

CST 310 / SER 417: Population, Space & Environment

# Spatial Approaches in Population Studies: Analytical Methods and Representation Techniques

## Basic Concepts and Measures in Demography

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# Demography



## 1) **Etymology** – word first used 1855 (Belgian Achille Guillard)

From dictionary:

Word origin of 'demography'

< Gr *dēmos*, the people (see democracy) + -graphy (*Graphein* = to write)

*noun*

the statistical science dealing with the distribution, density, vital statistics, etc. of human populations

*Webster's New World College Dictionary, 4th Edition. Copyright © 2010*

## 2) **Formal Demography**

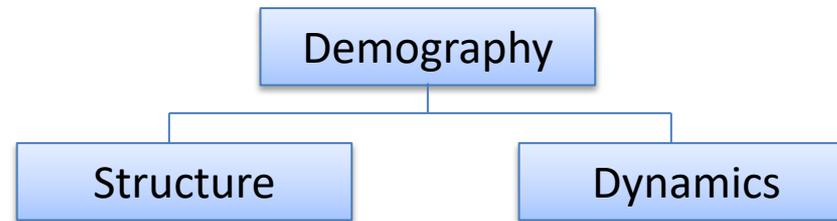
Demography is a *Science* with focus on:

Study of human populations and their temporal evolution in relation to their size, spatial distribution, composition and general characteristics.

# Demography



## VARIABLES



**STRUCTURE** – describe the population status (number & structure)– relating to a geographical area and a specific time → **Population Statistical Analysis**

- Size
- Distribution
- Structure or composition

(age, sex, education level, income, households/family, urbanization, ethnicity,...)

**DYNAMICS** - dynamic demographic variables for a given geographic space and time:

- Vital Statistics: births (natality), fertility, deaths (mortality), reproduction, marital status (marriage, divorce)
- Migration : Emigration, Commuters, Immigration

# Population

Set of Human being with a certain characteristic.

- Inhabitants of the same country or region;



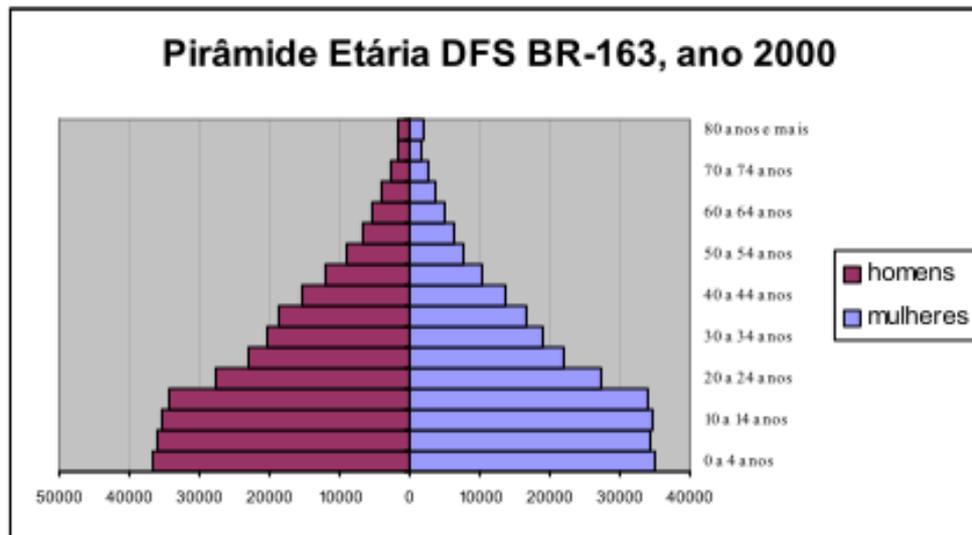
# Population

Set of Human beings with a certain characteristic.

- Group of people in a given age group;



**Figura 2. Gráfico da pirâmide etária do Distrito Florestal da BR-163, no ano 2000.** Fonte: FIBGE, Censo Demográfico 2000.



