county must be in the nonagricultural labor force.

"4. In addition to criterion 3, the county must meet at least one of the following conditions:

> *"(a)* It must have 50 percent or more of its population living in contiguous minor civil divisions with a density of at least 150 persons per square mile, in an unbroken chain of minor civil divisions with such density radiating from a central city in the area.
>
> *"(b)* The number of nonagricultural workers employed in the county must equal at least 10 percent of the number of nonagricultural workers employed in the county containing the largest city in the area, or be the place of employment of 10,000 nonagricultural workers.
>
> *"(c)* The nonagricultural labor force living in the county must equal at least 10 percent of the number of the nonagricultural labor force living in the county containing the largest city in the area, or be the place of residence of a nonagricultural labor force of 10,000.

"5. In New England, the city and town are administratively more important than the county, and data are compiled locally for such minor civil divisions. Here, towns and cities are the units used in defining standard metropolitan statistical areas. In New England, because smaller units are used, and more restricted areas result, a population density criterion of at least 100 persons per square mile is used as the measure of metropolitan character.

*Criteria of Integration*

"The criteria of integration relate primarily to the extent of economic and social communication between the outlying counties and central county.

"6. A county is regarded as integrated with the county or counties containing the central cities of the area if either of the following criteria is met:

> *"(a)* If 15 percent of the workers living in the county work in the county or counties containing central cities of the area, or
>
> *"(b)* If 25 percent of those working in the county live in the county or counties containing central cities of the area.

*Area Titles*

*"7.* The following general guidelines are used for determining titles for standard metropolitan statistical areas:

*"(a)* The name of the standard metropolitan statistical area is that of the largest city.

*"(b)* The addition of up to two city names may be made in the area title, on the basis and in the order of the following criteria:

"(1) The additional city or cities have at least 250,000 inhabitants.

"(2) The additional city or cities have a population of one-third or more of that of the largest city and a minimum population of 25,000, except that both city names are used in those instances where cities qualify under criterion *1(b).*

*"(c)* In addition to pity names, the area titles will contain the name of tie State or States included in the area.

**Population Density**

The density of population is a simple concept much used in studies relating population size to resources and in ecological studies. Density is usually computed as population per square kilometer, or per square mile, of land area rather than of gross area (land and water).
Population density is **the number of individuals per unit geographic area**, for example, number per square meter, per hectare, or per square kilometer.

Another measure of population density has been suggested by George. His measure relates to the "ratio between the requirements of a population and the resources made available to it by production in the area it occupies." The ratio is $\Delta_e = Nk/Sk'$ , where $N$ is the number of inhabitants, $k$ the quantity of requirements per caput, $S$ the area in square kilometers, and $k'$ the quantity of resources produced per square kilometer. George concludes, however, that, "It is impossible to make a valid calculation of economic density in an industrial economy . . .". Duncan, Cuzzort, and Duncan have discussed the conceptual difficulties in comparing the population density of different areas.
If there have been no changes in boundaries, the change in population density for a different date is, of course, simply proportionate to the change in population size. Thus, if the population has increased 10 percent, the density has also increased 10 percent.

The density of population is usually computed as population per square kilometer (Km2 ) of land area excluding area occupied by water. Different scholars have devised different types of densities for utilization in different situations with the aim to arrive at a better indicator for the population –resource relationship. These ratios are known as arithmetic density, physiological or nutritional density, agricultural density, economic density etc. The analysis of population density will be confined to the ratio of population of a given geographical or administrative unit to the area occupied by that unit.

**How is population density calculated?**

The formula for population density is **Dp= N/A**, where Dp is the population density, N is the total population, and A is the land area covered by the population. For human populations, A is typically expressed as square miles or square kilometers.

## METHODS OF ANALYSIS

There are a number of measures for describing the spatial distribution of a population and many graphic devices for portraying population distribution and population density. The interdisciplinary nature of demography is particularly displayed in this field. Geographers, statisticians, sociologists, and even physicists have contributed to it. Duncan gives the following classification, which is not claimed to be exhaustive or free of overlapping:

A. Spatial measures

(1) Number and density of inhabitants by geographic subdivisions
(2) Measures of concentration
(3) Measures of spacing
(4) Centrographic measures
(5) Population potential

B. Categorical measures

(1) Rural-urban and metropolitan-nonmetropolitan classification
(2) Community size distribution
(3) Concentration by proximity to centers or to designated sites

In this book, topics B (1) and (2) are treated more fully in chapter 6 (Population Distribution-classification of residence) than in chapter 5 (Population Distribution-geographic areas).

### Percentage Distribution

A simple way of ordering the statistics that is appropriate for any demographic aggregate is to compute the percentage distribution living in the geographic areas of a given class.

### Rank

Another common practice is to include a supplementary table listing the geographic areas of a given class in rank order. Again, the rankings can be compared from one census to another and the changes in rank indicated. In cases of an exact tie. it is conventional to assign all tying areas the average of the ranks involved, for example, if two areas tied for seventh place, they would both be given a rank of $7\frac{1}{2}$. The choice of sign for the change in rank requires a little reflection. It was decided to use the sign resulting from the literal arithmetic operation even though a minus sign denotes a move toward the "top" rankings.

### Measures of Average Location and of Concentration

There has long been an interest in calculating some sort of average point for the distribution of population within a country or other area. Both European and American statisticians have measures are the median point or location; the mean point, often called the "center of population"; and the point of minimum aggregate travel. A somewhat different concept is that of the point of maximum "population potential." There has been somewhat less scientific interest in measuring the concentration, or dispersion, of the population. Here we will describe Bachi's "standard distance." Average positions and dispersion, density surfaces, etc., are treated systematically by Warntz and Neft.

