

# Human population at 8 billion: past, present, future

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Ashokan Reservoir, NY JEC 2003-10-18

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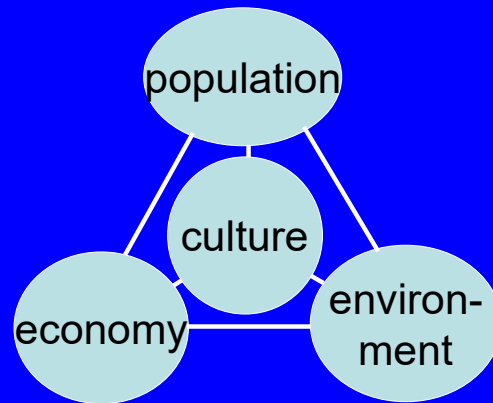
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Population  
Economy  
Environment  
Culture  
interact.



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## Global human population: summary

Very recent past: 200 years: 8X (1B → 8B);  
since 1974: 2X (4B → 8B). Growth was  
super-exponential, then sub-exponential.

Present: 8B population grows by ~80  
million/year (another USA in 4 years), not  
uniformly. >1 child in 5 under 5 years old  
is stunted from chronic hunger.

Future population (to 2050, excluding  
nuclear war, plague, climate catastrophe,  
comets): larger, older, more urban, slower,  
more Asian, more African.

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## Past

Genus *Homo* evolved early in Pleistocene Epoch, starting 2.58 million years ago.

*Homo* left Africa 4 times; only 4th survived.

By end of the Pleistocene Epoch 11,700 years ago, modern humans, *Homo sapiens*, had displaced all other species of humans & migrated from Africa to all continents except Antarctica.

Holocene history (11,700 before present to now) omits >99.5% of human history.

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## Population history in round numbers

Early (Pleistocene, 2.57 million years):

human population 1,000 → 10 million

10,000-fold growth =

average annual growth of 0.0004%/year

Recent (Holocene, 11,700 years):

human population 8 million → 8 billion

1,000-fold growth =

average annual growth of 0.06%/year

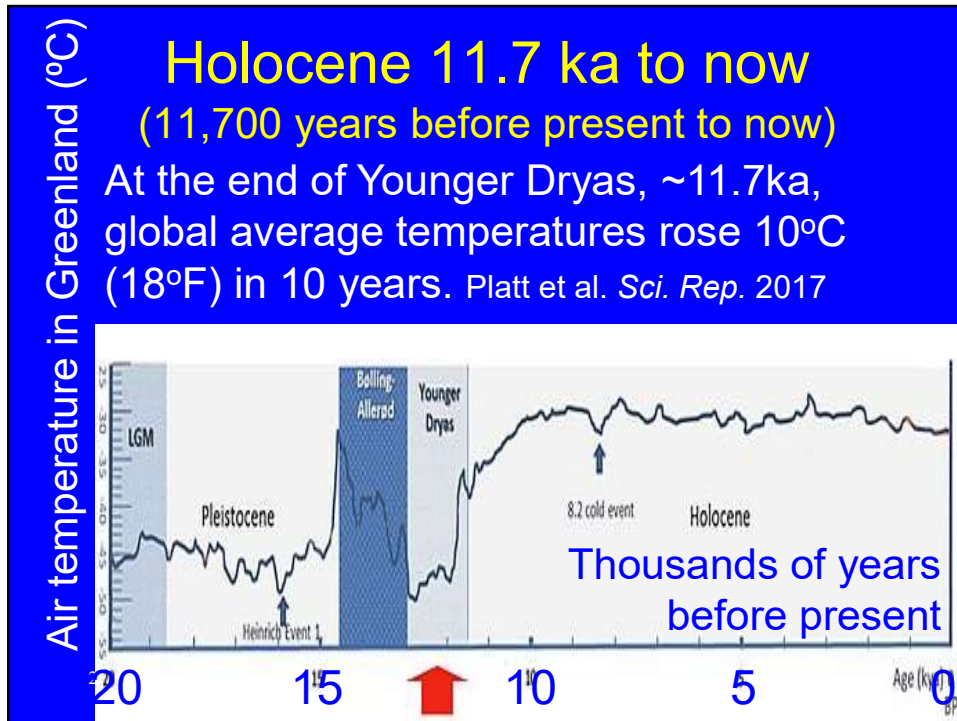
150-fold acceleration from early to recent

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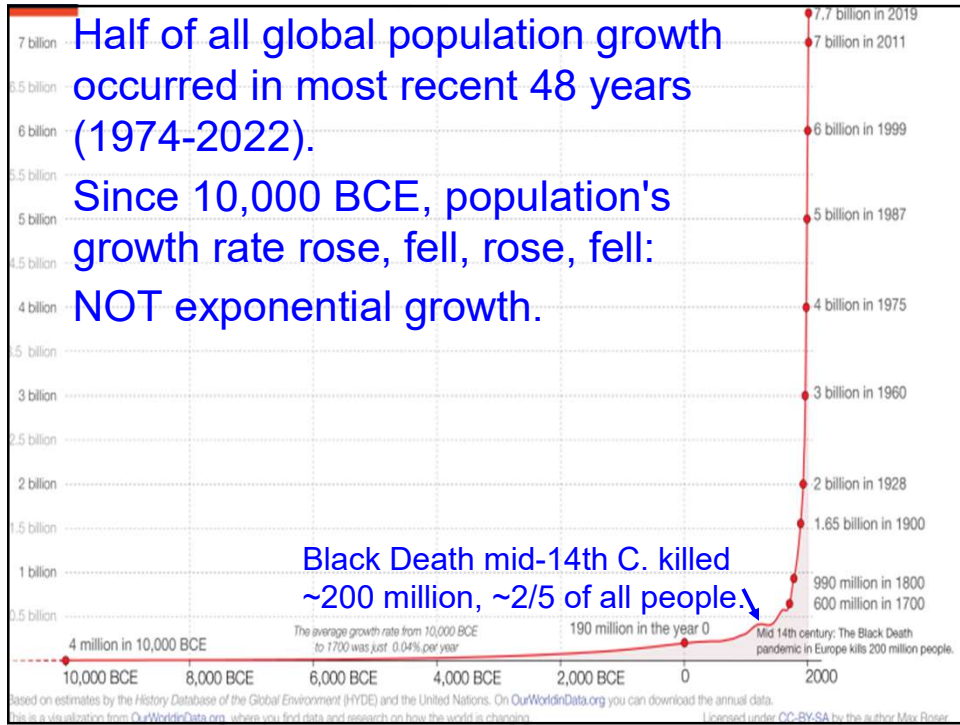
## 4 changes in population growth

1. independent inventions of agriculture in Middle East, Asia, Africa, Americas
2. exchanges of plants, animals, & people between Old World & New World
3. reduced death rates of children in poor countries
4. decline in fertility rates

invention	dates	people	doubling time (years)	
			before	after
local agriculture	10,000-6,000 BCE	1-10 million	35,000-350,000	1,400-3,000
global agriculture	1750	750 million	750-1,800	100-130
public health	1950	2.5 billion	87	36
fertility control	1970	3.7 billion	34	50

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### Milestones of population growth

people	year	years to add 1B
1-10 million	-10,000	
100-300 million	0	
500 million	1500	
1 billion	1800-20	~300,000
2 billion	1927-30	110-130
3 billion	1959-60	30
4 billion	1974	14
5 billion	1987	13
6 billion	1999	12
7 billion	2011-12	12-13
8 billion	2022	10

Growth rate from 1950 (2.5B) to 1974 (4.0B) was ~2%/y, ~50 times growth rate up to 1500.

Growth rate -10,000 to 1500 was 0.03-0.05%/y.

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## 20th century was unique demographically.

1. Highest global population growth rate in history: 3.8 x. Only century in which global population even doubled.
2. Largest voluntary decline in fertility
3. Last century with more young people than old people
4. Last century with more rural people than urban people

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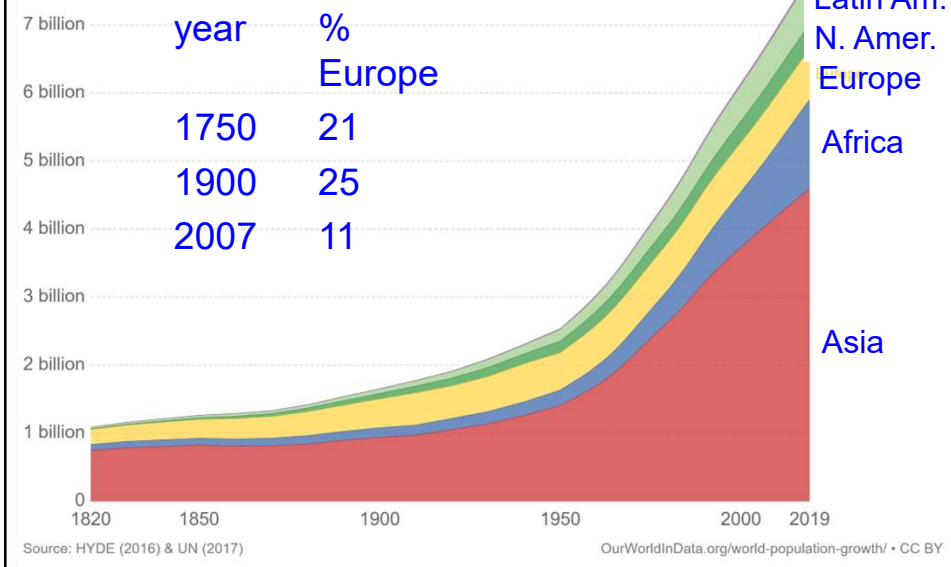
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## World population by region 1820-2019

<https://ourworldindata.org/world-population-growth> (CC BY 4.0)



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Fertility = number of children born  
Fecundity = potential for fertility

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## Total fertility rate (TFR)

TFR is the most widely used measure of fertility. It assumes no maternal deaths during childbearing ages.

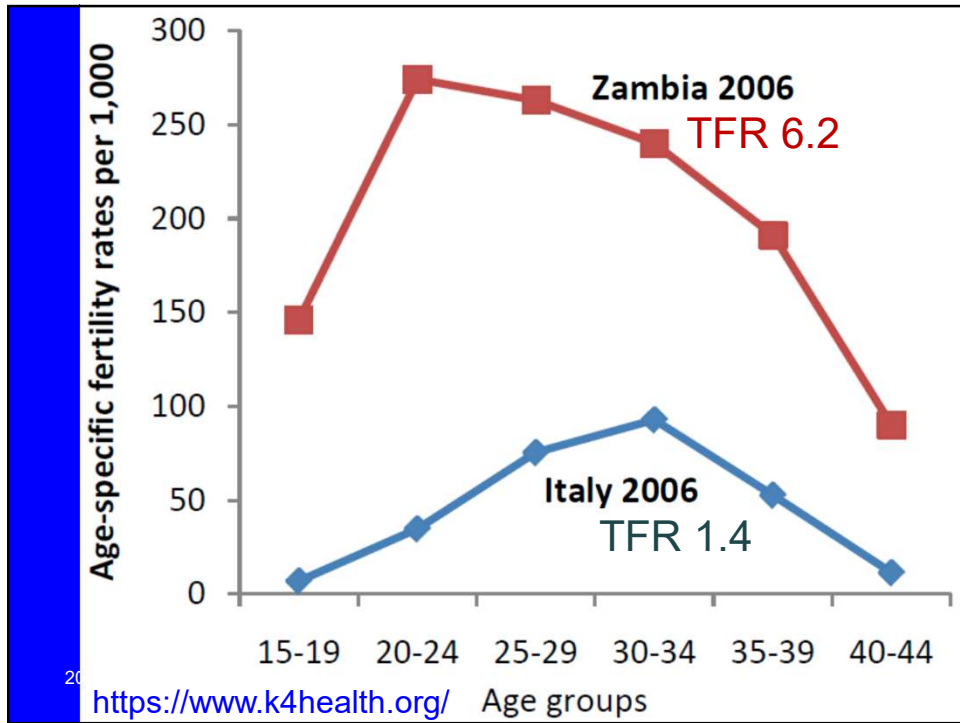
TFR = sum of age-specific birth rates  
= average number of children born per woman who lives to last age of reproduction.

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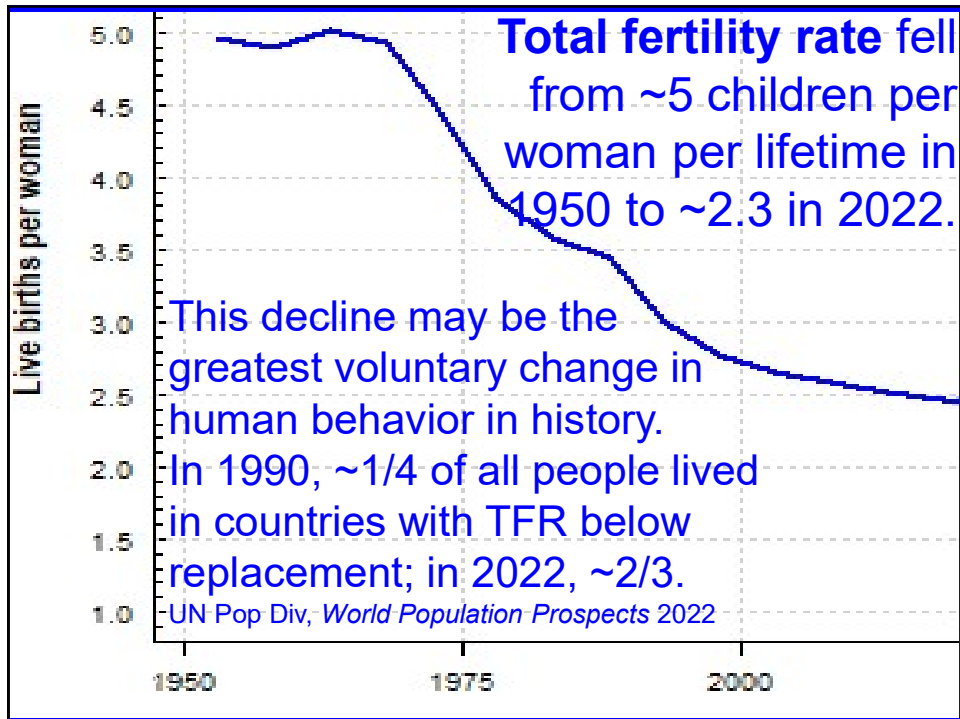
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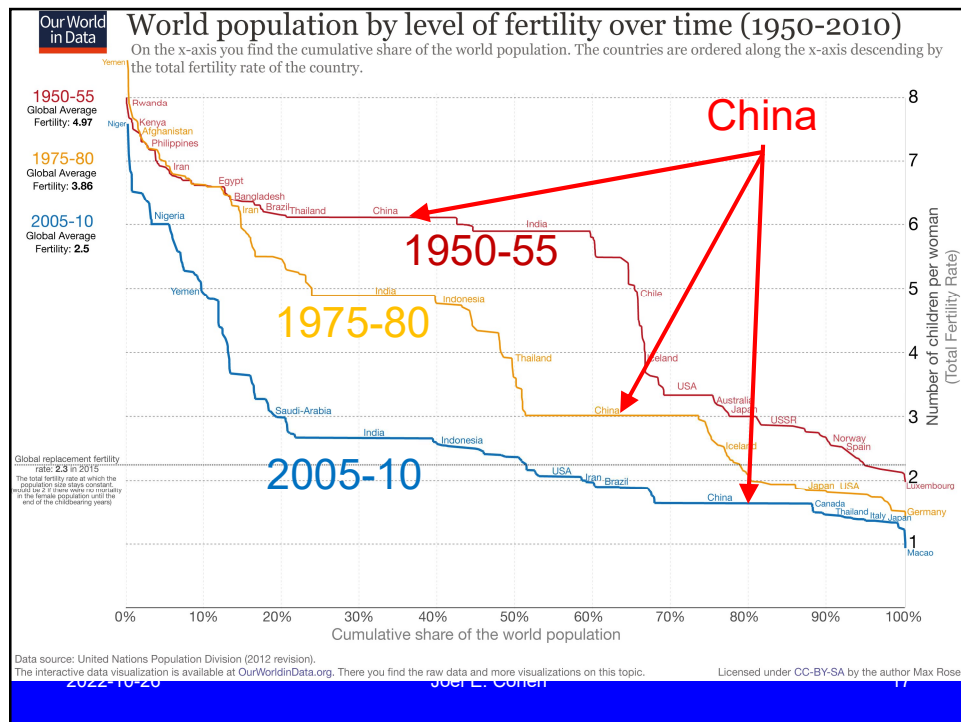


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### 3 measures of fertility

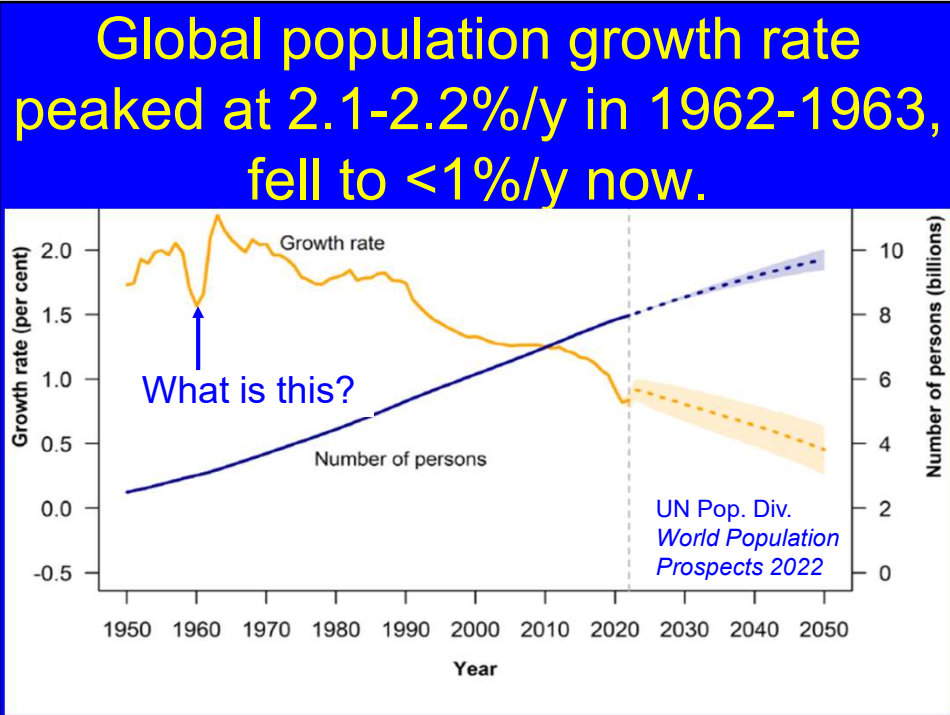
1. Birth rate (BR) = number of **births** (both sexes) per **year** per person (both sexes, including non-reproductive ages)
2. Total fertility rate (TFR) = average number of **births** (both sexes) per woman's **lifetime** at age-specific birth-rates, no female mortality
3. Net rate of reproduction (NRR) = average number of **daughters** per woman's **lifetime** at age-specific female birth- & female death-rates (includes effects of sex-ratio at birth)

