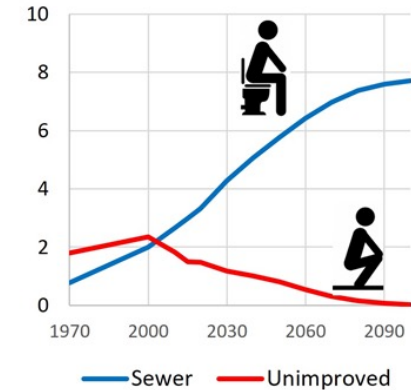
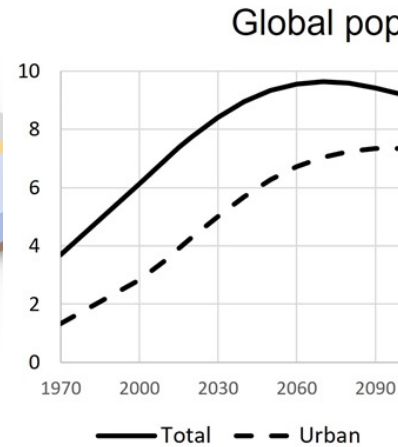
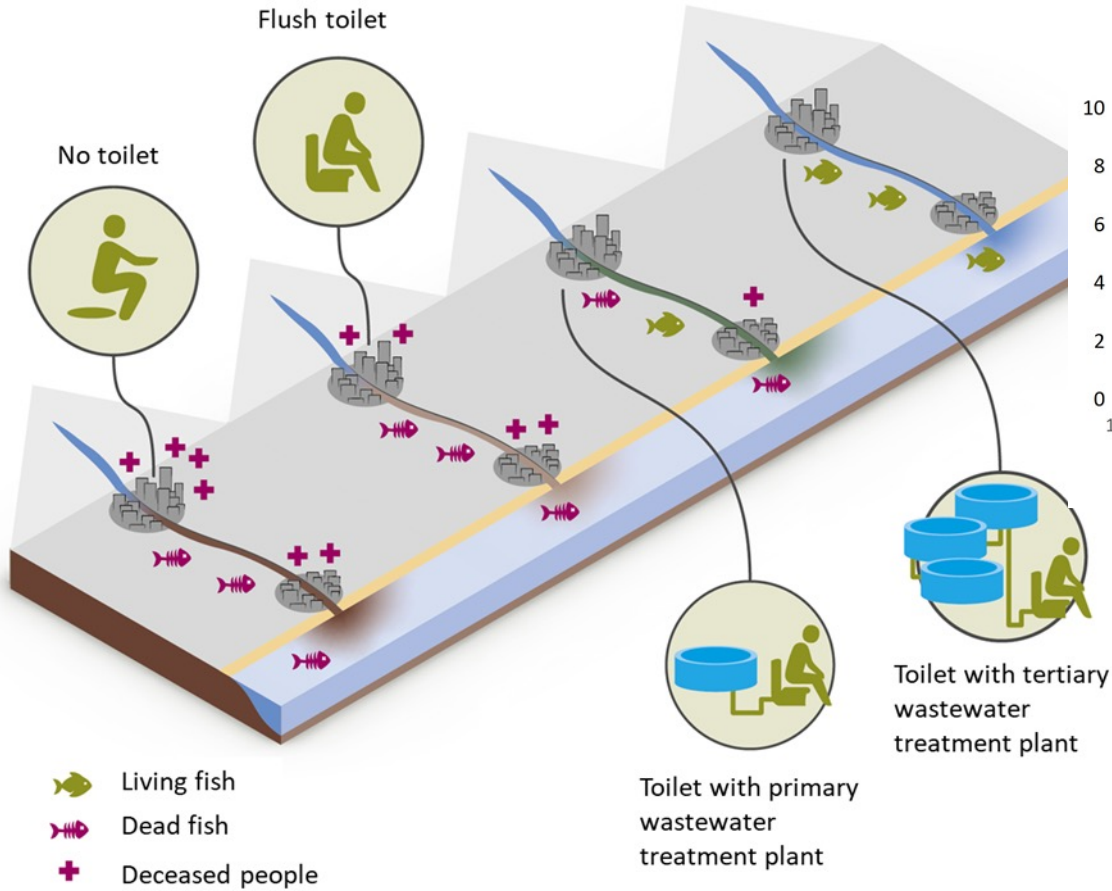


Global future developments in sanitation and wastewater treatment with consequences for SDG targets

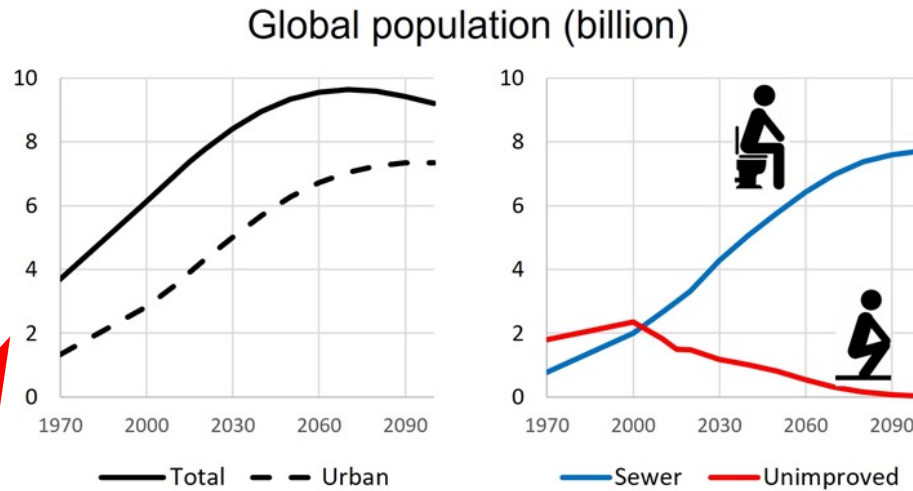


6 CLEAN WATER AND SANITATION

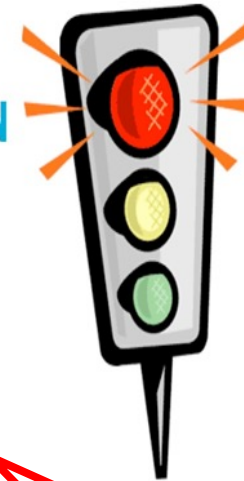


Peter van Puijenbroek, AIWW 2023

Global future developments in sanitation and wastewater treatment with consequences for SDG targets



