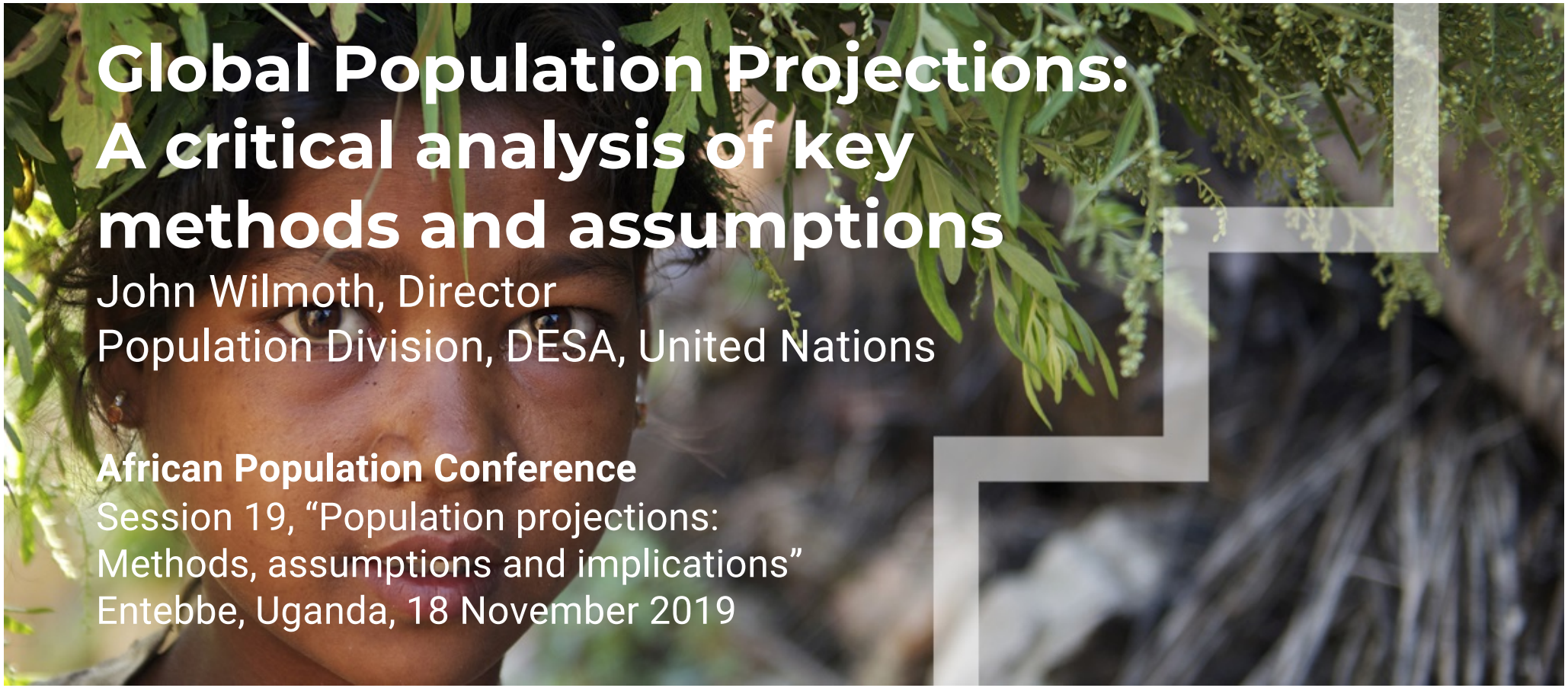
United Nations | Department of Economic and Social Affairs



Global Population Projections: A critical analysis of key methods and assumptions

John Wilmoth, Director
Population Division, DESA, United Nations

African Population Conference
Session 19, "Population projections: Methods, assumptions and implications"
Entebbe, Uganda, 18 November 2019

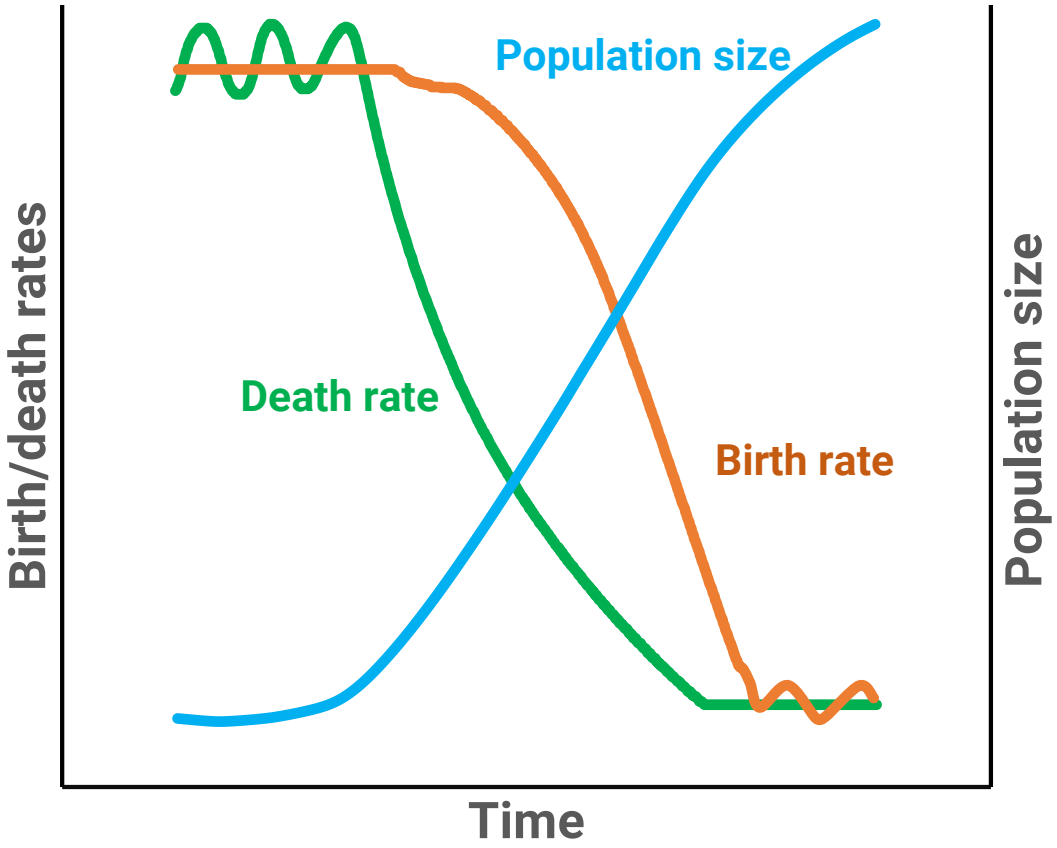
Brief history of UN projections

- 26 sets of population projections, every 2 or 3 years since 1951
- Early projections were for the world or large regions only
- Projections for individual countries beginning in 1968
- 2019 edition includes projections from 2020 to 2100 for 235 countries or areas

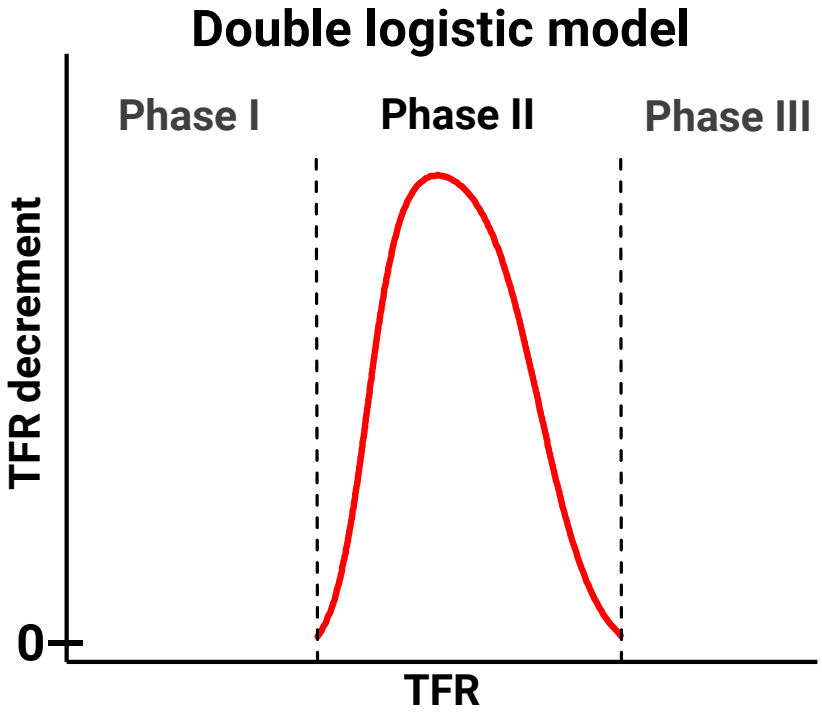
Methods and assumptions of UN projections