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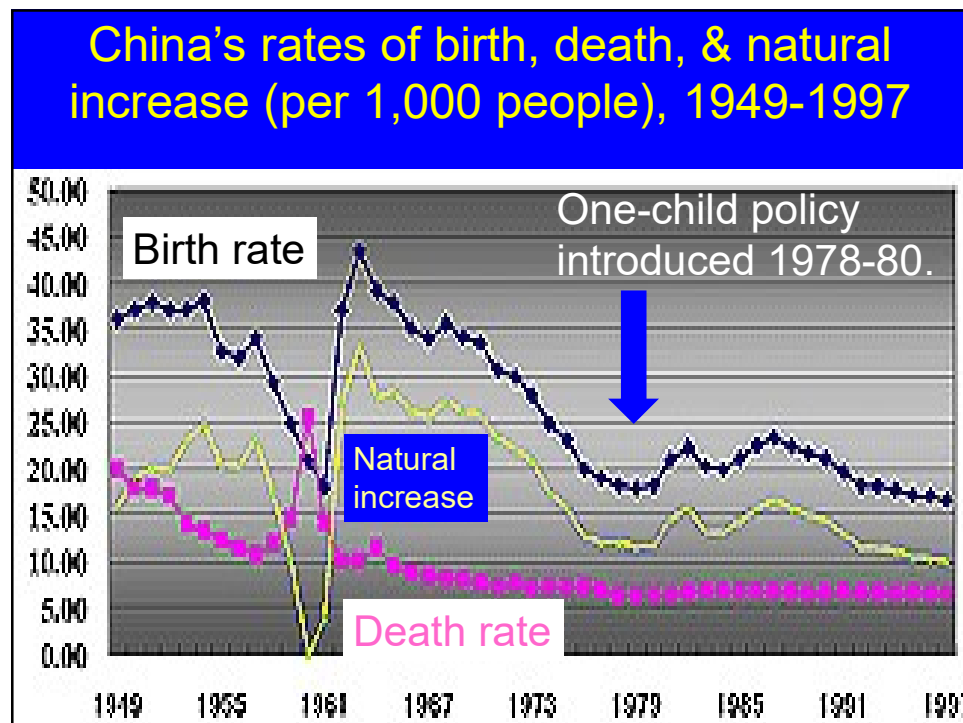
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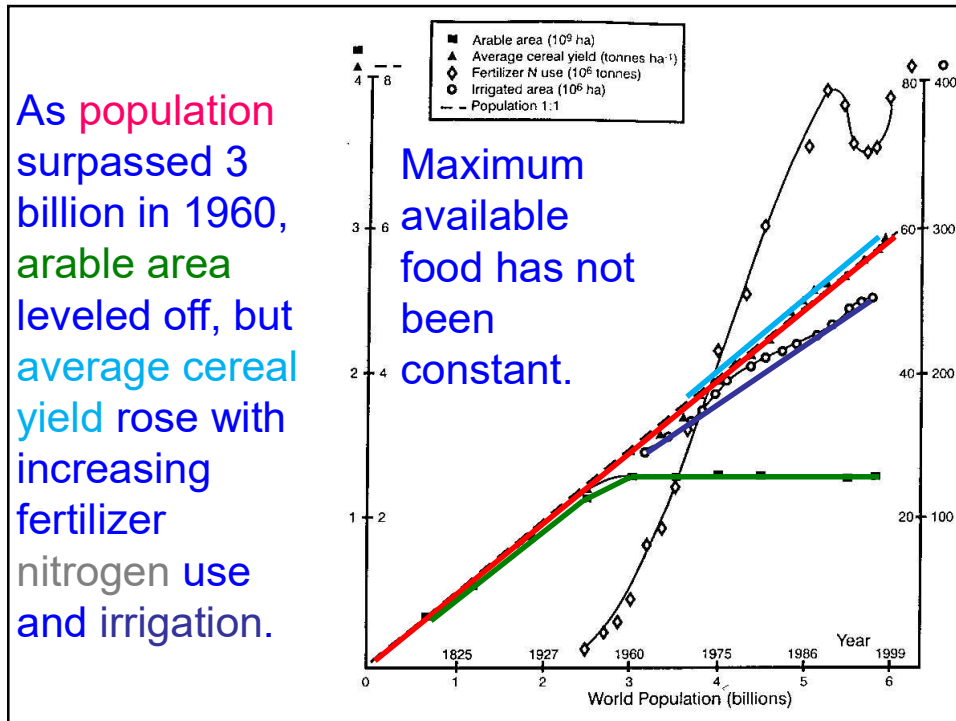
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**Green revolution (mid-1960s+) coincided with decline of population growth rate. Malthus was wrong.**

Population growth rates fell in countries with more abundant food because of lower child mortality & lower birth rates.

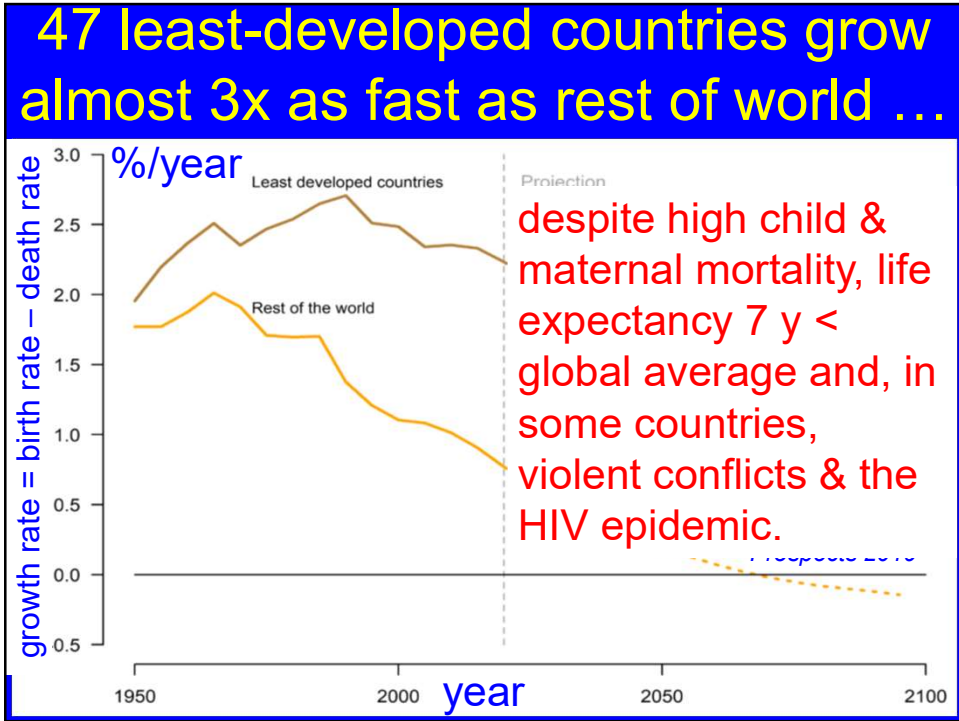
The 1960s marked both the peak of the global population growth rate, which has since fallen by half, & the beginning of the "green revolution."

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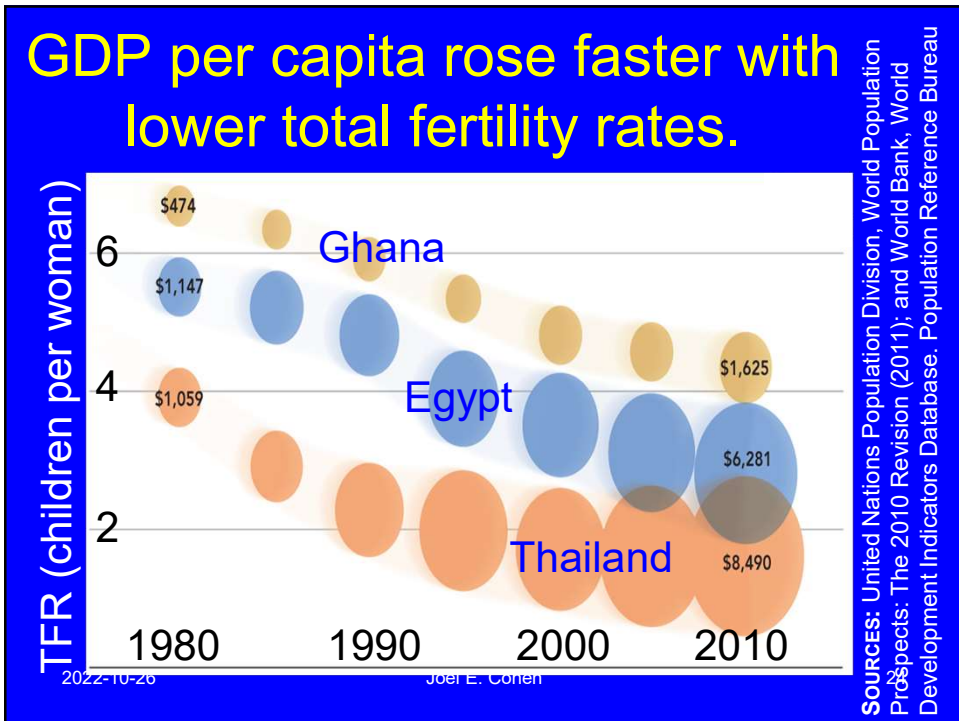
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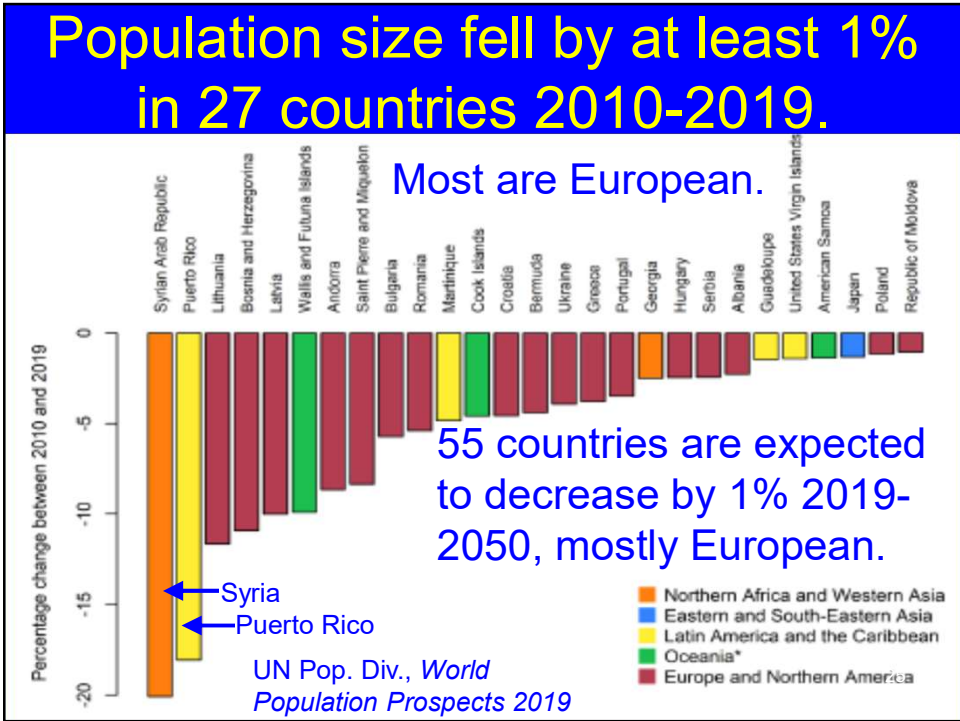
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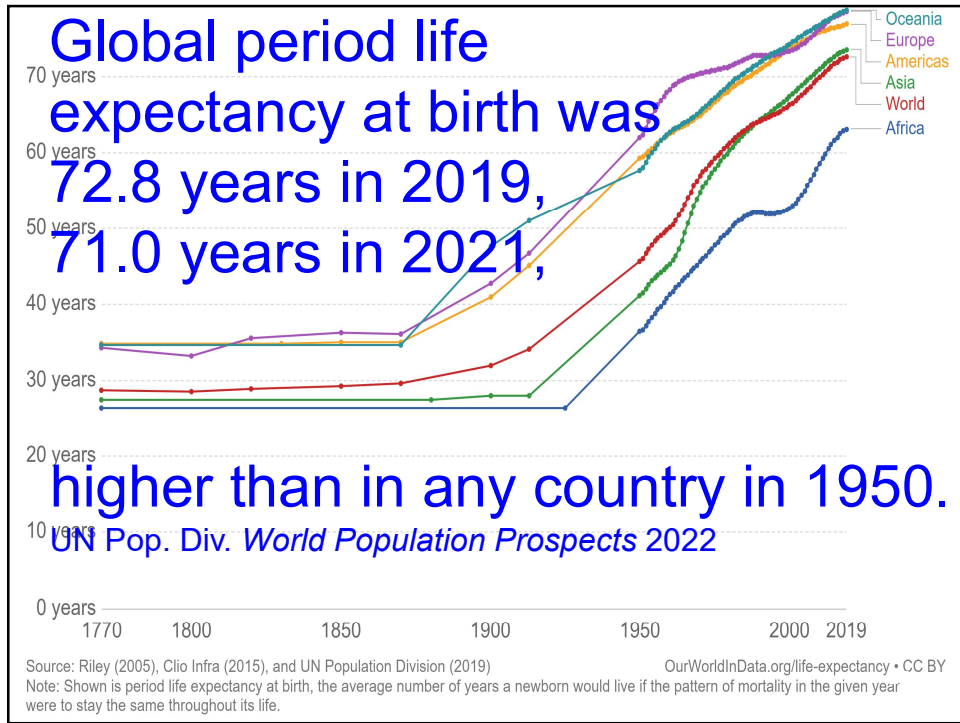


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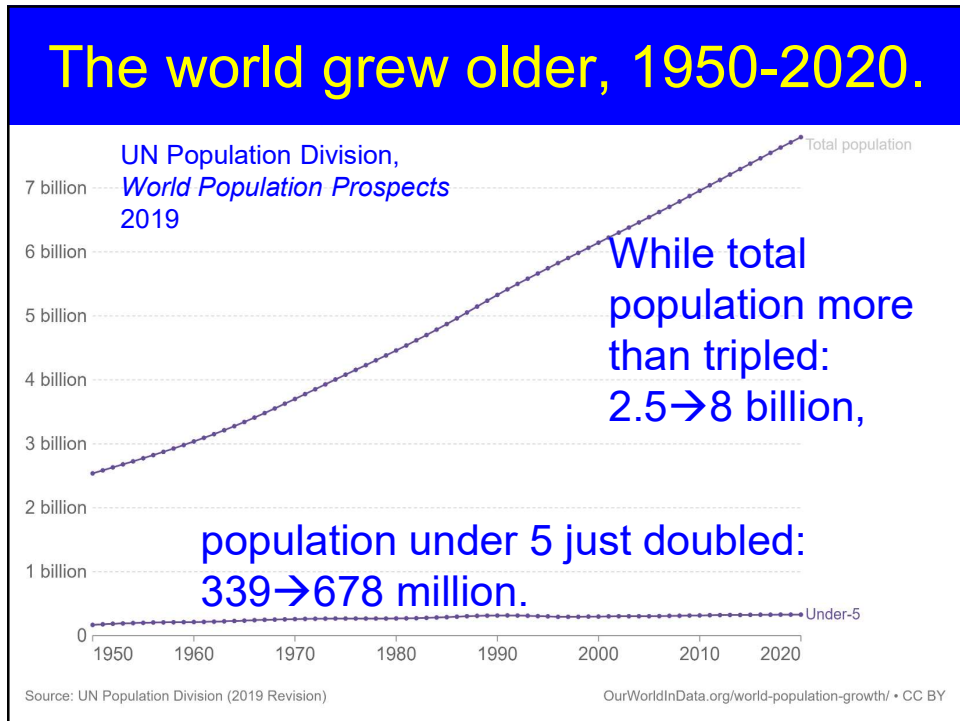
# Population aging

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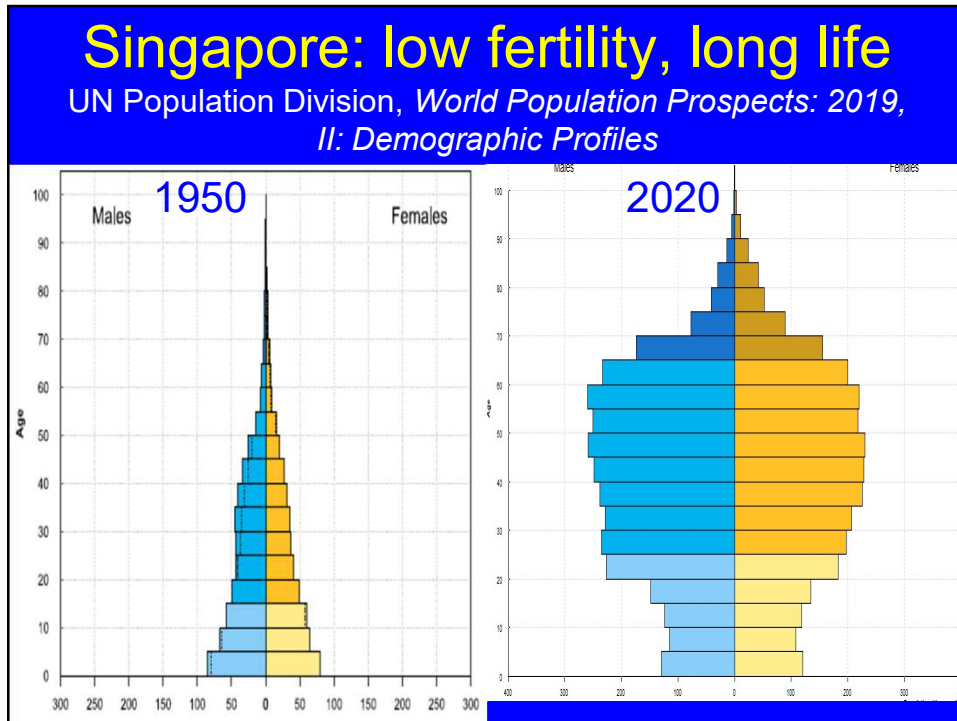
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The fraction of old people (e.g.,  
%65+ years) in a population  
depends more on its fertility rates  
than on its death rates.

Why? Most people are born at age 0.

Birth rates control the size of the bottom of  
the age pyramid.

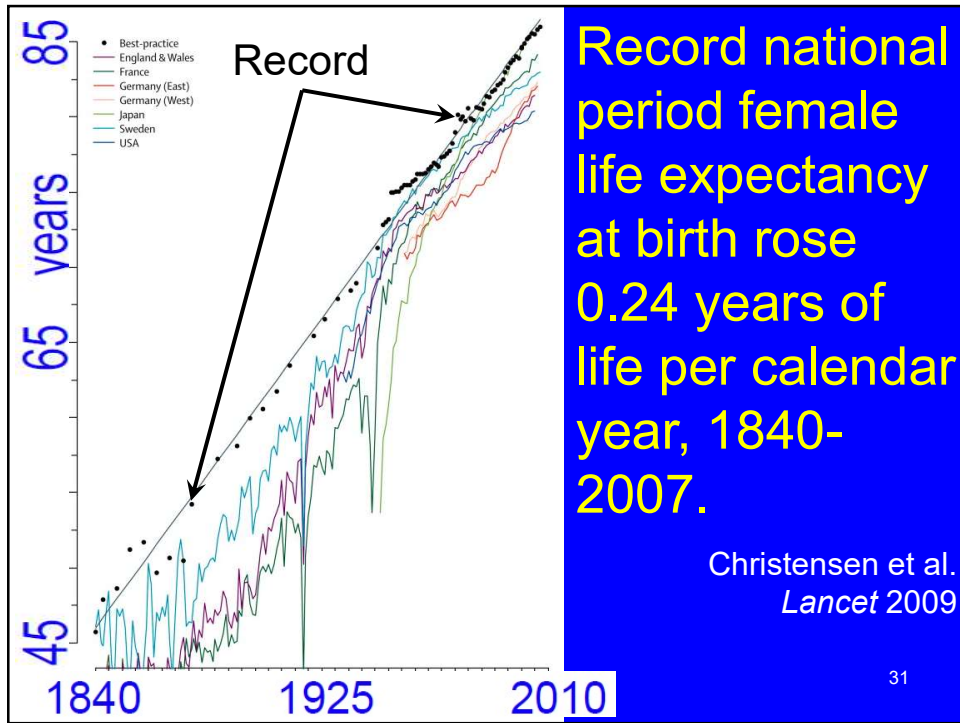
Immigration cannot keep a population young  
because immigrants age, too.

