

Introduction to Human Population Dynamics

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Key concepts, drivers, and implications for societies and the planet

1. What Is Population Dynamics?

Term	Definition
Population dynamics	The study of how human numbers change over time and space, and the factors that cause those changes.
Demography	The statistical science that measures population size, structure (age, sex, etc.), and vital events (births, deaths, migration).
Population growth rate	The net change in population size per unit time, usually expressed as a percentage per year.

2. Core Components of Population Change

1. Fertility (Births)

- *Crude Birth Rate (CBR)* – births per 1,000 people per year.
- *Total Fertility Rate (TFR)* – average number of children a woman would have over her reproductive life (replacement level 2.1 in most societies).

2. Mortality (Deaths)

- *Crude Death Rate (CDR)* – deaths per 1,000 people per year.
- *Life expectancy at birth* – average years a newborn is expected to live under current mortality conditions.

3. Migration

- *Immigration* – people moving into a region.
- *Emigration* – people leaving a region.
- *Net migration* = immigration – emigration.

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4. Population Structure

- Age pyramid shape (young, expanding, stationary, or aging).
 - Sex ratio, dependency ratios (young dependent vs. old dependent).
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3. Stages of the Demographic Transition

Stage	Fertility	Mortality	Population Growth	Typical Societies
1. Pre-transition	High & variable	High & variable	Low or stagnant	Pre-industrial, agrarian
2. Early transition	Declining	Rapid decline	Rapid increase	Early industrialization
3. Late transition	Low	Low	Slowing increase	Mature industrial economies
4. Post-transition	Very low (often <2.1)	Low	Near-zero or negative	Highly developed economies
5. (Proposed)	Below replacement, possibly rising again due to policy	Low	Decline, aging population	Some European & East Asian nations

Key drivers: improvements in public health, nutrition, education (especially of women), and economic development.

4. Mathematical Foundations

1. Exponential Growth (idealized, no constraints)

$$[P(t) = P_0 e^{rt}]$$

- $P(t)$ = population at time t
- P_0 = initial population
- r = intrinsic growth rate (births – deaths per capita)

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2. Logistic Growth (growth limited by resources)

$$[P(t) = \frac{K}{1 + \left(\frac{K-P_0}{P_0}\right) e^{-rt}}]$$

- K = carrying capacity (maximum sustainable size)

3. Cohort-Component Method (most common projection technique)

- Separate the population into age-sex cohorts.
 - Apply age-specific fertility, mortality, and migration rates to each cohort year-by-year.
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5. Major Global