**Median Lines and Median Point** —The "median lines" are two orthogonal lines (at right angles to each other), each of which divides the area into two parts having equal numbers of inhabitants. The "median point" is the intersection of these two lines. The median lines are conventionally the north-south and east-west lines, but the location of the median point depends slightly upon how these axes are rotated. Hart and others also mention that, in addition to median lines that divide a territory into halves in terms of population, other common fractions may be used, such as quarters and tenths. For the population and area of the United States in 1960, equal tenths ("decilides") have been computed in the north-south and the east-west directions. These devices describe population distribution rather than central tendency, of course.

**Center of Population.** — The center of population, or mean point of the population distributed over an area, may be defined as the center of population gravity for the area, ". . . in other words, the point upon which the [area] would balance, if it were a rigid plane without weight and the population distributed thereon, each individual being assumed to have equal weight and to exert an influence on the central point proportional to his distance from the point. The pivotal point, therefore, would be its center of gravity . . . " The formula for the coordinates of the center of population may be written $\bar{x} = \frac{\sum p_i x_i}{\sum p_i}$ and $\bar{y} = \frac{\sum p_i y_i}{\sum p_i}$ where $p_i$ is the population at point $i$ and $x_i$ and $y_i$ are its horizontal and vertical coordinates, respectively. Thus, the mean point, unlike the median point, is influenced by the distance of a person from it. It is greatly affected by extreme items and is influenced by *any* change of the distribution over the total area.

A more exact method for computing the center of population and one that is required when dealing with a very large area is described by the set of equations shown below.

$$\bar{x} = \frac{\sum p_a(x_a - \bar{x}') - \sum p_b(\bar{x}' - x_b)}{\sum p_i} + \bar{x}'$$

$$\bar{y} = \frac{\sum p_c(y_c - \bar{y}') - \sum p_d(\bar{y}' - y_d)}{\sum p_i} + \bar{y}'$$

where $\bar{x}'$ and $\bar{y}'$ are the coordinates of the assumed mean, $x_a$ is any point east of that mean, $x_b$, any point west of it, $y_c$, any point north of it, $y_d$, any point south of it; and $p_a$, $p_b$, $p_c$, $p_d$ are the populations in areas east, west, north, and south ofthe assumed mean, respectively.

The definition of the **center of area** is analogous to that of the center of population, but the computation is somewhat simpler.

**Point of Minimum Aggregate Travel.** —This centrographic measure, sometimes called the "median center/1 is defined as "that point which can be reached by all items of a distribution with the least total straight line travel for all items," or "the point from which the total *radial* deviations of an areal distribution are at a minimum. "Hart gives a graphic method for locating this point. This concept has fairly obvious applications to location theory, e.g., to estimating the optimum central location for a public or private service of some sort.

**Standard Distance.** —Measures of the dispersion of population have been proposed from time to time, but the most recent exposition and the one that has been most thoroughly developed is Bachi's "standard distance." The standard distance bears the same kind of relationship to the center of population that the standard deviation of any frequency distribution bears to the arithmetic mean. In other words, it is a measure of the dispersion of the distances of all inhabitants from the center of population.

If $\bar{x}$and $\bar{y}$are the coordinates of the center of population.say its longitude and latitude, then the distance from any item $i$, with coordinates $x_i$and $y_i$, to the center is given by

$$D_{ic} = \sqrt{(x_i - \bar{x})^2 + (y_i - y)^2}$$

and the standard distance,

$$D = \sqrt{\frac{\sum_{i=1}^{n} D_{ic}{}^2}{n}}$$

In practice, the distance would not be measured individually for each person but rather we should use data grouped by political areas (or square degrees), and it would then be assumed that the population of a unit area is concentrated at its geographic center. Here, then,

$$D = \sqrt{\frac{\sum_i f_i (x_i - \bar{x})^2}{n} + \frac{\sum_i f_i (y_i - \bar{y})^2}{n}}$$

Where $f_i$is the number of persons in a particular unit of area.

**Population Potential.** —The concept of population potential as developed by Stewart applies to the accessibility to the population, or "level of influence" on the population, of a point on a map or of a small unit of area. "If the 'influence' of each individual at a point is considered to be inversely proportional to his distance from it, the total potential of population at a point. Lo, is the sum of the reciprocals of the distances of all individuals in the population from the point. In practice, of course, the computation is made by assuming that all the individuals within a suitably small area are equidistant from Lo, whence.

Potential at $L_0 = \sum_{i=1}^{n} \frac{P_i}{D_i}$

where the $P_i$ are the populations of the *n* areas into which a territory is divided and the $D_i$ are the respective distances of these areas from *Lo* (usually measured from the geographic centre or from the approximate centre of gravity of the population, in each area)."Like the center of population, the population potential at any point in the territory is thus affected by the distribution of population over the entire territory.

**Population in Distance Zones from Map Features.** —Still another way of summarizing the population distribution of a nation, province, etc., is to compute the absolute or relative number of people within a specified distance from its borders, from its seacoast, or from selected points. The measure can be extended to successive distance zones, e.g., within 10 km.. 20 km., etc., inland from the coast.

**Population Density.** —A conventional way of indicating population density is that of shading or hatching, with the darker shadings representing the greater densities. Such shadings may gloss over considerable internal variation within an area since they represent simply the area's average density.

## FACTORS AFFECTING POPULATION DISTRIBUTION

Much has been written about the factors determining the geographic distribution of population —among international regions, among countries, among national divisions and subdivisions, and within urban agglomerations. Some of this literature was summarized in a United Nations.