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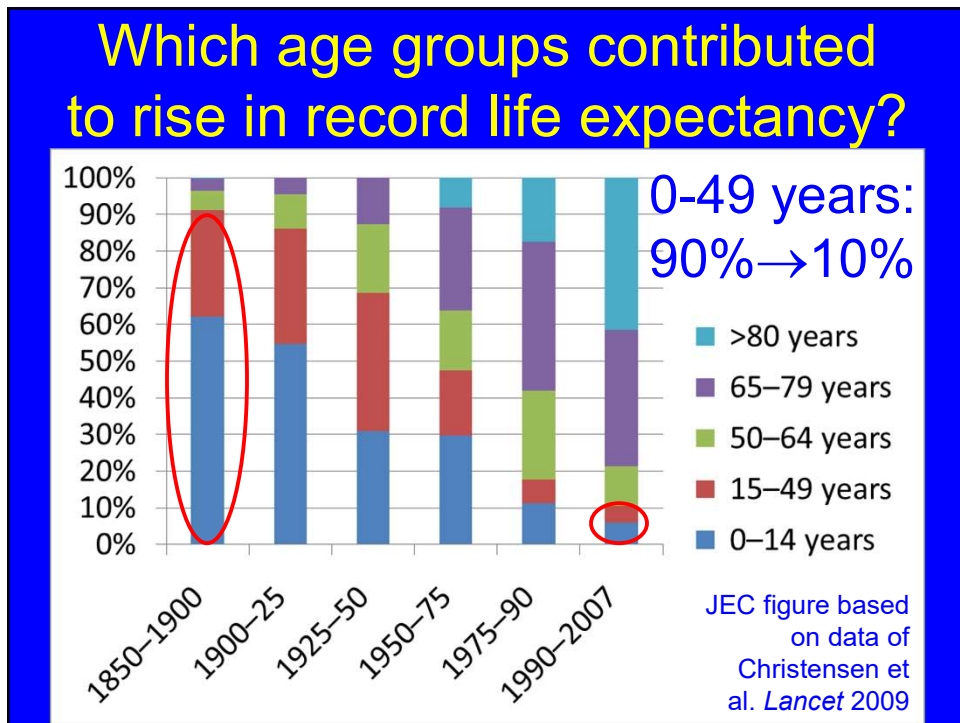
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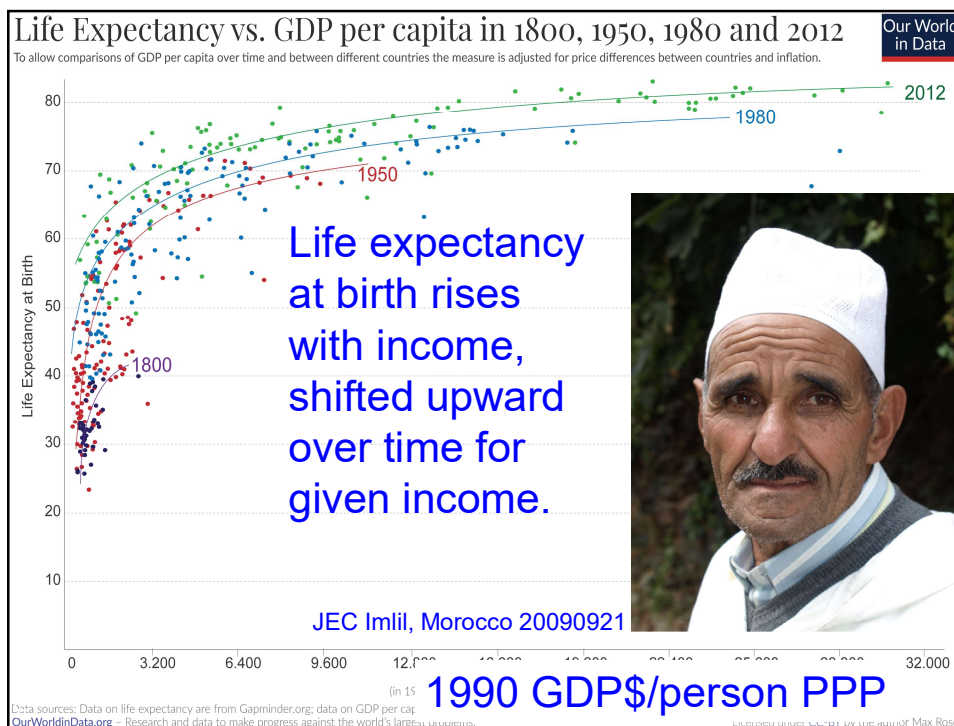


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## 70 is the new 60.

In USA, people (of both sexes) aged 70-74 in 2005-2009 had remaining life expectancy of people aged 60-64 years in 1935-39.

Year	Age	Remaining life expectancy
1935-1939	70-74	9.95
1935-1939	60-64	15.72
2005-2009	70-74	15.24

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# Cities

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## How many people are "urban"?

UN Population Division estimates about  
55% of people live in urban areas.

UN Population Division, *World Urbanization Prospects 2018*

European Commission estimates about  
85% of people live in urban areas.

Pesaresi, M., et al. (2016). *Atlas of the human planet ... JRC103150.*  
*Publications Office of the European Union*

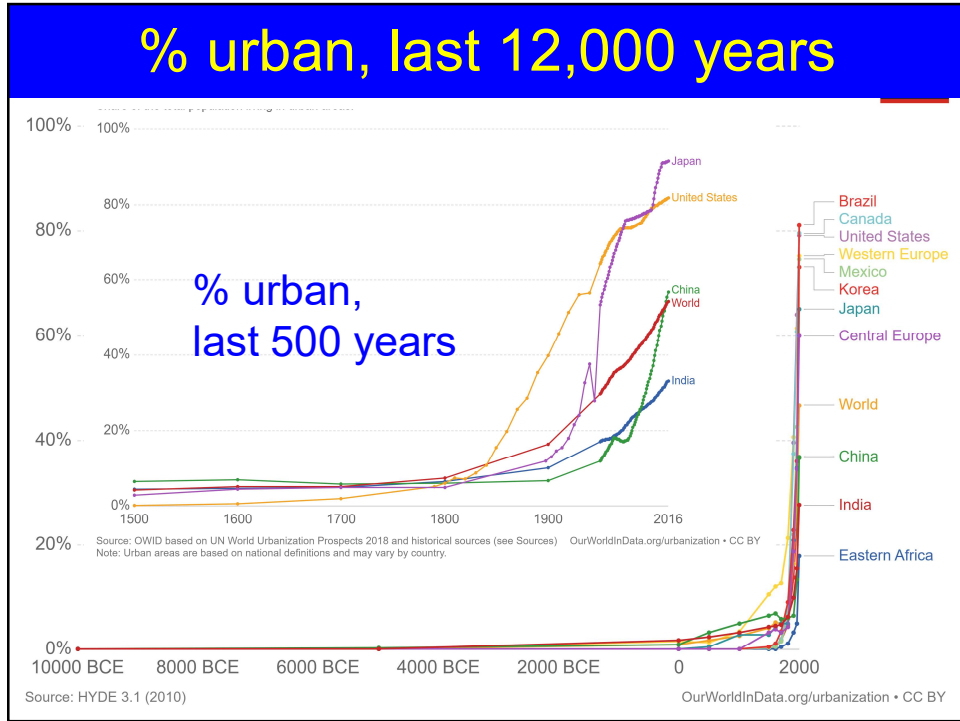
There is no international standard or  
consensus on the definition &  
measurement of "urban."

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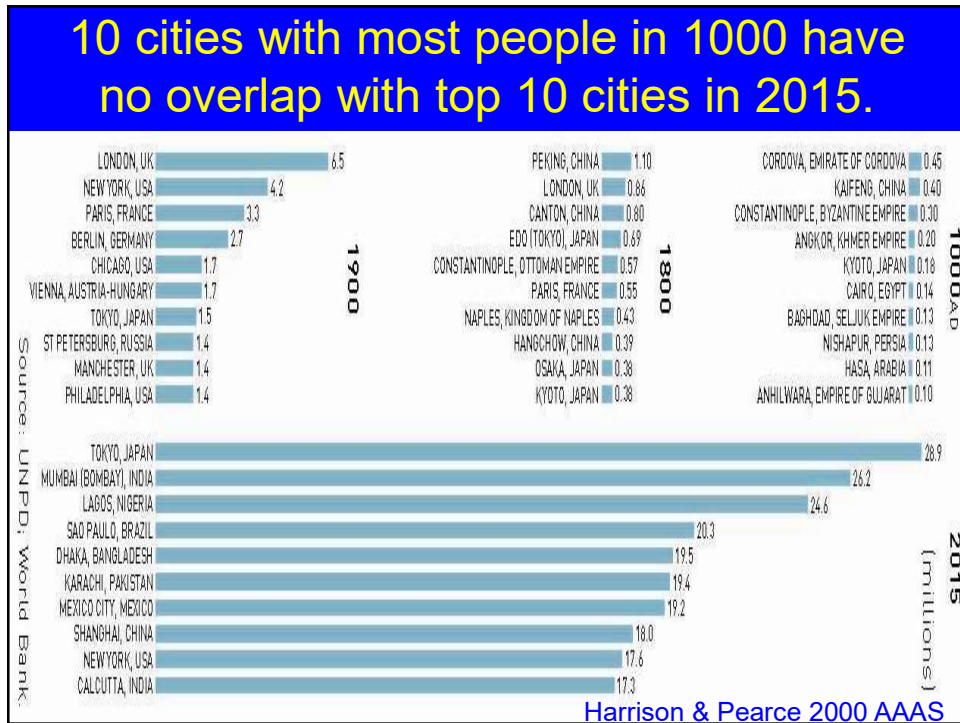
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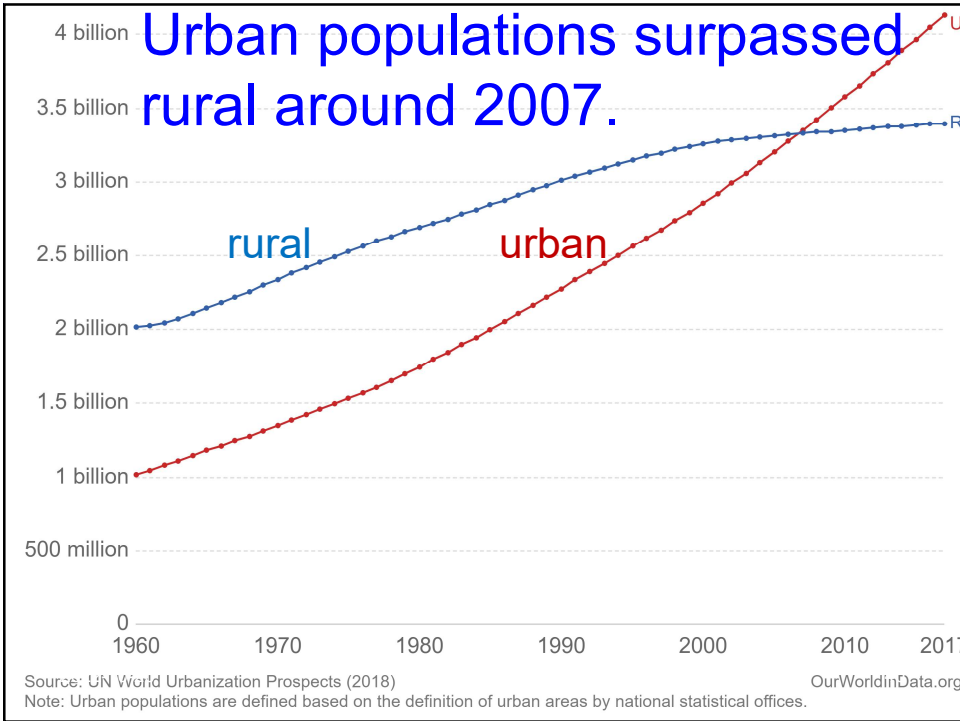
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### Cities grew in 20th century.

	1900	1950	2000
Urban population (billions)	0.21	0.75	2.87
% of total	13%	30%	47%
Number of cities with ≥10 million people	0	1	20
% of urban people living in cities with ≥10 million people	0	1.6	9.6

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## Urban expansion competes with surrounding farms.



Rice field, Fuji City, Japan 2006-01-22, Michiko Shimoda

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## Urban growth could affect food supply.

Many cities (~3% of land) are located on prime agricultural land (~10% of land).

If doubling of urban population doubles urban area, prime agricultural land could be removed from food production.

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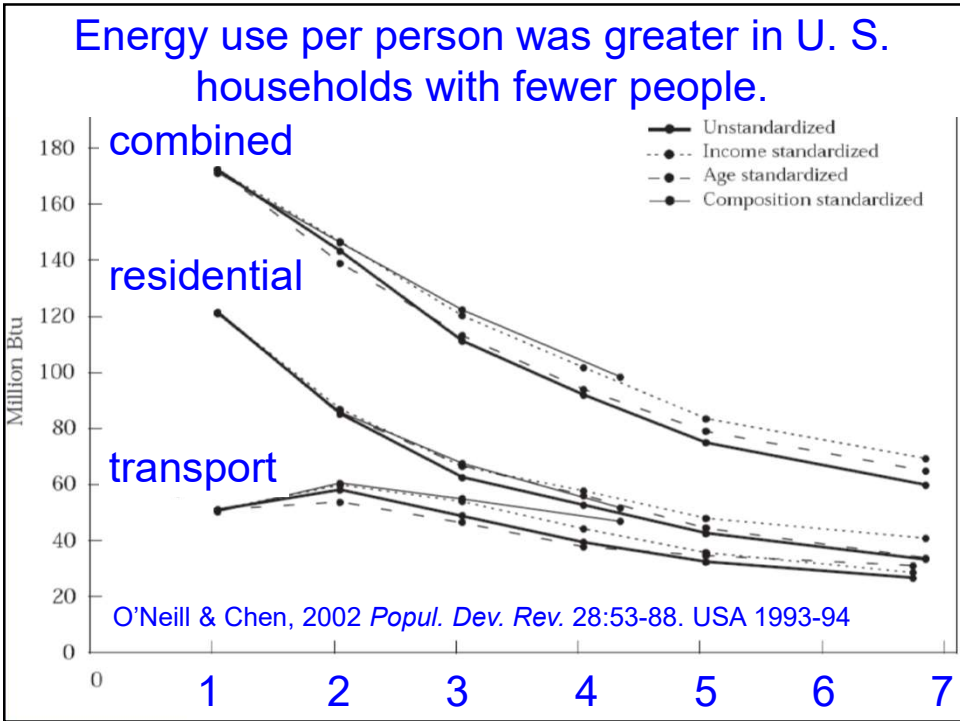
## Number of households grew faster than number of people.

Average people per household 1970-2000 fell in less-developed countries, from 5.1 to 4.4, in more-developed countries, from 3.2 to 2.5.

Reasons: lower fertility, greater longevity, later marriage, more divorce, rising wealth, urbanization, changing preferences

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# Migrants

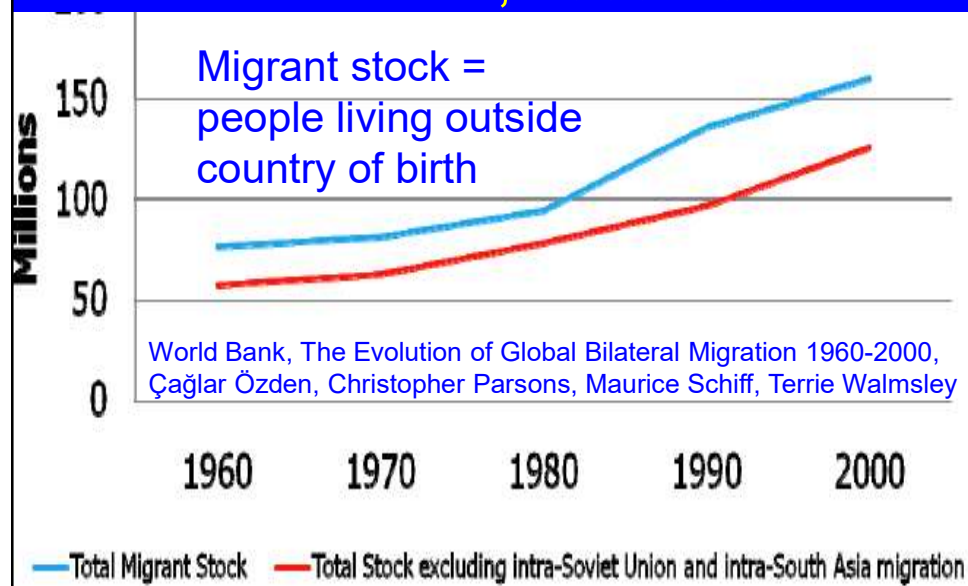
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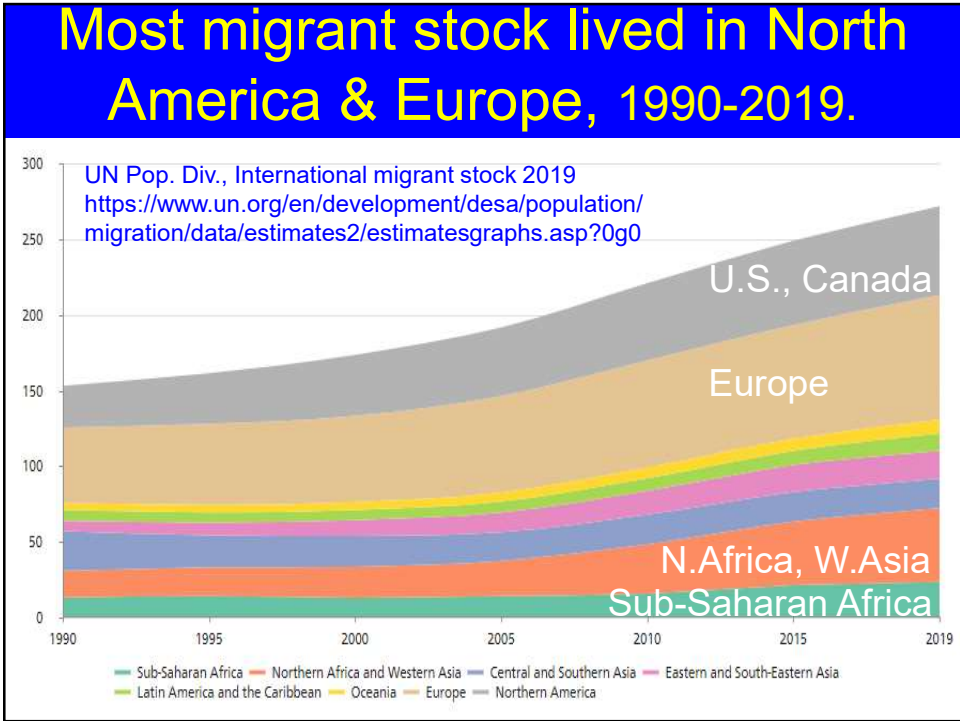
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## International migrant stock more than doubled, 1960-2000.