# Population

Set of Human beings with a certain characteristic.

**Inhabitants ??** - Military? Diplomats? Students? People on vacation???

IBGE - Censo 2010: **Population Recorded x Resident**

**Recorded** (recenseada): people who had the home as a place of residence and were present at the reference date (present residents) + people who had the home as a place of habitual residence and who, on the reference date, they were absent for a period not exceeding 12 months from that date (absent residents).

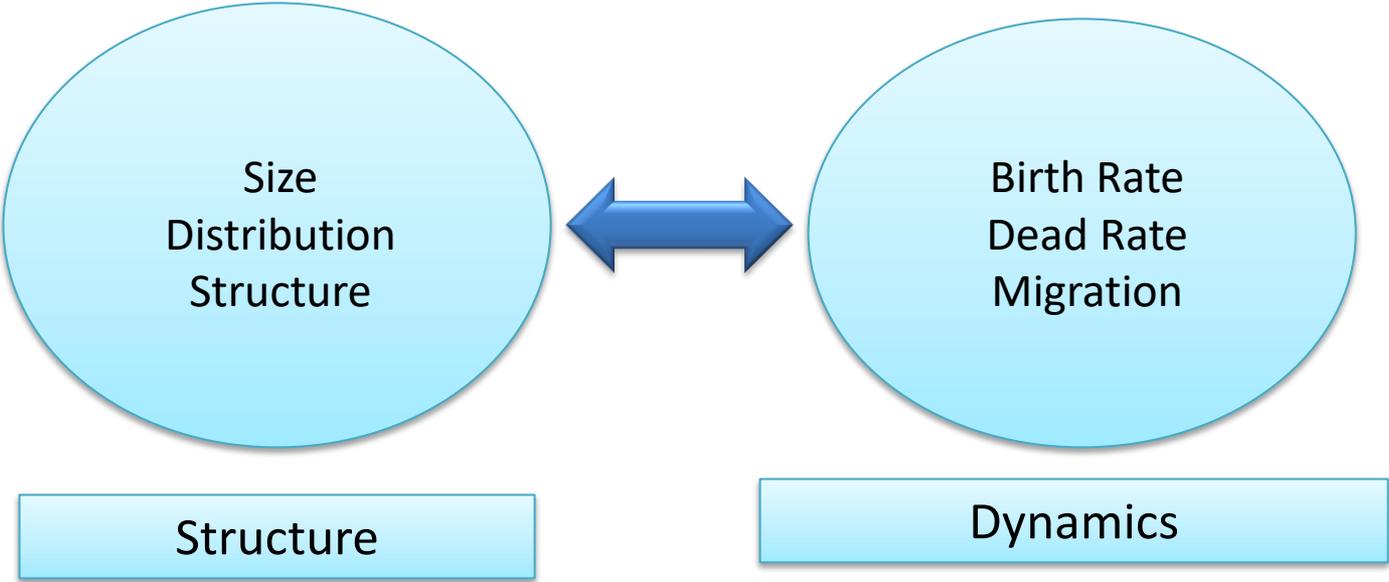
**Resident:** the residents of the place of residence at the date of reference, whether they were present or absent. People living in the home who were absent were censused since your absence has not been more than 12 months on that date, for the following reasons: travel, admission in educational establishment or lodgings in another residence, detention without final sentence declared, temporary admission in hospital or similar establishment and boarding the service (shipping).



# Demography



Interrelationships between static analysis and demographic dynamics  
demographic variables



# Population



- Population Characteristics - Size and Structure

- ✓ How many people/local / time ?
- ✓ How many youth/children? Adults? Elderly?
- ✓ How many male / female ?
- ✓ How many are economically active?

- Factors that affect population

- ✓ How many are born?
- ✓ Die?
- ✓ Migrate?

- 
- How many women of reproductive age?
  - How many married?
  - Ratio of effective contraceptive?