The following list of factors is adapted from *The Determinants and Consequences of Population Trends,* with a few additions and other changes:

- Climate
  - Temperature
  - Precipitation
- Landforms
  - Topography (altitude and slope)
  - Swamps, marshes, deserts
- Soils
- Energy resources and mineral raw materials
- Space relationships (accessibility)

- Distance from sea coast, natural harbors, navigable rivers
- "Fall lines" (heads of river navigation)

Cultural factors
- Historical
  - Recency of discovery and settlement

Political
- Political boundaries
  - Buffer zones
  - Controls on migration and trade
- Government policies

Types of economic activities

Technology
- State of the arts
- Type of farming
- Highway, rail, water, and air transportation facilities

Social organization

**Demographic factors**
- Variations in natural increase
- Variations in net migration

# Population Distribution-Classification of Residence

## THE URBAN-RURAL CLASSIFICATION

The Census Bureau’s (US) urban-rural classification is a delineation of geographic areas, identifying both individual urban areas and the rural areas of the nation. The Census Bureau’s urban areas represent densely developed territory, and encompass residential, commercial, and other non-residential urban land uses. The Census Bureau delineates urban areas after each decennial census by applying specified criteria to decennial census and other data. “Rural” encompasses all population, housing, and territory not included within an urban area.

The Rural Urban Classification (UK) is an Official Statistic and is used to distinguish rural and urban areas. The Classification defines areas as rural if they fall outside of settlements with more than 10,000 resident population. Wherever possible the Rural Urban Classification should be used for statistical analysis.

It is in the case of intermediate situations that somewhat arbitrary rules have to be set up for making the urban-rural classification.

### Difference between urban and rural population

Human settlements are classified as rural or urban depending on the density of human-created structures and resident people in a particular area. Urban areas can include town and cities while rural areas include villages and hamlets.

While rural areas may develop randomly on the basis of natural vegetation and fauna available in a region, urban settlements are proper, planned settlements built up according to a process called urbanization. Many times, rural areas are focused upon by governments and development agencies and turned into urban areas.

Unlike rural areas, urban settlements are defined by their advanced civic amenities, opportunities for education, facilities for transport, business and social interaction and overall better standard of living. Socio-cultural statistics are usually based on an urban population.

While rural settlements are based more on natural resources and events, the urban population receives the benefits of man’s advancements in the areas of science and technology and is not nature-dependent for its day to day functions. Businesses stay open late into the evenings in urban areas while, sunset in rural areas means the day is virtually over.

**Which one is an important criterion for classification of urban city?**

The criteria used by countries to decide whether to define a place as 'urban' include **population size, population density, type of economic activity**, physical characteristics, level of infrastructure, or a combination of these or other criteria.

**International Recommendations for Rural-Urban Classification**

Because of **national differences** in the characteristics that distinguish urban from rural areas, the distinction between the urban and the rural population is not yet amenable to a single definition that would be applicable to all countries or, for the most part, even to the countries within a region. Where there are no regional recommendations on the matter, countries must establish their own definitions in accordance with their own needs.

"Urban area" can **refer to towns, cities, and suburbs**. An urban area includes the city itself, as well as the surrounding areas. ... Rural areas are the opposite of urban areas. Rural areas, often called "the country," have low population density and large amounts of undeveloped land (WHO).

**National Practices for Rural-Urban Classification (UN classifications of urban area)**

What then are these different definitions of urban that are used by the several national statistical organizations? (It can be said at the outset that the rural population is almost always not defined directly but is simply the residual population after the urban population is distinguished.) **The Statistical Office of the United Nations has classified the definitions in use into five principal types.** The underlying concept is that of (1) administrative area, (2) population size, (3) local government area, (4) urban characteristics, or (5) predominant economic activity.

**Administrative Area.** —This concept treats as urban the administrative divisions (municipios, shi, districts, communes, Gemeinden, etc.) that have been so classified by the national government or such parts of them as their administrative centers, capitals, or principal localities. This classification is based primarily on historical, political, or administrative considerations, rather than on statistical considerations. It tends to be relatively static and is not automatically changed after each census to recognize the decreasing size of formerly important places or the increasing size of places that have recently become important.

**Population Size.** —This concept treats as urban those places (cities, towns, agglomerations, localities, etc.) having either a specified minimum number of inhabitants or a specified minimum population density. ("Population density" could well be regarded as an independent concept in this set.) The discussion of this concept in the U.N. *Handbook* cited recognizes that suburbs of large places, densely populated fringes around incorporated municipalities, and the like are sometimes classified as urban in this approach. This type of classification can readily be brought up-to-date at the time of each census, but it is almost impossible to do so in each postcensal year for classifications used in tabulations of data from sample surveys or registrations of vital events.

**Local Government Area.** —This concept defines urban interms of those places, agglomerations, or localities "possessing some form of local government." For some countries, at least, this phrase might be interpreted as referring to a particular form of local government, especially one having relatively great autonomy. Note that no minimum population size is used in this definition. The remarks about the relatively static character of classifications under concept (1) apply here also.

**Urban Characteristics.** —This concept requires an urban place to possess specific types of urban characteristics, such as established street patterns, contiguously aligned buildings, and public services (sewer system, piped water supply, electric lighting, police station, hospital, school, court of law, and local transportation system). A classification of this sort would need to be developed during or shortly before the census canvass. This concept has the possibility of regular up-dating, therefore. Some of the characteristics, like electric lighting, could only have been used in modern times.