6 CLEAN WATER AND SANITATION



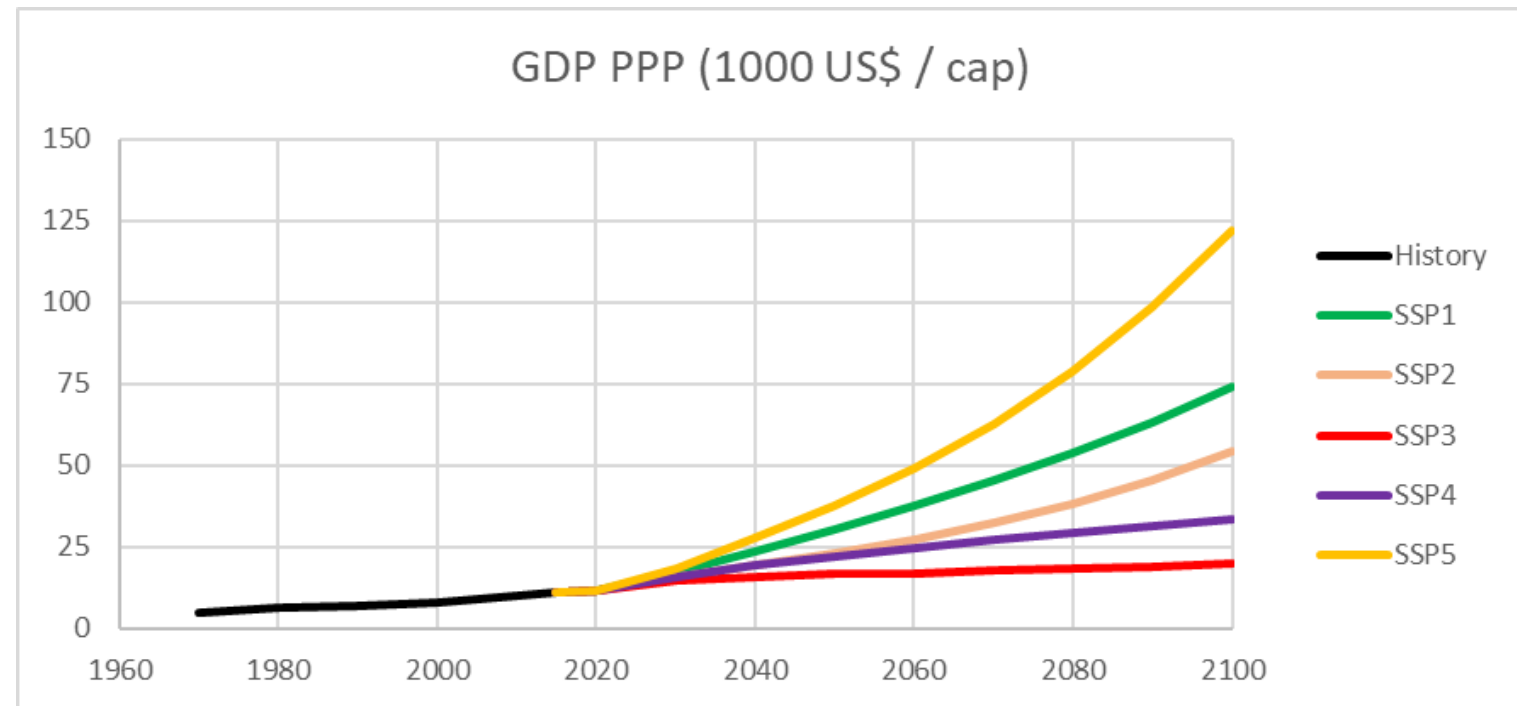
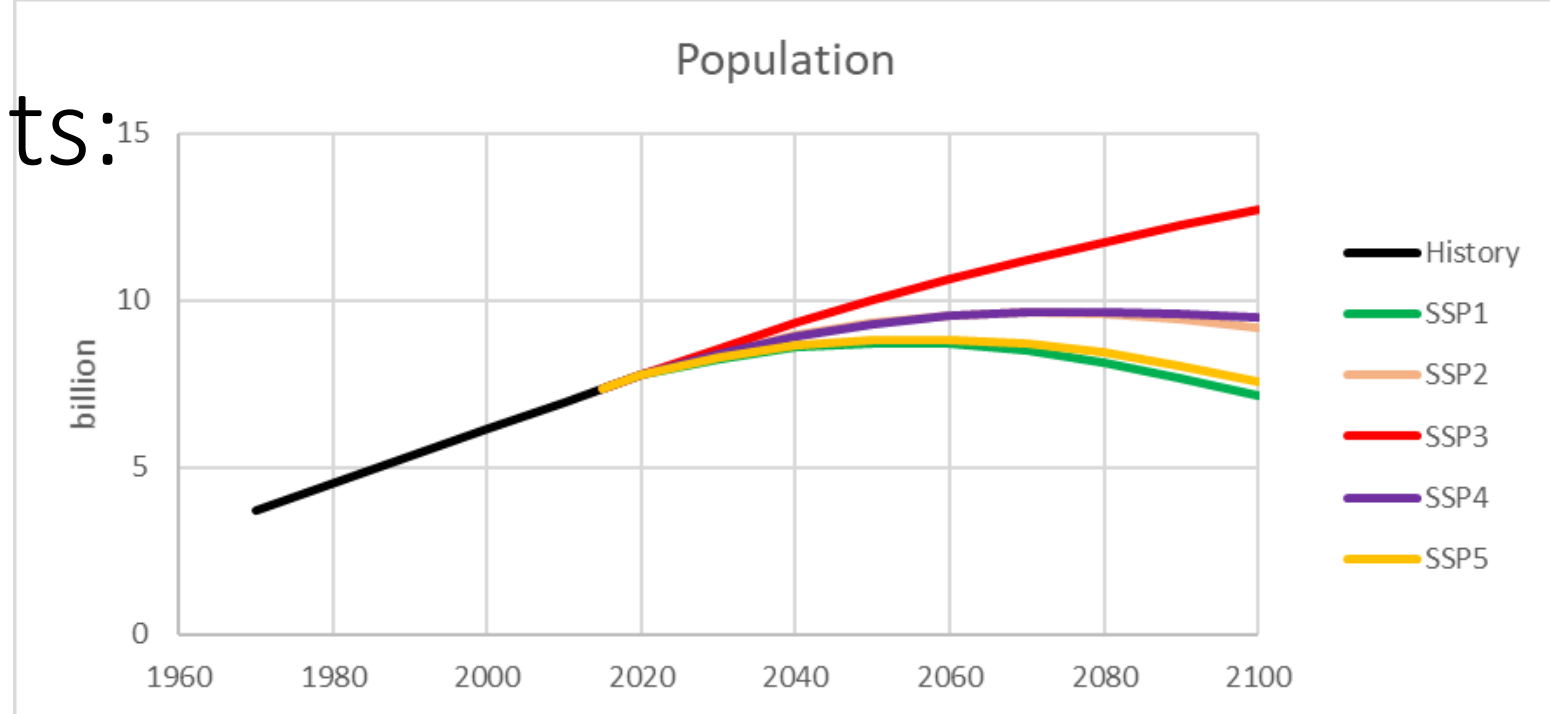
Global development: scenarios for population growth, urbanization and economy.

Consequences for sanitation and wastewater treatment based on economy, population and story lines

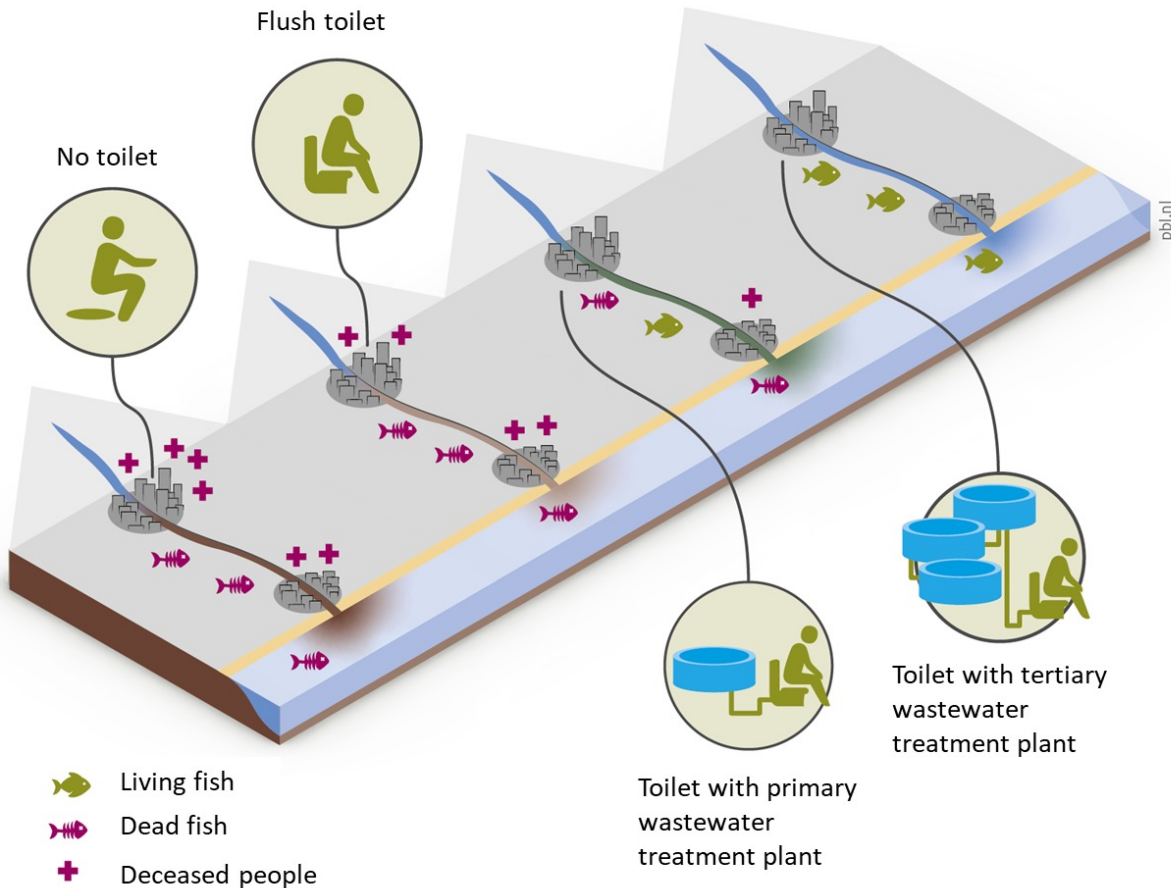
Sustainable Development Goals: definition and outlook for realization

Global developments: what is coming?

- Shared socio-economic Pathways: SSP
 - Population, urbanization and economy
 - Storylines
 - Developed for climate change research
- SSP3: high population growth, low economy
- SSP1 and SSP5: optimistic scenario, low population
- SSP2: Middle of the road scenario, with high/low variants



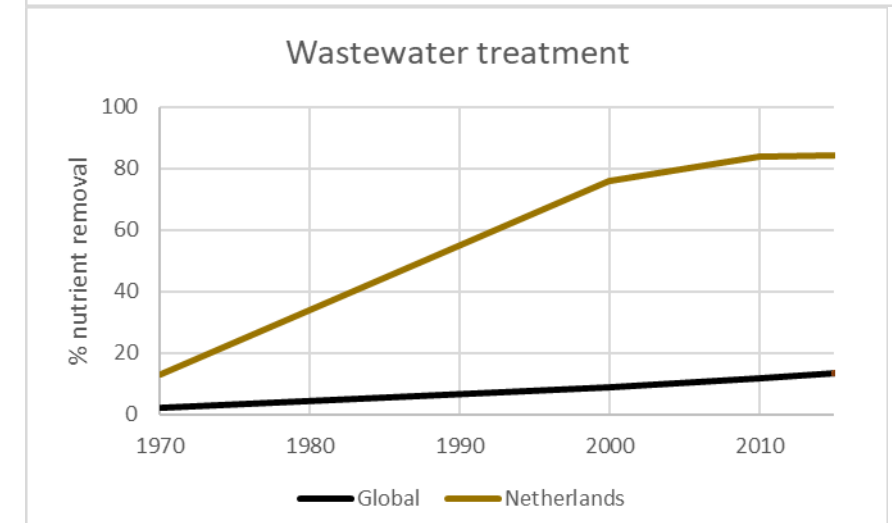
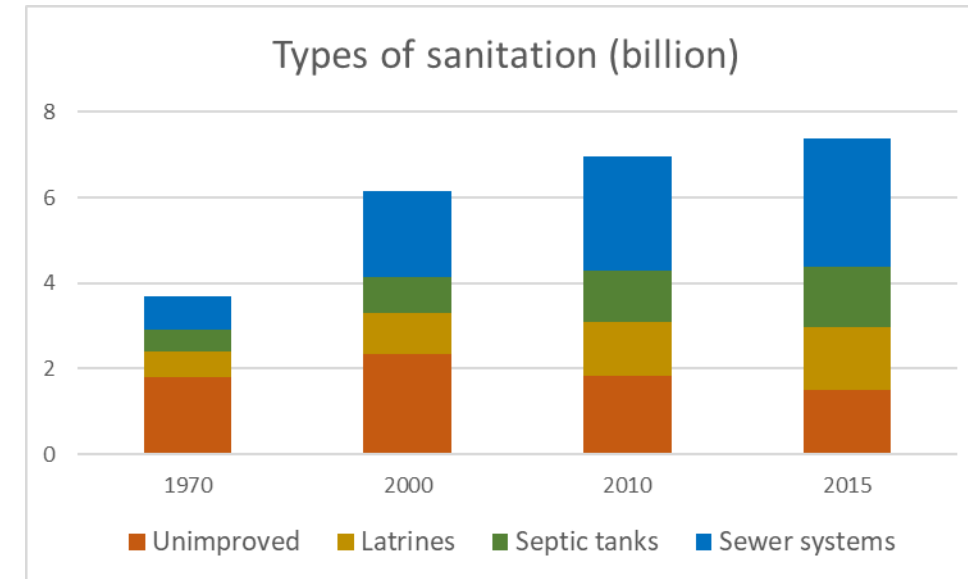
Sanitation – ecology – human health