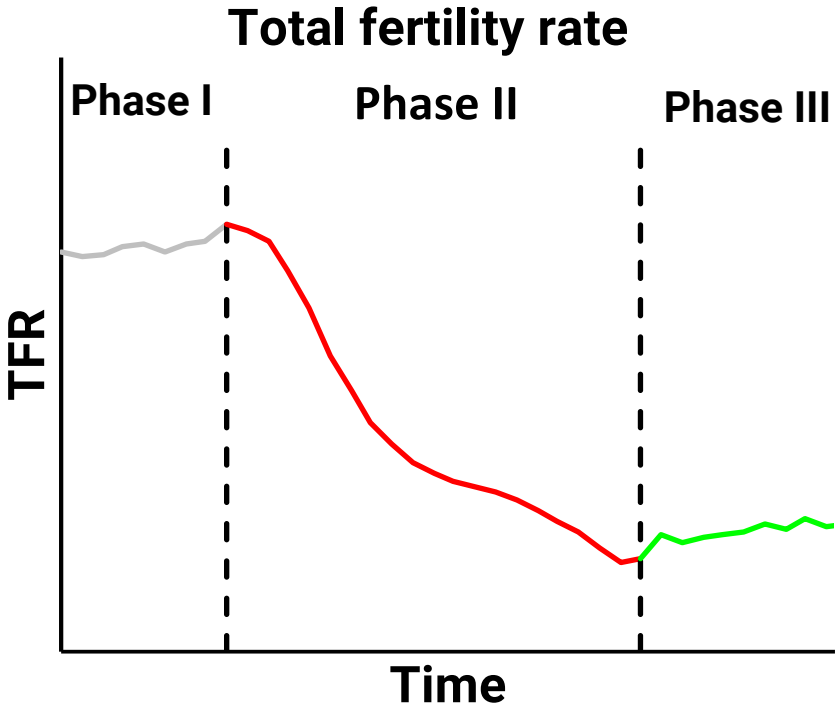
- Core assumptions about future trends grounded in **theories of demographic transition**
- Transition theory reflected in **functional form of fertility and mortality models**
- Enhancements due to **Bayesian hierarchical model**
  - More reliable results for countries/areas with less reliable data or at earlier stages of transition
  - Provides probabilistic assessment of alternative future trends