**Predominant Economic Activity.** — Here places or other areas qualify as urban if they have at least a specified proportion of their economically active population engaged in nonagricultural activities. It would be difficult to base the urban-rural classification on the statistics regarding economic activity from the current census unless that classification were presented only in a report or reports appearing relatively late in the publication program.

**Concepts of Urban and Rural in Demographic Theory**

The writings of demographers, sociologists, etc., about the concept of urban population or of urbanization, from the theoretical standpoint may help us in our consideration of operational definitions. Eldridge (formerly Tisdale), for example, defines urbanization as " . . . a process of population concentration (কেন্দ্রীভূতকরণ). It proceeds in two ways: the multiplication of points of concentration and the increase in size of individual concentrations . . . Consistent with the definition of urbanization, cities may be defined as points of concentration . . . It is convenient from time to time arbitrarily to name certain levels beyond which concentrations are designated as cities."

In many, if not most countries, it is associated with fairly sharp differentials in demographic, social, and economic characteristics for persons or families. The precise population size chosen to separate urban from rural is obviously fairly arbitrary within a wide range. Nevertheless, there would be some advantages in a uniform definition among all countries. A fixed classification in terms of size of place (or population density) can serve as a framework against which differences in various characteristics viewed as representing contemporary urban character (industrial composition, presence of specified municipal services, smaller families, etc.) and the changes over time in these characteristics can be measured.

What is concept of urbanization?

In demography, urbanization refers to **the process of population concentration whereby populations move from a rural area to an urban one, leading to a relative rise in the number of city dwellers**. Urban geography considers urbanization a local phenomenon.

## SUBURBS

The ideal type of a suburb is a residential area that extends out from the central city following transportation arteries in a stellate shape, is dependent on the central city for many of its services, has an intermediate population density, is growing rapidly by horizontal expansion, and is peopled mainly by upper and middle class families of commuters. But there are exceptions. There are, for example, industrial as well as residential suburbs.

### Standards and Definitions of SUBURBS

**International Standards.** —One of the United Nations handbooks recognizes that, "The urban agglomeration has been defined as including the suburban fringe or thickly settled territory lying outside of, but adjacent to, the city boundaries." The United Nations' recommendations for the 1970 population censuses include a table that would give the population of both the city proper and its urban agglomeration. Although it is not suggested, subtraction of the former from the latter would yield a figure that could be regarded as the suburban population of the given city. Summing these remainders would give the total suburban population for these "principal localities."

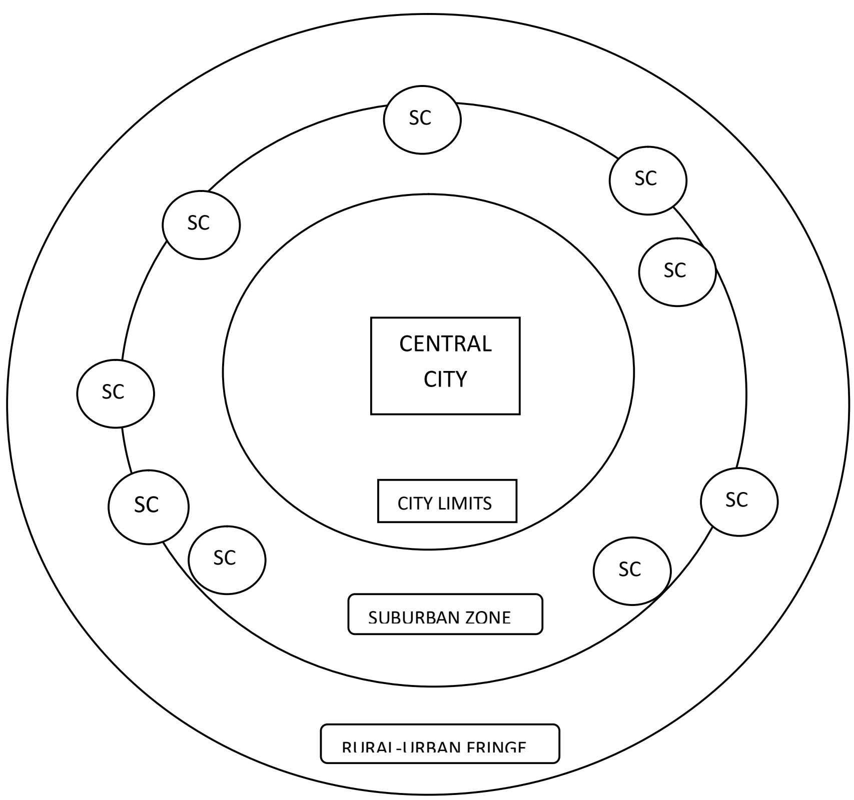
**Attempts at Operational Definition of SUBURBS.** — A bridge between sociological and demographic theory and an operational definition of a suburb is provided by Dobriner: A rough 'content analysis' of the relevant literature reveals that suburbs are (1) communities (2) outside the central city and politically independent of it (3) culturally and economically dependent upon the central city, and (4) in general, highly specialized communities particularly along familistic and residential lines.

Accordingly, a working definition of the suburb might be: *those urbanized, residential communities which are outside the corporate limits of a large central city, but which are culturally and economically dependent upon the central city.* Obviously, terms such as "urbanized," "residential," "communities," "large central city," and "culturally and economically dependent" would have to be translated into specific metrics and quantified. Duncan and Reiss give a similar definition and contend that, although peripheral parts of the central city may otherwise have a suburban character, "the only workable criterion yet discovered for identifying suburbs is their political separation from the central municipality." We might add that some contiguous industralized areas resemble the central city more than they do the suburb in all respects except that they are not within the corporate limits of the central city.