# Concepts & MEASURES



## AGE

the age of the individuals is important to various demographic phenomena

The **age** of an individual can be defined as the number of days, months and years after your birth;

Or the **number of full years**:

- the age group of 20 to 24 years - is formed for all individuals aged between 20 and 24 years

→ on reference date of a census survey *individuals born in the same year may have different ages in terms of full years.*

Calendar year = 1 January to 31 December.



Which population include in the denominator for calculating rates?

# Concepts & MEASURES



## AGE

→ the denominator should contain the number of people-year, which corresponds to the sum of the time spent (in years) for each component of the population!

Concept of **people-year** : take the population at a given time of the year.

But at what time?

- at the **beginning** of the year – not include people who are born during the year.
- at the **end** of the year - not include people who died during the year and, include people who were born at different times during the year and who were not exposed all the time to the risk of die.

Solution: the total of people-year population in the **middle of the year**, assuming there is uniformity in the event of births and deaths during the year.

# Demographic MEASURES



For demographic measures & indicators, one need to identify :

- a) Which population subgroup or type of event being analyzed;
- b) What is the geographical area
- c) Which the instant of time/period considered

**Stock statistics** - measures refer to a moment of time, for an specific date (until)

**Flow measures**, - it refer to a calendar-year (Jan-Dec the same year), but can be obtained for any interval of 12 months, or varied .

# Demographic MEASURES



## 1 ) FREQUENCY - **absolute** measurement

**Total number of persons** in the population or sub-group in a specific moment of time, or

**total n of occurrences** of the event during the period of time considered:

- useful as numerator of population-based measures or guiding public resource allocation
- does not measure the intensity of stock and flow statistics

Ex: N of live births → n vaccines calculation

Without distinguishing RURAL from URBAN births

Are there more men or women? Did the Mortality rate increase?

OBS: Do not use frequency when population have different sizes!

# Demographic MEASURES



**Relative** measurement for Stock statistics

**2) RATIO:** relationship between values that belong to different populations.

EX: the relationship between the total of MEN and WOMEN in total a population, usually called the SEX RATIO.

Ex: **Brazil Sex ratio (SR)**

**2011** Men = 94.7 million

Women = 100.5 million



$$SR = \frac{P^m}{P^f} \times 100$$

$$SR = 94.2 \text{ (2011)}$$

|               | 1991                      | 1996 | 1999 | 2000 | 2010  | 2013 | 2014 | 2018* |
|---------------|---------------------------|------|------|------|-------|------|------|-------|
| <b>BRASIL</b> | 97.5                      | 97.3 | 96.8 | 96.9 | 96    | 94.5 | 93.9 | 97    |
| <b>RJ</b>     | smaller MAN pop           |      |      |      | 91.2  | 88.4 |      |       |
| <b>AM</b>     | only state man pop stable |      |      |      | 101.3 |      |      |       |

**2014:**

More man: MT, PA,RO

AP = 100!!!

\*<https://www.states101.com/gender-ratios/global/brazil>

Quotient between distinct events

# Demographic MEASURES



**Relative** measurement for Stock statistics

### 3) PROPORTION:

- relationship between values that come from the **same population**,
- the numerator is part of the denominator.

For example: the proportion of men in a population,

➔ the ratio between the number of men and the total population.

2010 Census:

190,173,694 people;

93,390,532 Man

Proportion = 0.49

Proportion and Percentage – relationship between the part and the whole –  
pay attention to the issues which refer to relative and absolute data

# Demographic MEASURES



**Relative** measurement for Stock statistics

## 4) RATE:

Represent the demographic event magnitude in a specific population or part of it, considering an specific **time** period.

For example: Mortality Rate

Rate of one event at a time =  $\frac{\text{n occurrences in the period}}{\text{pop at risk of having the event}}$

- In general \* 1000 to facilitate interpretation
- Others, like .... of Population Growth Rate.