Classic model of demographic transition

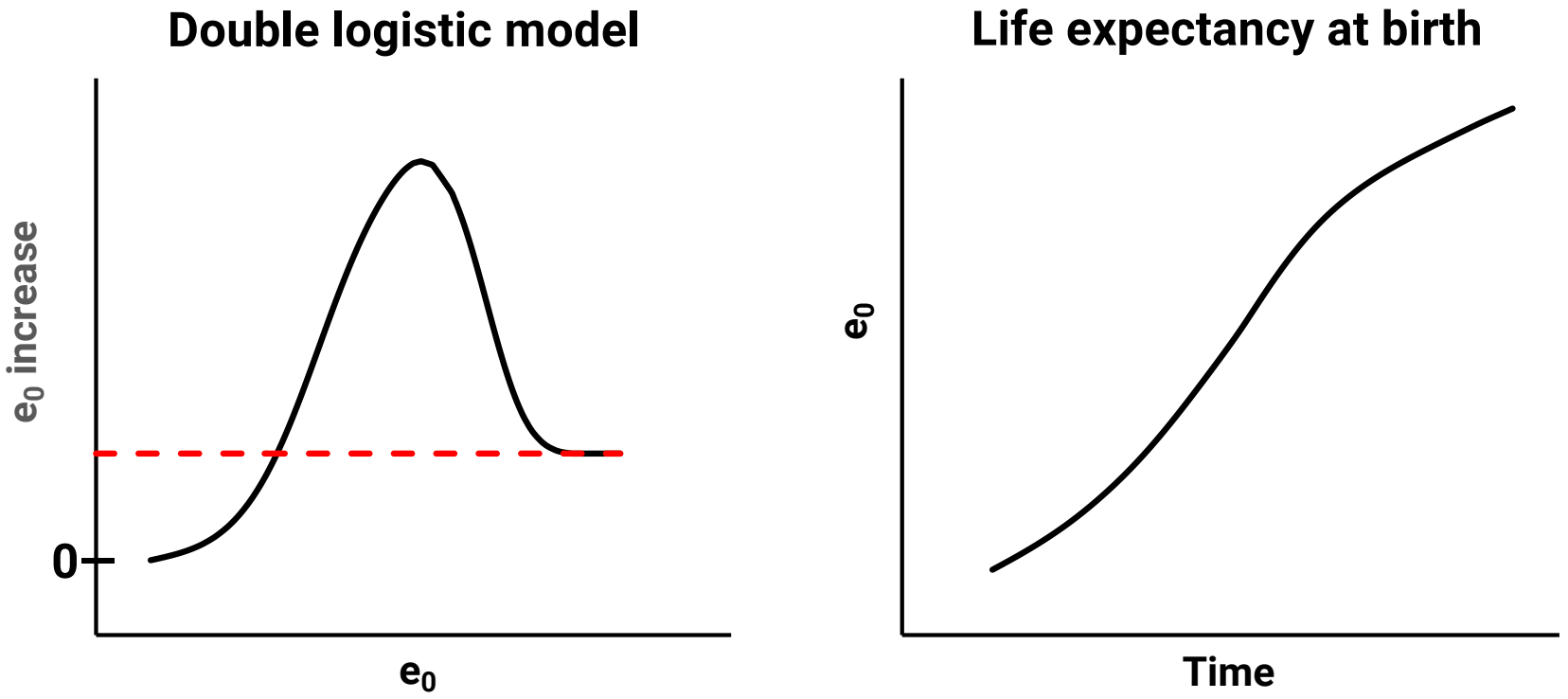


Three phases of TFR trend: Pre-decline, decline and post-decline



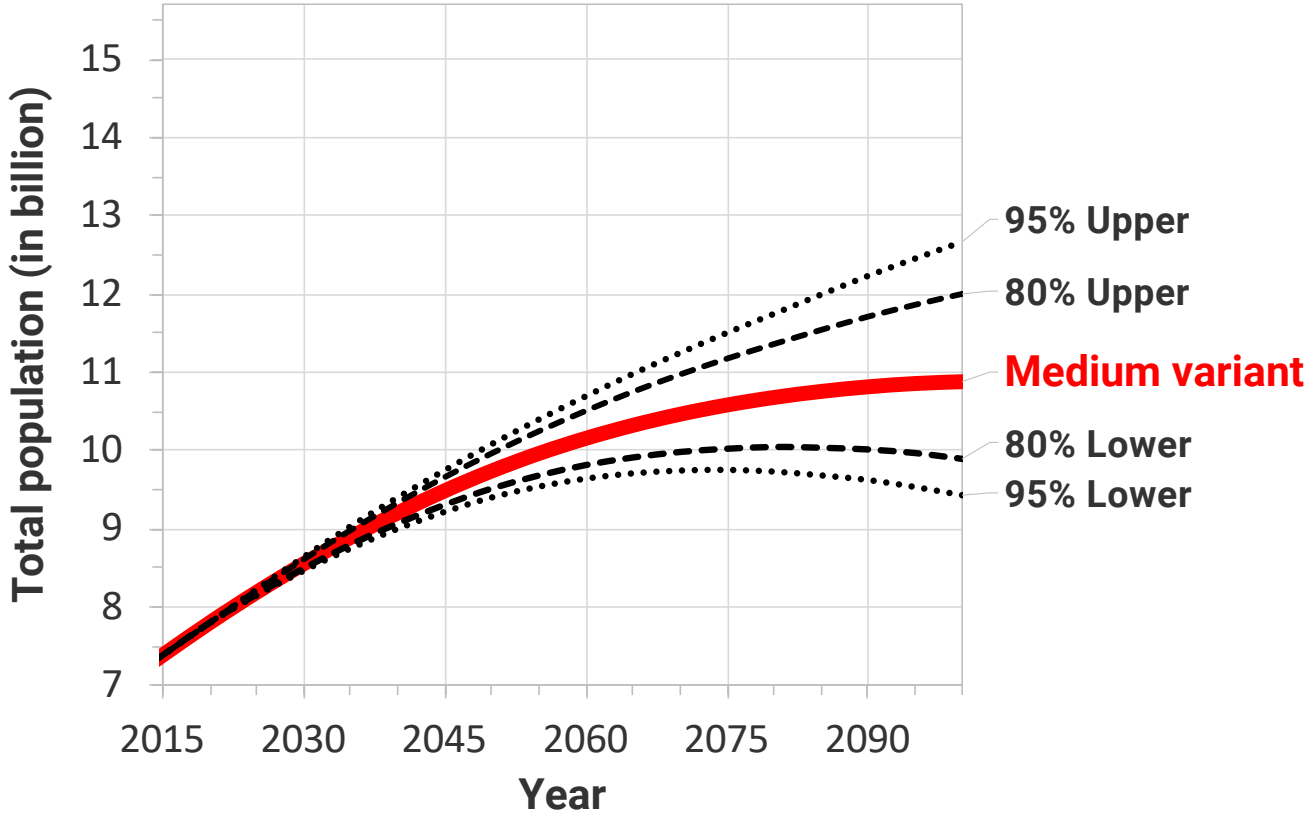


Model of historical trend in life expectancy at birth



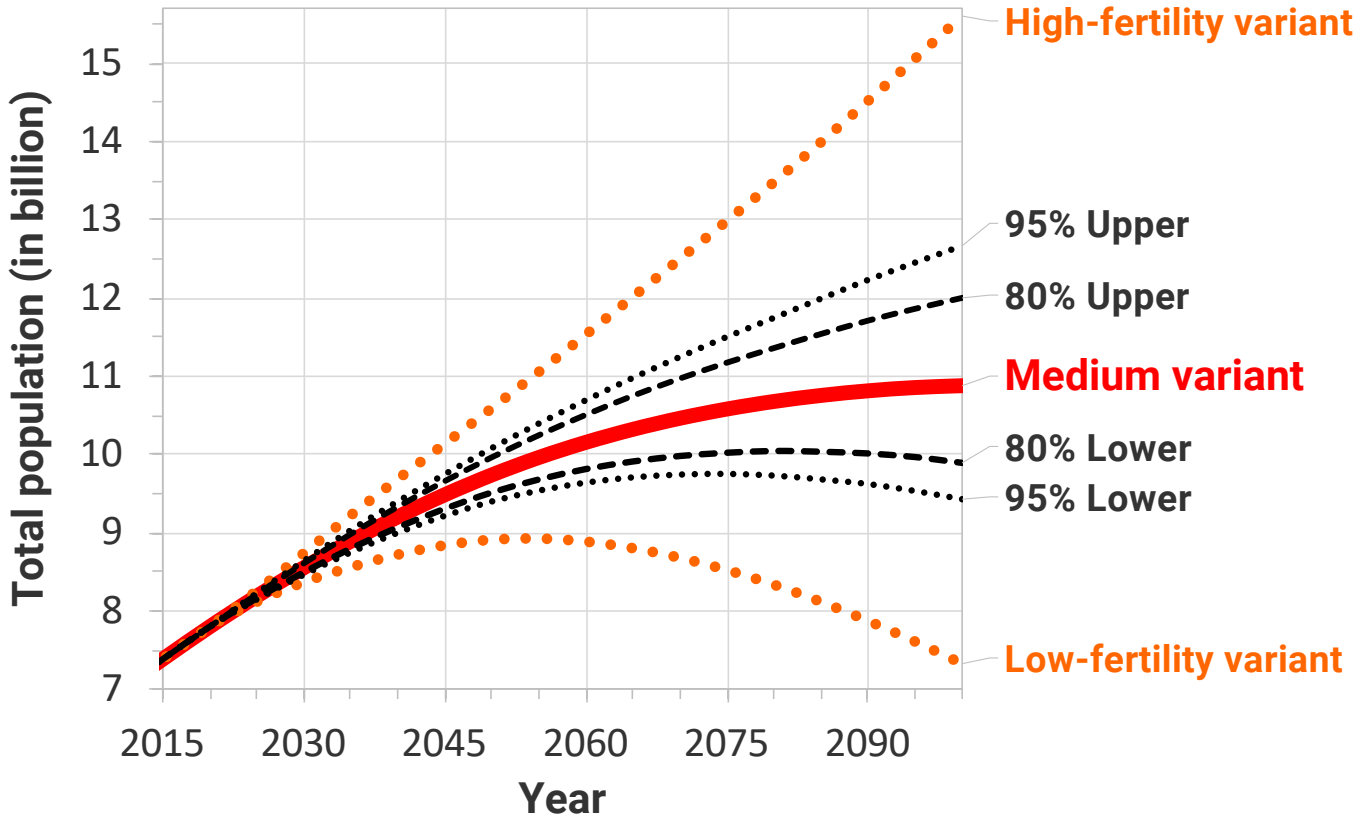
Projected global population 2015-2100

UN 2019 medium variant with 80- and 95-percent prediction intervals



Projected global population 2015-2100

UN 2019 medium with prediction intervals and high/low-fertility variants

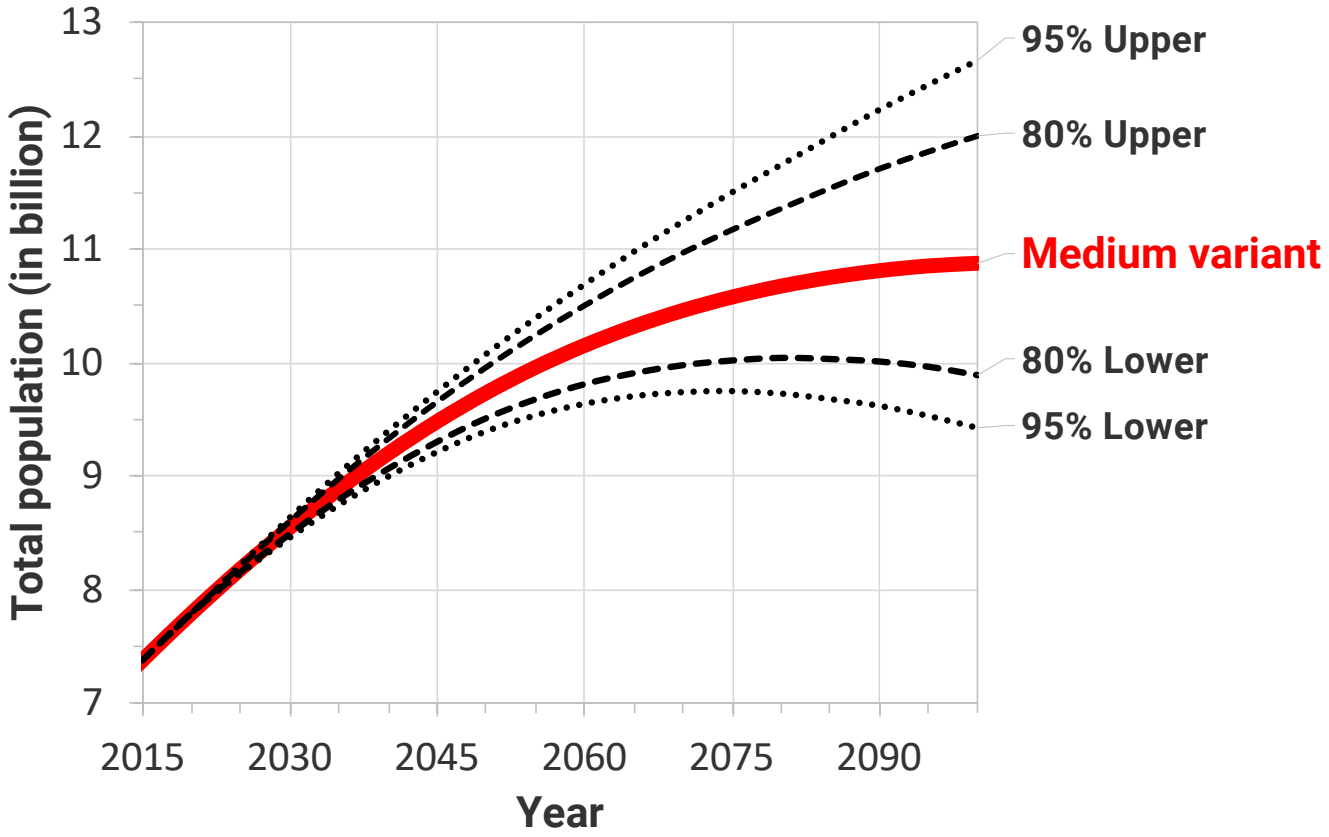


UN and IIASA projections

- What are the key differences?
- How to explain the differences?
- Begin by comparing medium projections

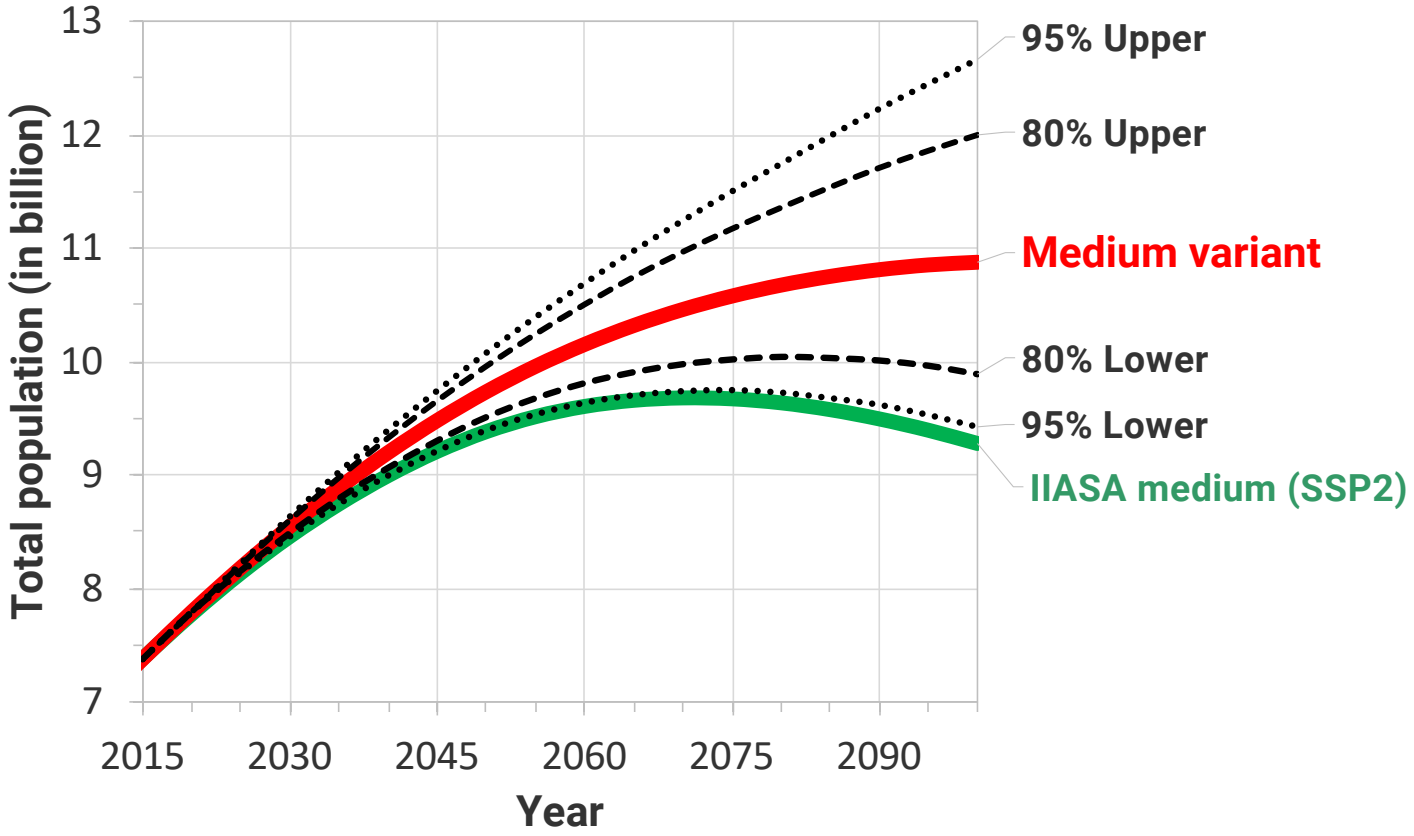
Global population trend 2015-2100

UN 2019 medium variant with 80- and 95-percent prediction intervals



Global population trend 2015-2100

UN 2019 medium with prediction intervals and IIASA medium (SSP2) scenario



What accounts for the difference in the two sets of projections?

