Water Resources Engineering and Management

(CIVIL-466, A.Y. 2024-2025)

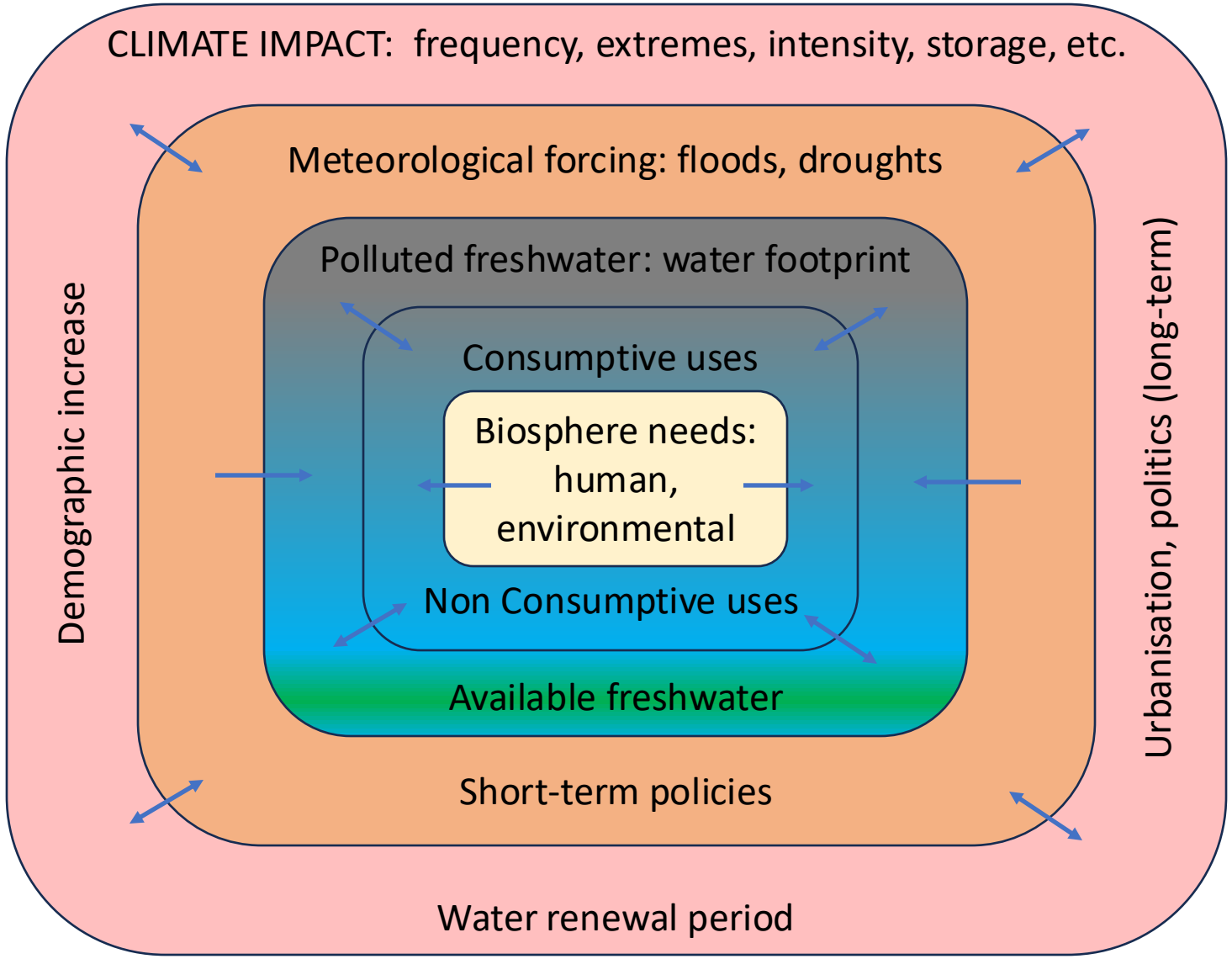
5 ETCS, Master course

Prof. P. Perona
Platform of hydraulic constructions

Lecture 1-2: water problems, scarcity, shortage, stress and water security, sustainaible water management

Water scarcity, shortage, stress and security

Water problem interdependencies



The management of water resource availability and sharing is peculiar because occurs at either local (e.g., catchment) or global (e.g., transboundary) scales or both

The stressor of the entire freshwater system are rarely directly perceivable to human being and related effects are typically oservable at medium to long-term scales

Short-term forcing

Long-term forcing

Stressors of the water resources system

By the time you finish reading this paragraph, ten people will be added to the population of the planet, one thousand tonnes of carbon dioxide will be added to the atmosphere and forty thousand m^2 of land will be deforested. Unless something dramatically changes about the way humans interact with the world and the products, processes, and systems we design, we will end up exactly where we headed – an unsustainable future.

(from Mihelcic and Zimmerman, 2010)

Water scarcity, shortage and stress

Scarcity: imbalance of supply/demand under given institutional/economic/social boundary conditions → relative concept

Shortage: low level of supply relative to minimum level for basic needs → absolute concept