**RURAL-URBAN FRINGE**

Closely related to the concept of suburbs, and no less vaguely defined, is that of the "rural-urban fringe." It is essentially an American sociological concept that has some similarity to the category "semiurban" as used in a few other countries. Duncan and Reiss define it as ". . . that area in which the countryside is in process of transition from a rural to an urban mode of settlement." The definition arrived at by Kurtz and Eicher is more detailed: "location beyond the limits of the legal city, in the 'agricultural hinterland', exhibiting characteristics of mixed land use, with no consistent pattern of farm and nonfarm dwellings. The residents are involved in rural and urban occupations. The area is unincorporated, relatively lax zoning regulations exist, and few, if any, municipal services are provided. The area shows potentialities for population growth and increasing density ratios. Present density ratios are intermediate between urban and rural. Thus rural-urban fringe is a concentric circles beginning with the city proper and proceeding successively to suburban and rural-urban zones. In these outer zones, both incorporated and unincorporated territory is included. In the case of metropolitan cities, the rural-urban fringe would be confined to the metropolitan area, for the most part.

Figure. — **A Model Metropolitan Area Showing the Ecological Relationship of a Central City and the Suburban Zone, Suburban Community (SC), and Rural-Urban Fringe**



## SIZE OF LOCALITY

If the urban-rural classification is based on size of locality, then a classification by multiple size categories can be regarded as an extension of the dichotomous classification that recognizes the fact that there is an urban-rural continuum; size differences and their associated demographic characteristics may be just as important within the urban, or within the rural, part of the range as are the differences between the smaller urban and the larger rural localities. Statistics on the number of people living in each size-of-place category, then, tell us a great deal about the settlement pattern in a country or region that cannot be appreciated directly from statistics for individual administrative areas.

"For census purposes, it is recommended that a **'locality be defined** as a distinct and indivisible population cluster (also designated as agglomeration, inhabited place, populated centre, settlement, etc.) of any size, having a name or a locally recognized status and functioning as an integrated social entity. This definition embraces population clusters of all sizes, with or without legal status, including fishing hamlets, mining camps, ranches, farms, market towns, communes, villages, towns, cities and many others".

## FARM POPULATION

The farm, or the agricultural, population is sometimes regarded as being equivalent to the rural population; but it is obvious that most of the definitions given above for the latter do not confine it to the population economically dependent on agriculture or to the population living on farms or in agricultural villages. Conversely, as will be seen, the definitions that have been used to define the farm population usually treat it as only part of the rural population or as overlapping the urban-rural classification. The more highly developed a country is economically the more its rural population will tend to exceed its farm population.

A fundamental **difference between the classification of the population as farm or nonfarm and the residence** classifications previously considered is that **the farm-nonfarm classification is usually applied to individual households or families and not to geographic areas**. In a sense then, this topic is intermediate between the territorial distribution of population and the composition of population in terms of personal, social, and economic characteristics. In some countries, the farm population has been treated as a final category in the distribution by size of place, as if it approximated the population living in the smallest places or in the open country.

**The importance and uniqueness of the farm population** are both well recognized. "Statistics of the population dependent on agriculture are especially valuable, not only because of the importance of agriculture as the primary source of livelihood for most of the world's peoples, but also for other reasons. The agricultural population tends to be set off more distinctly from other population groups, in its cultural traits, living standards and social institutions, than the population dependent on any other major branch of economic activity. This is so because, in most countries, the people who make their living from agriculture are, to a comparatively great extent, geographically isolated; and because the home life of a farming household is intimately connected with the operation of the farm."

**MEASURES of Population Distribution-Classification of Residence**

Some of the measures described in the previous chapters are also applicable to classifications by type of residence. There are a few additional ones that are particularly appropriate to the present classifications.

1. **Percentage Distributions**

As with any demographic variate or attribute, more meaning can be comprehended from the statistics by type of residence when the absolute numbers are reduced to percentage distributions. Comparisons can then be made more effectively between two areas of widely different sizes or between observations on the same area at two points in time.

2. **Extent of Urbanization**

The most obvious measure of the extent of urbanization is the percent of the total population living in urban territory. But is this the best measure? For purposes of international comparisons, the percentage living in agglomerations of at least a given size is certainly an improvement. Some writers go further and regard the use of measures based on the distribution of the population by size of place as being preferable even where there is a uniform definition of urban. Such measures do not depend upon an arbitrary decision as to what minimum size of place is to be chosen for the definition of urban. As Gibbs puts it, "Even if a rationale could be formulated for a universally applicable minimum urban size limit, the conventional measure of the degree of urbanization would still reveal only one dimension of urbanization. Assume for the sake of argument that the minimum size limit is 2,000 or more inhabitants. Two countries, *X* and K, have a degree of urbanization of 50.0, meaning that in both instances exactly one-half of the total population resides in points of population concentration of that size range.

Gibbs's measures are the "scale of urbanization" $(S_u)$ and the "scale of population concentration" ($S_p$). If $X_i$ is the proportion of the urban population in urban size class ($i$) and all size classes above it, and $Y_i$ is the proportion of the total population in urban size class ($i$) and all size classes above it, then,

$$S_u = \sum X_i Y_i.$$

If $Z_i$ is the proportion of the total population in size class ($i$) and all sizes above it, then,

$$S_p = \sum Z_i .$$

Both of these indexes measure the extent to which population is concentrated at the upper end of the scale of size of locality. These two measures, plus what Gibbs called the "degree of urbanization," which is merely the percentage of the total population classed as urban using a uniform definition in terms of population in localities of 2,000 inhabitants or more.