- Statistical modeling versus scientific reasoning
- Educational change: considered versus ignored
- Historical experience versus expert judgement

What accounts for the difference in the two sets of projections?

"This difference is mostly due to different methods of deriving long-term fertility assumptions for the different parts of the world, where the **UN relies primarily on statistical extrapolation models** and **IIASA gives more weight to expert arguments and scientific reasoning**."

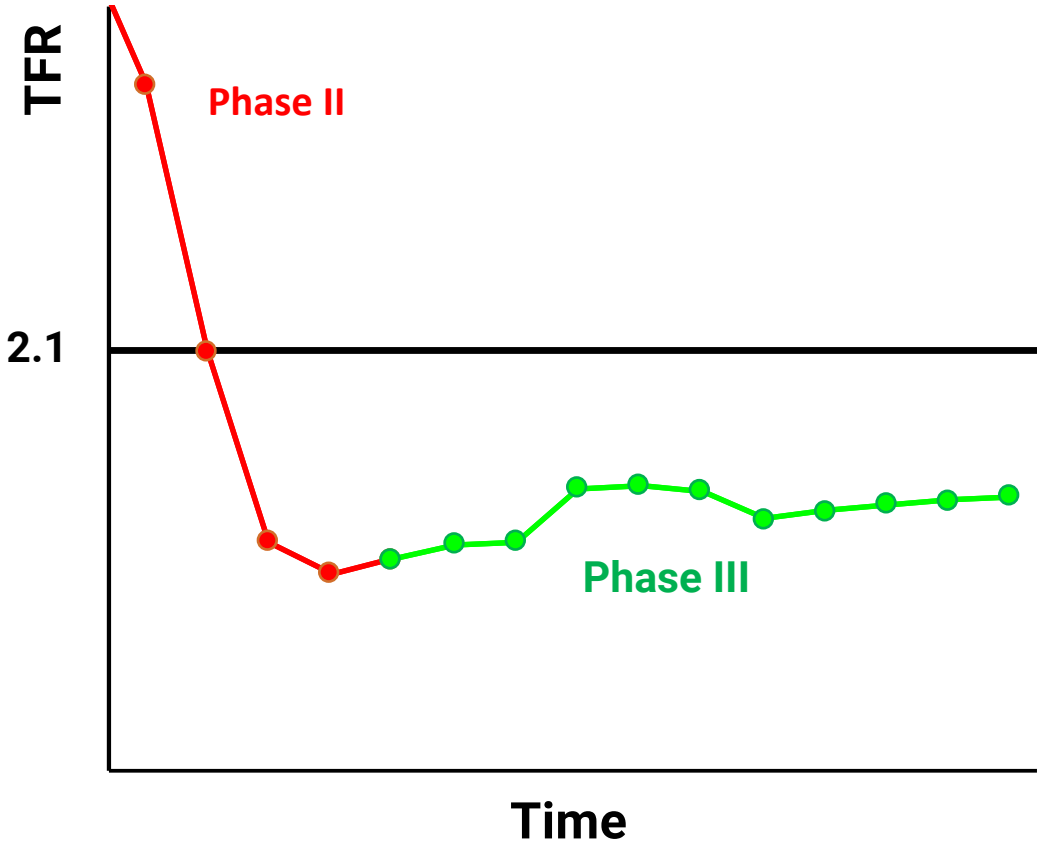
Lutz et al. 2018, p. 117 (emphasis added)

Statistical extrapolation model of fertility decline

- Role of expert arguments and scientific reasoning
- Informed by data and theory, including theories of demographic transition
- Three examples:
  - Exclusion of observations pre-dating modern contraception
  - Long-term mortality trends informed by trends in record longevity
  - Post-decline fertility model well justified by data and theory

Post-transition fertility trend

Phase III begins, by definition, after the first of two consecutive increases in TFR over 5-year intervals after reaching its minimum when TFR < 2



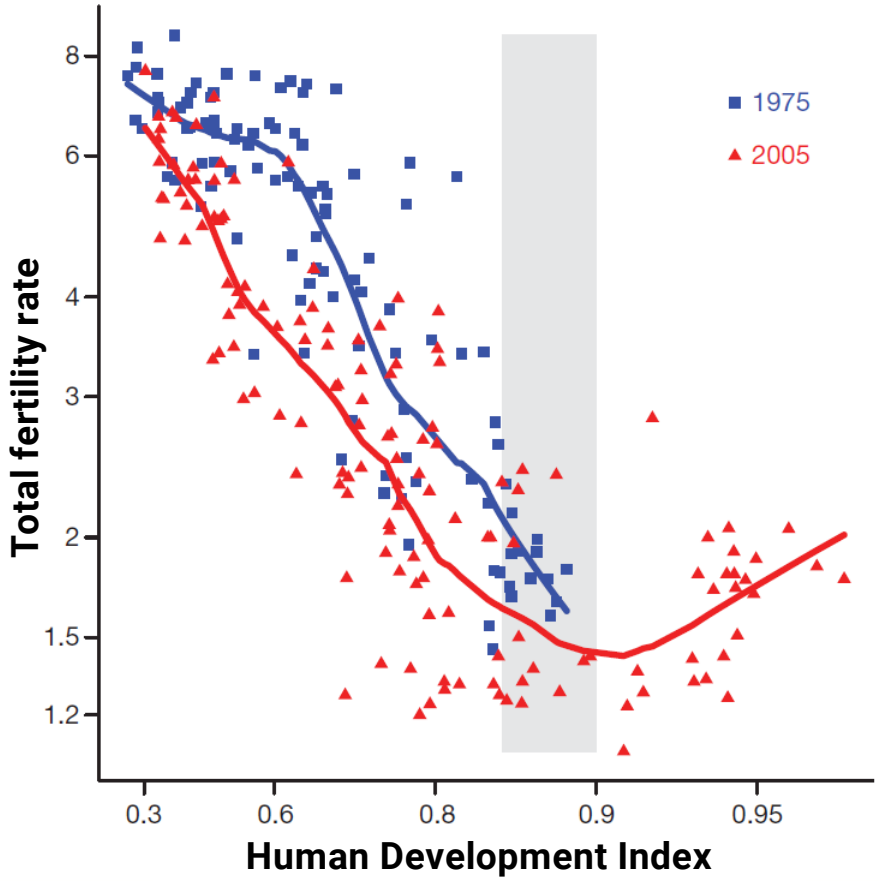
40 countries/areas in Phase III by 2019

- Europe
  - Armenia
  - Austria
  - Belarus
  - Belgium
  - Bulgaria
  - Channel Islands
  - Czechia
  - Denmark
  - Estonia
  - Finland
  - France
  - Germany
  - Hungary
  - Italy
  - Latvia
  - Lithuania
  - Luxembourg
  - Malta
  - Netherlands
  - Norway
  - Republic of Moldova
  - Romania
  - Russian Federation
  - Slovakia
  - Slovenia
  - Spain
  - Sweden,
  - Switzerland
  - Ukraine
  - United Kingdom
- Eastern & South-Eastern Asia
  - China
  - China - Hong Kong SAR
  - China - Macao SAR
  - China - Taiwan Province of China
  - Japan
  - Singapore
  - Viet Nam
- Latin America and the Caribbean
  - Aruba
  - Barbados
- Northern America
  - United States of America

Reversal of fertility decline

"Although development continues to promote fertility decline at low and medium HDI levels, our analyses show that **at advanced HDI levels, further development can reverse the declining trend in fertility**. The previously negative development-fertility relationship has become J-shaped, with the HDI being positively associated with fertility among highly developed countries."

Myrskylä et al. 2009, *Nature*, p. 741 (emphasis added)



Education as a predictor

photo credit: UN Photo/Harandane Dicko, Mark Garten, Eskinder Debebe

Assertion that treatment of education explains the difference

"The assessment of these recent trends in Africa is one of the main reasons why **the UN projections – based on an extrapolative model of the total fertility rates that does not consider the changing educational structure** – results in higher assumptions of future fertility than the IIASA (Wittgenstein Centre) projections. **The medium (SSP2) scenario from IIASA is based on the assumption that improvements in female education will continue, and result in a more rapid fertility decline.**"

Lutz et al. 2018, p. 117 (emphasis added)

IIASA mid- and long-term assumptions

"For the **definition and substantive reasoning of the specific assumptions made**, the reader is referred to the chapters of [Lutz et al. 2014] which provide **comprehensive reviews of the scientific literature** on the drivers of future fertility mortality, migration and education trends **and the results of the largest ever expert survey** for assessing the validity of alternative arguments **drawing from over 550 international experts** who either participated in a series of five substantive meetings or took part in an extensive online survey."