**RATE – intensity of variation per time unit**

Useful for comparisons. It must consider:

- availability of a convenient denominator;
- availability of data that enable the comparability between different periods.

# Demographic MEASURES



## 4) RATE:

Ex: **Vital Rates:** to general, not related to intensity

– **Birth (natality) and Death Rate (mortality)**

– event and population belong to the same universe

General Rate (T)

$$T_1 = A_i / P_i$$

where:

**A<sub>i</sub>:** vital events vitais – in a certain área and time interval .

ex: Natality

**P<sub>i</sub>:** population over wich the events happened - not necessarily all members are evenly exposed to the risk

ex: Total Population

# Demographic MEASURES



## 4) RATE:

Ex: more **restricted Rates:**

– event and population belong to the same universe

General Rate (T)

$$T_2 = A_i / (B_i + C_i)$$

where:

**A<sub>i</sub>**: vital events vitais – in a certain área and time interval .  
ex: Mortality

**P<sub>i</sub>**: population over wich the events happened -  
ex: population of an specific age interval

## Generic Demographic rates

RATE = N event /people-year exposed to the event risk

## Period Demographic Rates:

RATE = N events between  $t_0$  and  $t$  / people-year exposed to the event risk  
between  $t_0$  and  $t$

- Gross Rate, General, Specifics (age, sex),

# Demographic MEASURES



## 4) RATE:

Some measures are called RATE, but by definition they are not.

Ex:

(a) Rate of Population Growth

$$\frac{P^t - P^{t_0}}{P^{t_0}} \times 100 \text{ ou } \frac{P^t - P^{t_0}}{P^{\frac{t+t_0}{2}}} \times 100$$

(b) Urbanization Rate

$$\frac{P^{urbana}}{P} \times 100$$

(c) Natality Gross Rate

$$\frac{N}{P} \times 1000$$

WHY ?

# Demographic MEASURES



## 4) RATE:

Some measures are called RATE, but by definition they are not.

Ex:

(a) Rate of Population Growth

$$\frac{P^t - P^{t_0}}{P^{t_0}} \times 100 \text{ ou } \frac{P^t - P^{t_0}}{P^{\frac{t+t_0}{2}}} \times 100$$

(b) Urbanization Rate

$$\frac{P^{urbana}}{P} \times 100$$

(c) Natality Gross Rate

$$\frac{N}{P} \times 1000$$

(a) & (b) - the numerator is not the number of occurrences of an event,  
(c) the denominator includes people who are not at risk, such as newborn children and elderly pop

# Demographic MEASURES



## 5) **Probability** - includes risk estimates

$$\text{Probability of an event in a given period} = \frac{\text{N of events during the period}}{\text{Population in risk of the event in the beginning of the period}}$$

- Generally \*1000 – better reading and interpretation
- Also a measure of Risk

# Demographic VARIABLES

**Size** and **composition** are considered as **static** aspects of a population.

Demography also deals with the **dynamic** aspects of populations, that is, the changes and interrelationships between basic demographic variables - **fecundity, mortality and migration**.

## VARIABLES

- Population Size
- Mortality
- Natality
- Fecundity
- Distribution – by sex, age, situation
- Geographic Distribution

# SIZE

## Giving:

- The population of a given geographic area, at any given time.
- The initial population in the distant past, there was no entry and exit of people from the area.
- A closed population → without migratory movements.



- What is the size of the current population?

# SIZE



- What is the size of the current population?

The trajectory between the initial population and the current population can be explained by:

births and deaths + migratory movements, that occurred in the period

It can be represented by the **Basic Equation of the Population Movement:**

$$P_n = P_o + N_t - O_t + I_t - E_t$$

$P_n$  = population in a time  $n$ ;

$P_o$  = initial population,  $t=0$ ;

$N_t$  = births in period  $t$  ( $t = n - 0$ );

$O_t$  = deaths in period  $t$  ( $t = n - 0$ ).