- Local and downstream effects for human health and ecosystems
- Unimproved sanitation: local health risk
- Untreated wastewater: downstream health risk, e.g. irrigation water
- Ecology: rivers, lakes and coastal seas are affected by eutrophication
 - Without good wastewater treatment: an increase of nutrient emissions

Consequences for sanitation: what happened

- A decrease of unimproved sanitation
- An increase of other types of sanitation, especially sewer connection
- An increase of wastewater treatment
 - Expressed as % nutrient removal
- Major contrast between the Netherlands and the global level.



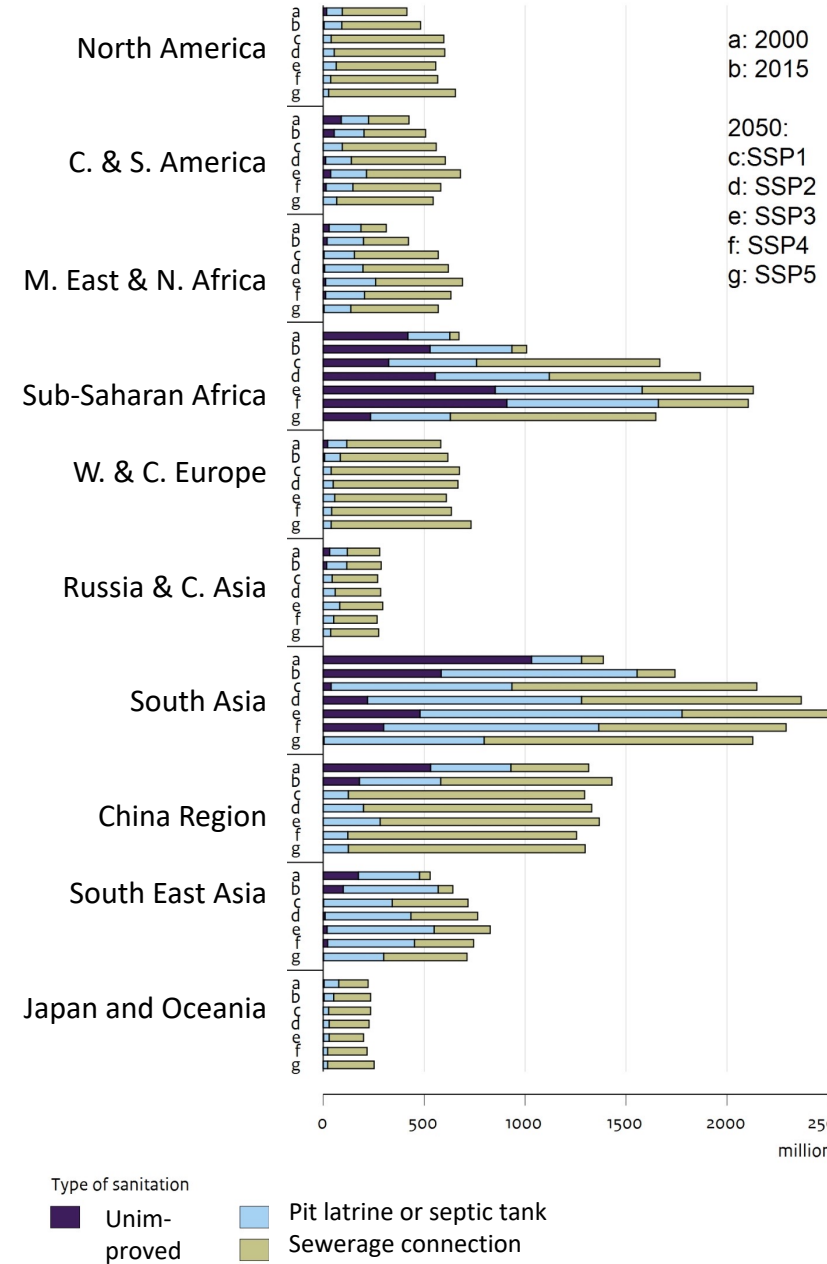
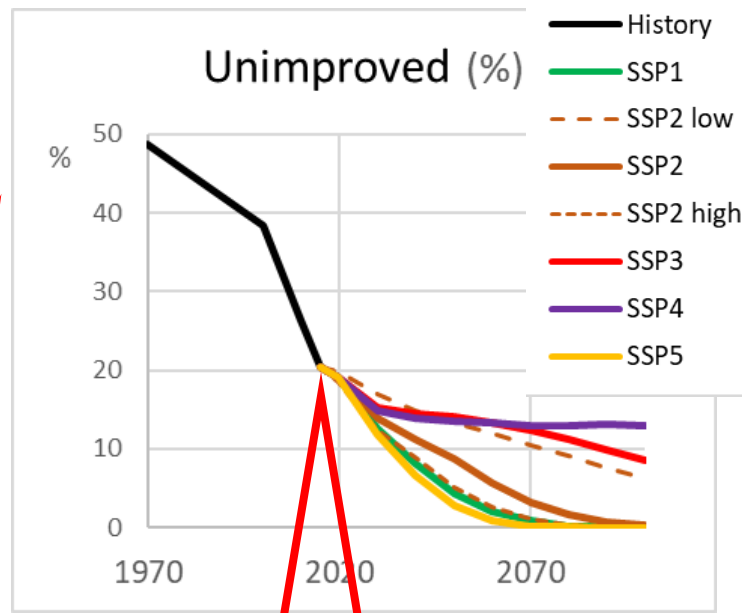
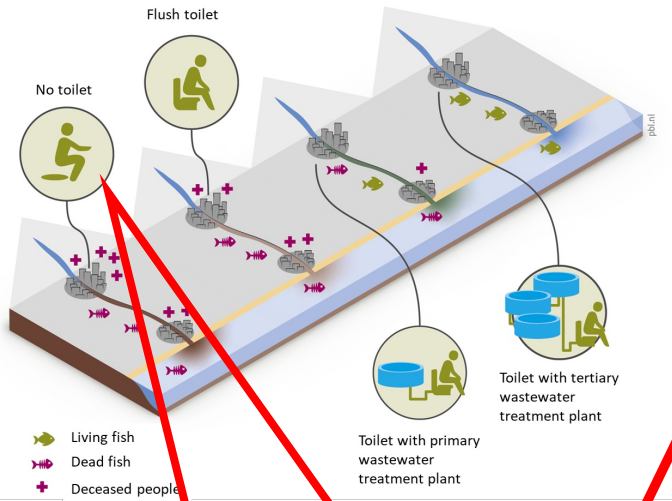
Overall improvement, but unequal distributed

- Not equally, between 2000 – 2015 (100 large countries)
 - Unimproved sanitation:
 - 16 countries a relative increase in %
 - 44 countries with an absolute increase in number of people with unimproved sanitation
 - Wastewater treatment
 - 20 Countries with more than 10% nutrient removal in 2010: increase in capacity
 - Countries with less than 10% nutrient removal in 2010:
 - 31 countries increased their capacity
 - 34 countries no or small improvement
 - 15 countries decreased their capacity

=> Population growth is a challenge to maintain sewer systems and wastewater treatment at same level.

=> Wastewater treatment is difficult to start, but easier to improve.

Toilets



Unimproved sanitation is a risk to human health by emissions of pathogens in the local environment.