Lutz et al. 2018, p. 22 (emphasis added)

Accounting for educational change: Does it explain the difference?

- **UN medium** projection, based on historical experience, accounts for educational change **implicitly**
- **IIASA medium** projection, based on expert judgement, accounts for educational change **implicitly**
- **Neither uses an explicit model** of educational change in setting assumptions for the medium projection

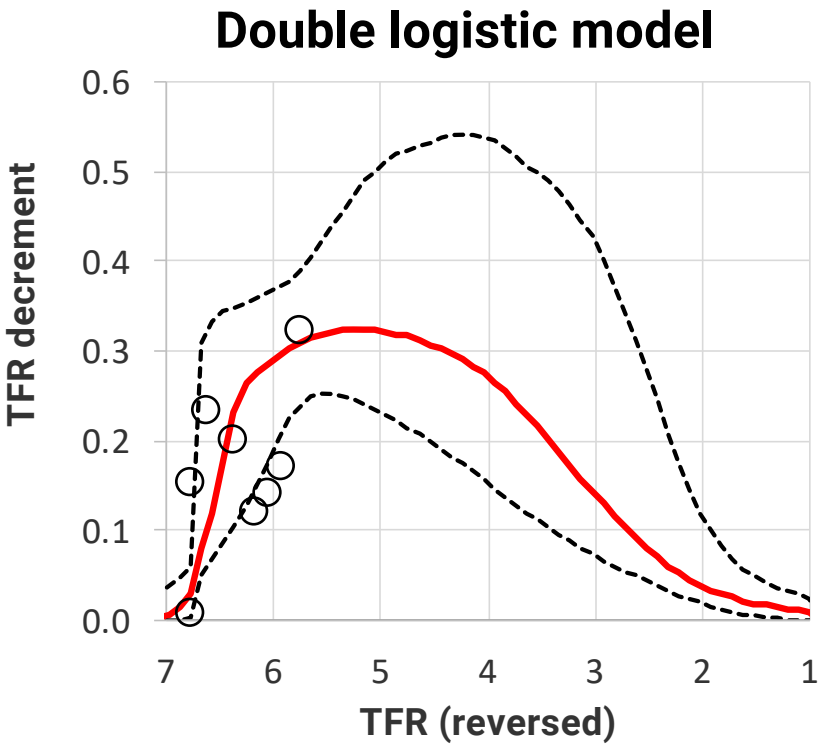
Widespread misunderstanding about role of education in projection models

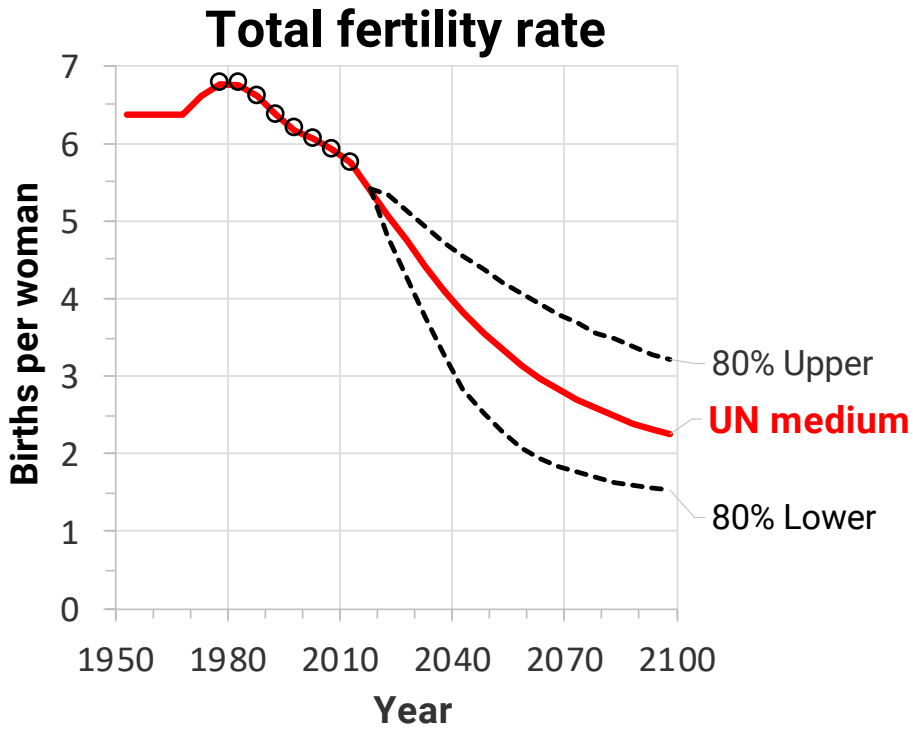
"Lutz and his fellow demographers at Vienna's International Institute for Applied Systems Analysis believe that **advancing education in developing countries**, brought about by increasing urbanization, **should be factored into future population projections, which the UN doesn't do. The IIASA, using those factors predicts a stabilizing population by mid-century, followed by a decline.** Lutz believes that the human population will be shrinking as early as 2060."

Bricker and Ibbitson 2019, *Empty Planet: The Shock of Global Population Decline*, chapter 2 (emphasis added)

Total fertility rate (TFR), Nigeria, 1950-2100

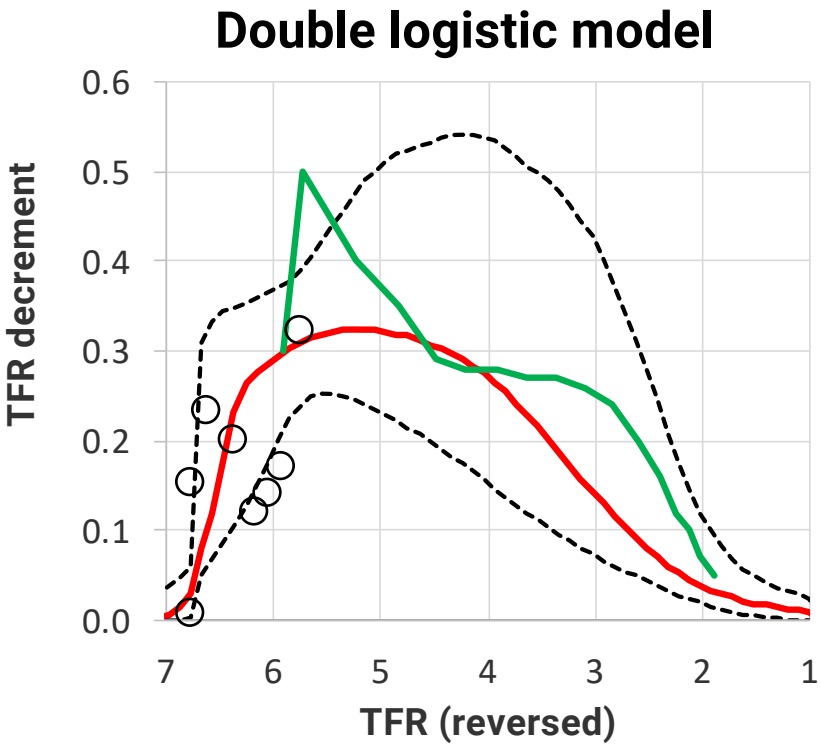
UN 2019 medium variant with 80-percent prediction intervals