$I_t$  = Immigrants in period  $t$  ( $t = n - 0$ );

$E_t$  = Migrants in period  $t$  ( $t = n - 0$ ).

# SIZE



- What is the size of the current population?

(CLOSED Population)>> Evolution from the initial population and the current population is explained by the **deaths** and **births** that occurred in the period.

**Without migratory movements**

Population size at any time during this period can be reproduced by:

$$P_n = P_o + N_t - O_t$$

$P_n$  = population in a time  $n$ ;

$P_o$  = initial population,  $t=0$ ;

$N_t$  = births in the periodo  $t$  ( $t = n - o$ );

$O_t$  = deaths in the periodo  $t$  ( $t = n - o$ ).

# SIZE



Basic Equation – Specific terms:

$$P_n = P_o + N_t - O_t$$

- Vegetative Growth:  $N - O$
- Migration balance:  
(Net migration Rate)  $I - E$
- Population Growth:  $P_n - P_o$
- Population Growth Rate:  $(P_n - P_o) / P_o \times 100$

# SIZE



Population growing with geometric progression...

$$P_n = P_0 (1+r)^t$$

$r$  = Growth rate by time period;

$t$  = period, in time unit, between 0 and  $n$

How to calculate  $r$ ?

$$P_n = P_0 (1+r)^t$$

$$(1+r) = \text{anti log} \left[ \frac{1}{t} \log \frac{P_n}{P_0} \right]$$

$$\frac{P_n}{P_0} = (1+r)^t$$

$$r = \text{anti log} \left[ \frac{1}{t} \log \frac{P_n}{P_0} \right] - 1$$

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

or (log 10base)

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

$$r = 10^{\left[ \frac{1}{t} \log \frac{P_n}{P_0} \right]} - 1$$

# SIZE



Population growing with geometric progression

To calculate the size of the population in the future ... or  
to calculate the time required to reach a given population volume, from a  
given initial population and a growth rate....

Consider the Brazilian population:  
in **2000: 169,799,170** residents, and  
in **2010: 190,755,799** .  
(without considering migrations)

## Calculate:

- Annual growth rate;
- Intercensal value for 2007;
- If this growth rate is maintained,  
how long would the population double?

$$P_n = P_0(1+r)^t$$

$$\frac{P_n}{P_0} = (1+r)^t$$

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

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

# SIZE: IBGE Projection estimates – BR & UF



## Population Projection (2013) - Demographic component Method

It incorporates information on observed *trends in mortality, fecundity and migration* at the national and regional levels

Demography's fundamental **population component estimating equation:**  
(*Equação compensadora ou equação de equilíbrio populacional*):

$$P_{(t+n)} = P_{(t)} + B_{(t, t+n)} - D_{(t, t+n)} + I_{(t,t+n)} - E_{(t,t+n)}$$

$P_{(t+n)}$  = population in year  $t + n$ ;

$P_{(t)}$  = population in year  $t$ ;

$B_{(t, t+n)}$  = births occurring between  $t$  and  $t + n$ ;

$D_{(t, t+n)}$  = deaths occurring between  $t$  and  $t + n$ ;

$I_{(t, t+n)}$  = immigrants, period  $t, t + n$ ;

$E_{(t, t+n)}$  = migrants, period  $t, t + n$ ;

$t$  = initial year;

$n$  = range size (interval)

# SIZE: Projections



## Demographic Component Method

In a given year  $t$ ,

the population of men and women in the age  $x$  (with  $x = 1, 2, 3, \dots, 89$ ) is  $P_x^t$ ,  
and

the proportion of people of a specific age who survives a year is  $S_x^t$ .