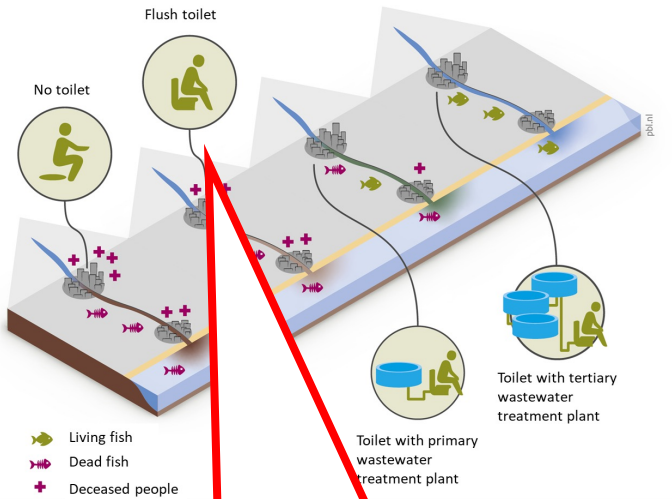
In SSP3 and SSP4, unimproved sanitation will not disappear: 1400 million people in 2050

In other scenarios: disappear after 2050

1970-2015: JMP data, 200 countries
2020-2100 modelled, especially economic growth

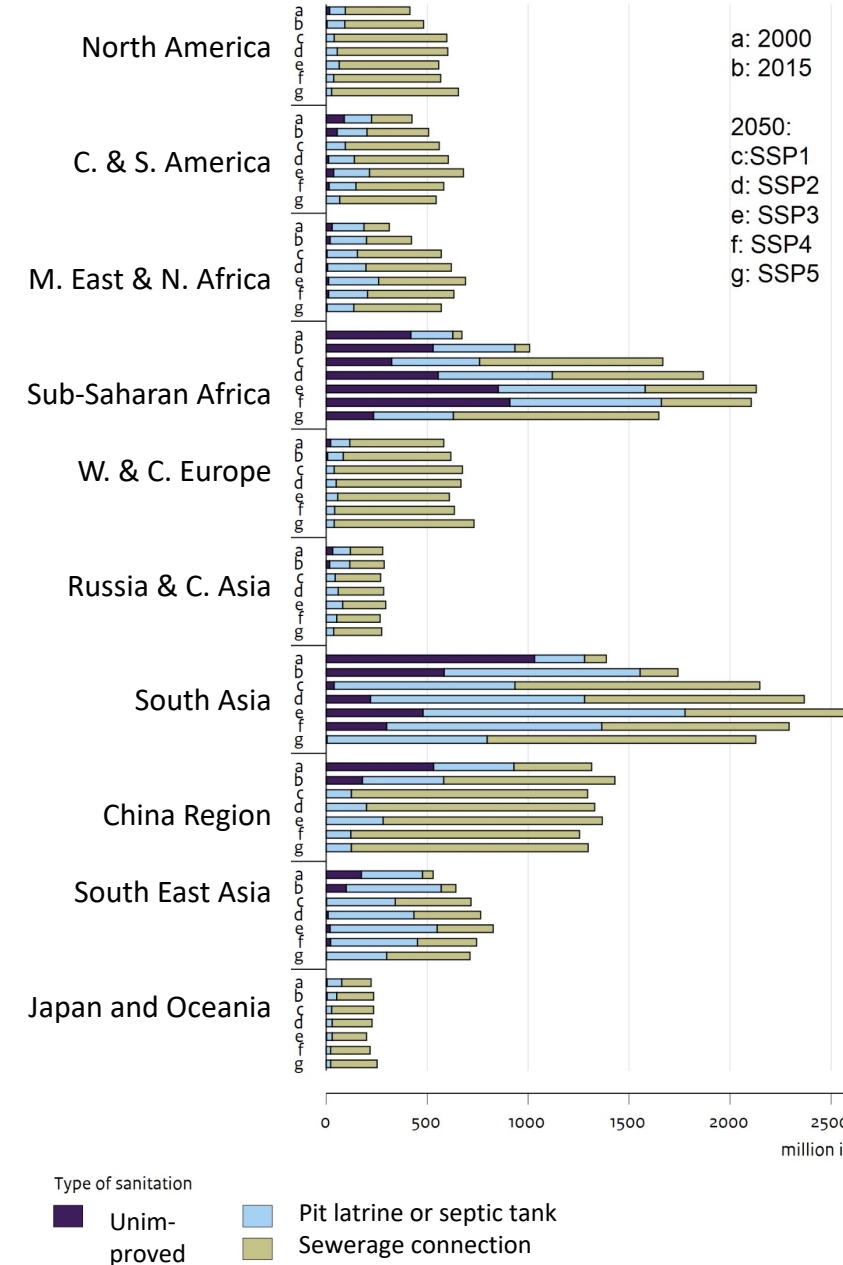
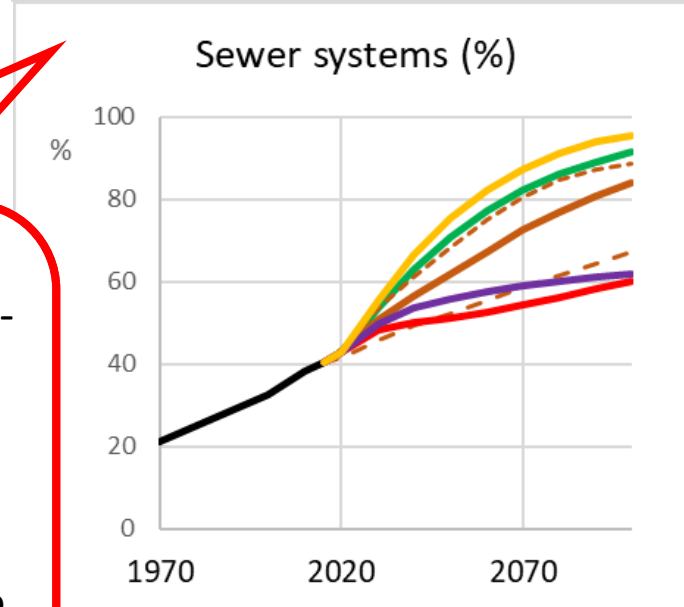
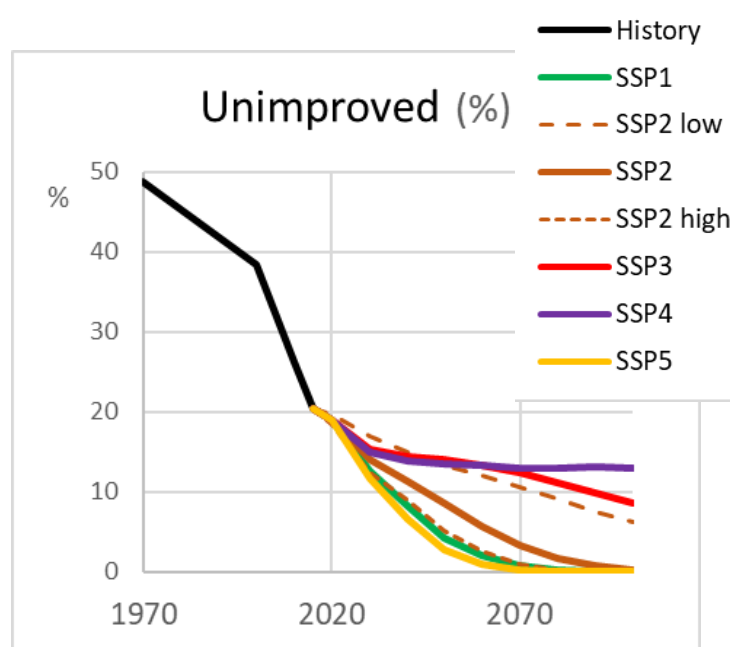
For SSP2: low and high ambition is included.

