Human populations and urban systems

Topic8 · SL

A country that started to shrink

> Birth totals can rise in a year when the population still falls.

- China's population fell in 2022, 2023 and 2024.
- NBS 2024: 9.54 million births, 10.93 million deaths; births rose from 2023 while population fell.
- This unit: populations $\rightarrow$ cities $\rightarrow$ urban air.

Measuring population change

Measure	How to calculate
Crude birth rate	births $\div$ population $\times$ 1000
Crude death rate	deaths $\div$ population $\times$ 1000
Natural increase (%)	(CBR $-$ CDR) $\div$ 10
Doubling time	70 $\div$ growth rate (%)

Rates from a town

1. **Given.** Invented one-year records: mid-year population 10000; 150 births, 100 deaths, 300 immigrants, 200 emigrants.
2. **Rates.** CBR $= 150/10000 \times 1000 = 15$; CDR $= 100/10000 \times 1000 = 10$ per 1000 per year. NIR $= (15-10)/10 = 0.5\%$ per year.
3. **Total change.** $150 - 100 + 300 - 200 = +150$, so 1.5 %
4. **Doubling time.** $70 \div 1.5 \approx 47$ years

Decision

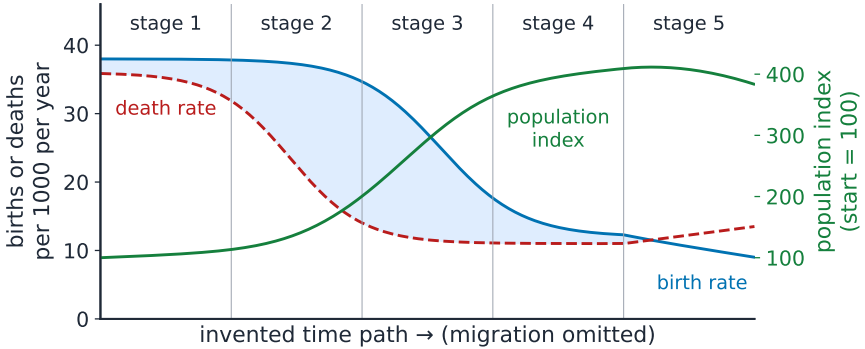
Migration makes this town grow three times faster than natural increase

Replacement level

> Period fertility, age structure, mortality and migration jointly shape change; replacement is not one universal immediate threshold.

- Period TFR applies current age-specific fertility rates to a hypothetical lifetime.
- A period TFR differs from completed family size; compare dated age-specific fertility estimates.

The demographic transition model



Invented rate curves give a population index; migration is omitted.

Why the rates fall

Death rate falls

Better food and clean water.

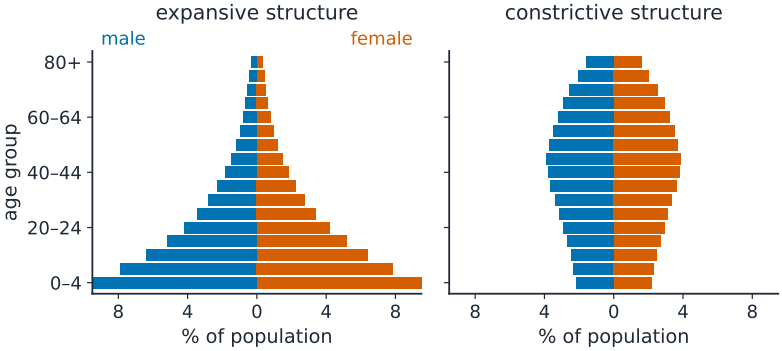
Sanitation, vaccines, medicine.

Birth rate falls

Contraception; girls' education.

Urban life; fewer infant deaths.

Population pyramids



Age structure shows cohorts; shape alone does not establish their causes.

Dependency ratio

- Many children need schools; many old people need pensions and healthcare.
- Age-based dependency is not an employment ratio; participation and productivity also matter.

$$\text{dependency ratio} = \frac{(0\text{–}14) + (65 \text{ and over})}{15\text{–}64} \times 100$$

Example, $(18 + 22) \div 60 \times 100 \approx 67$.

Malthus or Boserup?

Malthus (1798)

Population outgrows food.

Famine, disease and war limit it.

Boserup (1965)

Pressure drives invention.

Food supply rises to meet demand.

Fertility policies and wider development

Direct interventions

China later relaxed birth restrictions; assess rights as well as births.

Singapore's dated Baby Bonus supported eligible families; policy versions change.

Indirect pathways

Bangladesh: education and employment alongside family planning.

Kerala: education, public health and child survival; multiple causes interact.

Pyramids describe cohorts

What is shown

Label five-year bands and numbers or percentages.

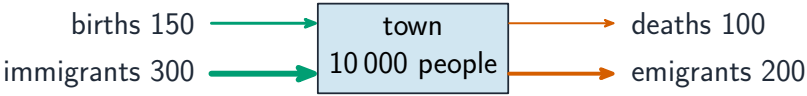
Large young cohorts can support growth momentum.