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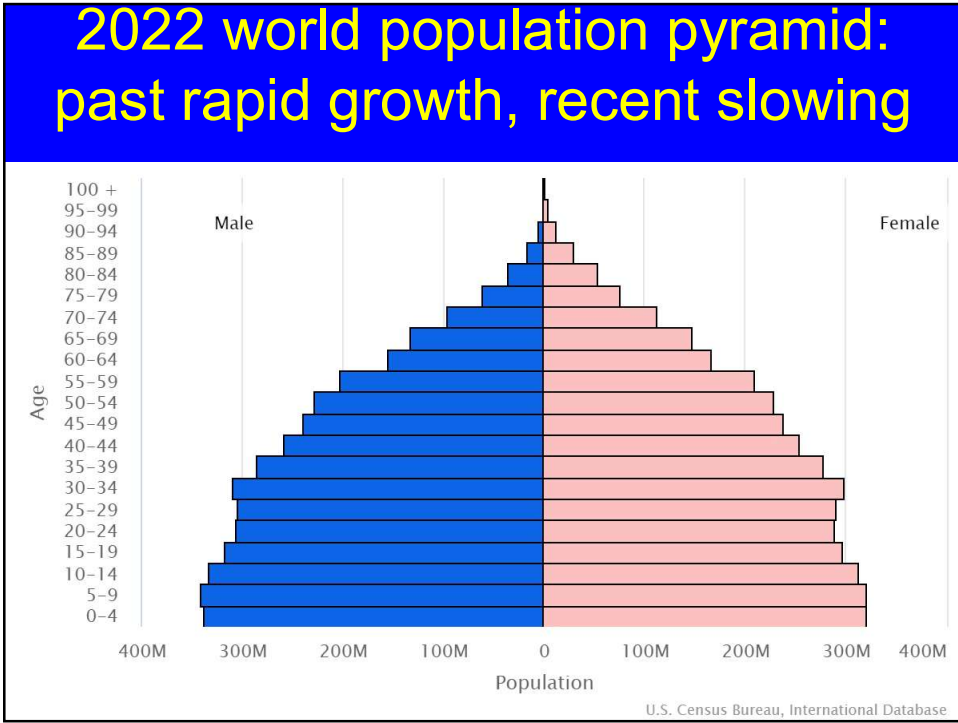


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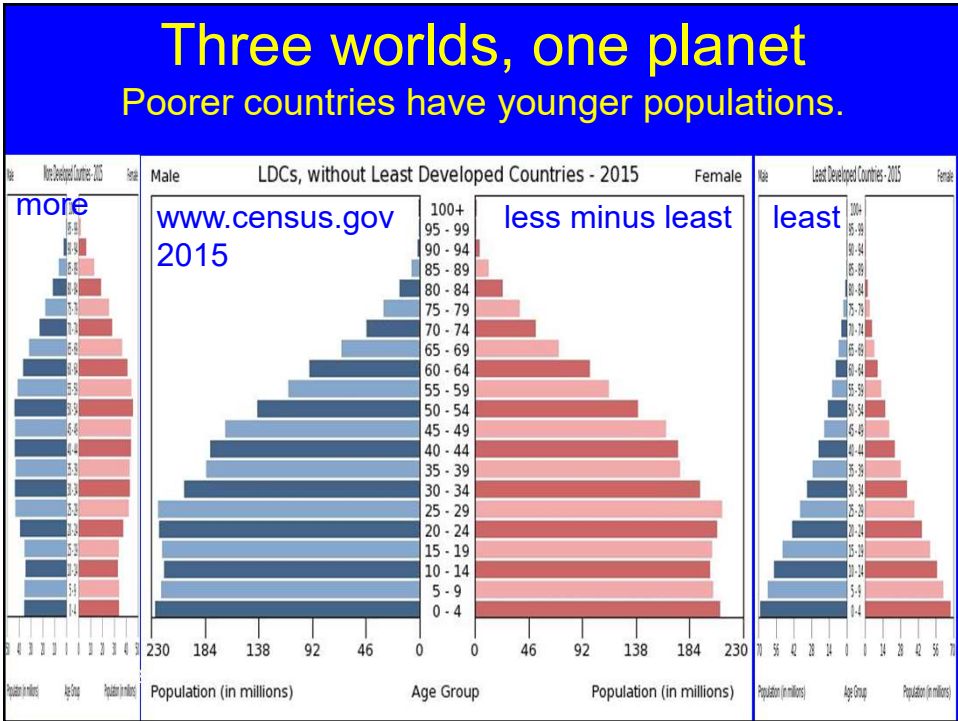


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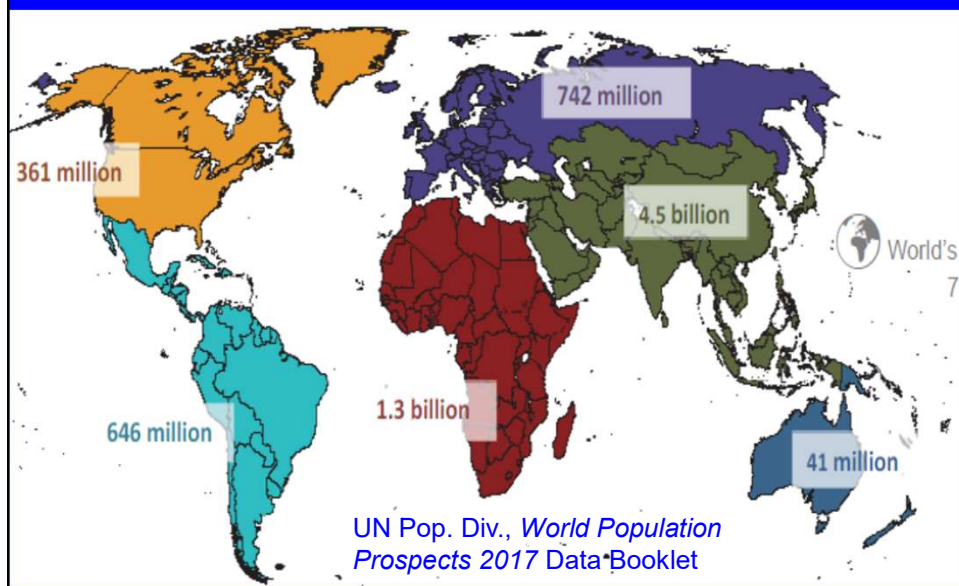
## Three worlds, one planet

Population Reference Bureau, <i>World Population Data Sheet 2021</i>	High Income	Middle Income	Low Income
Population (billions, mid-2021)	1.2	5.9	0.7
Infant Mortality Rate (deaths/1000 born)	4	29	51
Total Fertility Rate (children/woman)	1.5	2.2	4.7
Urban Population (%)	82	54	33
Population per km <sup>2</sup> of Arable Land	362	648	508
GNI / person, USD PPP	\$52,629	\$11,719	\$2,449

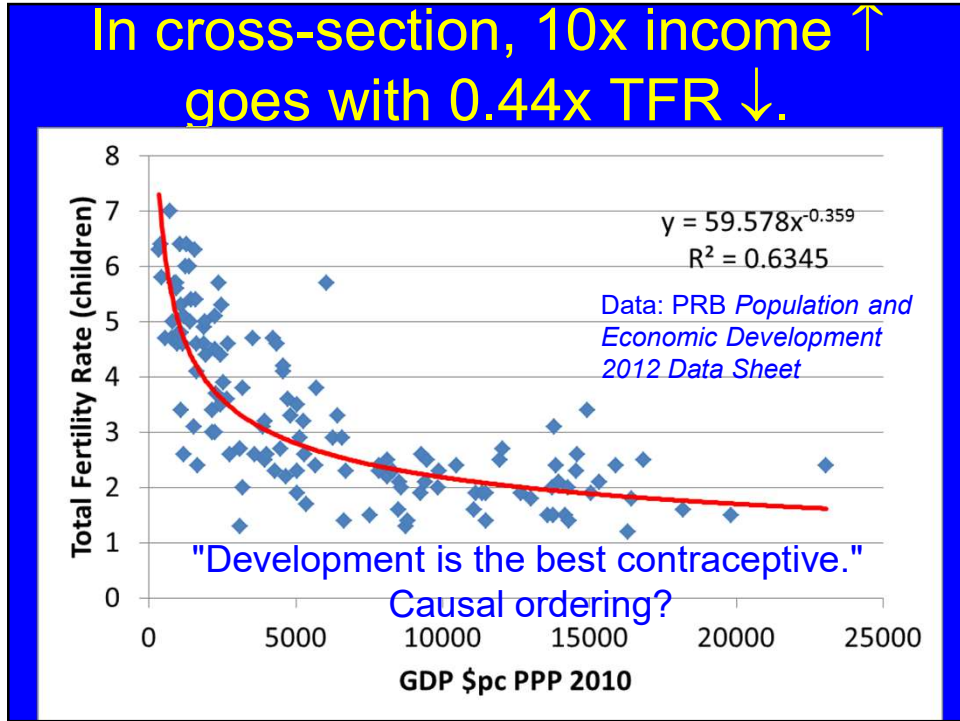
Ratio of High to Low income:  $52,629/2,449 = 21.5$

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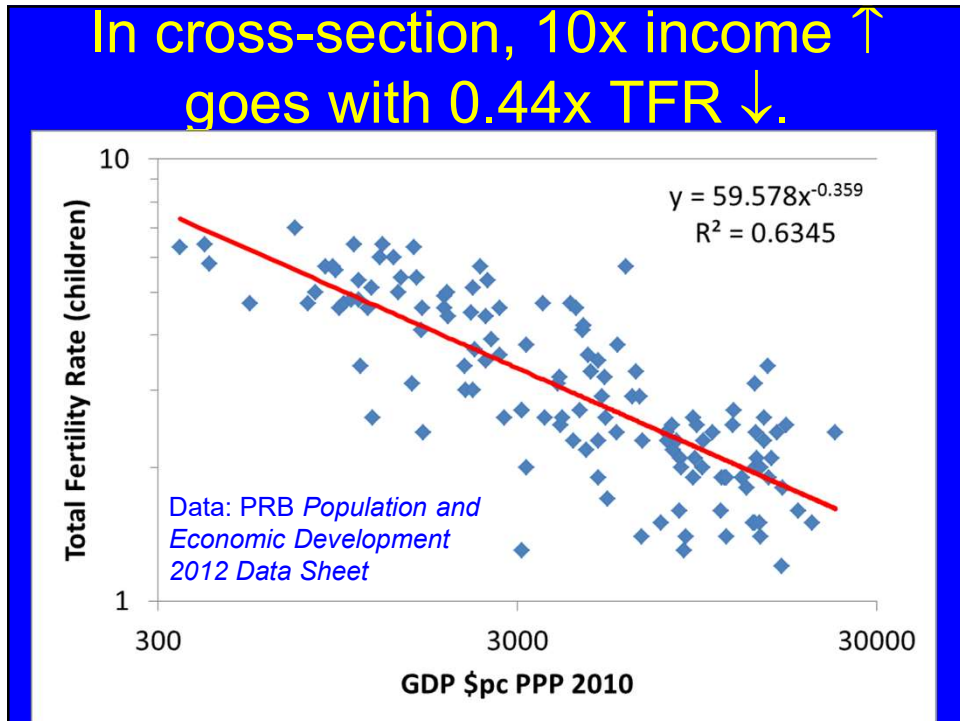
Of world's ~8 billion people,  
Asia has ~60%, Africa ~17% (2020).



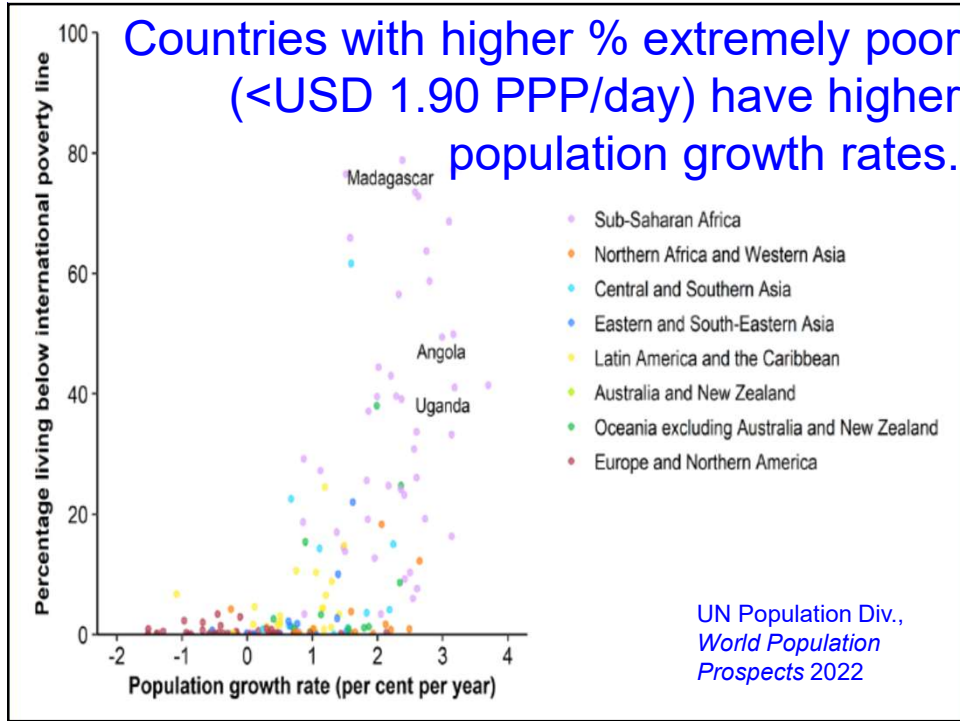
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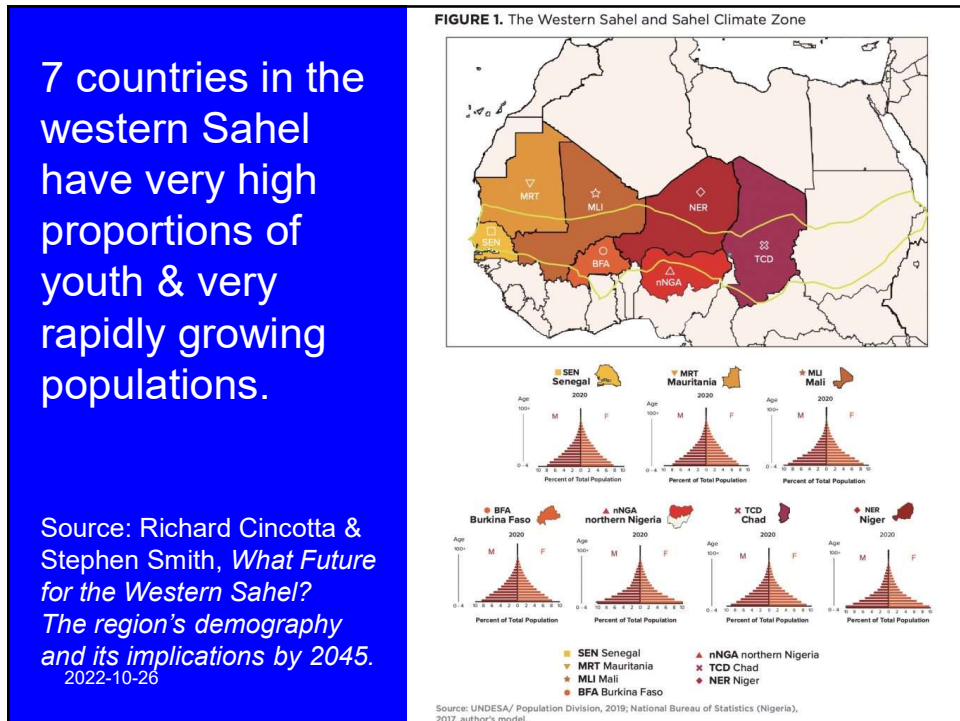
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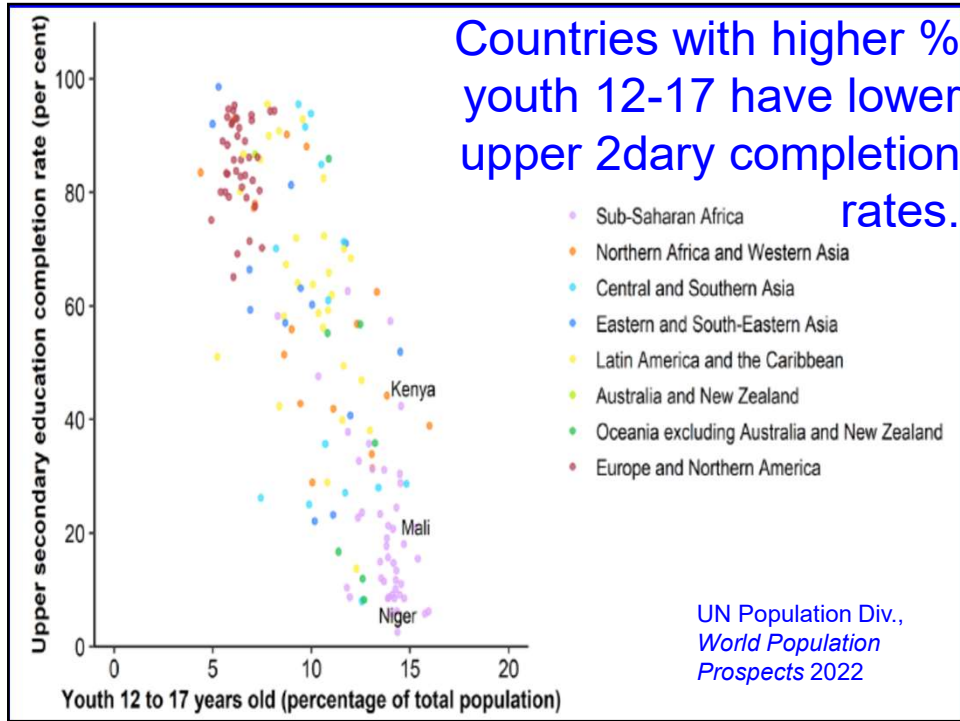
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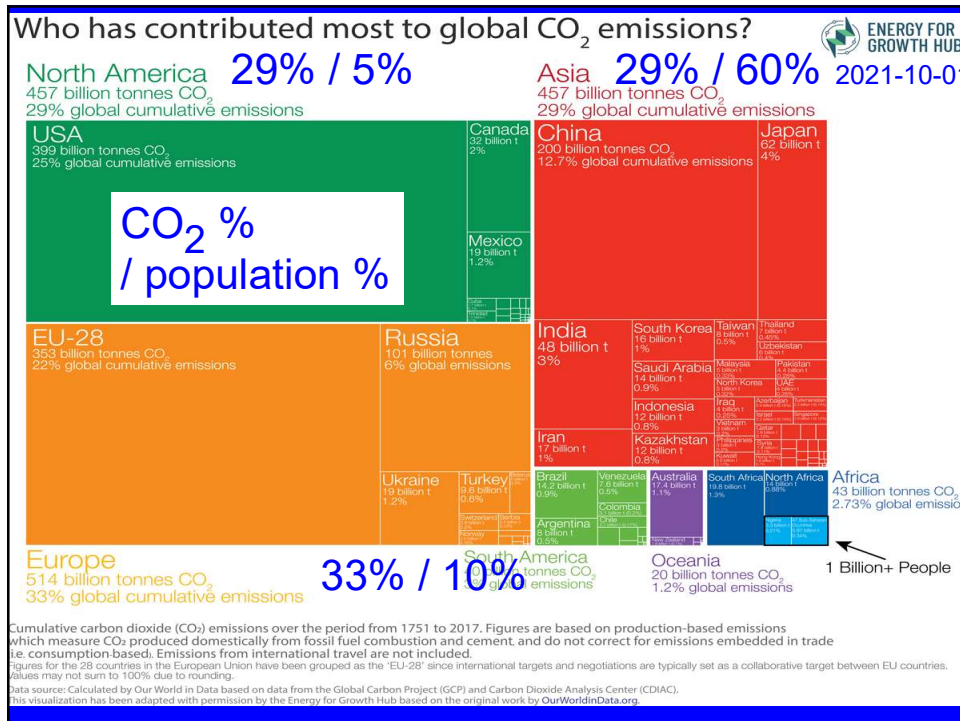
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## No population at COP26, COP27.