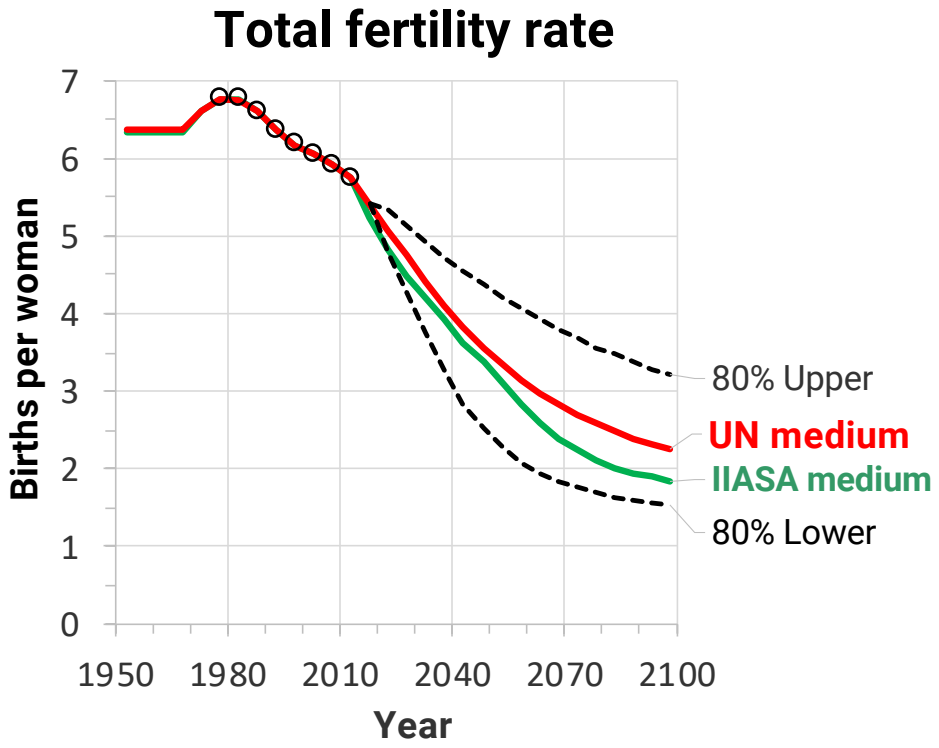




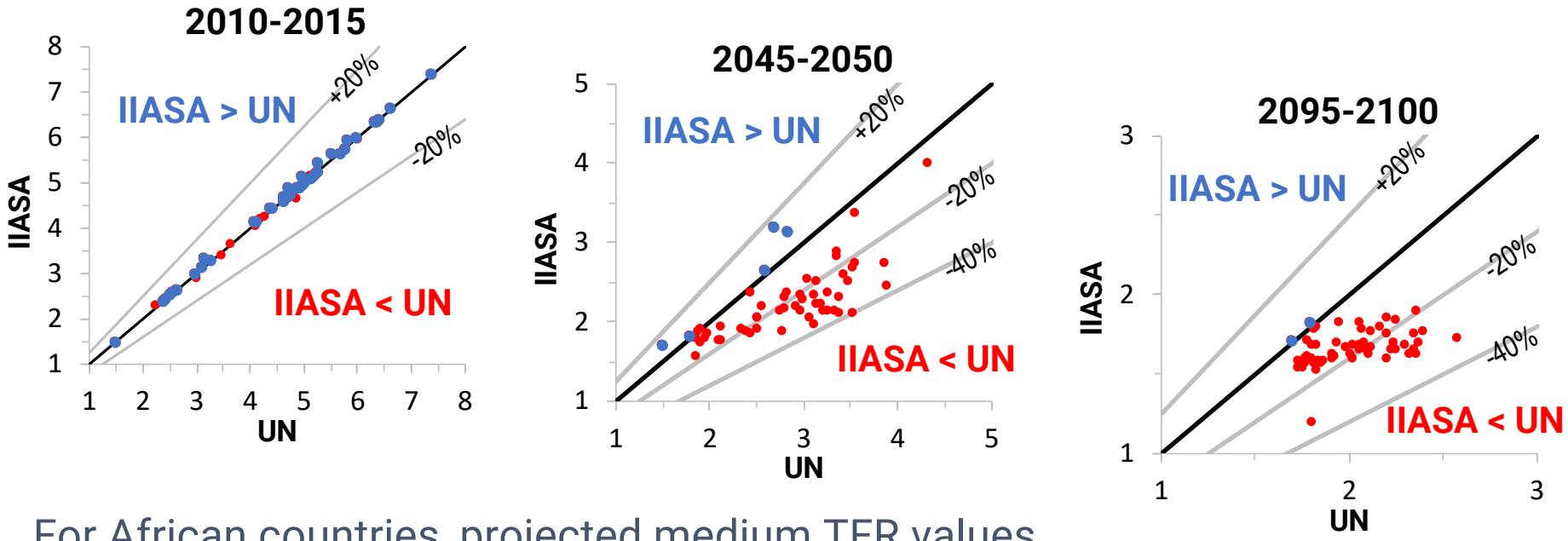
Total fertility rate (TFR), Nigeria, 1950-2100

UN 2019 medium with prediction intervals and IIASA medium (SSP2) scenario





TFRs for African countries, IIASA vs. UN medium



For African countries, projected medium TFR values are on average 18% lower for IIASA compared to UN (up to 40% lower for some countries), with smaller relative differences by 2100

Critical assessment of two methodologies

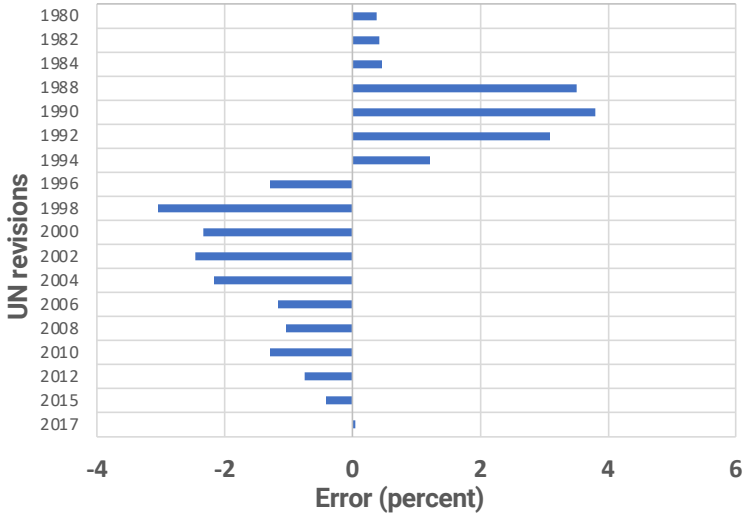
- Track record of UN projections
- Validation of probabilistic intervals
- Reliability of expert predictions
- Coherence of IIASA alternative scenarios
- Accelerated fertility decline for Africa
- Aggregation of alternative scenarios

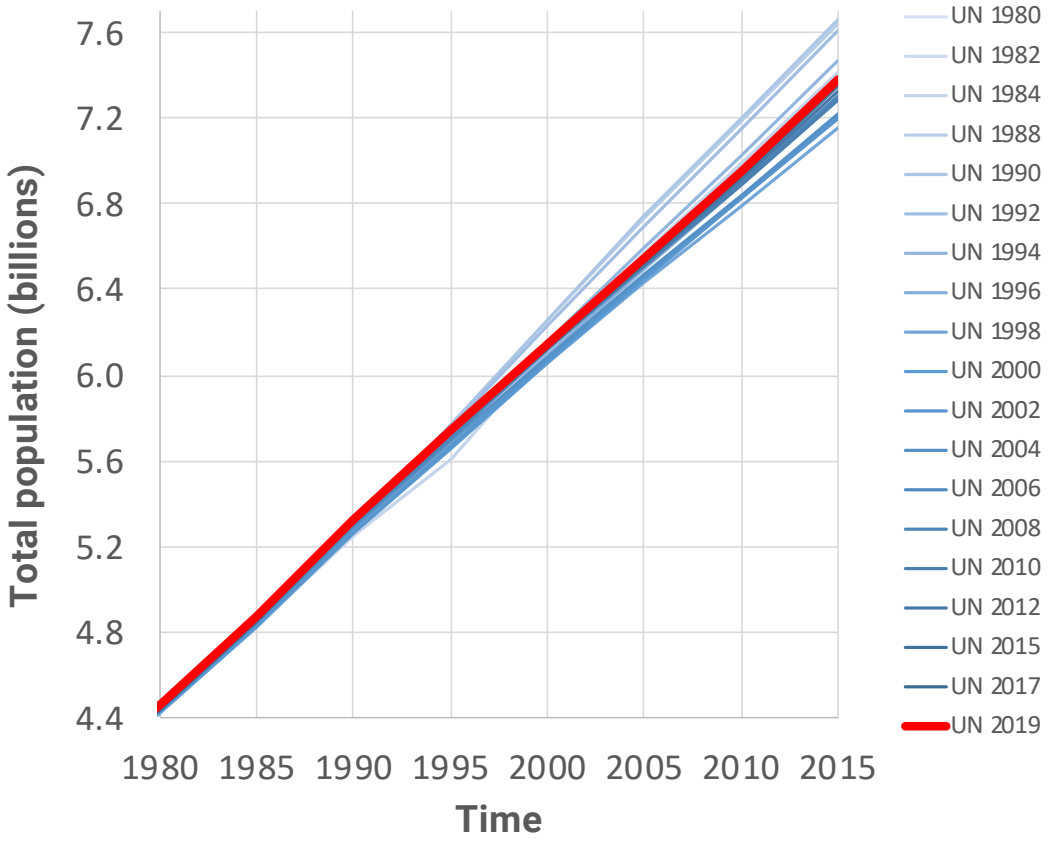
UN population projections: Past and Present

1980 to 2019 revisions of the World Population Prospects (WPP)

Population in 2015:

- +3.8% (280 mio) to -3.1% (-225 mio)



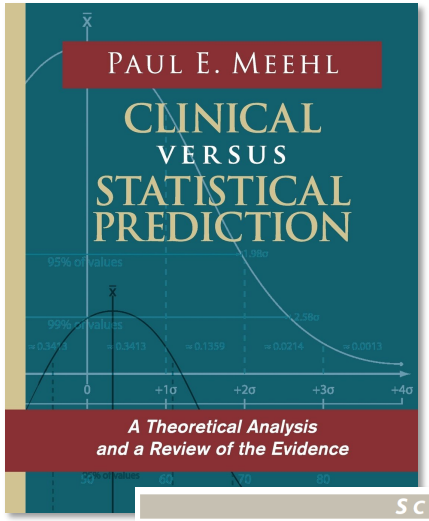


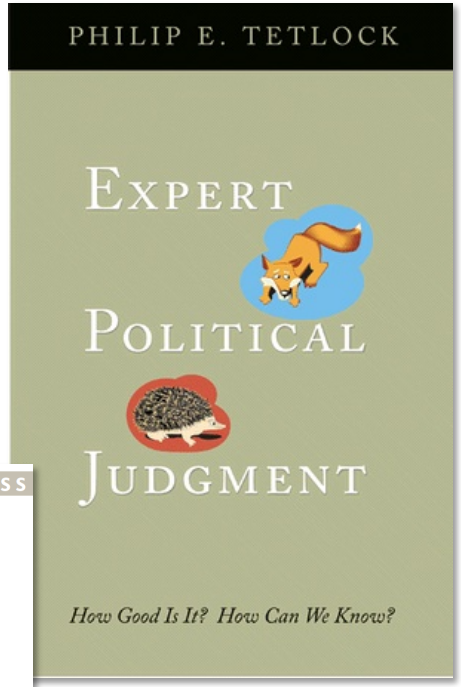
UN 2010 out-of-sample validation: 1990-2010

Quantity	MARE (%)	Coverage (percent) 80% prediction interval	95% prediction interval
Total fertility rate	12.3	72	87
Female life expectancy	2.0	83	94
Male life expectancy	2.5	83	91
Total population	2.7	73	85

* MARE is the mean absolute relative error. Coverage is the proportion of the 1990-2010 observations that fell within their prediction interval, in percent.