The population at age  $x + 1$  in year  $t + 1$  is given by:

$$P_{x+1}^{t+1} = P_x^t * S_x^t + M_x^t$$

Where:  $M_x^t$  represents the migratory component.

ex. For the age group of 90 years or over ( $P_{90+}$ ):

$$P_{90+} = P_{89+} * S_{89+} + M_{89+}$$

# SIZE: IBGE Projection estimates – BR & UF



**Population Projection (2013)**  
**Demographic Component Method – MCD**

## **Componentes demográficas, parâmetros utilizados e construção de hipóteses: cálculo e projeção (...)**

[https://ww2.ibge.gov.br/home/estatistica/populacao/projecao\\_da\\_populacao/2013/default.shtm](https://ww2.ibge.gov.br/home/estatistica/populacao/projecao_da_populacao/2013/default.shtm)

[ftp://ftp.ibge.gov.br/Projecao\\_da\\_Populacao/Projecao\\_da\\_Populacao\\_2013/srm40\\_projecao\\_da\\_populacao.pdf](ftp://ftp.ibge.gov.br/Projecao_da_Populacao/Projecao_da_Populacao_2013/srm40_projecao_da_populacao.pdf)

# SIZE: IBGE Projection estimates – BR & UF



Instituto Brasileiro de Geografia e Estatística

<https://www.ibge.gov.br/apps/populacao/projecao/notatecnica.html>



Projeções e estimativas da população do Brasil e das Unidades da Federação



↑ nota técnica

## Popclock Projeção 2013

(1° de julho de 2000 a 01 de julho de 2020)

### METODOLOGIA DE CÁLCULO

O Popclock calculado a partir da nova Projeção de População do Brasil 2013 apresenta a população residente do Brasil, ajustada a cada segundo, e estimada da seguinte forma:

- Foram utilizadas as populações projetadas para 1° de julho, cobrindo os anos de 2000 a 2020, extraídas da Projeção de População do Brasil 2013, elaborada pelo Método das Componentes Demográficas (MCD) para cada uma das 27 unidades da federação, com as seguintes características:
  - População de partida – Estrutura ajustada por sexo e grupos quinquenais de idade para o Censo Demográfico 2000;
  - Mortalidade – oriunda da Projeção da população do Brasil 2013 por sexo e idade para o período 2000 – 2060, utilizando as tábuas construídas para 2000 e 2010;
  - Fecundidade oriunda da Projeção da população do Brasil 2013 por sexo e idade para o período 2000 – 2060, utilizando as taxas específicas de fecundidade construídas para 2000 e 2010; e
  - Migração internacional – oriunda da Projeção da população do Brasil 2013 por sexo e idade para o período 2000 – 2060.

Para detalhes adicionais, ver em:

[www.ibge.gov.br/home/estatistica/populacao/projecao\\_da\\_populacao/2013/default.shtm](http://www.ibge.gov.br/home/estatistica/populacao/projecao_da_populacao/2013/default.shtm)

# SIZE: IBGE Municipal Projection estimates



## Population Estimates – MUNICIPALITIES - July 1, 2017:

**Madeira & Simões (1972)** Methodology: “the trend of population growth of the municipality, between two consecutive demographic census, is given in relation to the growth trend of a hierarchically superior geographical area (greater area).”

- Basis of projection for each Federation Unit –UF (larger area)
- UF - Population value (2017) → demographical component method
- Pop T municipalities - Censuses 2000 and 2010, linear adjustment + calibration factor: values applied for the respective UF  
(reference date on July 1, 2017)

# SIZE: IBGE Projection estimates – BR & UF



## Population Estimates – MUNICIPALITIES - July 1, 2017:

Demographical component - Population estimates UF (2013)  $\rightarrow P(t)$

Larger Area (UF)  $\rightarrow P(t)$  = pop estimated at  $t$ , subdivided in smaller areas  $i$