Toilets

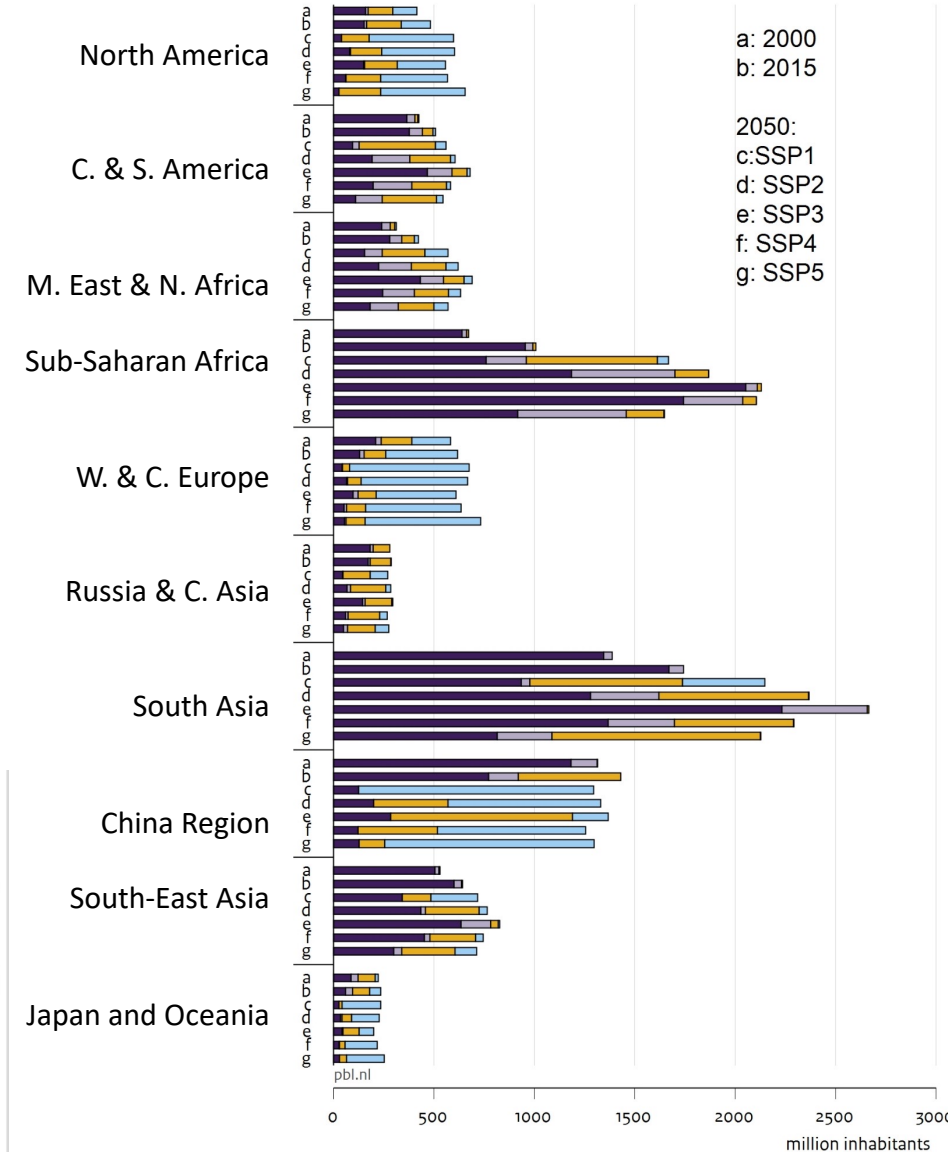
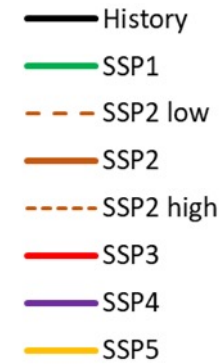
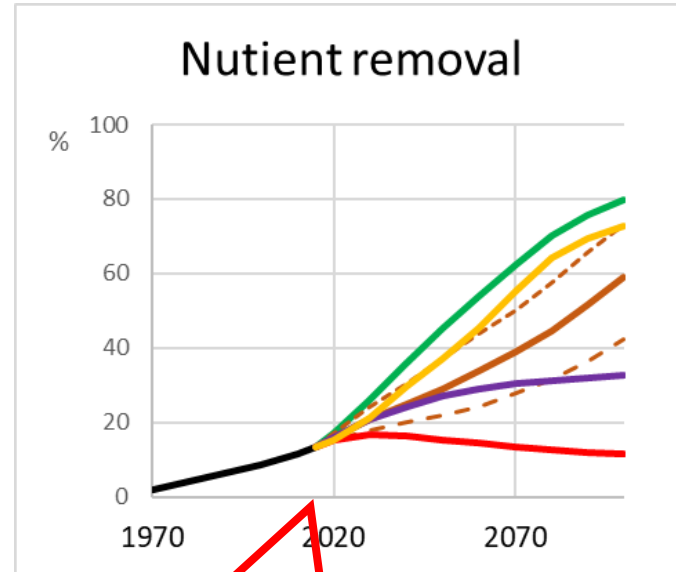
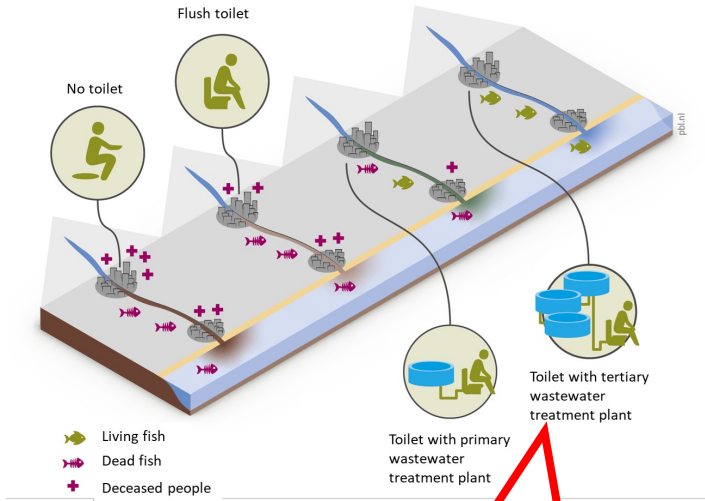


Number of people with sewerage connection will increase in period 2015-2050 from 3 billion to:

- 5.1 in SSP3, low income, high population growth
- 5.7 in SSP2, range 4.9 – 6.4
- 6.5 in in SSP1 and SSP5, high income and low population growth



Wastewater treatment

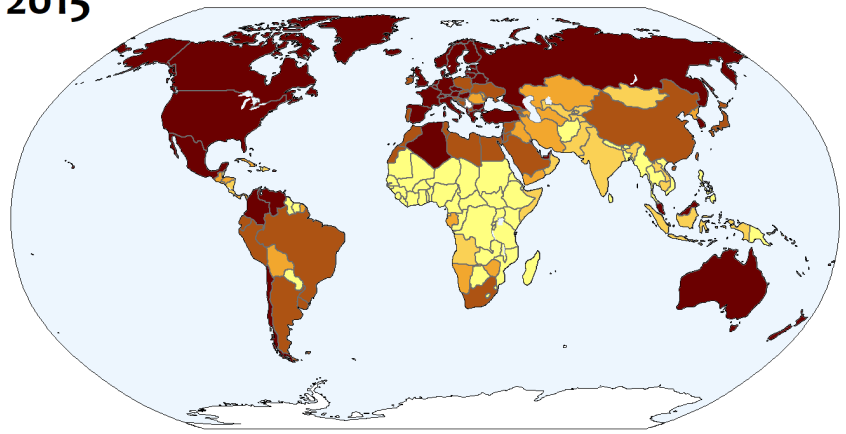


Wastewater treatment expressed as nutrient removal:

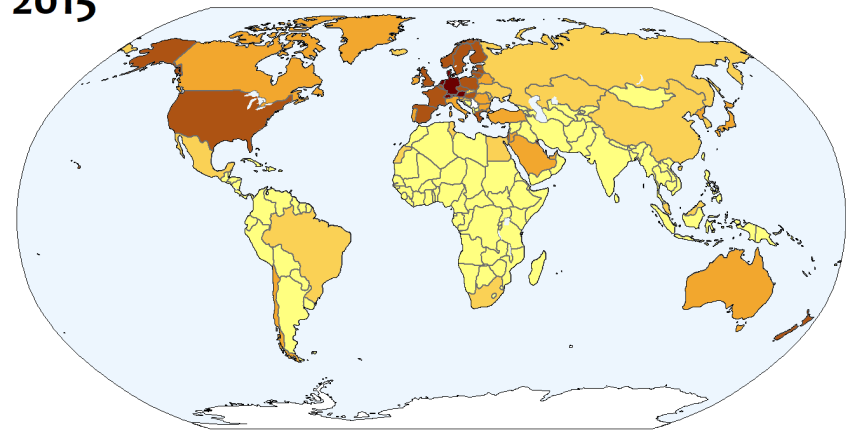
- primary treatment to reduce organic load,
- secondary 35% nutrient removal,
- tertiary 80%,
- quaternary-future: remove pathogens, toxic, reuse nutrients.

With high economic growth: improvement
With low economic growth: hardly improvement, deterioration