# WHAT DO WE NEED TO ACHIEVE AT COP26?

## COP27: mitigation, adaptation, finance, collaboration

### SECURE GLOBAL NET ZERO BY MID-CENTURY AND KEEP 1.5 DEGREES WITHIN REACH.

Countries are being asked to come forward with ambitious 2030 emissions reductions targets (NDCs) that align with reaching net zero by the middle of the century. To deliver on these stretching targets, countries will need to accelerate the phase-out of coal, encourage investment in renewables, curtail deforestation and speed up the switch to electric vehicles.

### ADAPT TO PROTECT COMMUNITIES AND NATURAL HABITATS.

The climate is already changing and it will continue to change, even as we reduce emissions, with devastating effects. At COP26 we need to work together to enable and encourage countries affected by climate change to protect and restore ecosystems, build defences, put warning systems in place and make infrastructure and agriculture more resilient to avoid loss of homes, livelihoods and lives.

### MOBILISE FINANCE

To realise our first two goals, developed countries must deliver on their promise to raise at least \$100bn in climate finance per year. International financial institutions must play their part and we need to work towards unleashing the trillions in private and public sector finance required to secure global net zero.

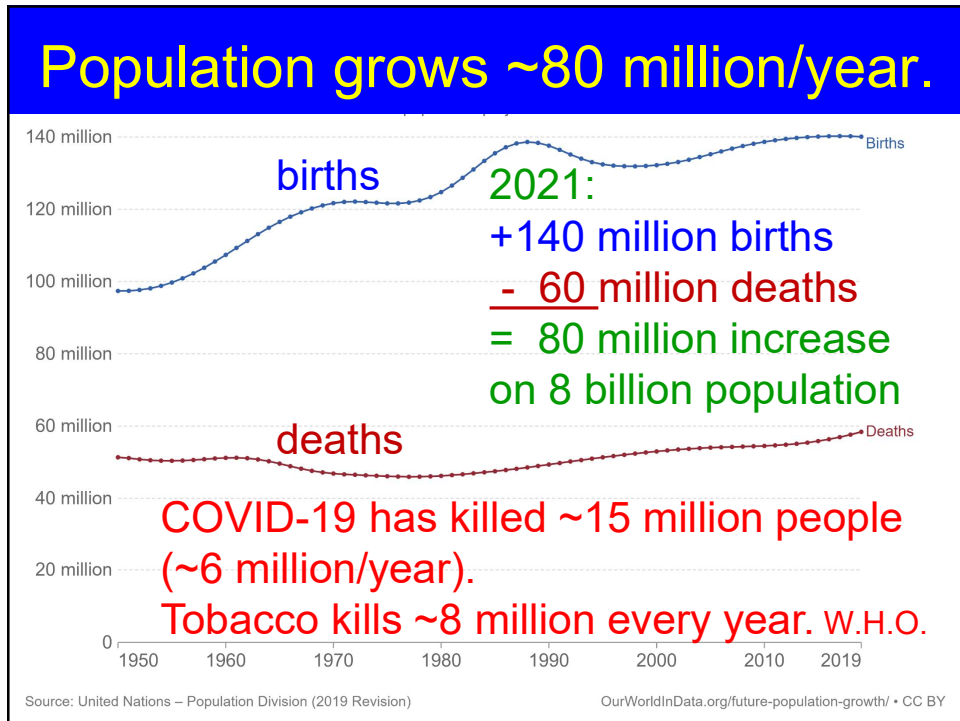
### WORK TOGETHER TO DELIVER.

We can only rise to the challenges of climate change by working together. At COP26 we must finalise the Paris Rulebook (the rules needed to implement the Paris Agreement). And, we have to turn our ambitions into action by accelerating collaboration between governments, businesses and civil society to deliver on our climate goals faster.

<https://ukcop26.wpenginepowered.com/wp-content/uploads/2021/07/COP26-Explained.pdf>

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# Fertility

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## Replacement (level) fertility

Replacement fertility is the TFR (number of live-born children per woman's lifetime) required to replace one new-born girl by one new-born girl in the next generation.

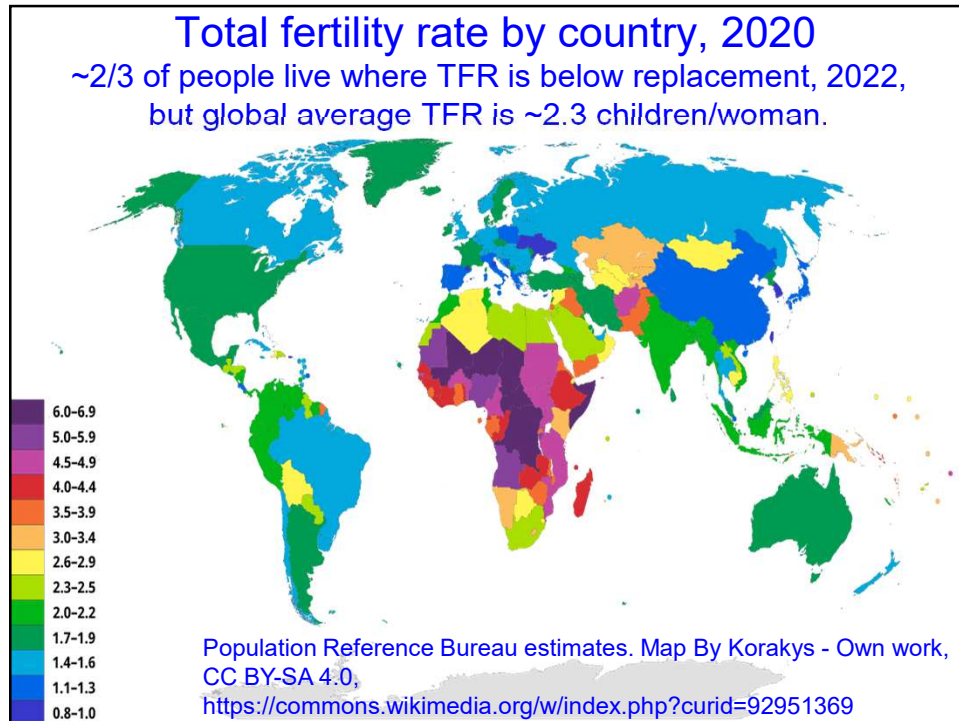
Because 106 boys are born per 100 girls, & because not all girls survive through reproductive ages, replacement TFR ranges from 2.1 to 2.4 in most cases, & as high as 3 in areas of very high mortality.

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## Large regions of high fertility remain.

In 2019, fertility remains above replacement level, on average, in  
 sub-Saharan Africa (4.6),  
 Oceania except Australia, New Zealand (3.4),  
 Northern Africa and Western Asia (2.9),  
 Central and Southern Asia (2.4) (Afghanistan 4.5; Pakistan 3.6).

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40% of global pregnancies are unintended.  
45% of pregnancies in USA

213 million pregnancies occurred worldwide in 2012, 190 million (89%) in developing world.

85 million pregnancies (40%) were unintended,

47% unintended in more developed,

39% unintended in less developed,

35% unintended in Africa,

56% unintended in LAC.



Jessica D. Gipson 2016

Sedgh, et al. 2014



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**In 2012, 222 million women had an “unmet need for modern contraception”**

**(do not want pregnancy, are sexually active, are not using modern contraception).**

In 2012, 57% of married women used modern contraceptives in the developing world.

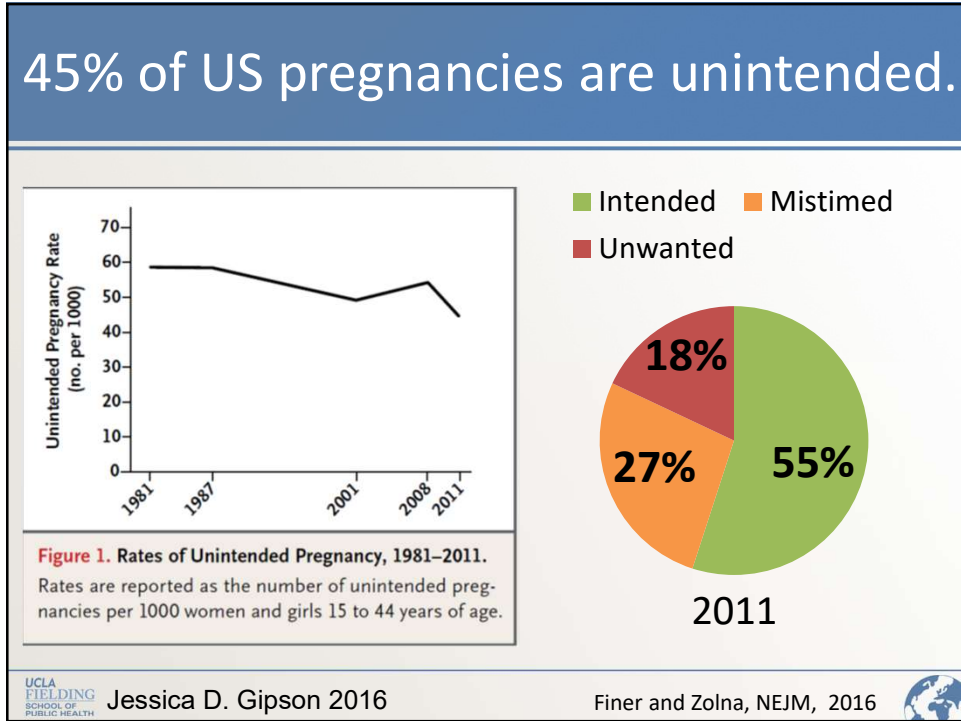
Modern contraceptive methods for all women in the developing world would cost \$8.1 billion per year. (Actual cost: \$4.0 billion in 2012.)

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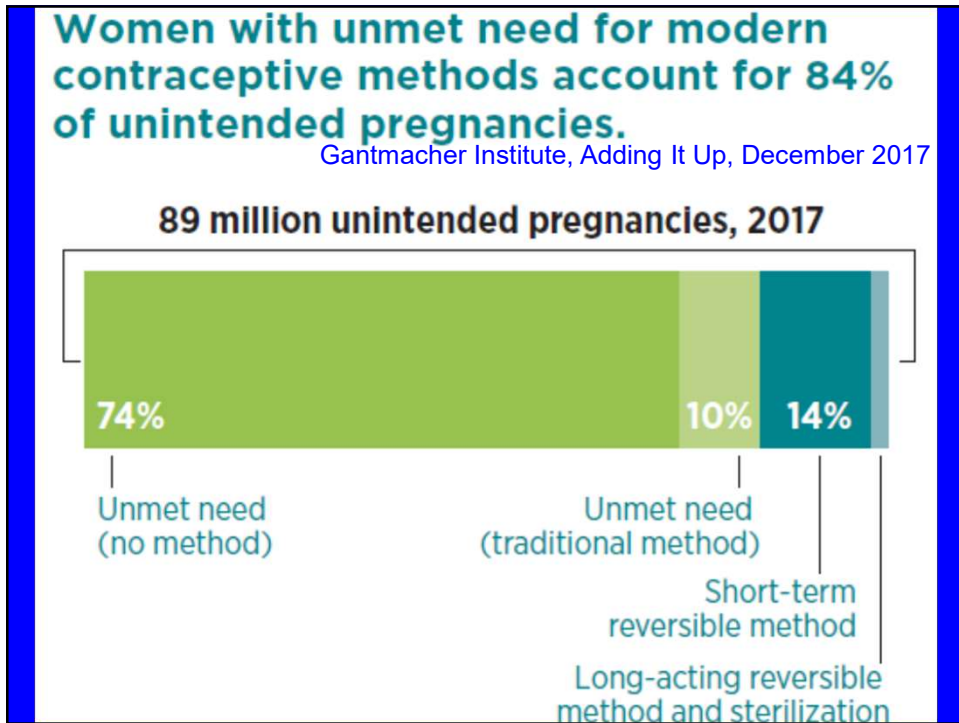
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**BEDSIDER** birth control method

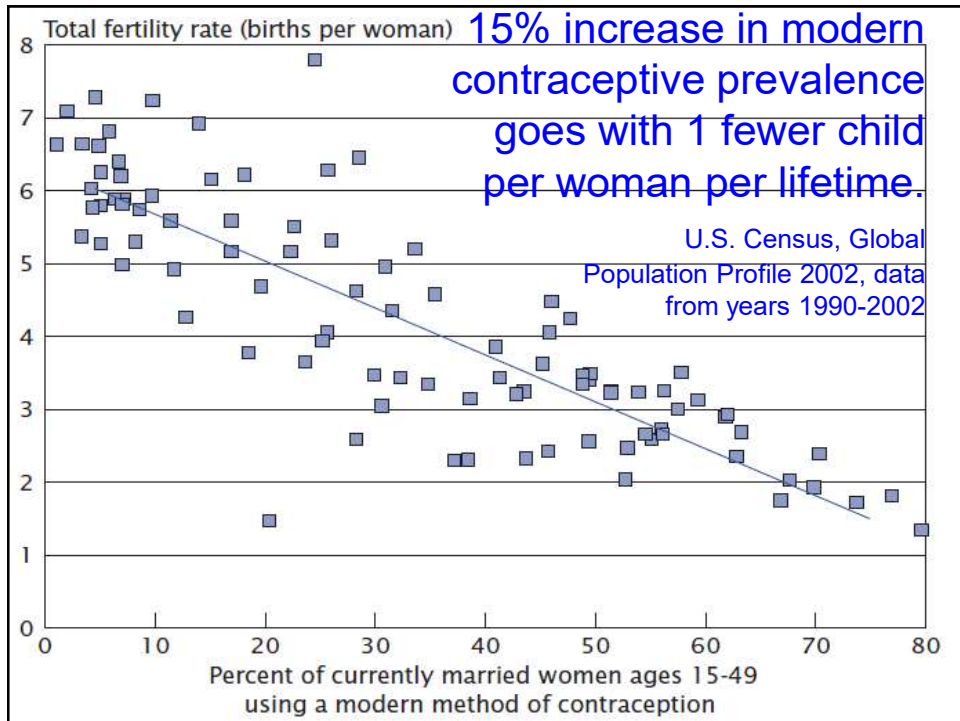
METHOD EXPLORER /

**CHECK OUT BEDSIDER.ORG**

- Random assignment to Bedsider vs. control group found women in Bedsider group less likely to have a pregnancy scare, an unintended pregnancy, or unprotected sex as compared to the control group (Antonishak et al. 2015)

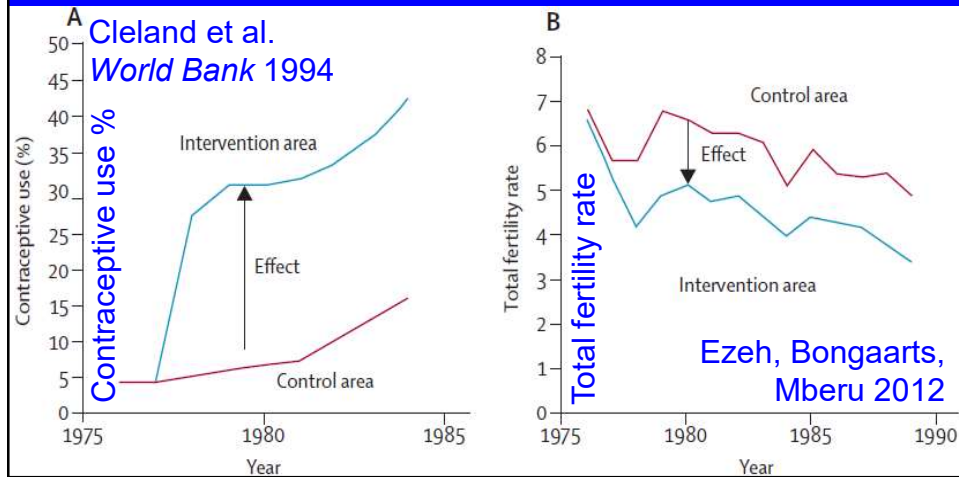
Jessica D. Gipson 2016

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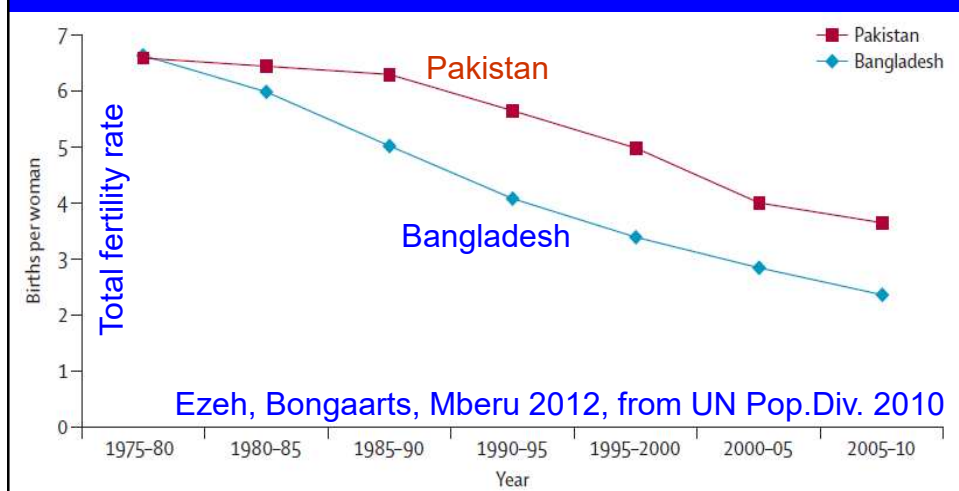
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## Contraceptive use lowered fertility in Matlab, Bangladesh.