Issues with expert-based approaches





SCIENCE'S COMPASS

POLICY FORUM: DEMOGRAPHY

Broken Limits to Life Expectancy

Jim Oeppen and James W. Vaupel*

Is life expectancy approaching its limit? Many—including individuals planning their retirement and officials responsible for health and social policy—believe it is. The evidence suggests otherwise.

in income, salubrity, nutriti
sanitation, and medicine,
varying over age, period, col
disease (*4*). Before 1950, m
in life expectancy was due

DISPATCHES

· BUSINESS

THE PECULIAR BLINDNESS OF EXPERTS

Credentialed authorities are comically bad at predicting the future. But reliable forecasting is possible.

BY DAVID EPSTEIN

THE BET WAS ON, and it was over the fate of humanity. On one side was the Stanford biologist Paul R. Ehrlich. In his 1968 best seller, *The Population Bomb*, Ehrlich insisted that it was too late to prevent a doomsday apocalypse resulting from overpopulation. Resource shortages would cause hundreds of millions of starvation deaths within a decade. It was cold, hard math: The human population was growing exponentially; the food supply was not. Ehrlich was an accomplished butterfly specialist. He knew that nature did not regulate animal populations delicately. Populations exploded, blowing past the available resources, and then crashed.

In his book, Ehrlich played out hypothetical scenarios that represented "the kinds of disasters that *will* occur." In the worst-case scenario, famine rages across the planet. Russia, China, and the United States are dragged into nuclear war, and the resulting environmental degradation soon extinguishes the human race. In the "cheerful" scenario, population controls begin. Famine spreads, and countries teeter, but the major death wave ends in the mid-1980s. Only half a billion or so people die of starvation. "I challenge you to create one more optimistic," Ehrlich wrote, adding that he would not count scenarios involving benevolent aliens bearing care packages.

The economist Julian Simon took up Ehrlich's challenge. Technology—water-control techniques, hybridized seeds, management strategies—had revolutionized agriculture, and global crop yields were increasing. To Simon, more people meant more good ideas about how to achieve a sustainable future. So he proposed a wager. Ehrlich could choose five metals that he expected to become more expensive as resources were depleted and chaos ensued over the next decade. Both men agreed that commodity prices were a fine proxy for the effects of population growth, and they set the stakes at $1,000 worth of Ehrlich's five metals. If, 10 years hence,

20 JUNE 2019 THE ATLANTIC

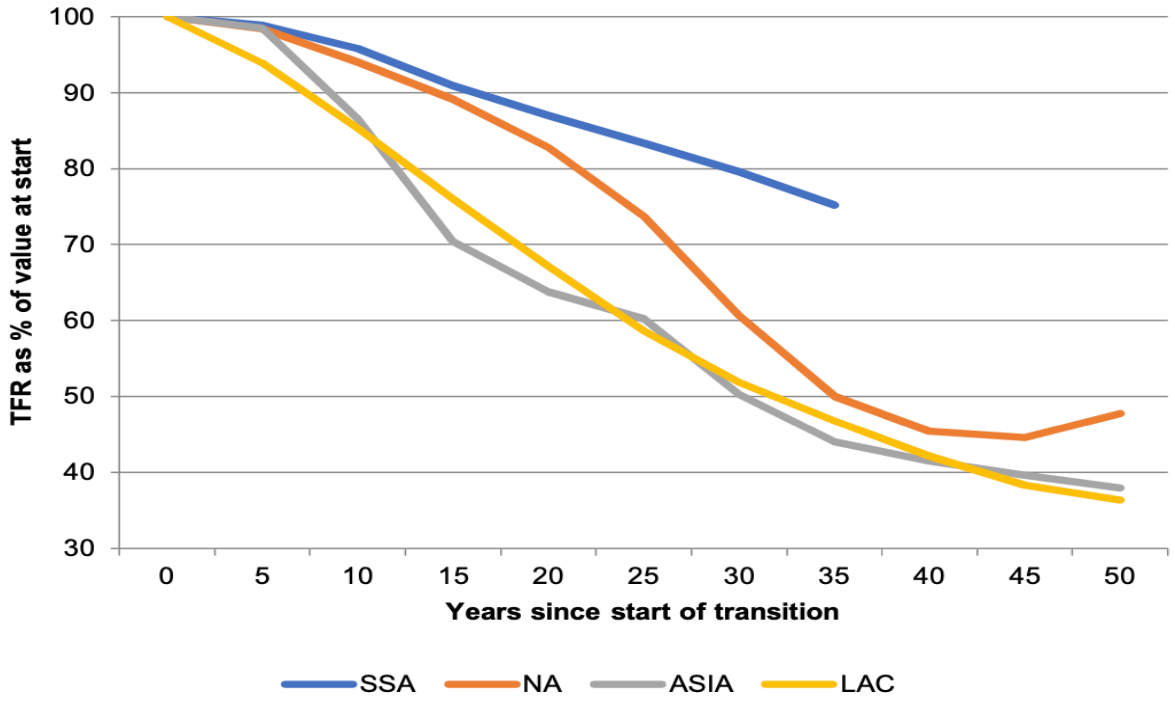
Illustration by NA KIM

Coherence of IIASA alternative scenarios (SSP1 and SSP3)

		Country groupings	Fertility	Mortality	Migration	Education
SSP1:	SUSTAINABILITY / RAPID SOCIAL DEVELOPMENT	HiFert	Low	Low	Medium	High (SDG)
		LoFert	Low-Med ?	Low	Medium	High (SDG)
SSP2:	CONTINUATION / MEDIUM POPULATION SCENARIO	HiFert	Medium	Medium	Medium	Medium (GET)
		LoFert	Medium	Medium	Medium	Medium (GET)
SSP3:	FRAGMENTATION / STALLED SOCIAL DEVELOPMENT	HiFert	High	High	Low ?	Low (CER)
		LoFert	High	High	Low	Low (CER)

Source: Lutz et al. 2018, p. 27

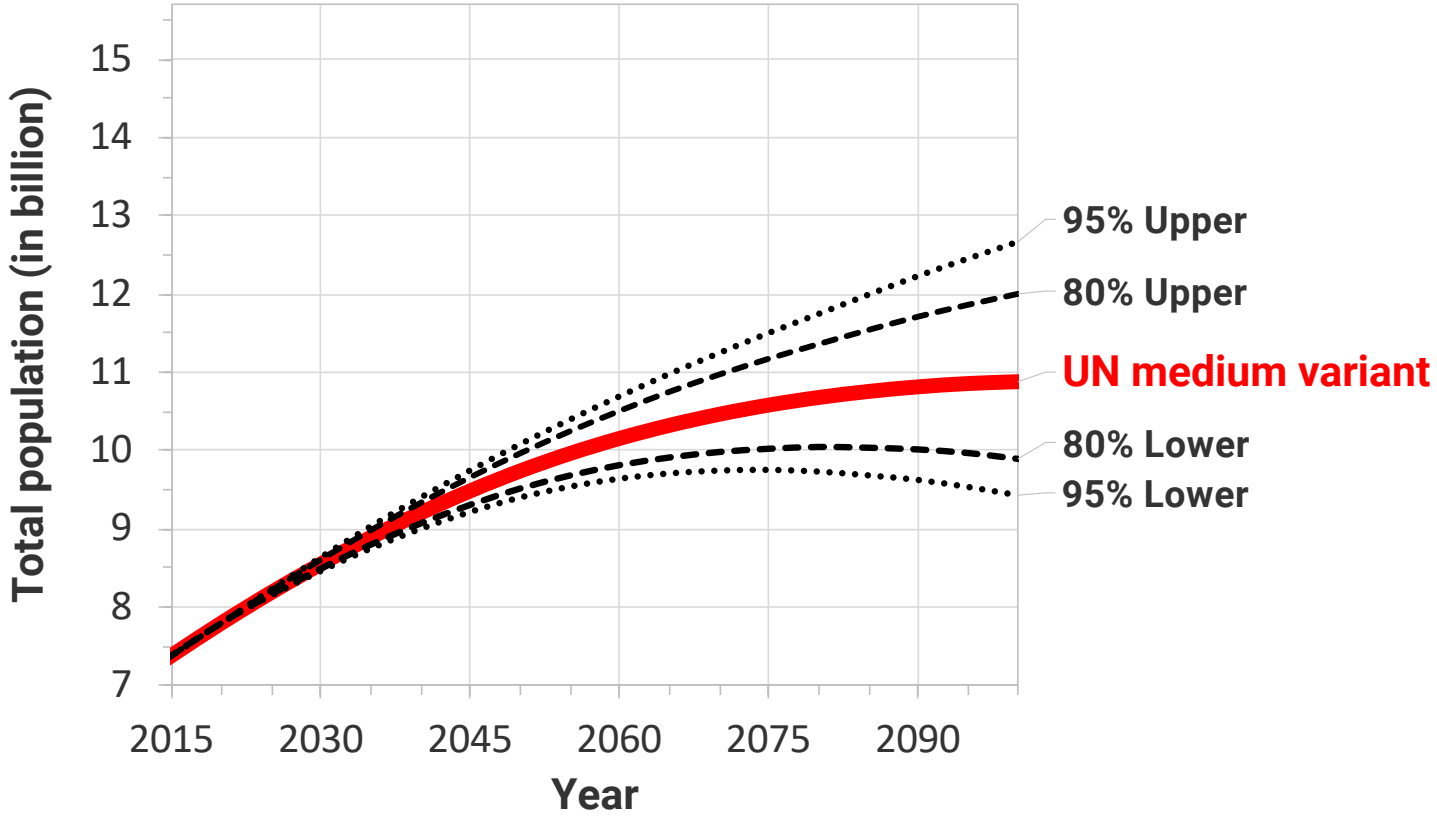
Plausibility of accelerated fertility decline in Africa