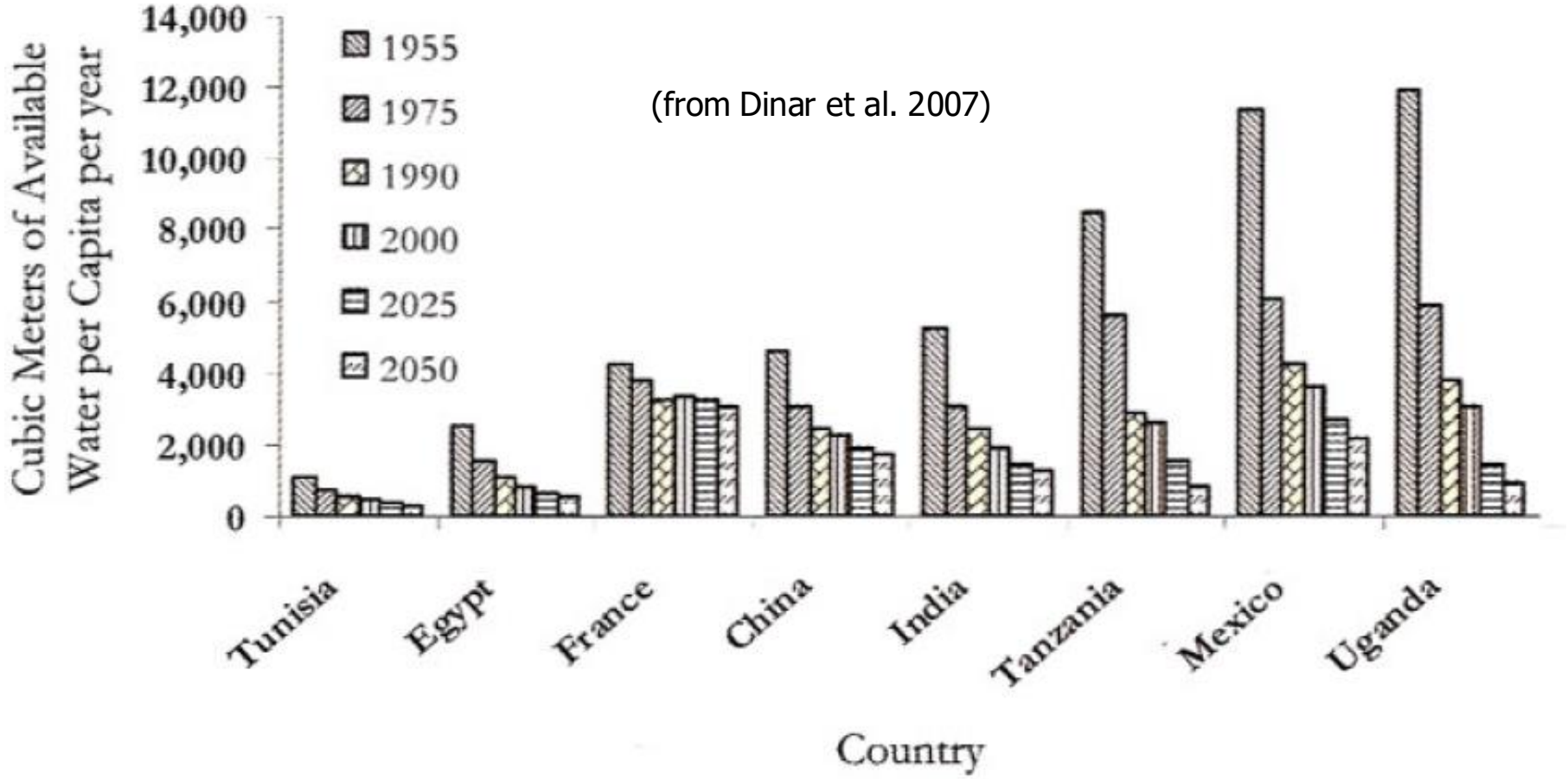
Stress: symptom of water scarcity/shortage → conflict between user, competition for water

EXAMPLES

SHORTAGE		
1000 m^3/yr capita	20 countries	North Africa, Middle east
2000 m^3/yr capita	40 countries	(e.g, see FAO)

SCARCITY		
< 1000 m^3/yr capita	Countries where level of water use is below 1000	Tunisia, Algeria, Mauritania. Etc.

Water Scarcity: a first glance



(from Dinar et al. 2007)

Water availability per capita (cm/yr) considering just one parameter (population growth rate) has been decreasing (60 ÷ 80%) nearly worldwide (Italy is an exception) between 1955 and 2050 (based on UN mean population growth prediction rates in the same years).