As Gibbs himself recognizes, however, the scale of urbanization, although it is affected by the full distribution, is not independent of the arbitrary population size used to define "urban." Moreover, it is also affected by the number of categories in the distribution so that international comparisons require the use of class intervals that are nominally identical.

### 3. Size of Place of Median Inhabitant

The median is the value that divides the distribution into two equal parts, one-half the cases falling below this value and one-half the cases exceeding this value. In the present application, the size of place of the median inhabitant is the size of locality that divides the population in half. It is quite distinct from the median size of locality. The first median applies to the distribution of people, the second to the distribution of. This measure is systematically affected neither by the definition of urban nor by the number of class intervals, although, like all measures of urbanization, it is affected by the way localities are defined. Since there are ordinarily more places at the lower than at the upper end of a size interval, the assumption that is usually made, namely, that there is a rectangular distribution within the class interval containing the median, is not very appropriate. If the median falls in a class containing very few localities (say near the top of the size distribution), the populations of the individual cities contained therein may be arrayed and the median computed from these discrete data. If the number of localities in the interval containing the median is large, then, as Duncan recommends, one could interpolate on the logarithms of locality size. In other words, if we take the logarithms of the class marks, interpolate between them, and find the antilog of the interpolated value as our median, this value will be lower, and more nearly accurate, than the median interpolated between the absolute values of locality size. If statistics are available on both agglomerations and cities proper (incorporated places), then a choice must be made concerning which to use for the distribution of localities by size. If the agglomerations represent the built-up area in and around the city, as is the case with the urbanized areas of the United States, then these would seem to be the preferable units.

Instead of the size of place of the median inhabitant, Arriaga proposes the corresponding mean value. A weighted average of this mean with the percent urban produces his "new index of urbanization."

### 4. Lorenz Curve and Gini Concentration Ratio

The Lorenz Curve, first expounded in 1905, has long been used to measure inequalities in the distribution of wealth or income. It has also been used to depict the state (as opposed to the process) of concentration of population and of other demographic aggregates. To plot the curve, the units are first either arrayed individually or grouped in class intervals according to the appropriate independent variate. Then the cumulative percentage of the number of areas ($Y_i$) is plotted against the cumulative percentage of population ($X_i$). For comparison a diagonal line is drawn at 45° to show the condition of equal distribution. To illustrate from data on urbanization, consider the cumulative percentage of population up through each size class. (We have to omit that part of the population, if any, reported as not living in localities.)

The Gini Concentration Ratio measures the proportion of the total area under the diagonal that lies in the area between the diagonal and the Lorenz Curve. This proportion may be computed thus:

$$G_i = \left(\sum_{i=1}^{n} X_i \, Y_{i+1}\right) - \left(\sum_{i=1}^{n} X_{i+1} \, Y_i\right)$$

where $X_i$ and $Y_i$ are respective cumulative percentage distributions and. $n$ is the number of class intervals (or units). The computations for Venezuela, 1961, are given in table 6-11, and the corresponding Lorenz Curve is shown in figure 6-2.

Steps 1 and 2. Post the number of localities and the population for each size-class in columns (1) and (2), respectively.

Step 3. Compute the proportionate distribution of localities from column (1) and post in column (3), e.g., 1÷24,177 is less than .00005 so we enter a dash, meaning that the number rounds to zero.

Step 4. Compute the proportionate distribution of the population from column (2) and post in column (4), e.g., 1,101,147÷7,426,743 = 0.1483.

Step 5. Cumulate the proportions of column (3) downward and post the results in column (5), e.g., 0 +.0002= .0002.

Step 6. Cumulate the proportions of column (4) downward and post the results in column (6), e.g., 0.1483 + 0.1239 = 0.2722.

Step 7. Multiply the first line in column (6) by the second line in column (5), the second line by the third line, etc., to obtain column (7), e.g., 0.1483X .0002 is less than .00005, so we enter a dash.

Step 8. Multiply the first line in column (5) by the second line in column (6), etc., to obtain column (8), e.g., 0 x 0.2722 = 0.

Step 9. Sum col. (7) and post the total, 0.9889, in the column. Sum col. (8) and post the total, 0.2068.

Step 10. Subtract the total of col. (8) from the total of col. (7), (0.9889-0.2068 = 0.7821).

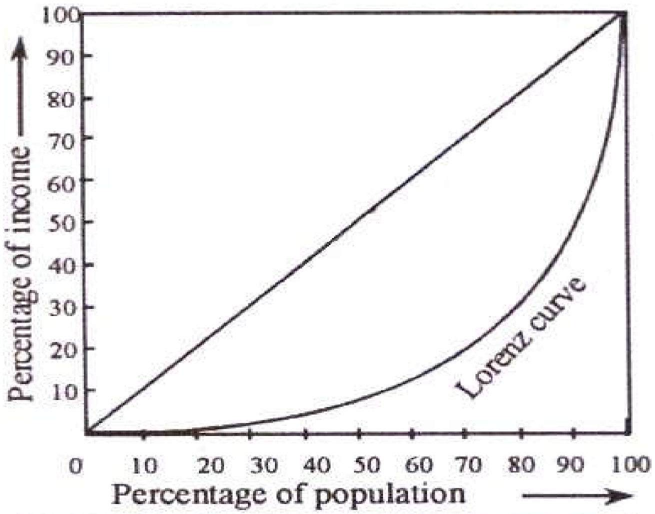



**Fig. 3:** A relatively unequal distribution

As was mentioned above, the Lorenz Curve and the Gini Ratio were recommended by Jones as measures of urbanization. By including the population living outside localities of 2,000 or more and assigning an arbitrary average size to the lowest level, he computes a Gini Concentration Ratio which he names the "coefficient of population concentration." Omitting this class, the index becomes the "coefficient of urban concentration." Multiplying the degree of urbanization (percent urban) by the coefficient of urban concentration, Jones obtains a measure that he calls the "scale of urbanization."