Shapiro and Hinde, Demographic Research, 2017, p. 1334

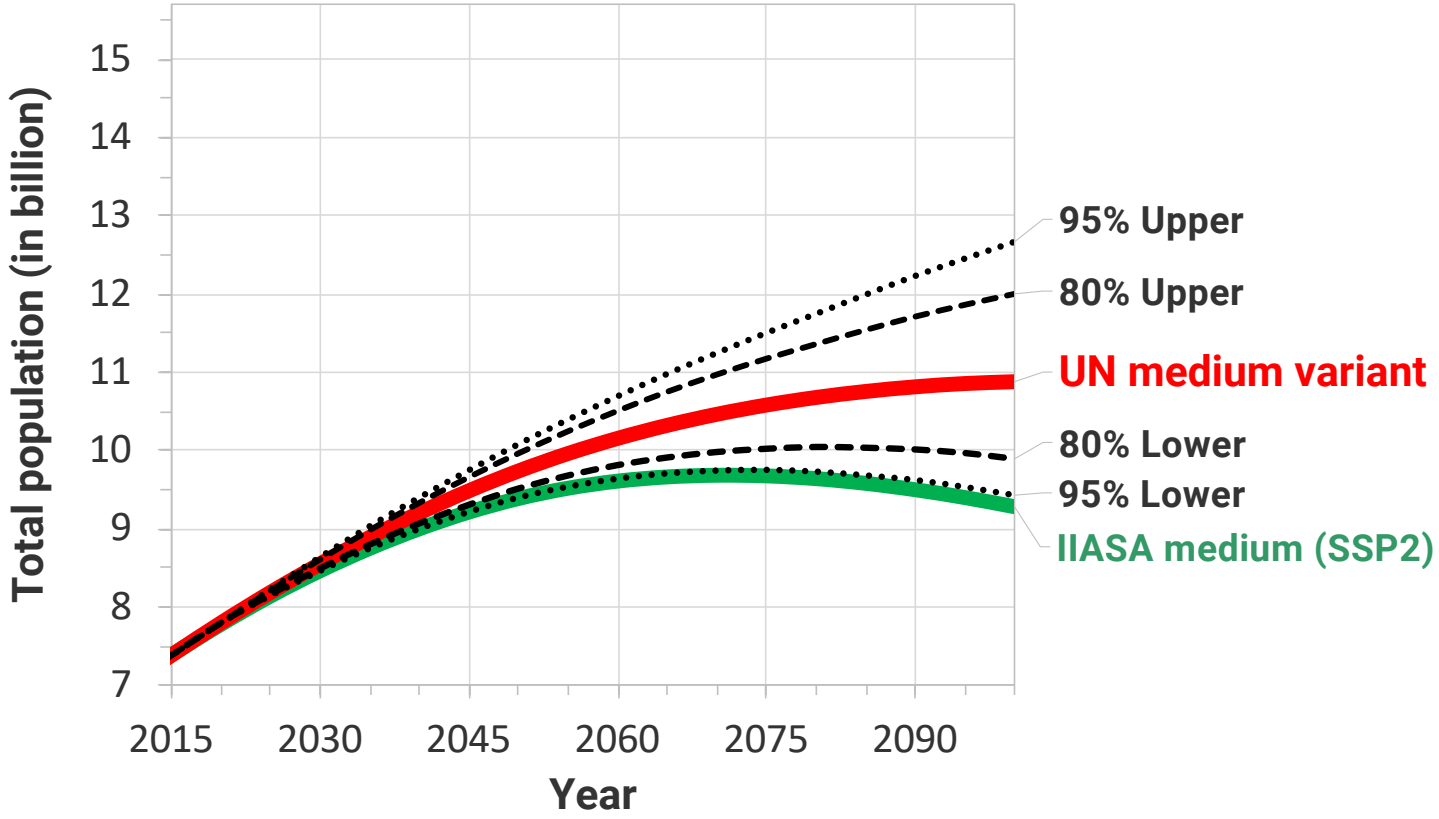
Global population trend 2015-2100

UN 2019 medium variant with 80- and 95-percent prediction intervals



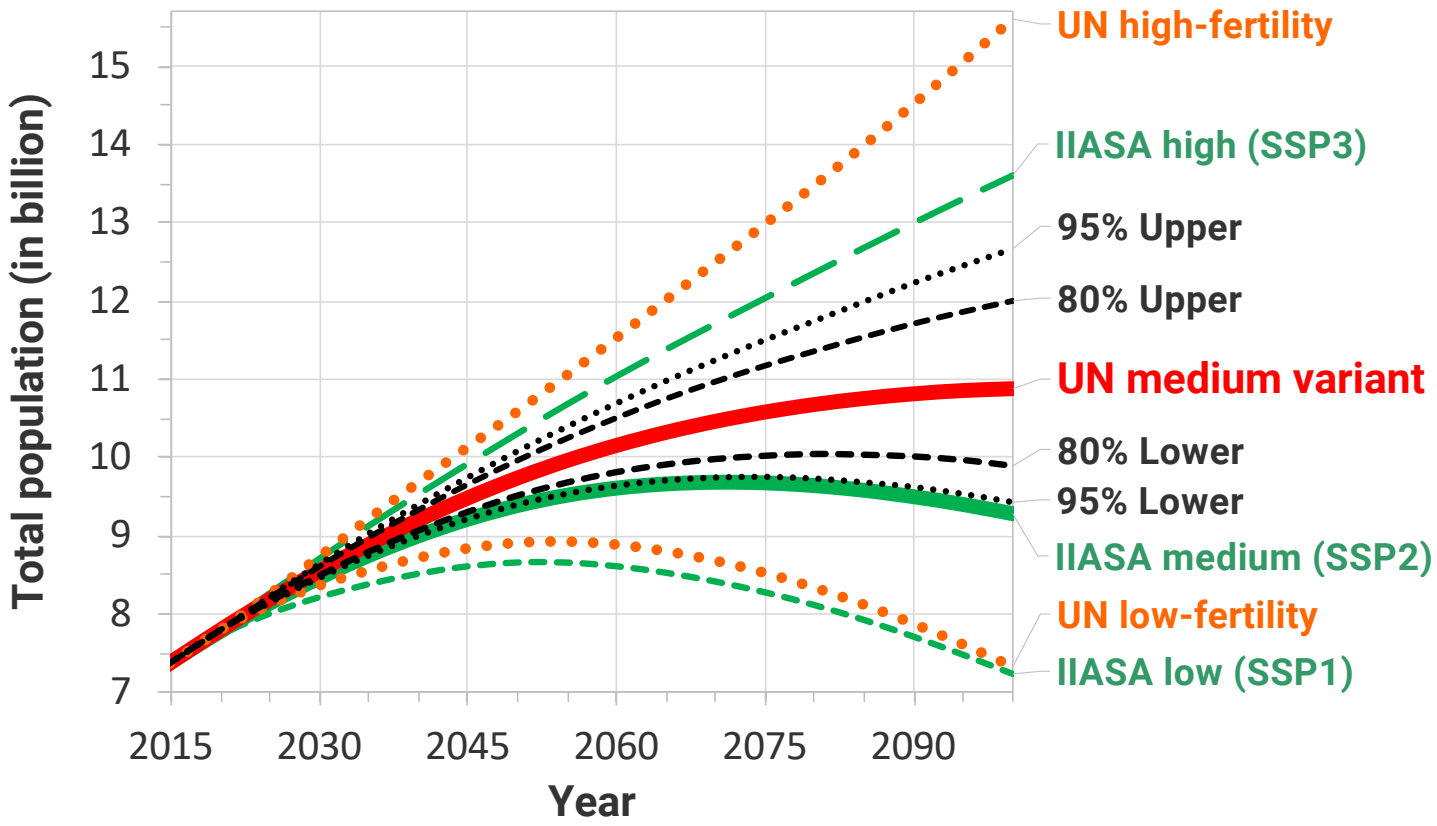
Global population trend 2015-2100

UN 2019 medium with prediction intervals and IIASA medium (SSP2) scenario



Global population trend 2015-2100

UN 2019 low/medium/high with prediction intervals and IIASA low/medium/high



Concluding remarks

- Relatively small differences between UN and IIASA projections in the short to medium term
- Larger differences in the long run are consequential for climate change and other environmental issues
- UN and IIASA teams should work together to understand better the sources of difference in their projections, to provide accurate explanations and to promote frank discussions of implications

For further information about the work of the Population Division, please visit population.un.org