Factors affecting water scarcity

Water scarcity

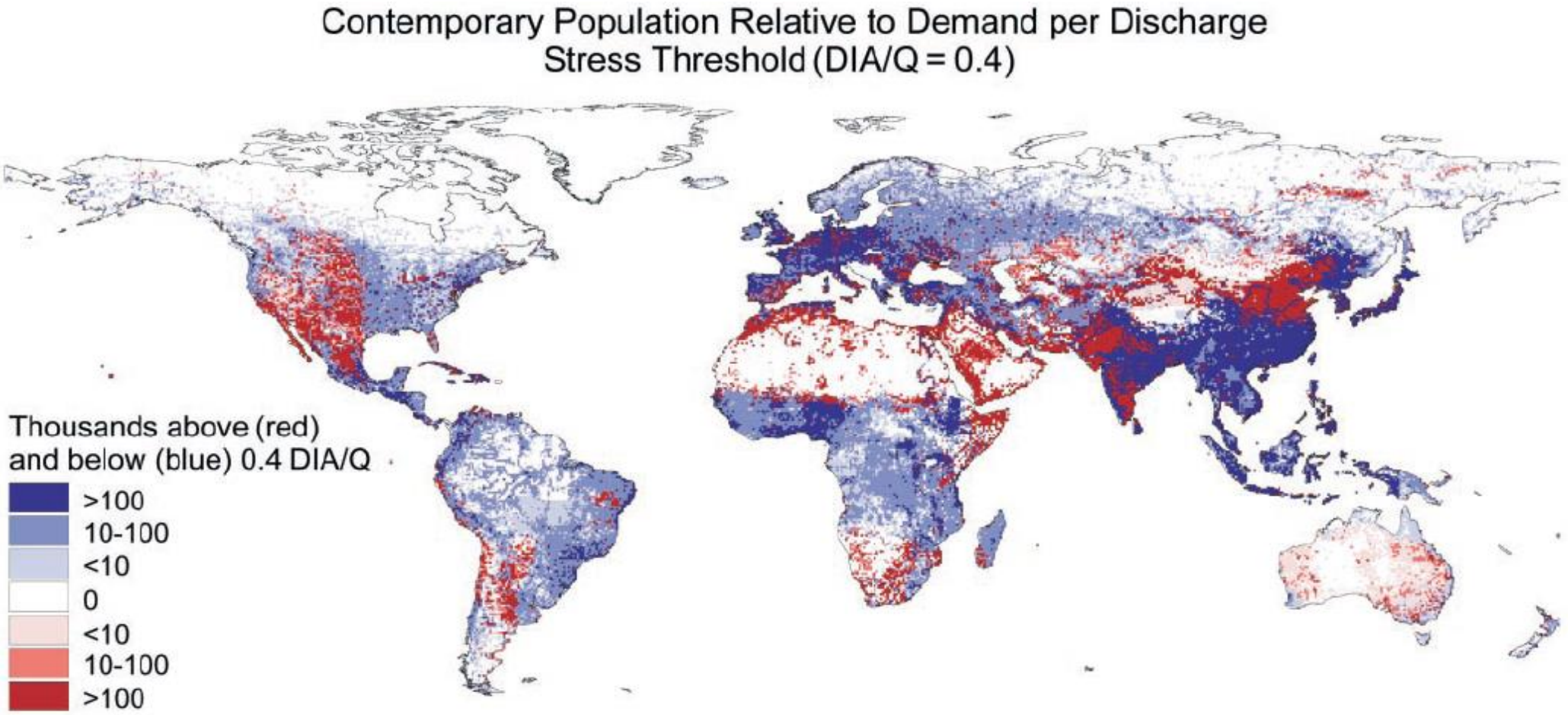
Anthropic origin

Hydrologic/climate origin

(We'll see in next lectures how to define it)

- Water quality maintainance due to water uses (e.g., pollution increases WS)
- High living standards (e.g, washing mashines, swimming pools) increase WS
- Technology level of a Country (decreases WS via water recycling technology, eg. California, Israel)

Water stress worldwide



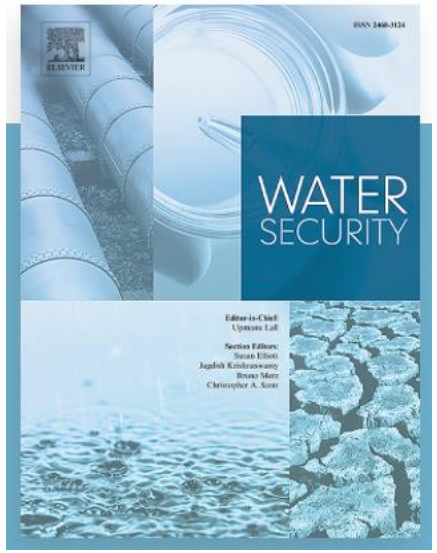
SOURCE: Vörösmarty et al. (2000) *Science* 289:284-288

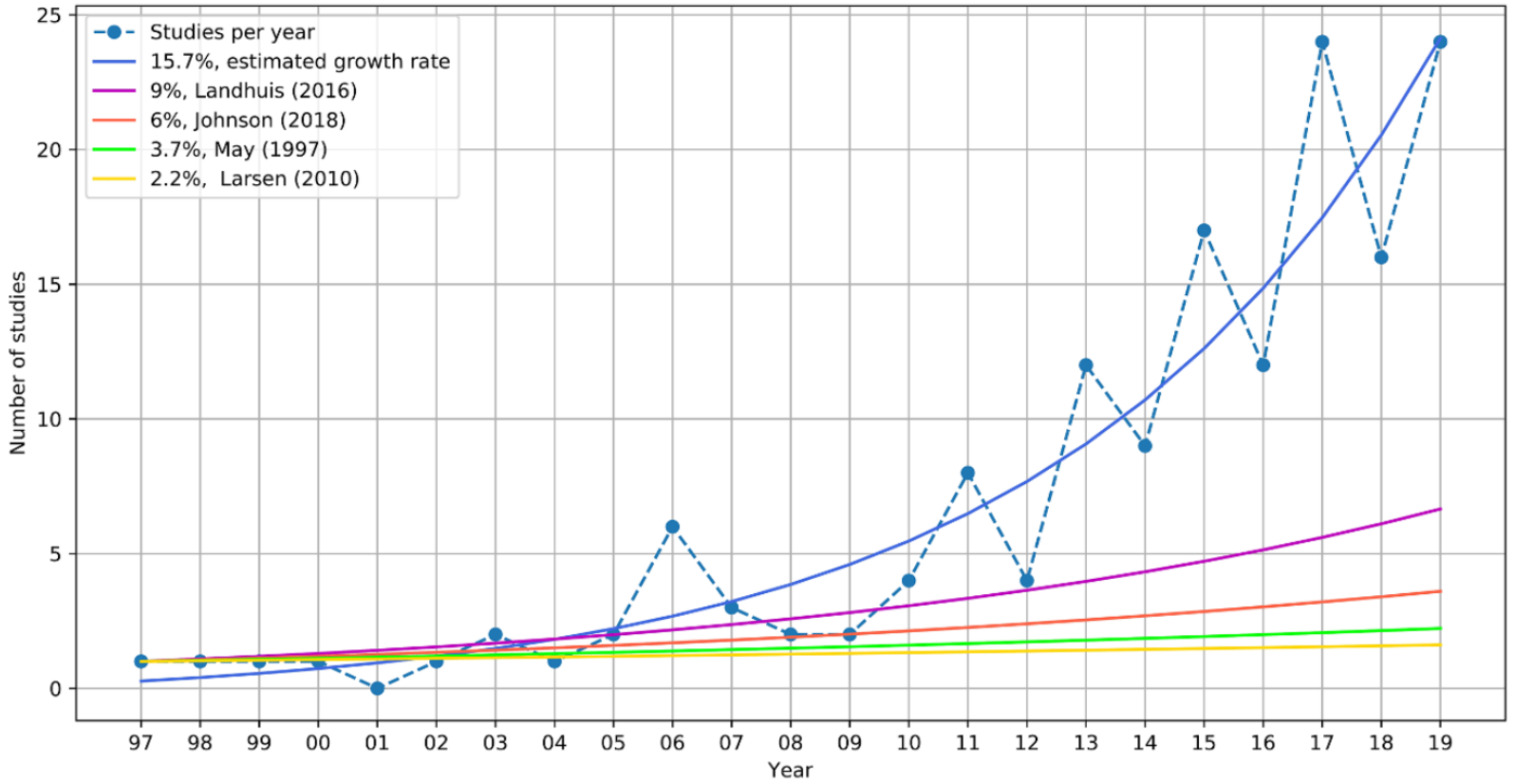
DIA=Domestic and Industrial and Agricultural uses