Another type of application of the Lorenz Curve and the Gini Ratio is more common. This application deals with the concentration of population in terms of area. A country's geographic units are arrayed in order of population density, and the cumulative percentage of area is plotted against the cumulative percentage of population. A good discussion of this application is available in the previously cited article by Duncan.

Example: The population and area of the major cities of **Chiba Prefecture in Japan** by census year 2015.

| **City** ⇩ | **Area (km$^2$)** | **Population** Census (Cp), 2015 |
|---|---|---|
| **Total** ⇨ | **1,149** | **3,789,229** |
| Chiba | 272 | 972,639 |
| Funabashi | 86 | 622,823 |
| Matsudo | 61 | 483,238 |
| Ichikawa | 57 | 481,492 |
| Kashiwa | 115 | 414,054 |

| | | |
|---|---|---|
| Ichihara | 368 | 274,558 |
| Yachiyo | 51 | 193,219 |
| Nagareyama | 35 | 174,417 |
| Sakura | 104 | 172,789 |

Questions:

(i) Compute Gini concentration ratio; Lorenz curve and Index of concentration.
(ii) Calculate density of population for different cities.
(iii) Comment on your findings.

## Solution:

(i). Gini Concentration Ratio = $(\sum_{i=1}^{n} X_i Y_{i+1}) - (\sum_{i=1}^{n} X_{i+1} Y_i)$

| **City** | **Area (km$^2$)** | **Population** Census (Cp), 2015 | **Proportion** | | **Cumulative Proportion** | | $X_i Y_{i+1}$ | $X_{i+1} Y_i$ |
|---|---|---|---|---|---|---|---|---|
| | **(1)** | (2) | **Area** ($y_i$) **(3)** | **Population** ($x_i$) **(4)** | **Area** ($Y_i$) **(5)** | **Population** ($X_i$) **(6)** | **(7)** | **(8)** |
| **Total** | **1,149** | **3,789,229** | 1.0000 | 1.0000 | - | - | - | |
| Chiba | 272 | 972,639 | 0.236728 | 0.256685199 | 0.236727589 | 0.256685199 | 0.079976763 | 0.099674597 |
| Funabashi | 86 | 622,823 | 0.074848 | 0.164366683 | 0.311575283 | 0.421051882 | 0.153542853 | 0.17092436 |
| Matsudo | 61 | 483,238 | 0.05309 | 0.127529373 | 0.364664926 | 0.548581255 | 0.227262556 | 0.246385802 |
| Ichikawa | 57 | 481,492 | 0.049608 | 0.127068594 | 0.414273281 | 0.675649849 | 0.347527468 | 0.325171862 |
| Kashiwa | 115 | 414,054 | 0.100087 | 0.109271306 | 0.514360313 | 0.784921154 | 0.655125663 | 0.441001545 |
| Ichihara | 368 | 274,558 | 0.320279 | 0.072457484 | 0.834638816 | 0.857378638 | 0.753657463 | 0.758161094 |
| Yachiyo | 51 | 193,219 | 0.044386 | 0.05099164 | 0.879025239 | 0.908370278 | 0.826150514 | 0.838941652 |
| Nagareyama | 35 | 174,417 | 0.030461 | 0.04602968 | 0.90948651 | 0.954399958 | 0.954399958 | 0.90948651 |
| Sakura | 104 | 172,789 | 0.090513 | 0.045600042 | 1 | 1 | - | - |
| Total | | | | | | | 3.997643239 | 3.789747421 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|

Therefore, Gini Concentration Ratio $=(\sum_{i=1}^{n} X_i Y_{i+1}) - (\sum_{i=1}^{n} X_{i+1} Y_i)$

= 3.997643239-3.789747421=0.207895818

**Comment:** Gini concentration measures the proportion of the total area under the diagonal line that lies in the area between the diagonal and Lorenz curve and Lorenz curve measures the state of concentration of population and other demographic aggregates i.e., localities. Here the value of Gini concentration ratio is 0.2079 that means there presents lower level of inequality as the value '0' means perfect equality and '1' means perfect inequality. As the value is near 0, it indicates low inequality and from the graph it is clear that the distribution of population at different cities in Japan is close to perfect equality line, i.e., the population is distributed almost equally, that clearly indicates that in those cities of Japan have a planned urbanization.