What needs more evidence

Shape alone does not measure life expectancy or current employment.

Birth history, survival and selective migration can alter a pyramid.

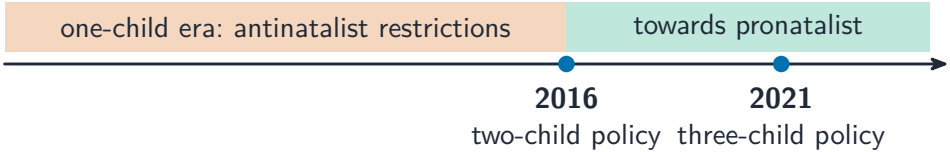
A town's population change



natural increase $150 - 100 = +50$ (0.5%); migration $300 - 200 = +100$
total $+150$ people $= 1.5\%$ a year; doubling time $\approx 70/1.5 \approx 47$ years (invented)

> Total $+150$, or 1.5% of 10,000

China's population policy



evaluate fertility with education, living costs, prior trends and reproductive rights

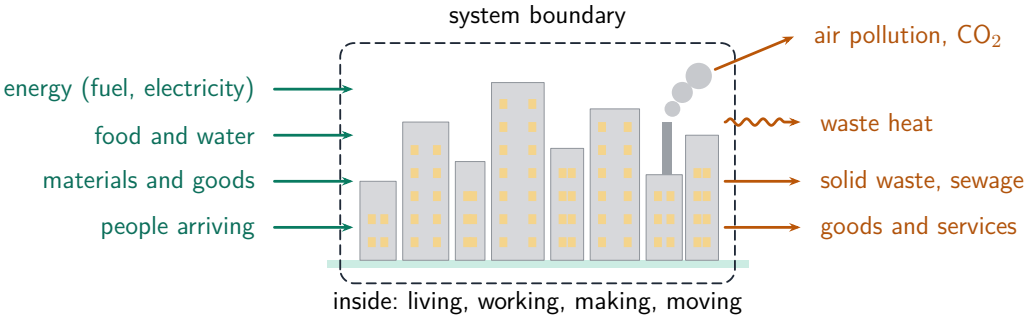
> The policy moved towards **pronatalist**

The rise of cities

> Push factors drive people from the countryside; pull factors draw them to cities.

- Urban shares depend on reference year, definition and geographic boundary.
- **Urbanisation** is an increasing share; urban growth concerns numbers or area.

A city as a system



> Track matter, energy and people across the stated city boundary.

Cities change their environment

> Housing security, reliable services and affordability vary among residents.

- **Urban heat island**, several degrees warmer, especially at night.
- Impermeable surfaces can increase rapid runoff; sprawl fragments habitats.

Sustainable urban planning

Strategy	Example
Compact, mixed-use design	Homes, shops, offices together
Public transport	Curitiba bus rapid transit
Green belts, green space	London green belt
Water-sensitive design	Sponge cities such as Wuhan

Urban numbers can rise while urban share falls

1. **Initial share** $60\,000 / 100\,000 \times 100 = 60\%$
2. **Later share** $66\,000 / 120\,000 \times 100 = 55\%$
3. **Urban-number growth** $6000 / 60\,000 \times 100 = 10\%$

Decision

Urban growth occurred; **urbanisation** did not under the increasing-share definition.

Land cover and an invented storm

1. **Rain volume** 0.010 m $\times$1 000 000 m^2 =10 000 m^3
2. **Sealed surface** Runoff fraction 0.8 gives 8000 m^3
3. **Vegetated surface** Runoff fraction 0.3 gives 3000 m^3

Decision

The 5000 m^3 difference illustrates a mechanism; real runoff needs site data.

Ecological planning connects functions

Land and living systems

Green roofs and wetlands can link habitat, cooling and water storage.

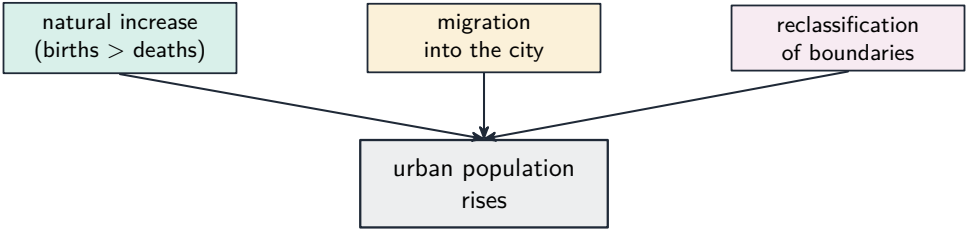
Map connectivity and permeable ground, not just green colour.

People and services

Include affordable housing, work, finance, health and safe transport.

Maintain systems and measure access and actual outcomes.