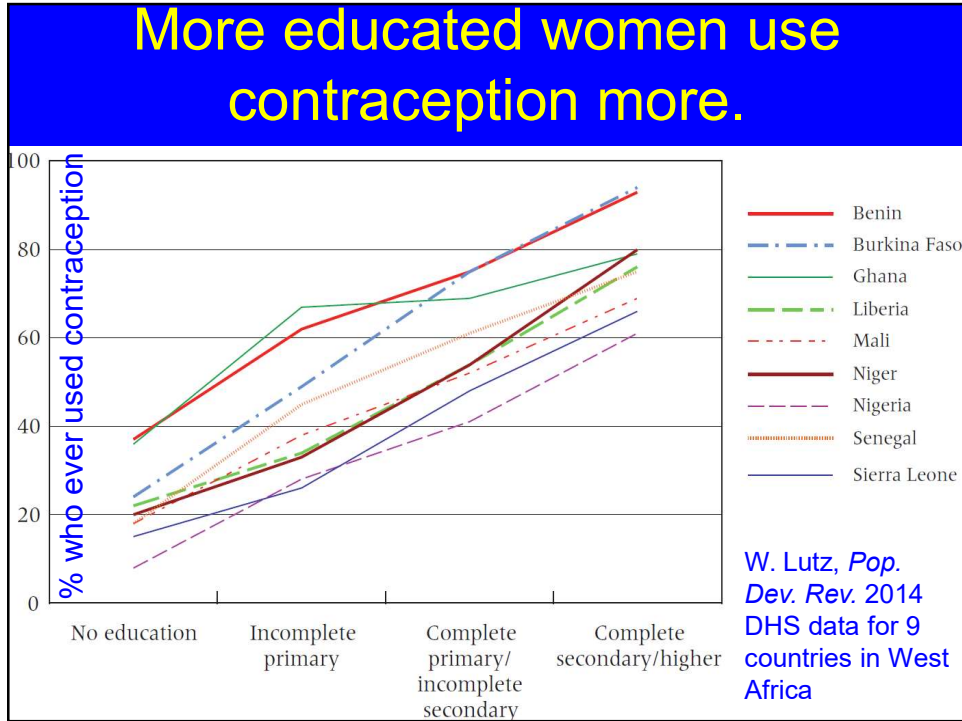


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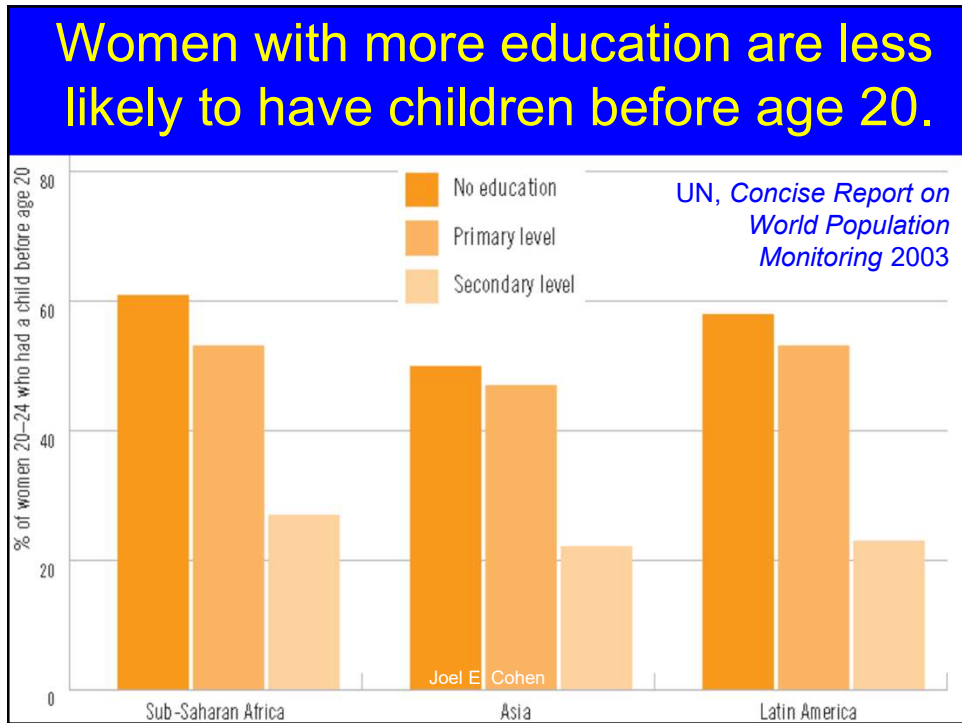
## National policy affected fertility.



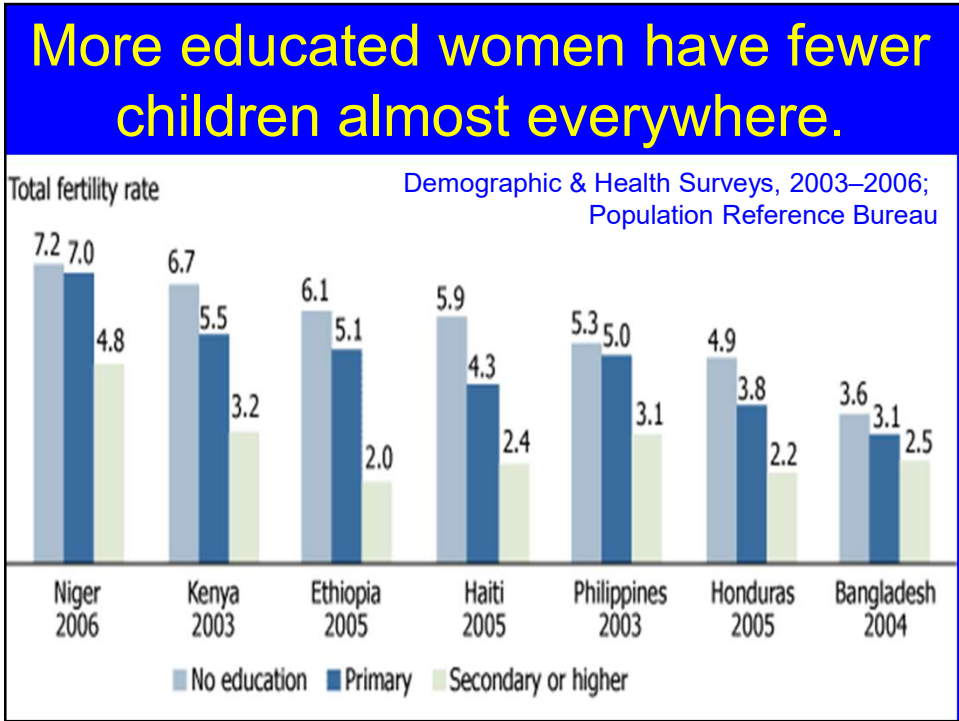
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## 1/3 of urban people live in "slum" households. UN Habitat

Definition: "slum" household is a group of individuals living under the same roof in an urban area who lack one or more of:

1. Durable permanent housing that protects against extreme climate conditions.
2. No more than 3 people sharing same room.
3. Easy access to sufficient, safe, affordable water.
4. Access to private or public toilet shared by a reasonable number of people.

Sometimes: 5. Security of tenure against forced evictions.

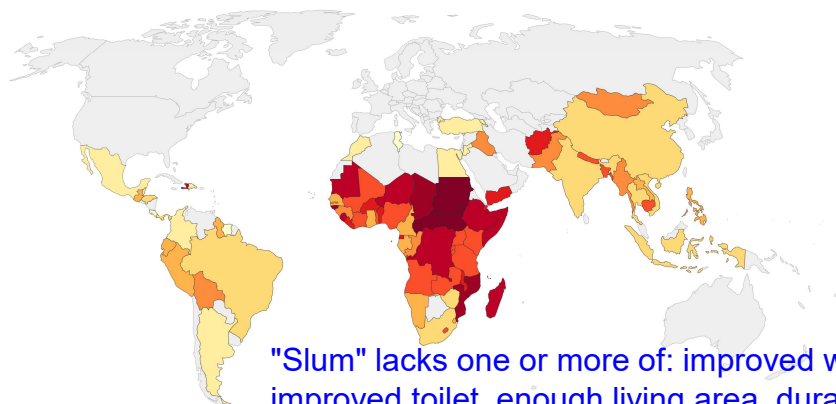
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## 1/3 of urban people live in "slums." 2018, UN Habitat via World Bank



No data 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Source: UN HABITAT

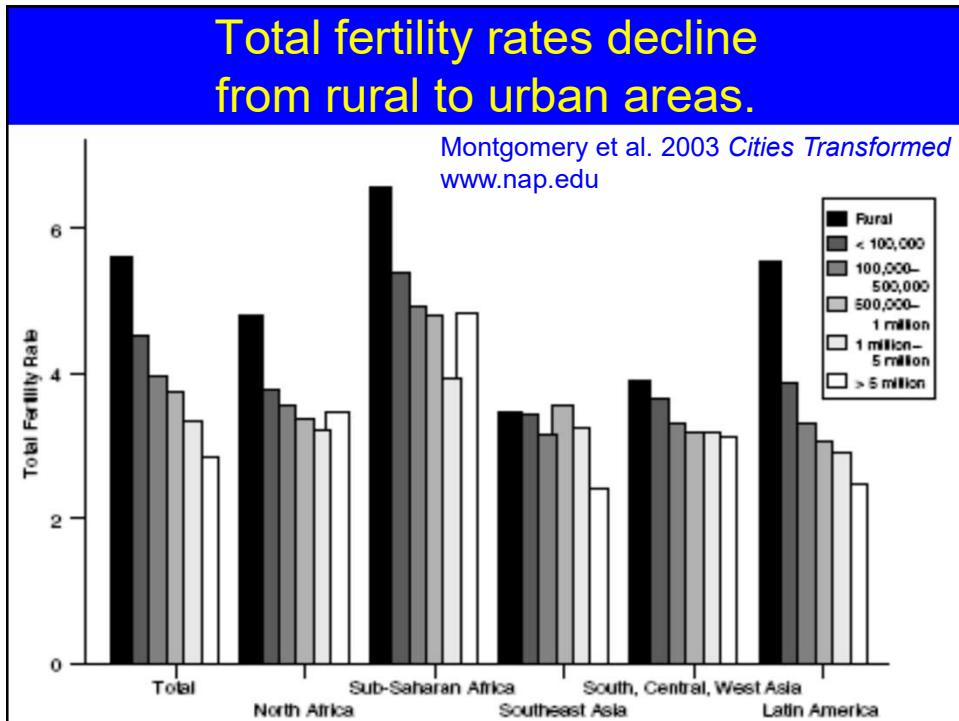
OurWorldInData.org/urbanization • CC BY

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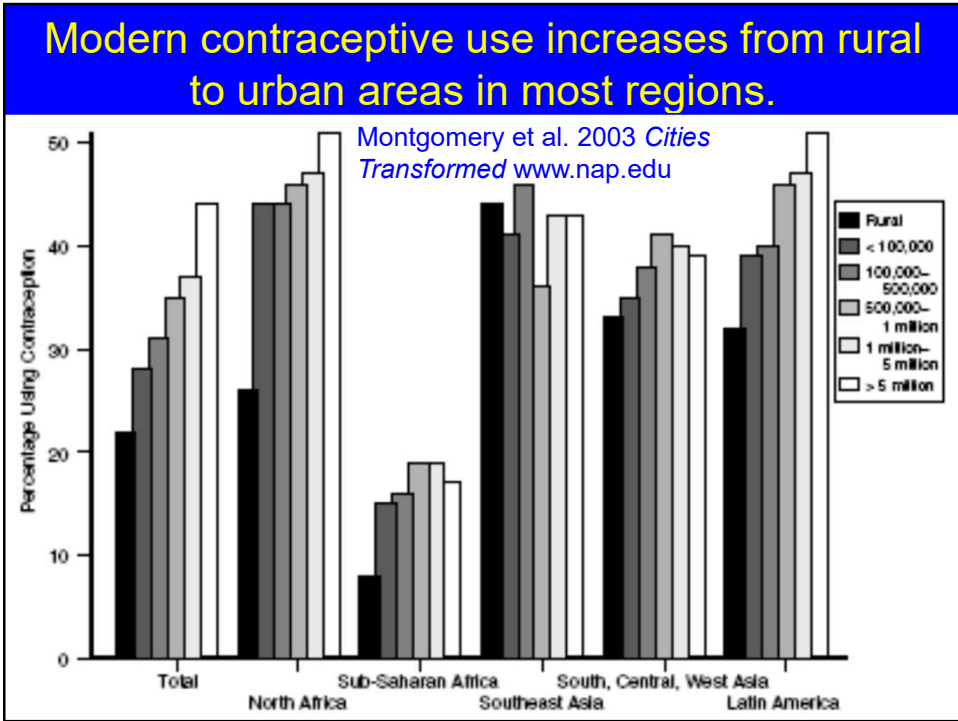




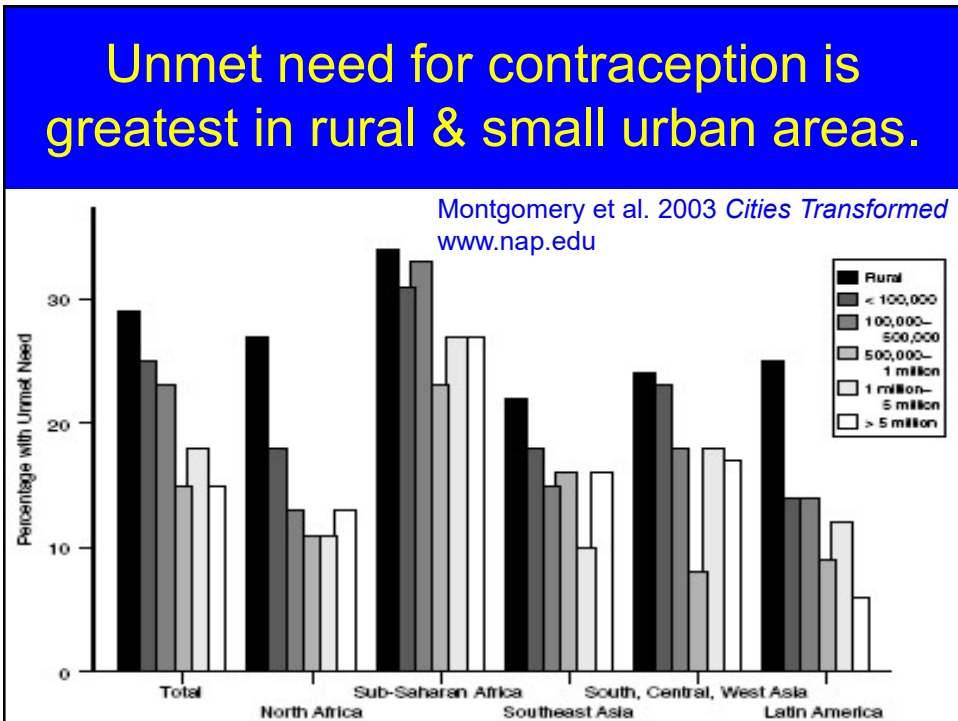
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634 million people live in coastal areas  
at <10 m (33 ft) above sea level.

Of those 634 million, 360 million are urban.  
>180 countries have people in low coastal  
zones. 2/3 of those countries have urban  
areas of more than 5 million people in low-  
elevation coastal zones.

McGranahan, Balk, Anderson *Environment & Urbanization* 2007

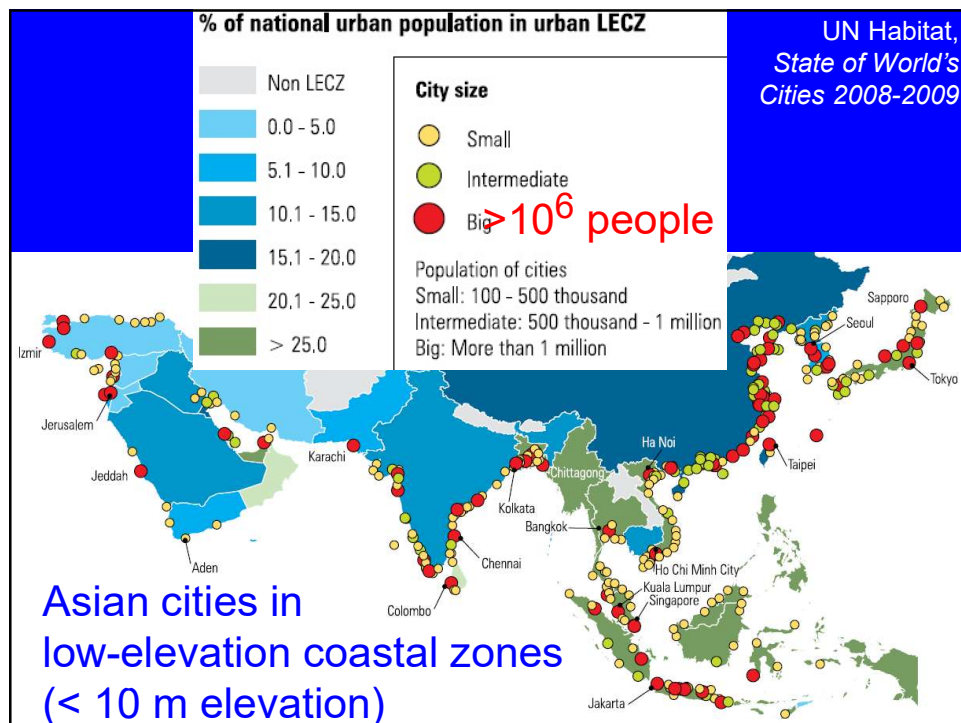
In last interglacial (Eemian, 130-115 ka),  
global sea level was ~6 m higher. Migration?

2008-03-01

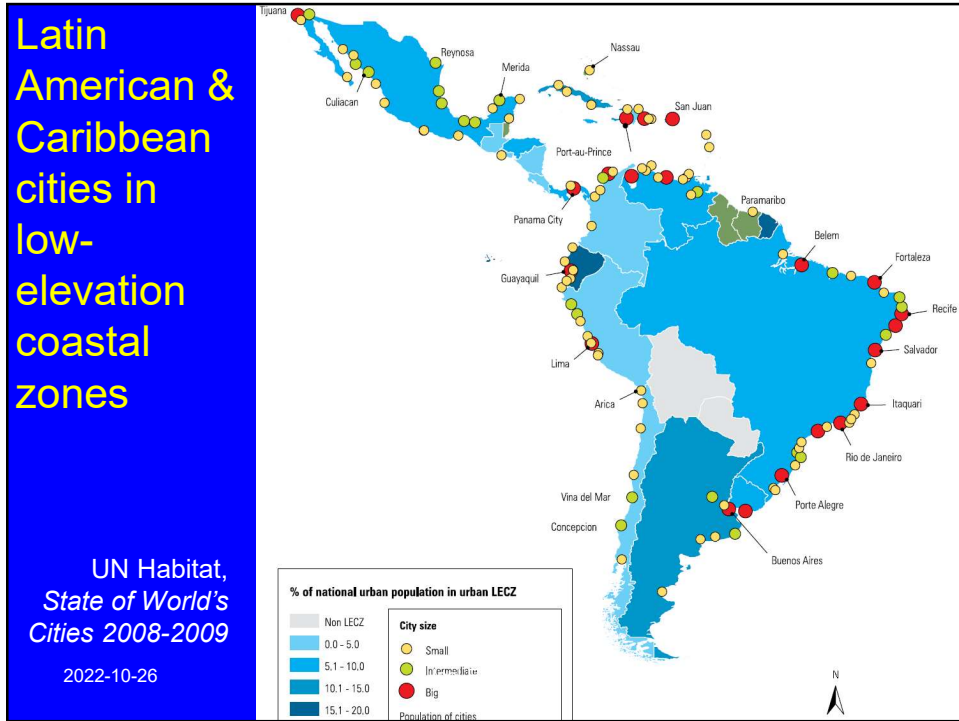
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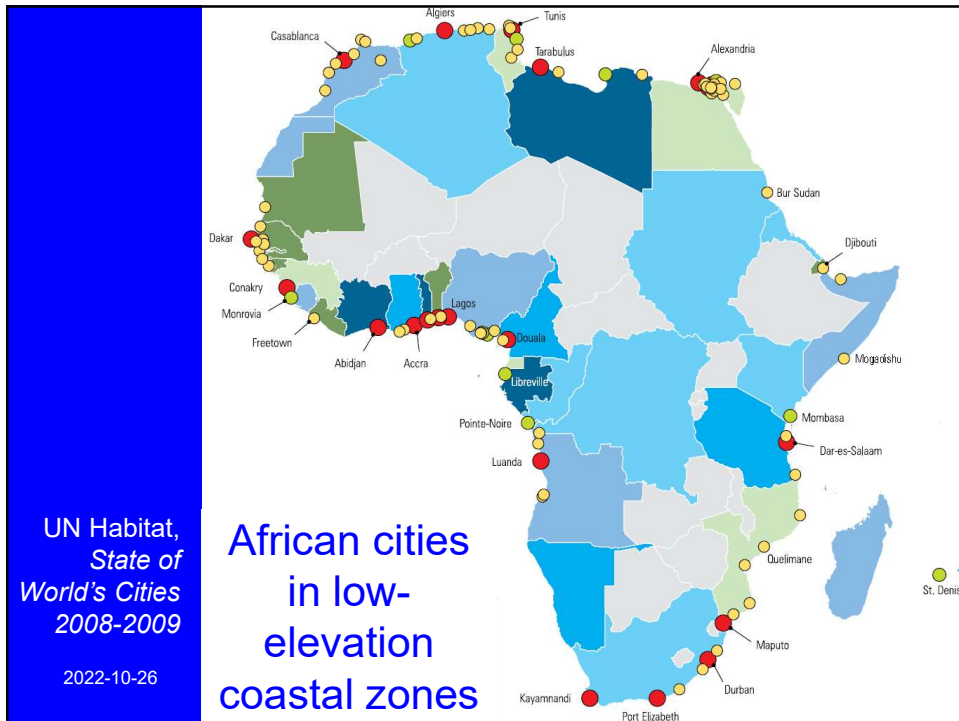
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**~750 million people (15% of adults)  
“desire to migrate permanently to  
another country.”**

Gallup polls of 453,122 adults in 152 countries 2015-2017  
"The one in six Americans (16%) in 2017 who said they would like to move to another country is the highest measure to date."