Q = River discharge for a given basin

Water security

Water security is a term that refers to a society's capacity to have enough water of sufficient quality for survival and to carry out different development actions





Evolution of studies in water security in central asian (CA) countries

Source: Xenarios et al., 2021

Approaches to solve water problems

Some considerations about water and environment issues

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Table / 1.1

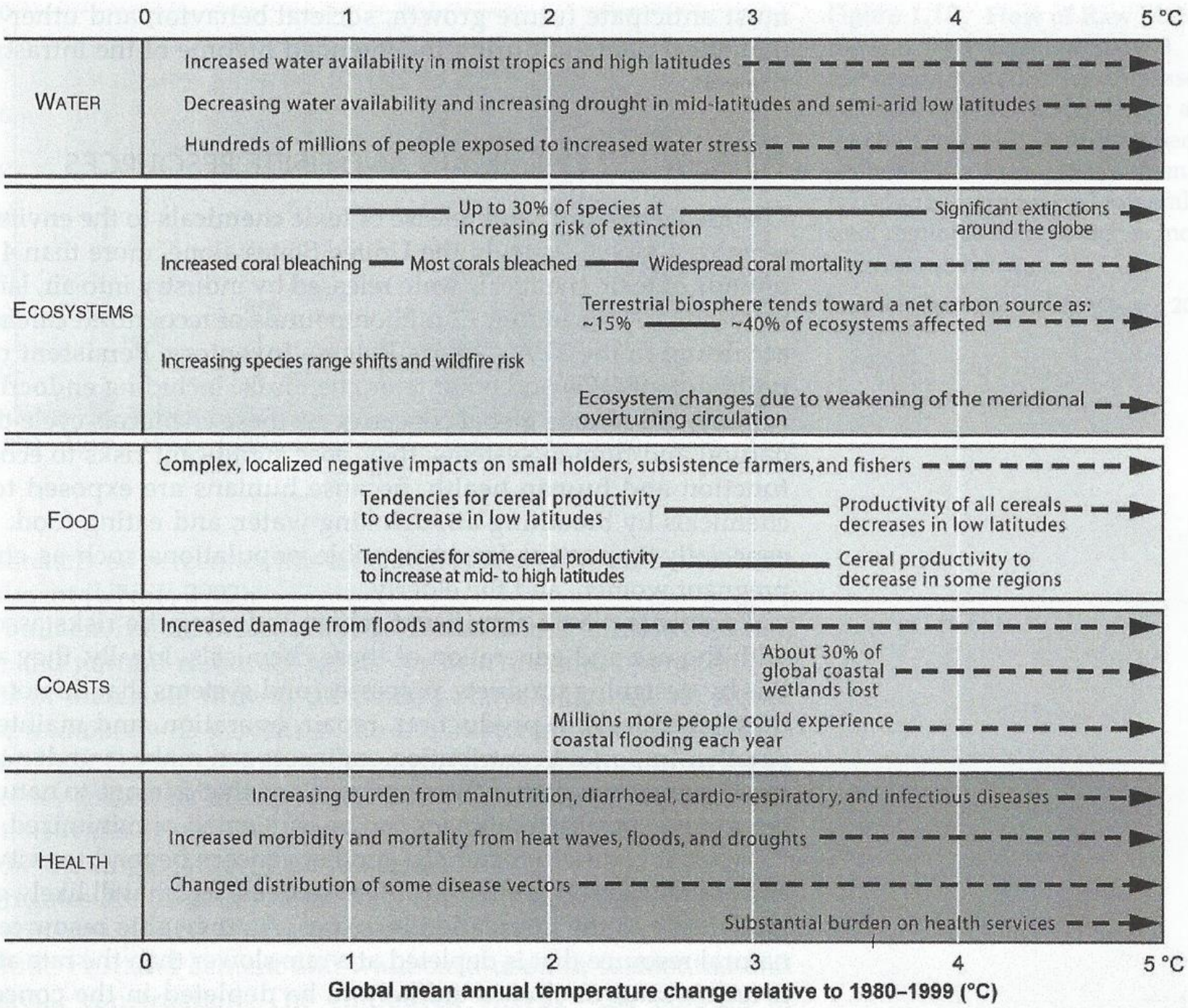
Existing and Emerging Environmental Issues

1. Globalization, trade, and development
2. Coping with climate change and variability
3. Growth of megacities
4. Human vulnerability to climate change
5. Freshwater depletion and degradation
6. Marine and coastal degradation
7. Population growth
8. Rising consumption in developing countries
9. Biodiversity depletion
10. Biosecurity

SOURCE: United Nations Environment Programme, 2002.