$P_i(t)$  ;  $i = 1, 2, 3, \dots, n$

$$P(t) = \sum_{i=1}^n P_i(t)$$

$$P_i(t) = a_i P(t) + b_i$$

$a_i$  = proportion of pop increase from smaller area (i) /larger area

$b_i$  = linear coefficient for adjustment

$t_0$  &  $t_1$  = Demographic Censuses 2000 and 2010

$$P_i(t_0) = a_i P(t_0) + b_i$$

$$P_i(t_1) = a_i P(t_1) + b_i$$



$$a_i = \frac{P_i(t_1) - P_i(t_0)}{P(t_1) - P(t_0)}$$

$$b_i = P_i(t_0) - a_i P(t_0)$$

# SIZE: IBGE Projection estimates – BR & UF



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## Estimativas de População

**Introdução**

**Resultados**

- ▶ **Estimativas de população enviadas ao TCU**
- ▶ **Estimativas de população publicadas no D.O.U**
- ▶ **Série 2001-2017 TCU**

**Legislação**

**Banco de Metadados**

**Cidades@**

**Estados@**

**Estimativas por ano**

2017 :: 2016 :: 2015  
2014 :: 2013 :: 2012  
2011 :: 2009 :: 2008  
2006 :: 2005 :: 2004  
2003 :: 2002 :: 2001  
1999 :: 1998 :: 1997  
1995 :: 1994 :: 1993  
1992

**Estimativas populacionais para os municípios e para as Unidades da Federação brasileiros em 01.07.2017**

Atendendo ao dispositivo legal, Lei nº 8443, de 16 de julho de 1992, no artigo 102, o IBGE fez publicar no Diário Oficial da União, em 30 de agosto de 2017, as estimativas de população para os municípios e para as Unidades da Federação brasileiros, com data de referência em 1º de julho de 2017. A Lei complementar nº 143, de 17 de julho de 2013, alterou o art. 102 da Lei nº 8443, revogando os parágrafos 1º e 2º, que estabelecia o prazo de 20 dias após a publicação das estimativas no Diário Oficial da União para apresentação de reclamações ao IBGE.

- [Tabela de estimativas \(em formato pdf\)](#)
- [Tabela de estimativas \(em formato ods\)](#)
- [Tabela de estimativas \(em formato xls\)](#)

Informações metodológicas sobre o cálculo das estimativas 2017 podem ser obtidas no relatório:  
<http://biblioteca.ibge.gov.br/visualizacao/livros/liv100923.pdf>