- 158 million → USA (312 million in 2010)
- 47 million → Canada (34 million 2010)
- 42 million → Germany (82 million in 2010)
- 36 million → France (63 million 2010)
- 36 million → Australia (22 million in 2010)

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## Future

High confidence (next 25-30 years, excluding nuclear war, plague, climate catastrophe, comets): larger by >1 billion, older, more urban, more slowly, more Asian, more African, more migration

Controversial (beyond 2050):

When will population growth end?

At what peak population size?

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## % people aged 65+ varies widely.

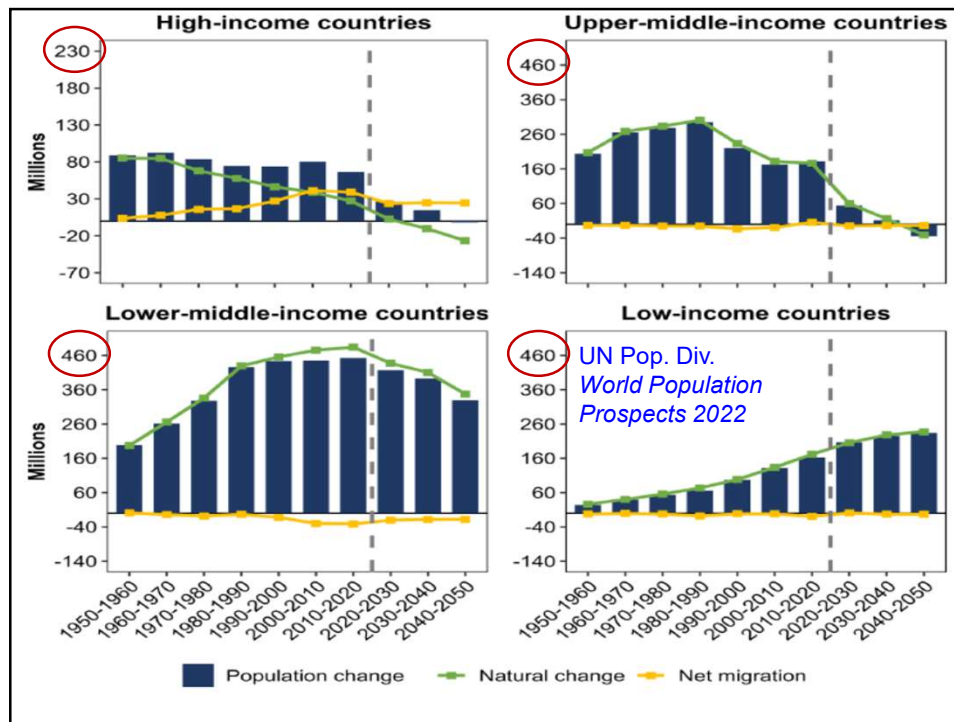
Region	2022	2030	2050
World	9.7	11.7	16.4
Sub-Saharan Africa	3.0	3.3	4.7 57% increase
Europe, Northern America	18.7	22.0	26.9 44% increase

UN Pop.Div. World Population Prospects 2022

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## "Long-range population projections to 2100" from UN WPP 2022

"Long-range population projections are highly uncertain, especially for high-fertility countries still in the early stages of the demographic transition."

95% probability of global population:

9.4-10.0 billion in 2050;

8.9-12.4 billion in 2100.

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## "Long-range population projections to 2100" from UN WPP 2022

"Thus, the size of the world's population is almost certain to rise over the next several decades, as is the degree of uncertainty associated with these projections. Later in the century, there is about 50 per cent chance that the world's population will peak—that its size will stabilize or begin to decrease—before 2100."

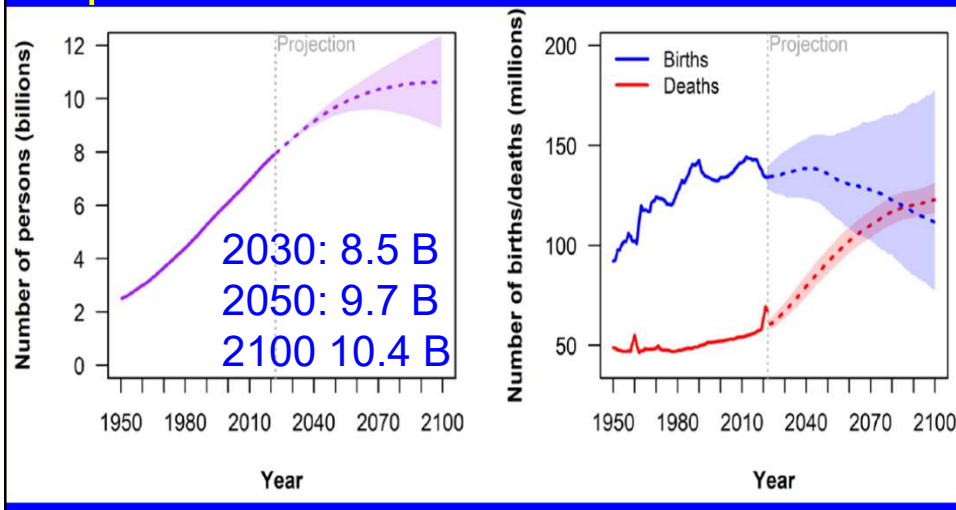
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## UN WPP 2022 estimates & medium scenario with 95% prediction intervals, 2022-2100

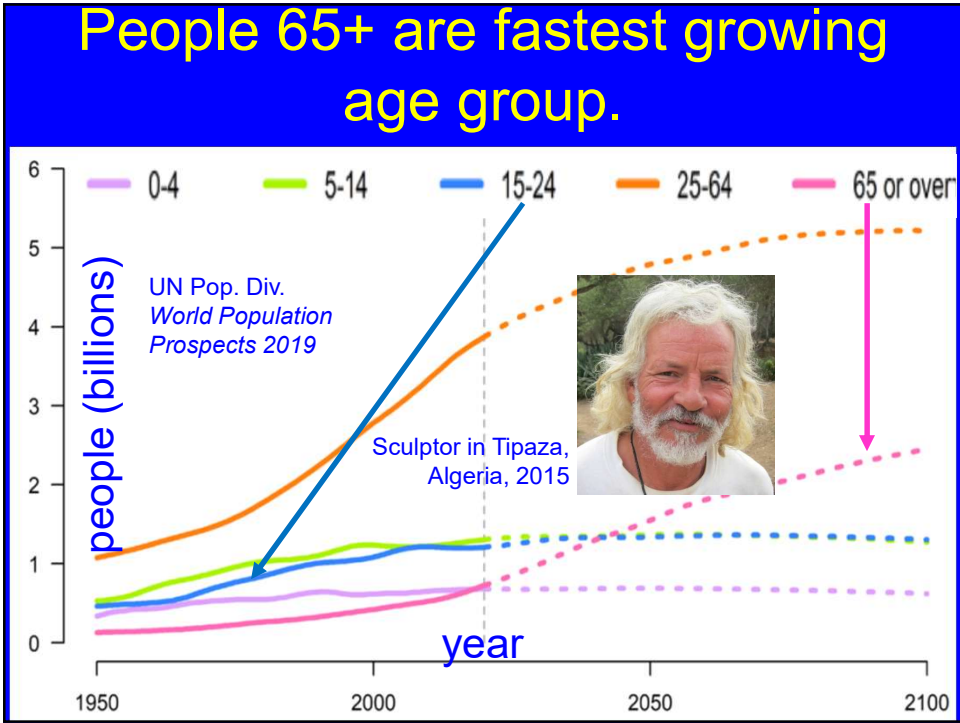


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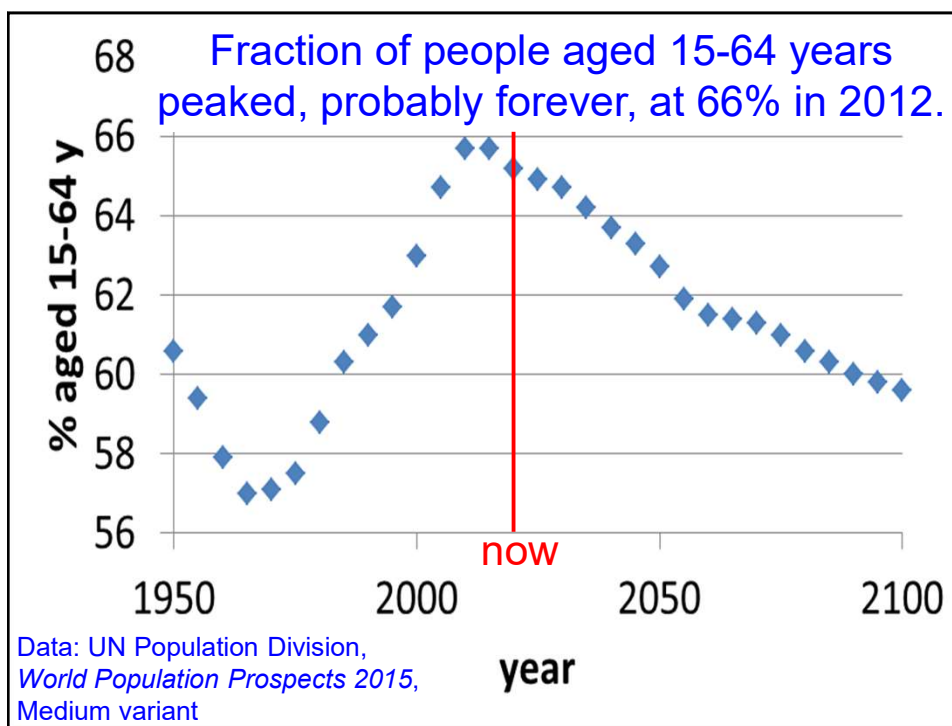
# Aging

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## What does “old” mean?

Age 65+ years? **OR**

Remaining life expectancy (RLE) of  
15 years or less? Norman Ryder 1975

In 2010, people had RLE of 15 years at age:

71 in North America,

63 in Africa,

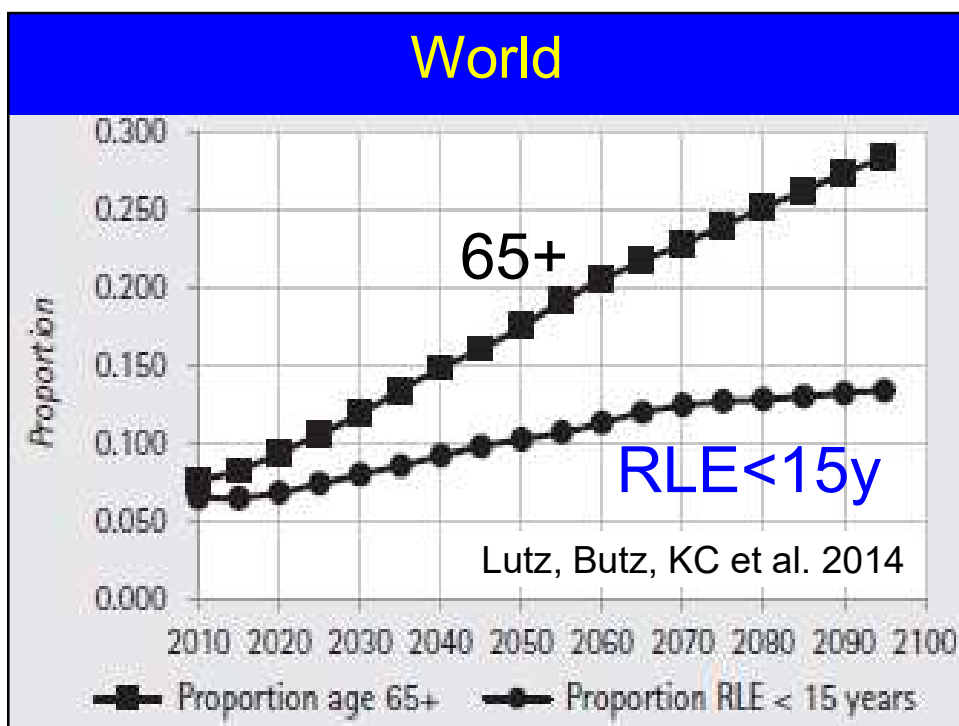
67 in world.

Lutz et al. 2014

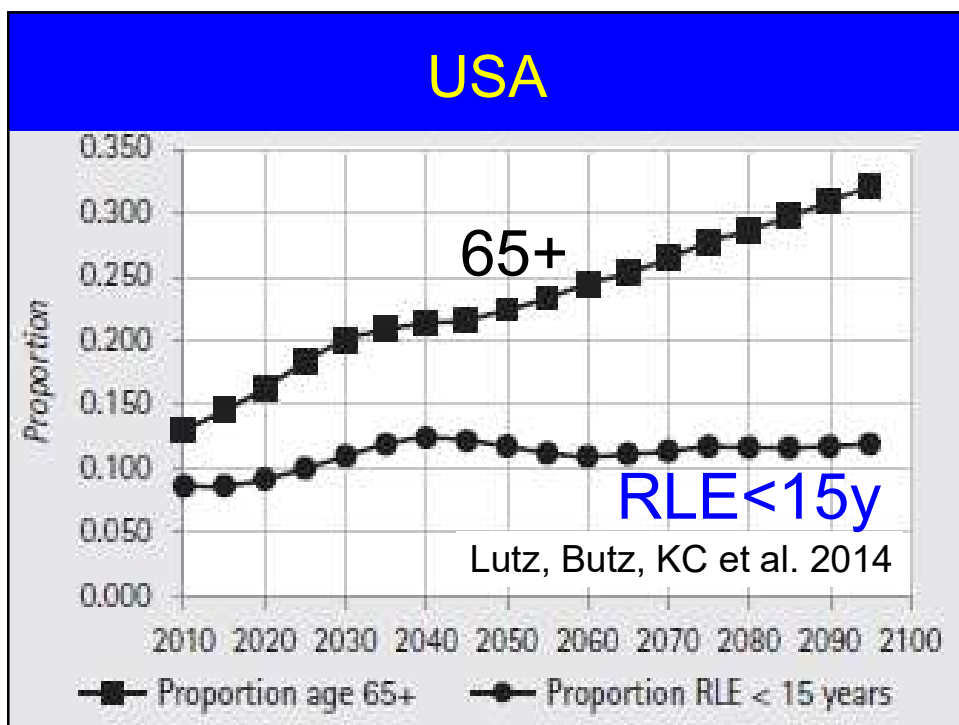
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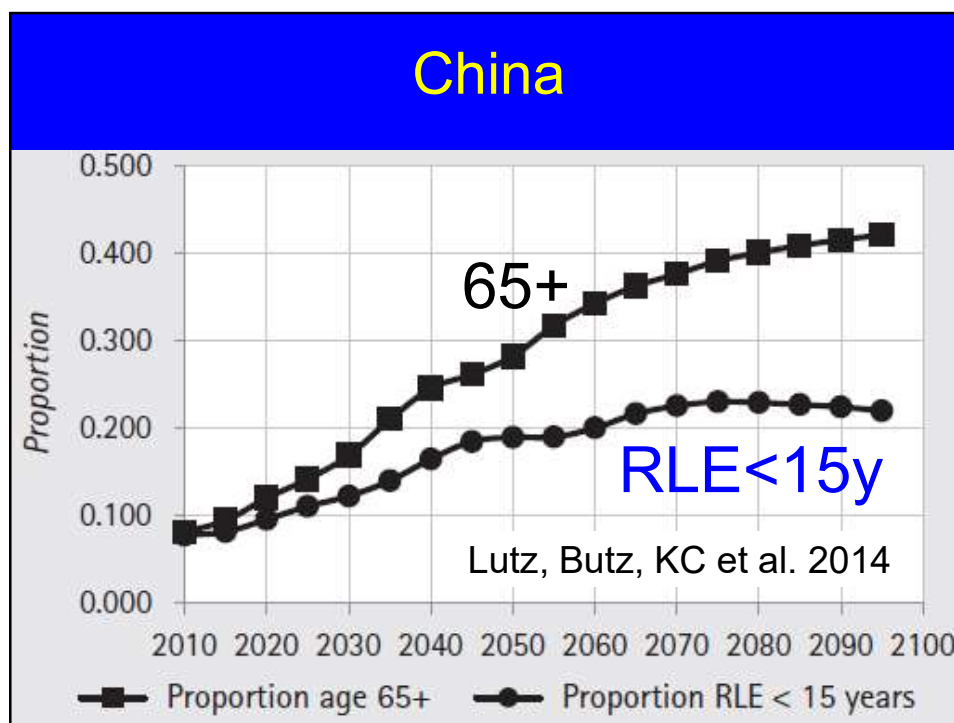
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## “What can grow younger as it grows older?”

“Because of education changes and scientific advances, human populations can grow in productivity, creativity, and remaining life expectancy, even as the median age of the population increases. Functionally, human populations can become younger even as they grow older chronologically. This is the key to understanding what ageing will really be like in the twenty-first century.”

Lutz, Butz, KC et al. 2014

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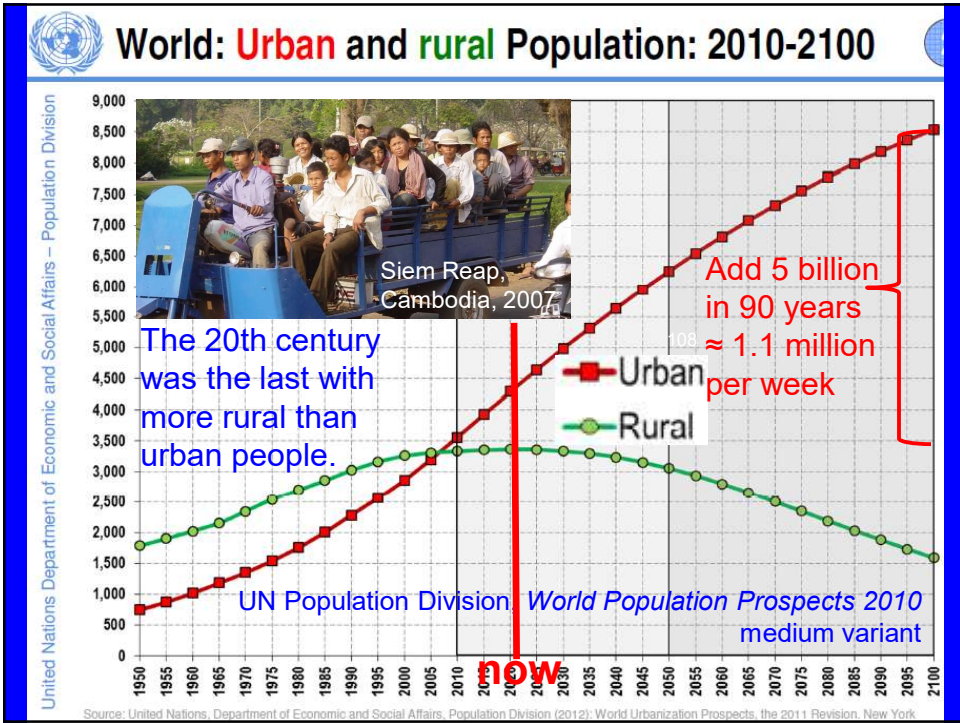
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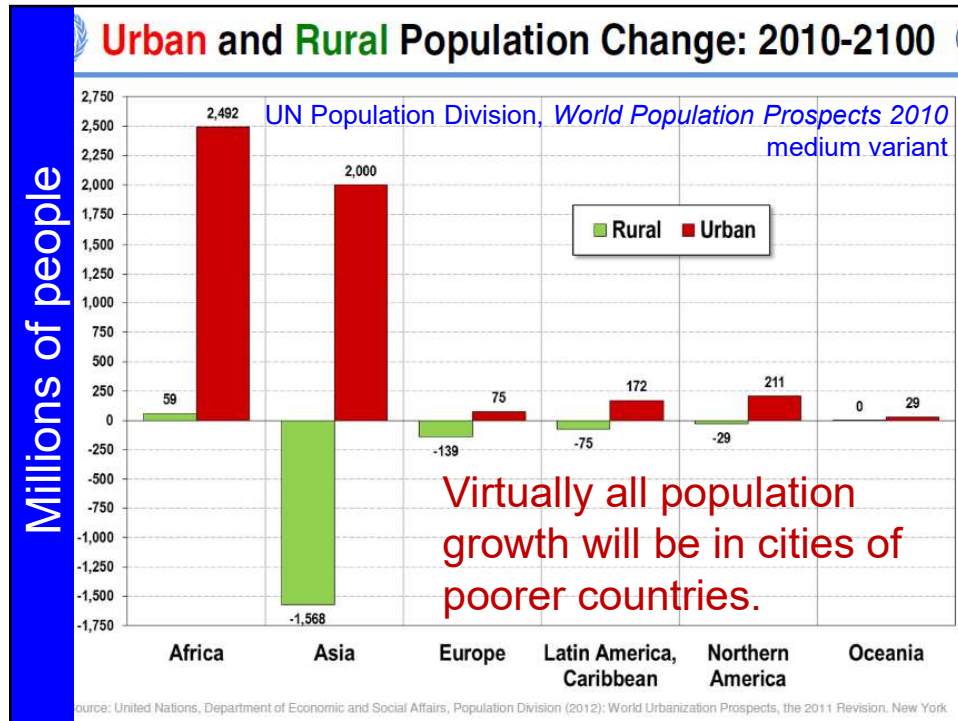
# Cities

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## Cities of the future will

- Have higher % of older people than now
- Be increasingly located in poor countries
- Have smaller household sizes
- Be concentrated along tectonic fault lines
- Be located coastally at low elevation
- Face energy & water limitations
- Demand more food from agricultural areas

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## Projections of future population size

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## Nobody knows

1. when global population growth will end; or
2. how big global population will be when growth ends.