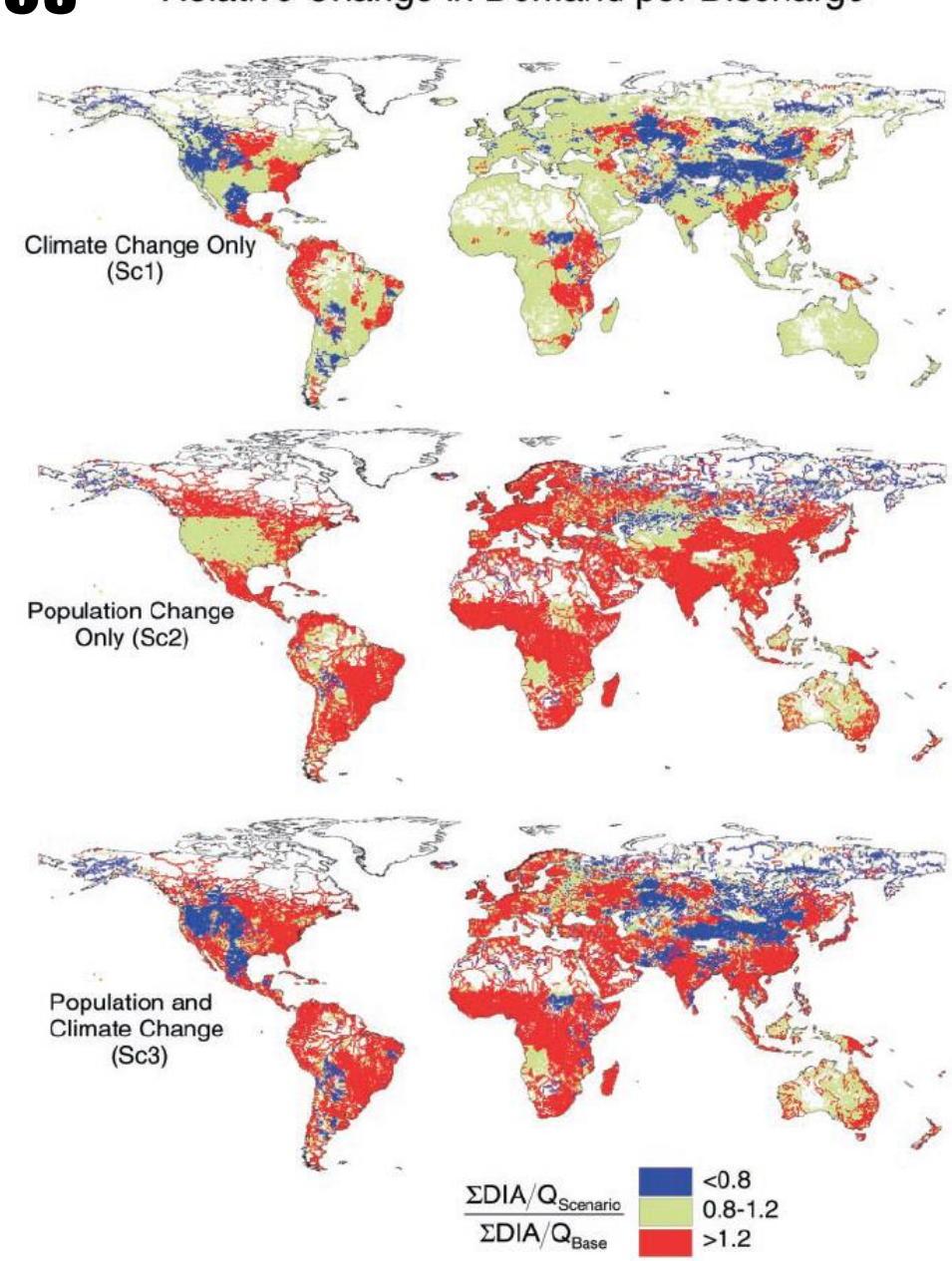
20th Century Environmental Issues	21st Century Environmental Issues
Local	Global
Acute	Chronic
Obvious	Subtle
Immediate	Multigenerational
Discrete	Complex

Climate change impact



Perspectives under climate changes

The slow but persistent impact of CC on precips and temperature distributions will result be crucial for International (and National) Water bodies, e.g. Conflicts and Cooperations dynamics



SOURCE: Vörösmarty et al. (2000) *Science* 289:284-288

Water Resources Managers: required knowledge

- Hydrology and ecohydrology
- Infrastructures of water management: structures and systems, water uses and users
- Planning and decision making
- Organizational theories
- System analysis and decision support systems
- Water and environmental laws
- Financial Management
- Principle of water resources managements

[Source: Grigg, 1996]

Approaches to solve water problems

„Anyone who solves the problem of water deserves not one Nobel Prize but two – one for science and the other for peace“ [John F. Kennedy]

WATER PROBLEMS

- CLASSIC: Availability, storage and allocation among Users (National and International) avoiding conflicts;
- MODERN: Environmental needs, Security, Pollution (Transboundary problems!), Water resources preservation...

The idea of sustainable development was born

Millennium Development Goals

"WE CAN'T SOLVE PROBLEMS BY USING THE SAME KIND OF THINKING WE USED WHEN WE CREATED THEM"
(A. Einstein)

Water engineers and managers, scientists from all disciplines have been working on local, regional, and global problems trying to develop integral (sustainable) solutions

MDGs failed because they were not measurable!