Lorenz curve

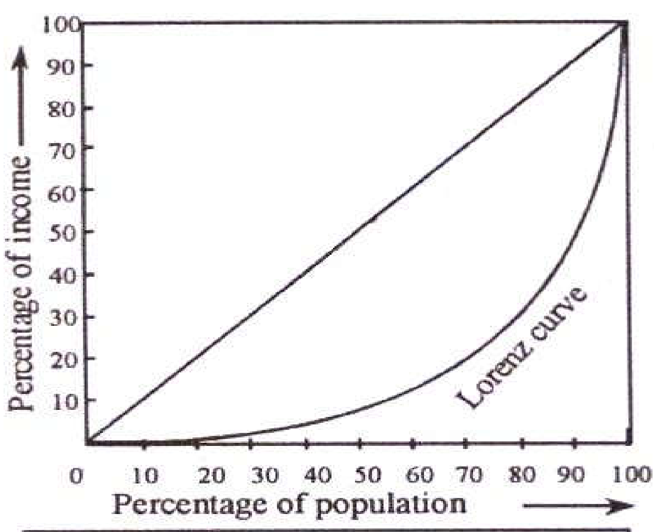
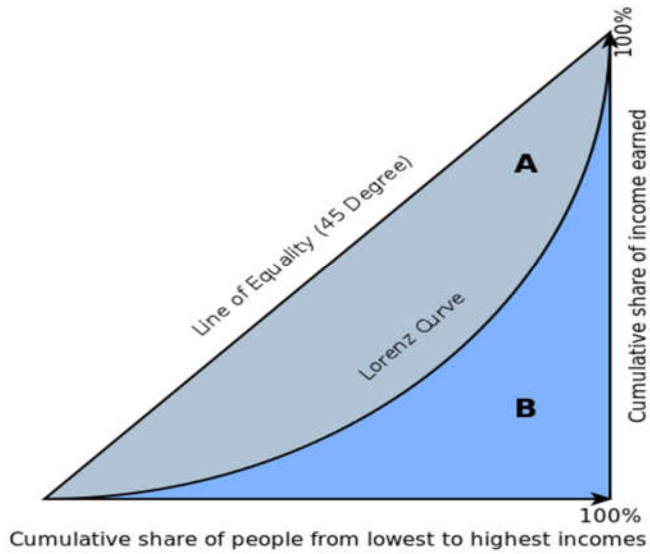



**Fig. 3:** A relatively unequal distribution




Index of concentration, $\Delta = \frac{1}{2}\sum_{i=1}^{k}|x_i - y_i|$

We have,

| City ⇩ | Area (km²) | Population Census (Cp), 2015 | Proportion | | $\lvert x_i - y_i \rvert$ | Cumulative Proportion | | $(X_i - Y_i)$ |
|---|---|---|---|---|---|---|---|---|
| | | | Area ($y_i$) | Population ($x_i$) | | Area ($Y_i$) | Population ($X_i$) | |
| **Total** ⇨ | **1,149** | **3,789,229** | 1.0000 | 1.0000 | | - | - | |
| Chiba | 272 | 972,639 | 0.236728 | 0.256685199 | 0.019957 | 0.236727589 | 0.256685199 | 0.01995761 |
| Funabashi | 86 | 622,823 | 0.074848 | 0.164366683 | 0.089519 | 0.311575283 | 0.421051882 | 0.109476599 |
| Matsudo | 61 | 483,238 | 0.05309 | 0.127529373 | 0.074439 | 0.364664926 | 0.548581255 | 0.183916329 |
| Ichikawa | 57 | 481,492 | 0.049608 | 0.127068594 | 0.077461 | 0.414273281 | 0.675649849 | 0.261376568 |
| Kashiwa | 115 | 414,054 | 0.100087 | 0.109271306 | 0.009184 | 0.514360313 | 0.784921154 | **0.270560841** |
| Ichihara | 368 | 274,558 | 0.320279 | 0.072457484 | 0.247822 | 0.834638816 | 0.857378638 | 0.022739822 |
| Yachiyo | 51 | 193,219 | 0.044386 | 0.05099164 | 0.006606 | 0.879025239 | 0.908370278 | 0.029345039 |
| Nagareyama | 35 | 174,417 | 0.030461 | 0.04602968 | 0.015569 | 0.90948651 | 0.954399958 | 0.044913448 |
| Sakura | 104 | 172,789 | 0.090513 | 0.045600042 | 0.044913 | 1 | 1 | 0 |
| Total | | | | | 0.585469 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

Therefore, Index of concentration, $\Delta = \frac{1}{2}\sum_{i=1}^{k}|x_i - y_i| = \frac{0.585469}{2}$ =**0.292735**

Duncan has introduced the 'index of concentration', $\Delta$. This measures "… algebraically is simply the maximum of the set of $k$ values of $(X_i - Y_i)$. Geometrically, it is the maximum vertical distance from the diagonal to the curve". (The "$k$ $values$" refers simply to all the values of the difference). $\Delta$ is also algebraically equivalent to the Index of Dissimilarity, which is the sum of the positive differences between the two percentage distributions.

Algebraically, therefore, $\Delta = \frac{1}{2}\sum_{i=1}^{k}|x_i - y_i|$, where $x_i$ and $y_i$ are uncumulated percentages of the two distributions.

The maximum value of $|X_i - Y_i|$ is read from the above table as **0.270560841.** This is $\Delta$. The corresponding value of $X_i$ is 0.784921154, so $\Delta$ is drawn with that abscissa.

(ii). **Population Density** = Number of People/Land Area. The unit of land area should be square miles or square kilometers.

| **City** ⇩ | **Area ($km^2$)** | **Population** Census (Cp), 2015 | **Population Density** |
|---|---|---|---|
| **Total** ⇨ | **1,149** | **3,789,229** | **(Number of people)/Land area** |
| Chiba | 272 | 972,639 | 3,576 |
| Funabashi | 86 | 622,823 | 7,242 |
| Matsudo | 61 | 483,238 | 7,922 |
| Ichikawa | 57 | 481,492 | 8,447 |
| Kashiwa | 115 | 414,054 | 3,600 |
| Ichihara | 368 | 274,558 | 746 |
| Yachiyo | 51 | 193,219 | 3,789 |
| Nagareyama | 35 | 174,417 | 4,983 |

| | | | |
|---|---|---|---|
| Sakura | 104 | 172,789 | 1,661 |