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## Projections to 2100: 3 methods, 3 results

UN Pop.Div. (Adrian Raftery): Bayesian time-series models of TFR, life expectancy, migration

IIASA et al. (Wolfgang Lutz): Expert judgment of TFR & life expectancy

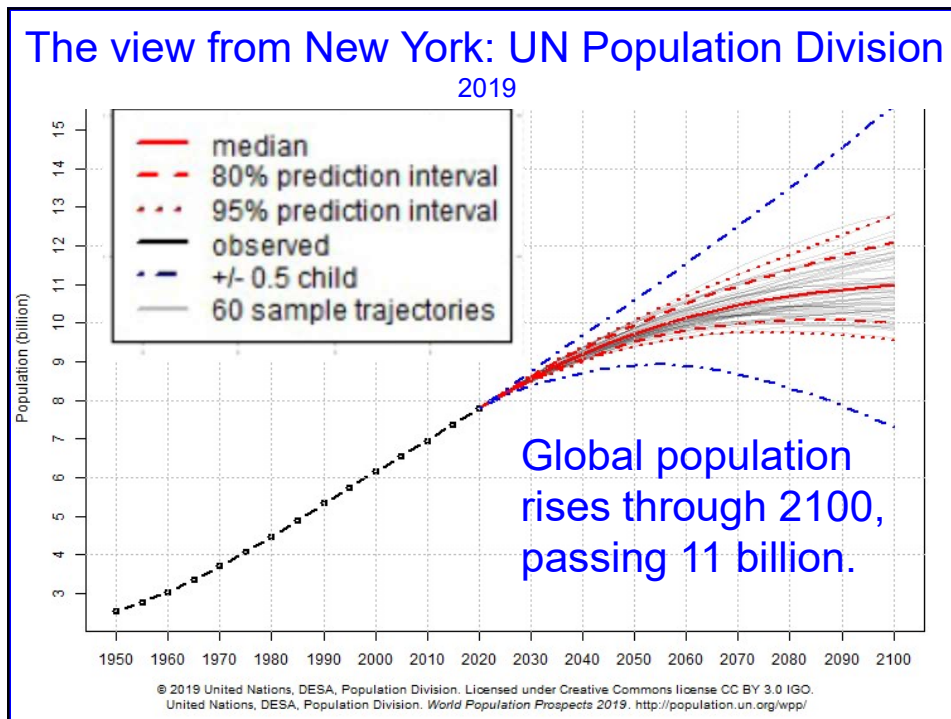
Global Burden of Disease (Christopher Murray): model TFR as function of education & unmet need for contraception

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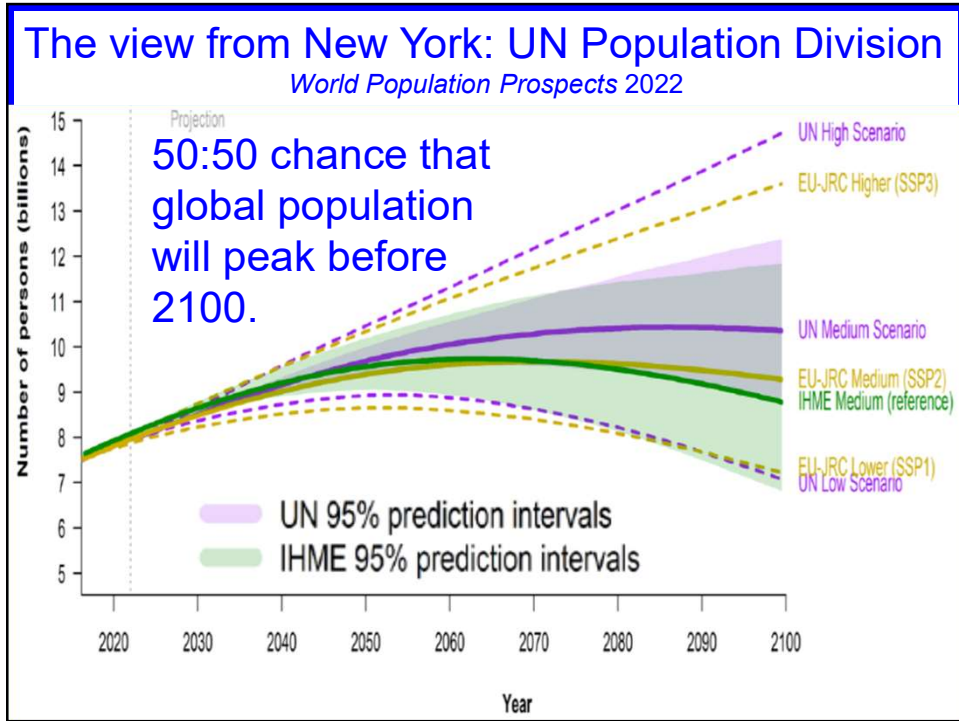
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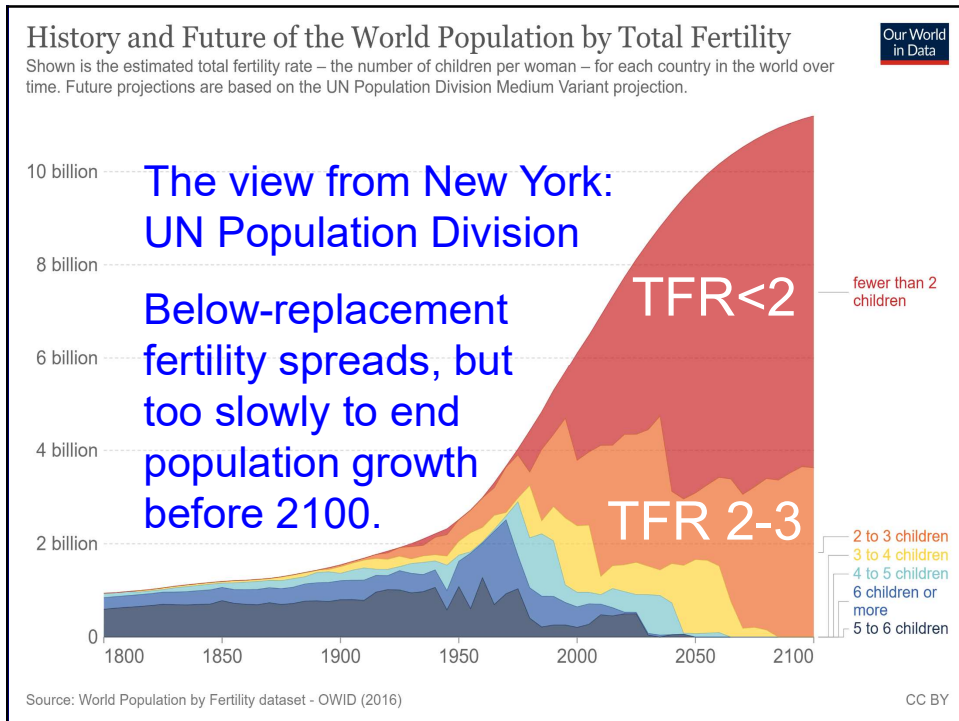
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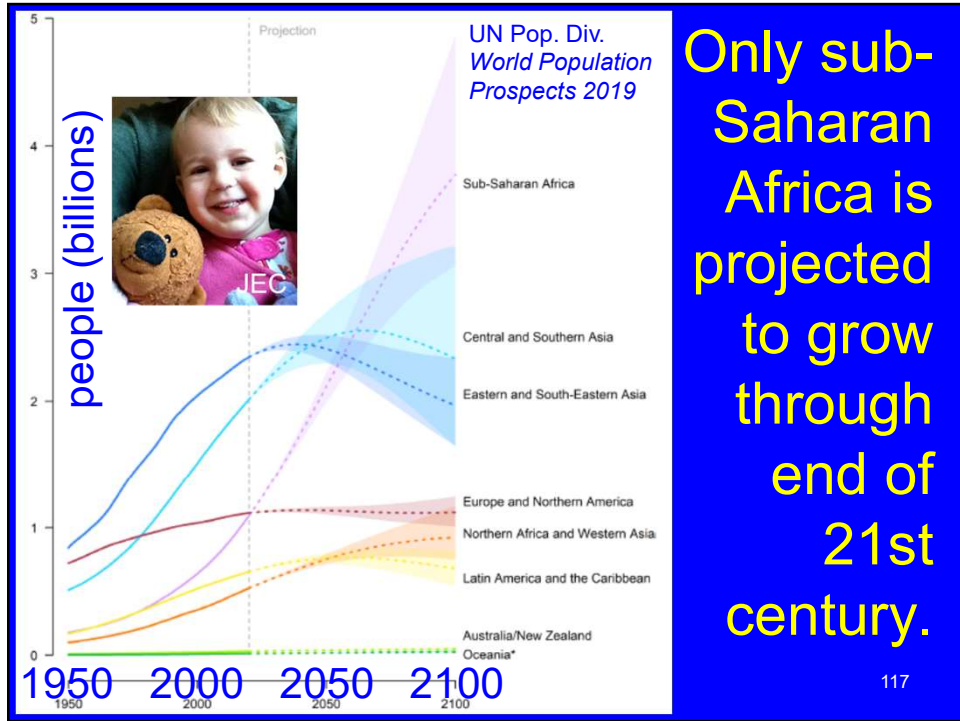
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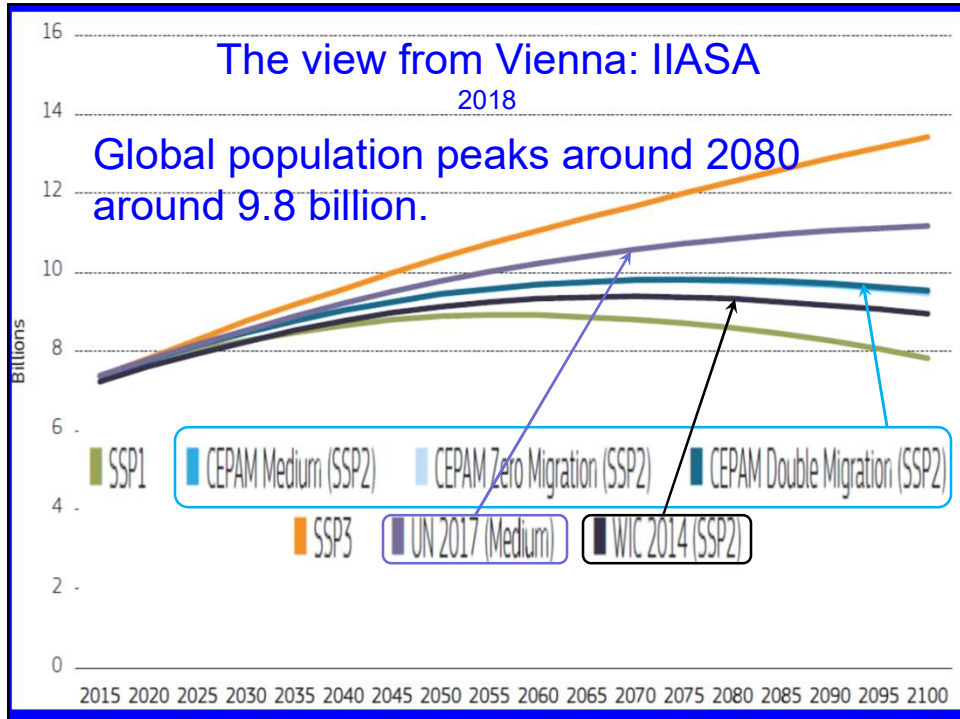
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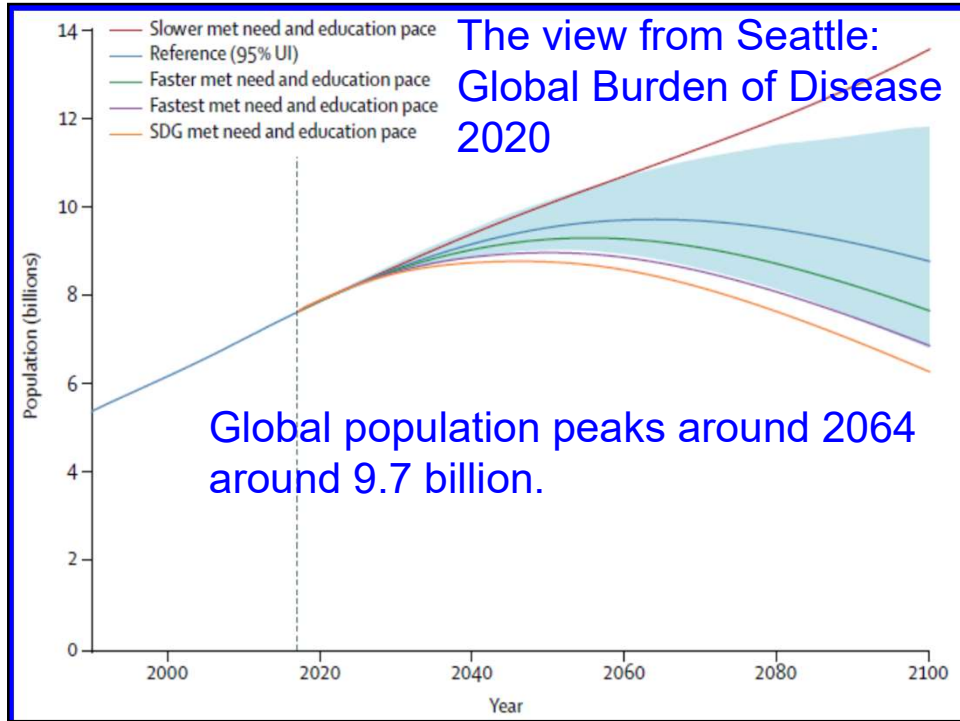
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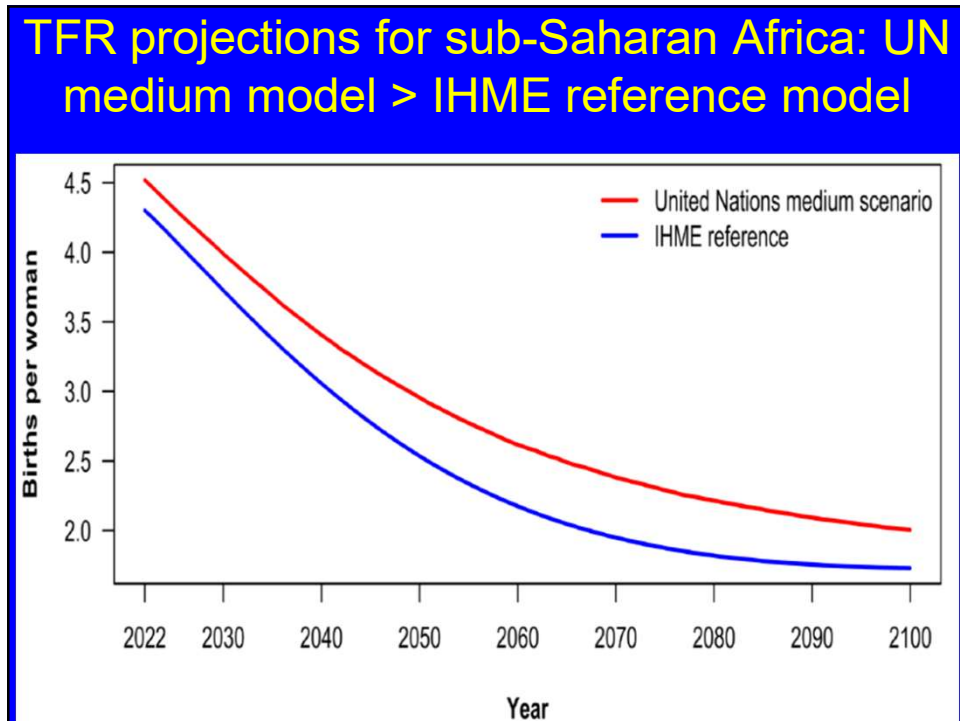
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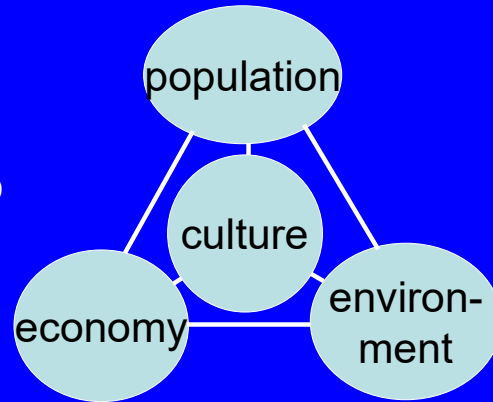
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Fundamental difficulty of forecasting:  
**Population interacts with economics,  
 the environment & culture.**

Culture,  
 economics &  
 environment are  
 at least as hard to  
 forecast as  
 population.  
 Choices influence  
 the future.



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**Recommendations  
 (based on science plus values)**

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## 5 targets for food security policy: the most vulnerable people

1. 200 million women or couples with unmet need for contraception
2. Pregnant women
3. Lactating women & nursing children
4. Weaned infants to 2-3 years
5. Teenage girls & boys

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## 5 targets need 3 programs, as part of food security policy.

Target	Family planning info, services, materials	Nutrition education for self & children	Balanced adequate diet
Unmet need	yes	yes	
Pregnant		yes	yes
Lactating	yes	yes	yes
Infants to 3			yes
Teenagers	yes	yes	

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# Thank you! Questions?

Najibullah MUSAFAER / Aina Photo



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