Table / 1.1

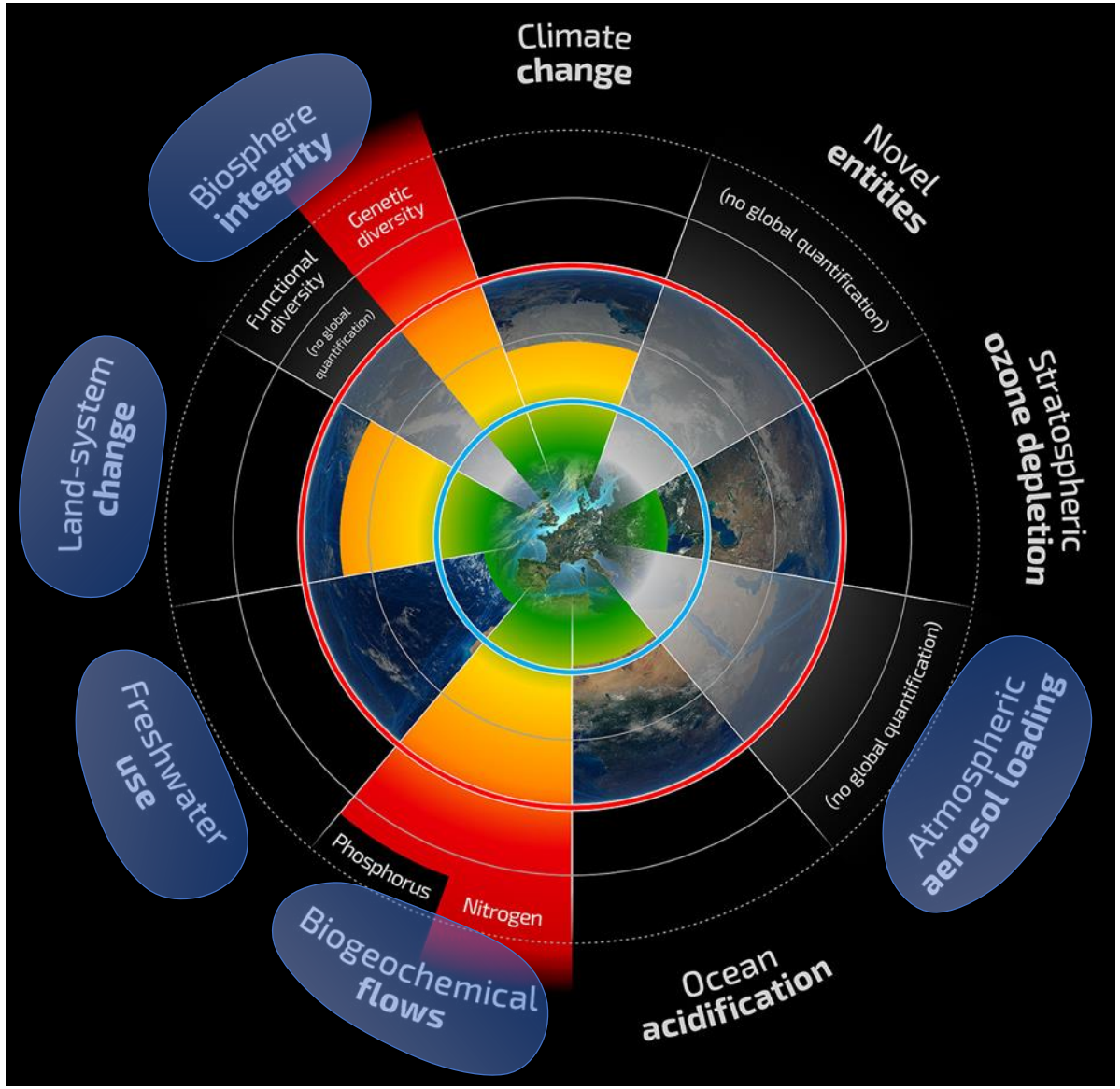
Millennium Development Goals (MDGs) MDGs are an ambitious agenda embraced by the world community for reducing poverty and improving lives of the global community. Learn more at www.un.org/millenniumgoals/.

Millennium Development Goal	Background	Example Target(s) (of 21 total targets)
1. Eradicate extreme poverty and hunger.	More than a billion people still live on less than $1 a day.	(1a) Halve the proportion of people living on less than $1 a day and those who suffer from hunger.
2. Achieve universal primary education.	As many as 113 million children do not attend school.	(2a) Ensure that all boys and girls complete primary school.
3. Promote gender equality and empower women.	Two-thirds of illiterates are women, and the rate of employment among women is two-thirds that of men.	(3a) Eliminate gender disparities in primary and secondary education, preferably by 2005, and at all levels by 2015.
4. Reduce child mortality.	Every year, nearly 11 million young children die before their fifth birthday, mainly from preventable illnesses.	(4a) Reduce by two-thirds the mortality rate among children under 5 years.
5. Improve maternal health.	In the developing world, the risk of dying in childbirth is one in 48.	(5a) Reduce by three-quarters the ratio of women dying in childbirth.
6. Combat HIV/AIDS, malaria, and other diseases.	40 million people are living with HIV, including 5 million newly infected in 2001.	(6a and 6c) Halt and begin to reverse the spread of HIV/AIDS and the incidence of malaria and other major diseases.
7. Ensure environmental sustainability.	768 million people lack access to safe drinking water and 2.5 billion people lack improved sanitation.	(7a) Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources. (7b) Reduce by half the proportion of people without access to safe drinking water. (7c) Achieve significant improvement in the lives of at least 100 million slum dwellers.
8. Develop a global partnership for development.		(8a) Develop further an open, rule-based, predictable, nondiscriminatory trading and financial system. (8b) Address the special needs of the least-developed countries. (8c) Address the special needs of landlocked countries and small island developing states. (8d) Deal comprehensively with the debt problems of developing countries through national and international measures to make debt sustainable in the long term. (8e) In cooperation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries. (8f) In cooperation with the private sector, make available the benefits of new technologies, especially information and communications.

SOURCE: www.un.org/millenniumgoals/.