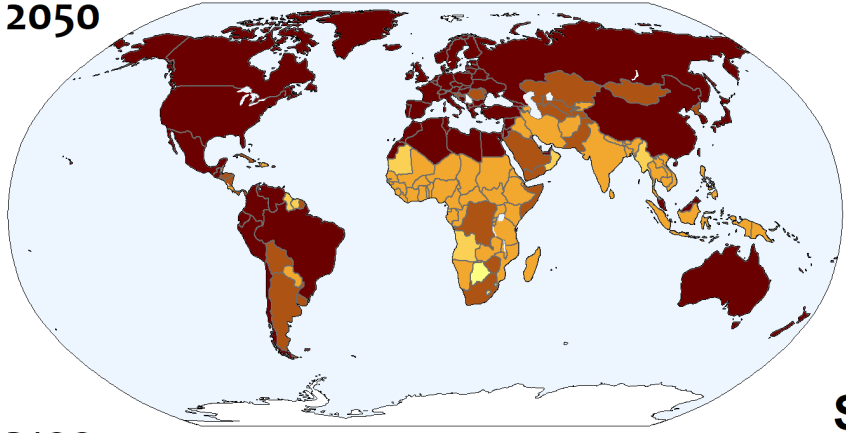
2015



2015

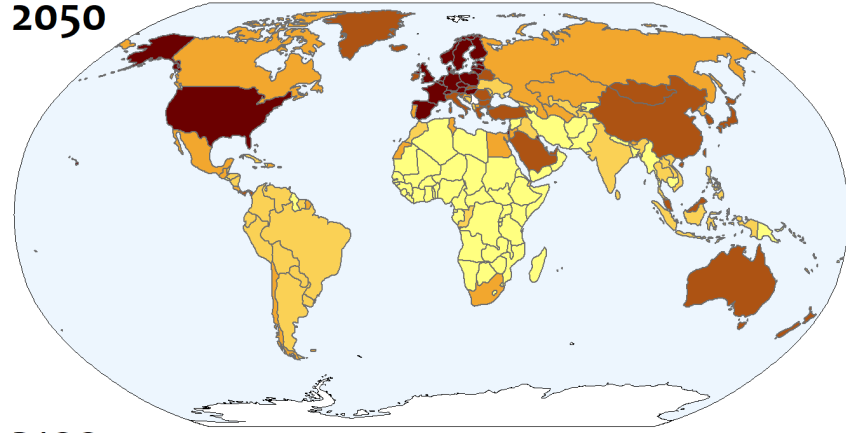


2050

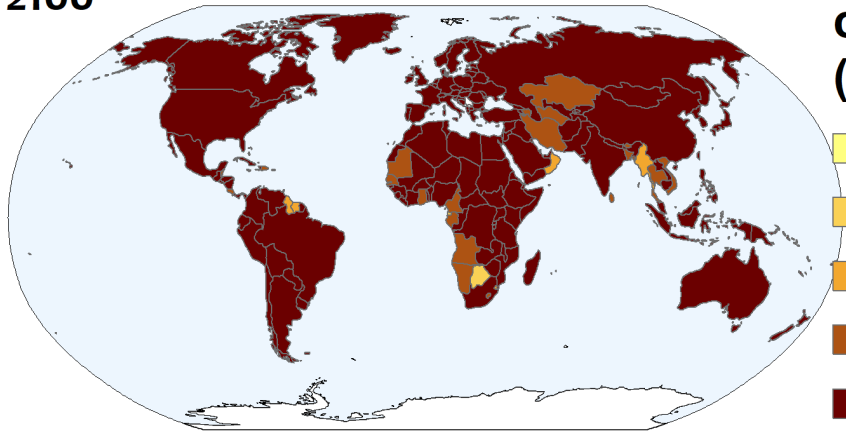


SSP2,
Middle of the road

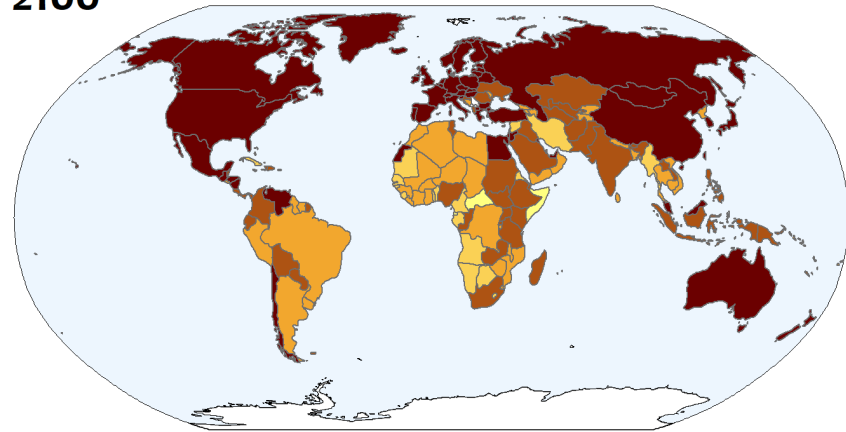
2050



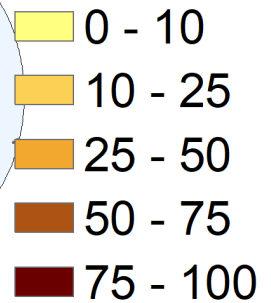
2100



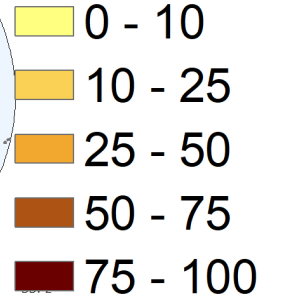
2100



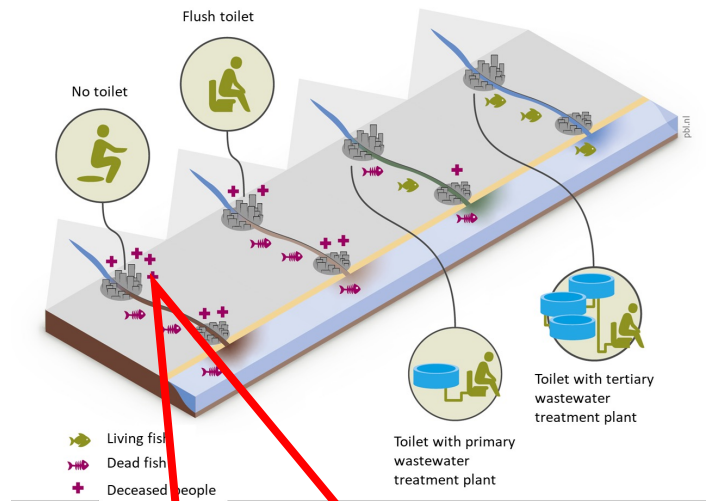
Sewerage connection (%)



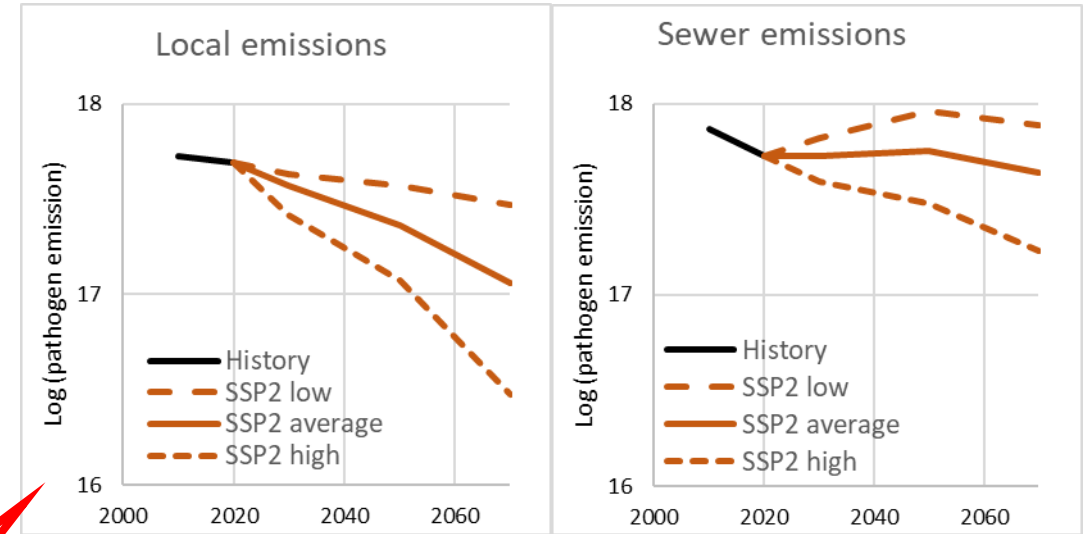
Wastewater treatment Nutrient removal (%)



Pathogen emissions

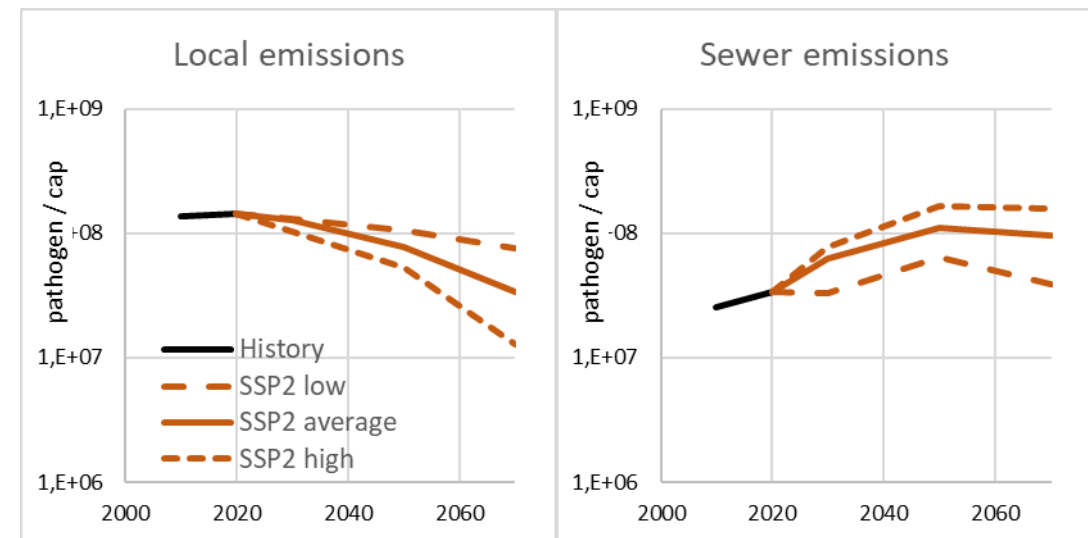


Pathogens emissions are risk to human health: 300,000 deaths in 2016.
 With sewage systems: local emissions reduce, downstream emissions increase
 Without tertiary wastewater treatment: sewer emissions increase.