Clique aqui para fazer download do Acrobat Reader

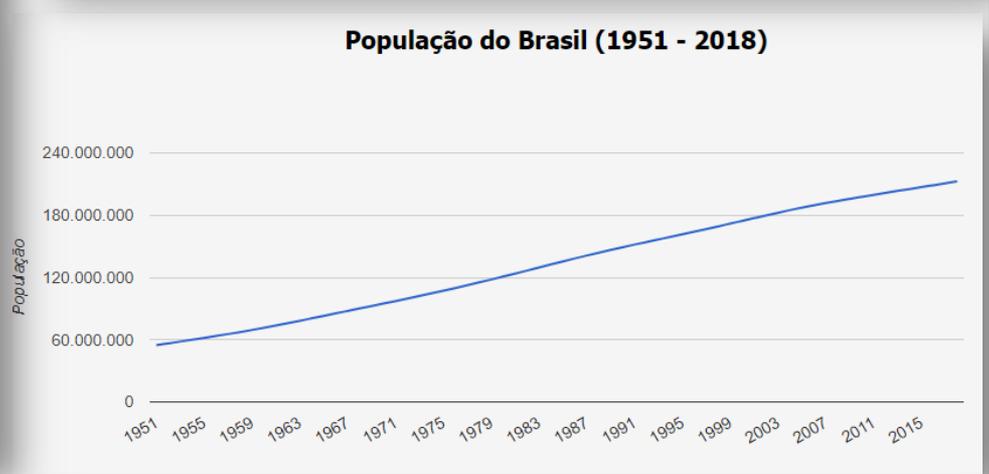
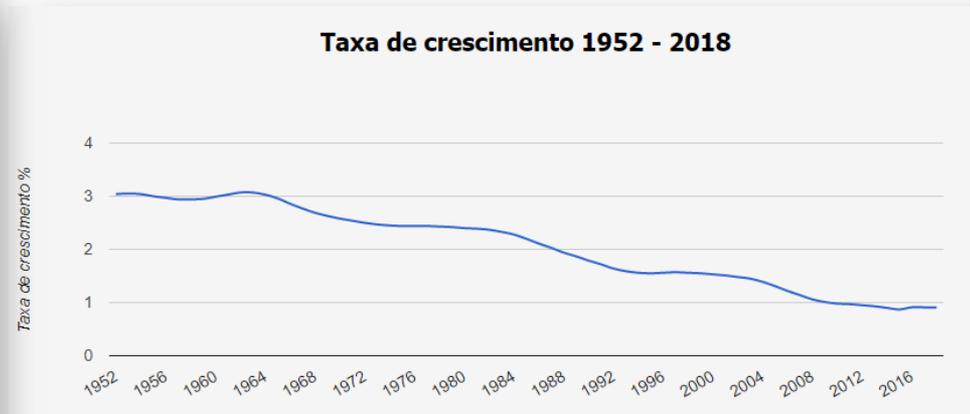
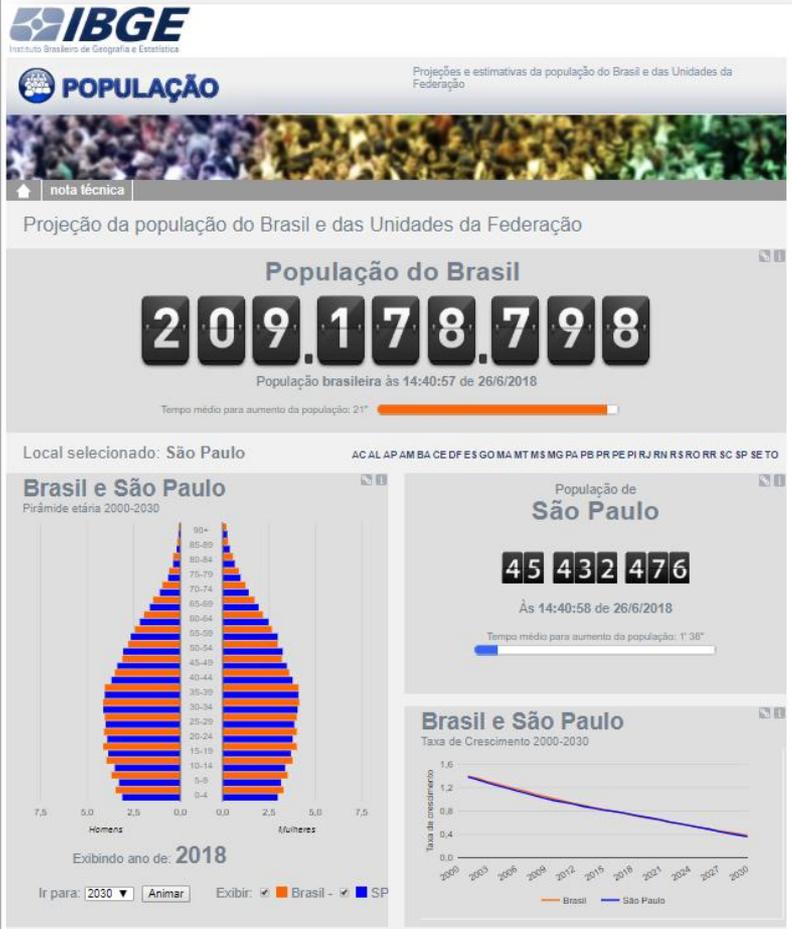
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<http://biblioteca.ibge.gov.br/visualizacao/livros/liv100923.pdf>

# Population - Projection estimates



<https://www.ibge.gov.br/apps/populacao/projecao/>



<http://countrysimeters.info/pt/Brazil>

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