The meaning of acute and global issues

Planetary boundaries in the anthropocene



"…There is increasing evidence that human activities are affecting Earth System functioning to a degree that threatens the resilience of the ES—its ability to persist in a Holocene-like state in the face of increasing human pressures and shocks…"

LOCAL (Regional)

↓

GLOBAL

Crossing boundaries

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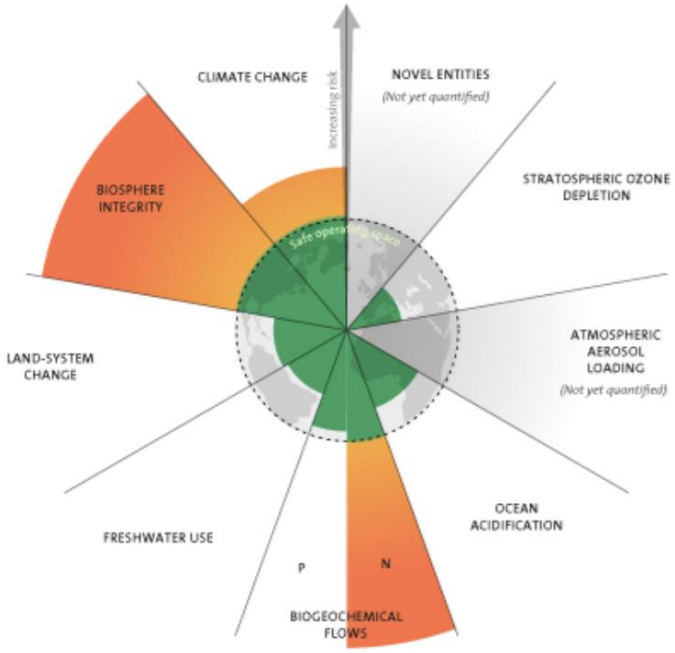
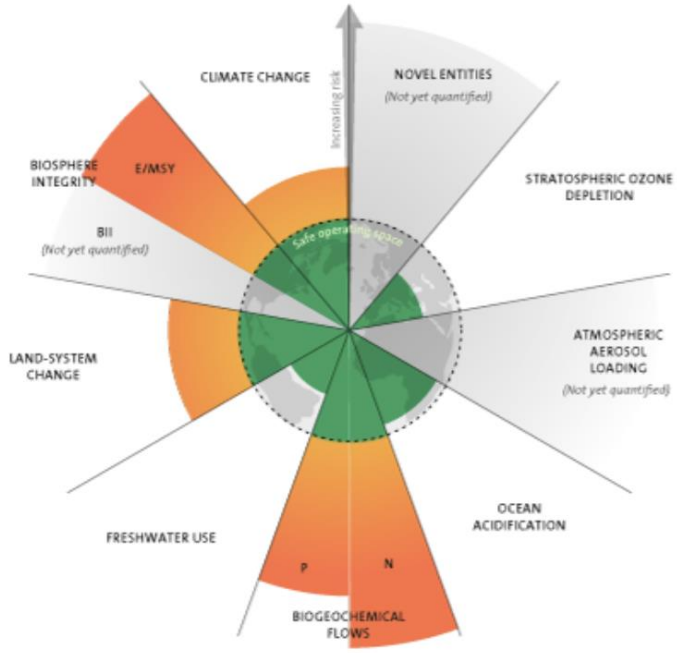
2009