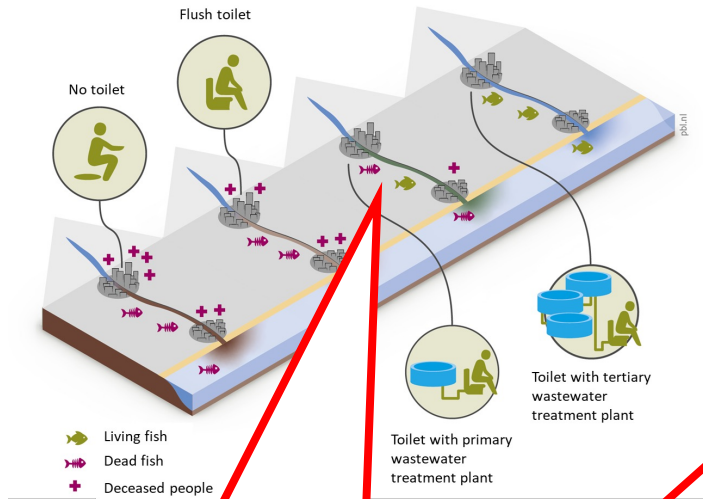


Global emissions for 3 SSP2 variants

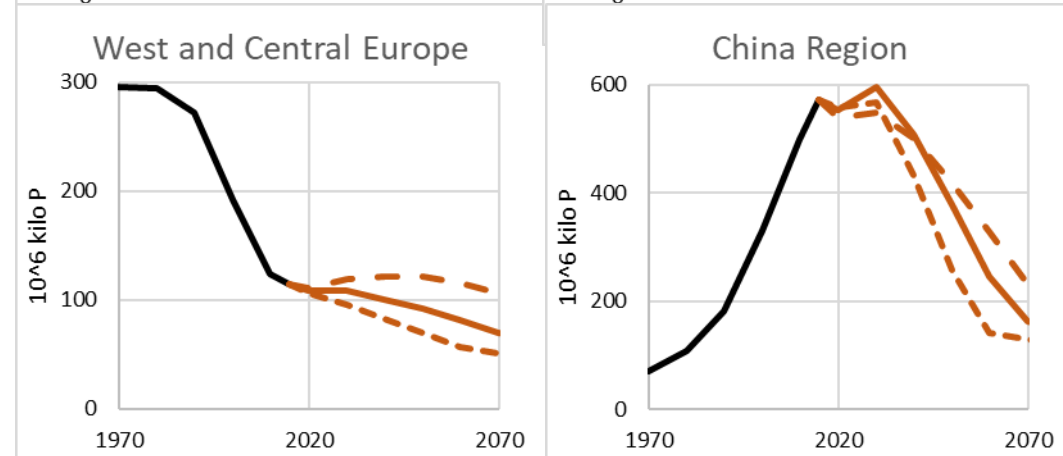
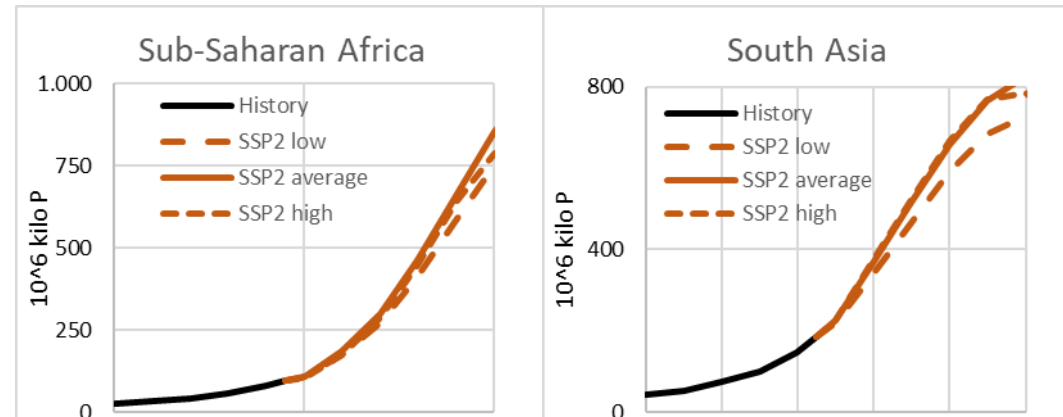
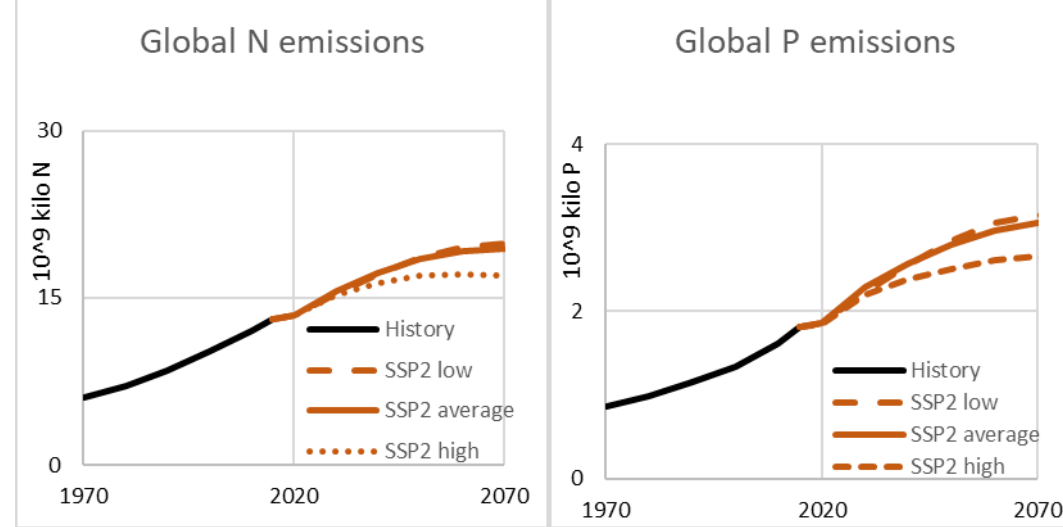
Emissions of Sub-Saharan Africa per capita.



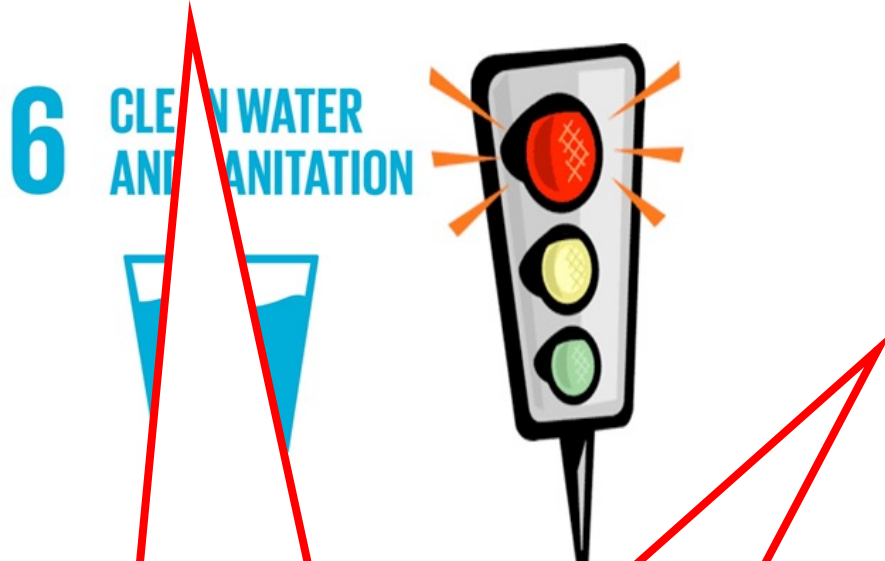
Nutrient emissions



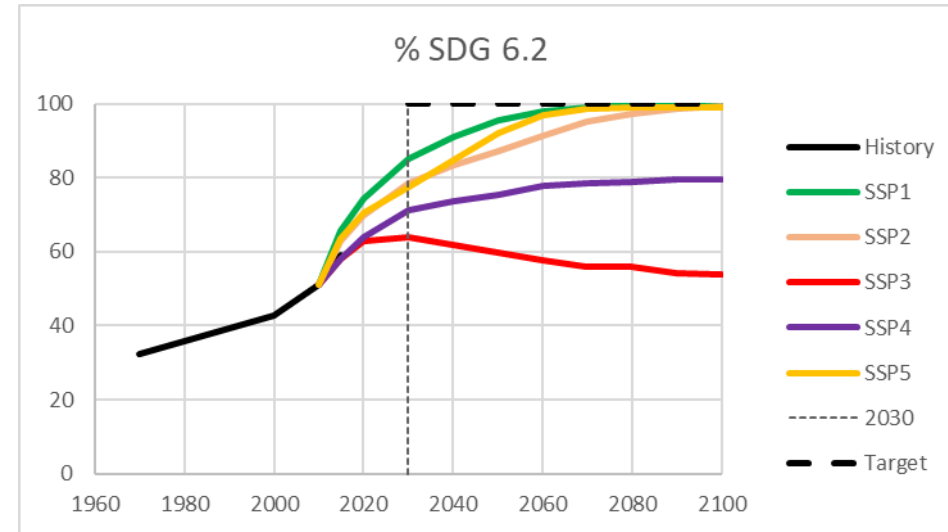
Nutrient emissions will increase: 50% for N, 70% for P.
 Extra investments in sewer systems and wastewater treatment are not sufficient.
 Major regional differences due to population growth and economy.



SDG 6.2 Ensure availability and sustainable management of water and sanitation for all



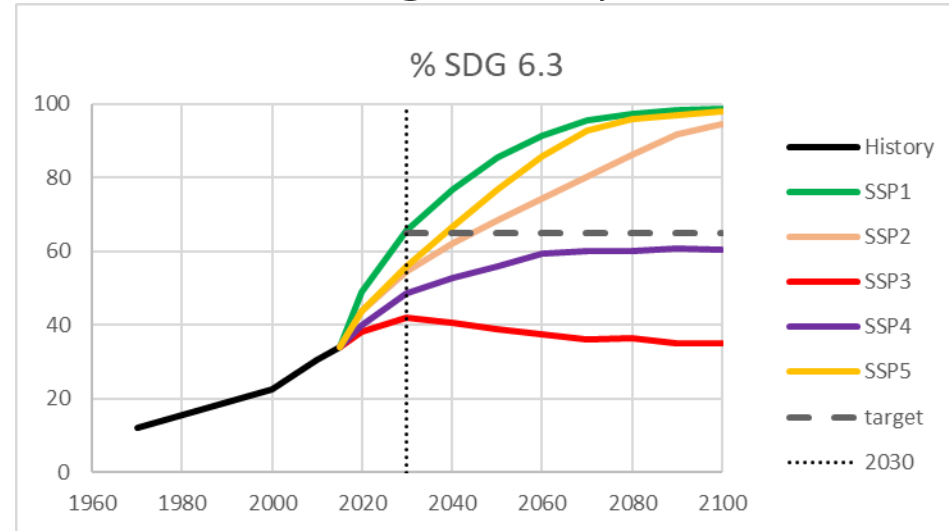
Ambitious target
 Target SDG 6.2, improved sanitation will not be met in 2030, at best in 2070 in SSP1.
 A decline in SSP3 with the growth of the population in SSA.