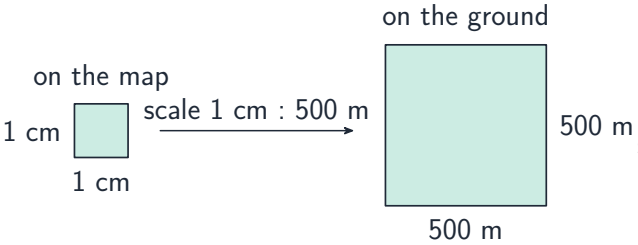
Why the urban population grows



compare maps at the same scale and boundary before blaming migration alone

> Three routes raise the urban count

Map scale and area



area: 500×500 m^2
$= 0.25$ km^2 per cm^2
square the length scale
(invented scale)

> Square the length scale for area

Primary and secondary pollutants

Primary (emitted)	Secondary (formed in air)
CO, NO_x, SO_2.	Tropospheric ozone.
Particulates, VOCs.	Sulfuric and nitric acids.

Acid deposition

> **Acid deposition** is regional; it falls hundreds of kilometres downwind.

- SO_2 and NO_x form sulfuric and nitric acids.
- Lakes lose fish; forests and limestone buildings are damaged.

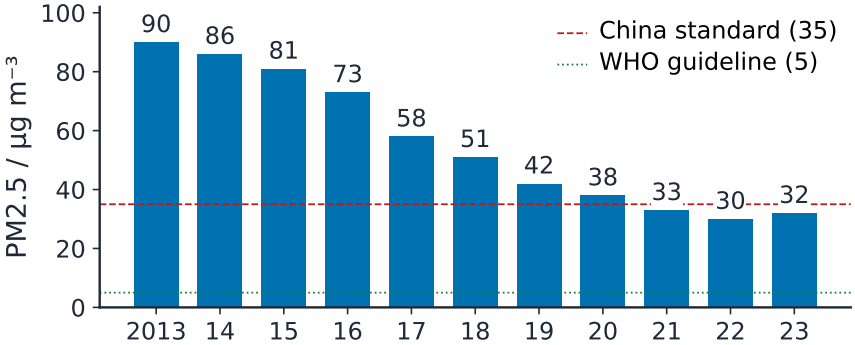
Check: which level?

Your turn

Fitting catalytic converters to cars works at which level of pollution management?

A. Changing the human activity
B. Controlling the release of the pollutant
C. Cleaning up and restoring
D. None of these

Beijing's cleaner air



The 2023 annual mean is 6.4 times the WHO annual guideline.

Primary, secondary and particle size

Formation

Primary emissions include dust, soot, CO and sulfur dioxide.

Ozone and some sulfate/nitrate particles form through atmospheric reactions.

Particle fractions

PM 2.5 is contained within PM 10; do not add as disjoint categories.

Natural dust or fire emissions can still harm health.

Acid deposition: chemistry and effects

Net formation

$2\ SO_2 + O_2 + 2\ H_2O \rightarrow 2\ H_2SO_4$

$4\ NO_2 + O_2 + 2\ H_2O \rightarrow 4\ HNO_3$; these are net summaries.

Damage and restoration

Acidity mobilises aluminium and removes nutrient ions; geology affects buffering.

Liming treats acidity, not upwind emissions; restoration may need repeating.

Plan a safe lichen investigation

Sampling

Equal quadrats, repeated trees, defined road distances and background sites.

Match tree species, height and aspect; protect organisms and people.

Inference

Record bark, shade and moisture; compare calibrated monitoring.

A lichen pattern does not identify one gas concentration or prove traffic causation.

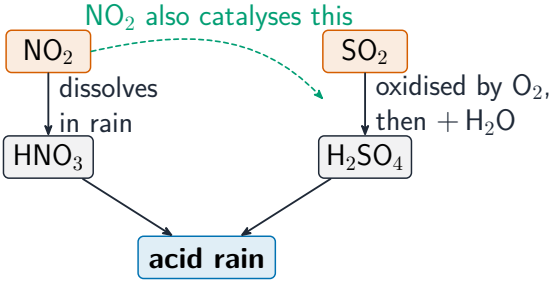
Beijing: distinguish rounding and benchmarks

1. **Rounded reduction** $(90-32)/90 \times 100 = 64.4\%$; official 64.2% uses unrounded data.
2. **WHO annual comparison** $32/5 = 6.4$ times the 2021 annual guideline.
3. **Interpretation** Annual means differ from daily peaks; one legal limit does not mean zero risk.

Decision

Evaluate weather, activity, costs, reliable heating, jobs and regional emissions.

How acid rain forms



> Both fall as acid rain

Exam tips

> Tropospheric ozone is a pollutant; stratospheric ozone protects us.

- Show working in rate calculations; give per 1000 or %.
- For the DTM, give each change and a reason.
- Use activity, release and clean-up for pollution management.

Check yourself

Try these

A country of 50 million has 900 000 births and 400 000 deaths in a year. Find CBR, CDR and NIR.

Evaluate China's one-child policy.

Plan a safe lichen investigation and explain its causal limits.