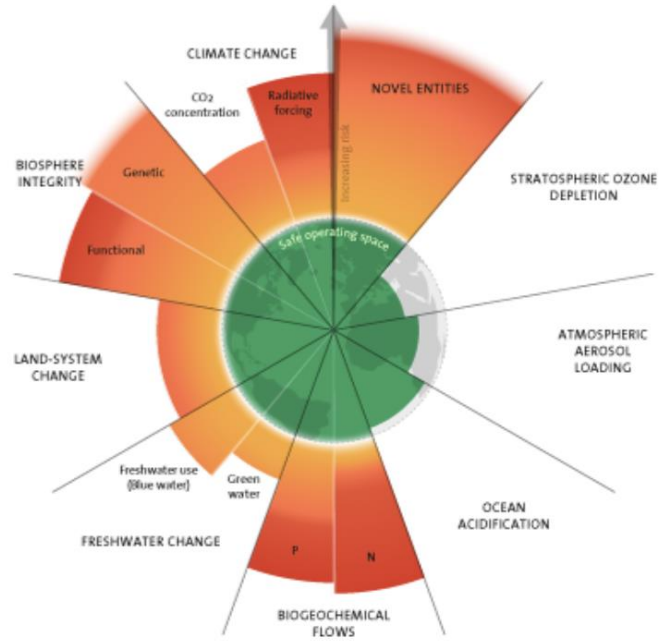
3 boundaries crossed

2015



4 boundaries crossed

2023

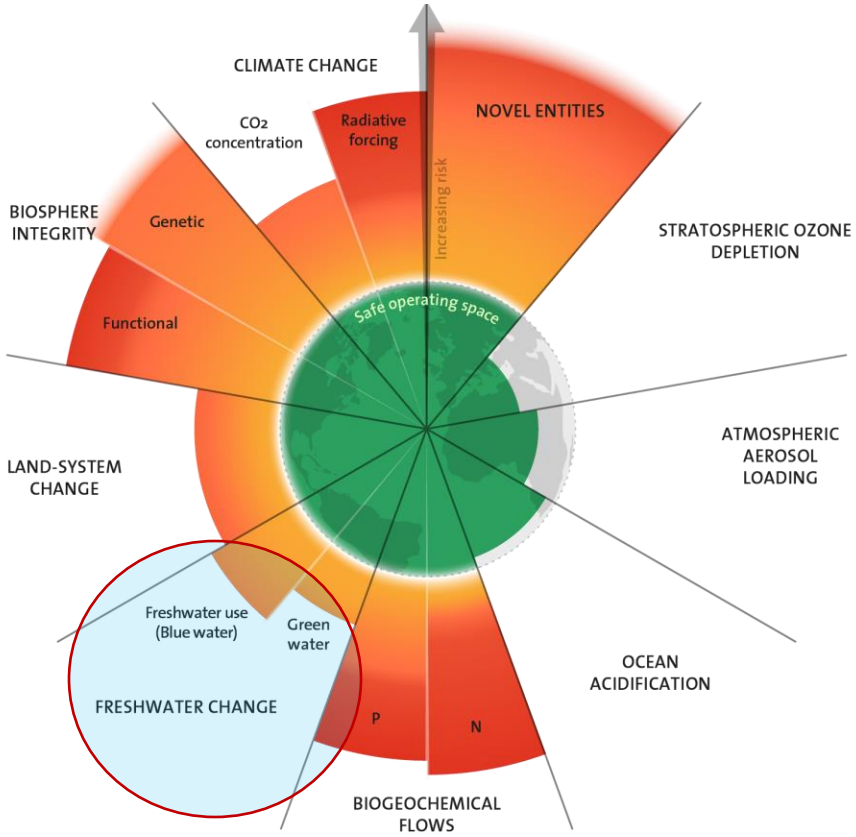


6 boundaries crossed

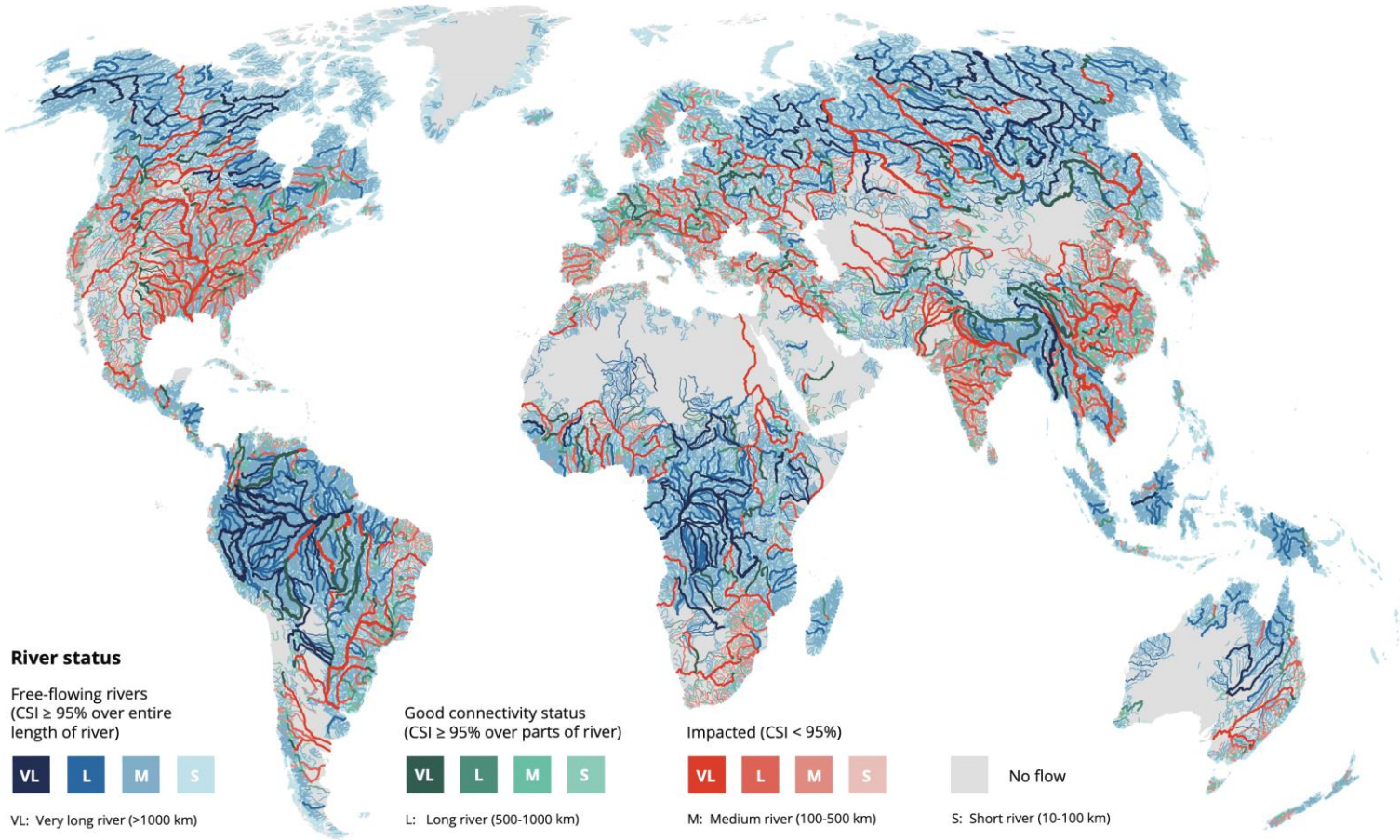
The evolution of the planetary boundaries framework. Licenced under CC BY-NC-ND 3.0. You are free to share — copy and redistribute the material in any medium or format. (Credit: Azote for Stockholm Resilience Centre, Stockholm University. Based on Richardson et al. 2023, Steffen et al. 2015, and Rockström et al. 2009) Click on image to download

Freshwater use and world rivers' status

Freshwater use



Richardson et al., *Sci. Adv.* 2023



https://www.worldwildlife.org/

6 out of 9 Planetary boundaries are now exceeded

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Towards Sustainable Water Management

EPFL

Sustainable development and sustainability

World Commission on Environment and Development (1986):

„Sustainable development is a process that meets the needs of the present without compromising our ability to meet those of the future“

Water Quality 2000 team:

„Sustainability mirrors a society living in harmony with healthy natural systems“

Sustainable Development Goals

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Sustainable Water Management

Seeking long-term solutions not harming the resources of future generations

Sustainable Water Resources Management (with caution!)

AIMS:

- Water use efficiency and conservation
- Ecological integrity and restoration
- Clean water
- Equity and partecipation in decision making
- Institutional reformes,

In general SWRM maintains and preserves the water resource for future generations, and does not degrade the natural environment

Turkana 02/08/2016
Video: P. Perona