	SSP1	SSP2	SSP3	SSP4	SSP5
North America	2040	2060	>2100	2060	2050
Central - and South America	2050	2080	>2100	>2100	2060
Middle East and North Africa	2050	2080	>2100	>2100	>2100
Sub-Saharan Africa	2080	>2100	>2100	>2100	>2100
West and Central Europe	2050	2070	>2100	2070	2070
Russia and Central Asia	2040	2070	>2100	2070	>2100
South Asia	2060	2070	>2100	>2100	2050
China Region	2030	2030	2040	2030	2030
South East Asia	2050	2070	>2100	>2100	2050
Japan and Oceania	2040	>2100	>2100	>2100	>2100
World	2070	2100	>2100	>2100	2090

SDG 6.3, by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

6 CLEAN WATER AND SANITATION

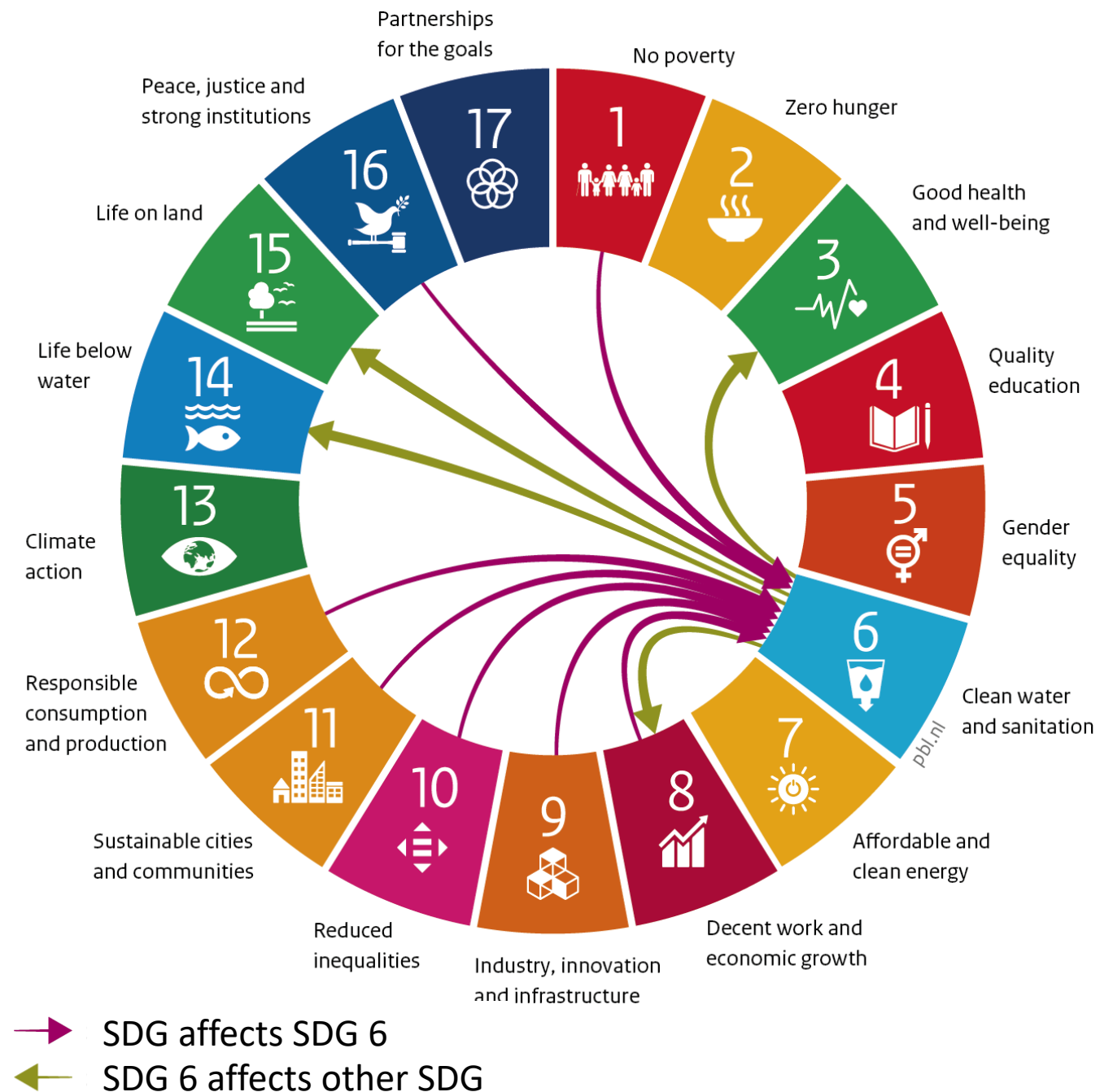


Target SDG 6.3, wastewater treatment will be met in 2030 in SSP1, SSP3 and SSP4 after 2100.
 Less ambitious target. To halve untreated wastewater. In coastal zones en drylands is primary treatment enough

	treatment in 2010	target	SSP1	SSP2	SSP3	SSP4	SSP5
North America	78	89	2030	2040	> 2100	2040	2040
Central - and South America	23	62	2040	2060	> 2100	2060	2050
Middle East and North Africa	43	71	2030	2040	> 2100	2060	2040
Sub-Saharan Africa	4	52	2050	2070	> 2100	> 2100	2060
West and Central Europe	81	90	2030	2030	2080	2030	2030
Russia and Central Asia	38	69	2030	2040	> 2100	2040	2040
South Asia	10	55	2040	2050	> 2100	2060	2040
China Region	26	63	2020	2020	2030	2020	2020
South East Asia	26	63	2030	2030	> 2100	2050	2030
Japan and Oceania	68	84	2030	2030	2030	2030	2030
World	30	65	2030	2050	> 2100	> 2100	2040

Sanitation and wastewater: relations to other SDGs.

- SDG 6 is affected by progress:
 - No poverty, inequality,
 - Infrastructure, sustainable cities, consumption and production
 - Peace and strong institutions
- SDG 6 affects:
 - Good health and well being
 - Life below water
 - Life on land
 - Economic growth

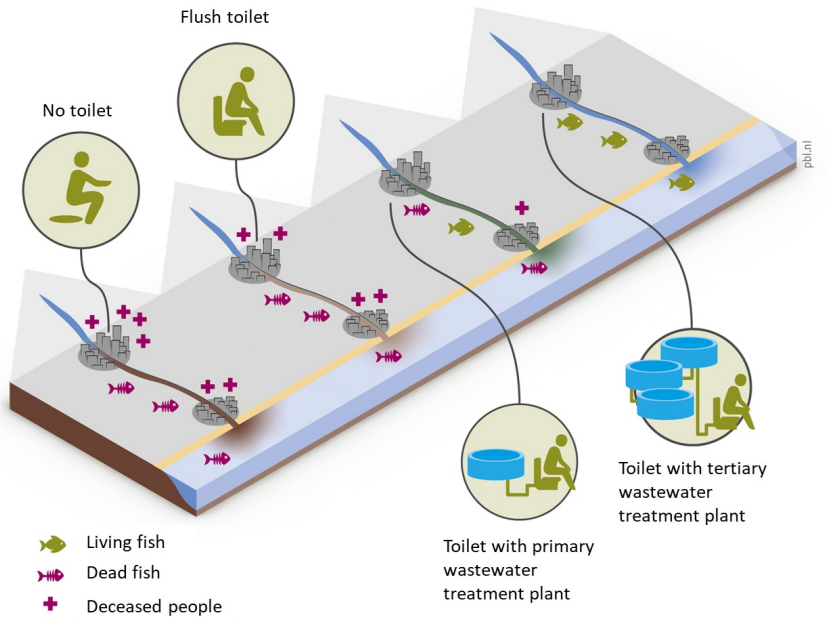


Conclusions

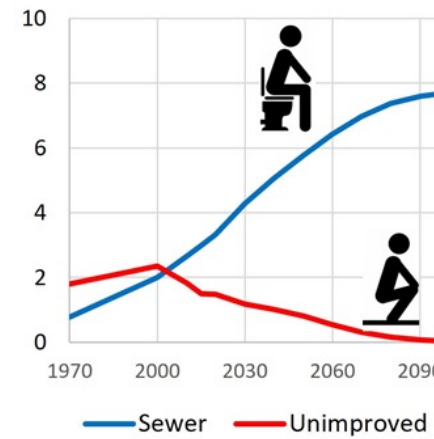
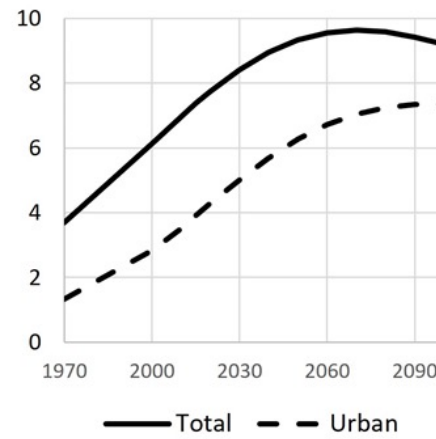
- Unimproved sanitation: from minimal improvement in low-income countries to small improvement in high-income countries
- Sewer systems: major investments needed, low-income: hardly sewers
- Pathogen emissions: locally a decrease, but with sewer effluent an increase, risk for downstream
- Global nutrient emissions will increase with 50% for N and 70% for P
- SDG 6.2 and 6.3 will not be met in 2030, but much later.

- Scenarios are based on relation with economic growth and storylines

Global future developments in sanitation and wastewater treatment with consequences for SDG targets



Global population (billion)



6 CLEAN WATER AND SANITATION



van Puijenbroek, P. J. T. M., A. H. W. Beusen, and A. F. Bouwman. 2019. Global nitrogen and phosphorus in urban waste water based on the Shared Socio-economic pathways. *Journal of Environmental Management* 231:446-456.

van Puijenbroek, P. J. T. M., A. H. W. Beusen, A. F. Bouwman, T. Ayeri, M. Stokal, and N. Hofstra. 2023. Quantifying future sanitation scenarios and progress towards SDG targets in the shared socioeconomic pathways. *Journal of Environmental Management* 346:118921.

van Puijenbroek, P. J. T. M. In prep. Sanitation and wastewater treatment effects global water quality and human health. PBL report

Including scenarios in S.I