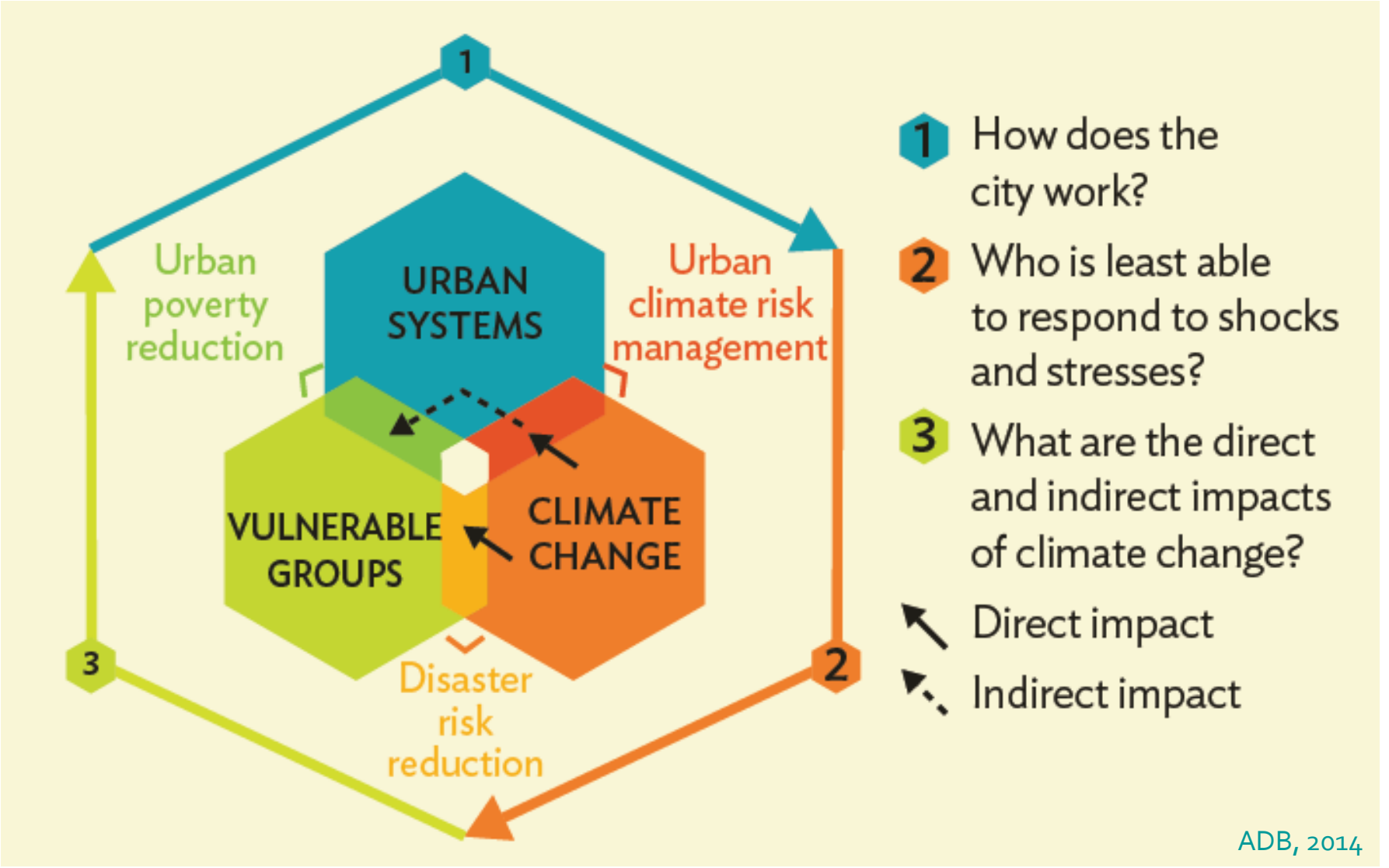
Building resilient cities within planetary boundaries



ADB, 2014

Tjaša Pogačar

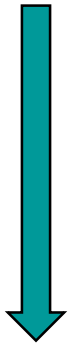
UNIVERZA V LJUBLJANI
BF Biotehniška fakulteta

URBAN RESILIENCE TO CLIMATE CHANGE:

✓ the systems of the city survive shocks and stresses;

✓ the people and organizations are able to accommodate these stresses into their day-to-day decisions;

✓ the city's institutional structures continue to support the capacity of people and organizations to fulfill their aims.



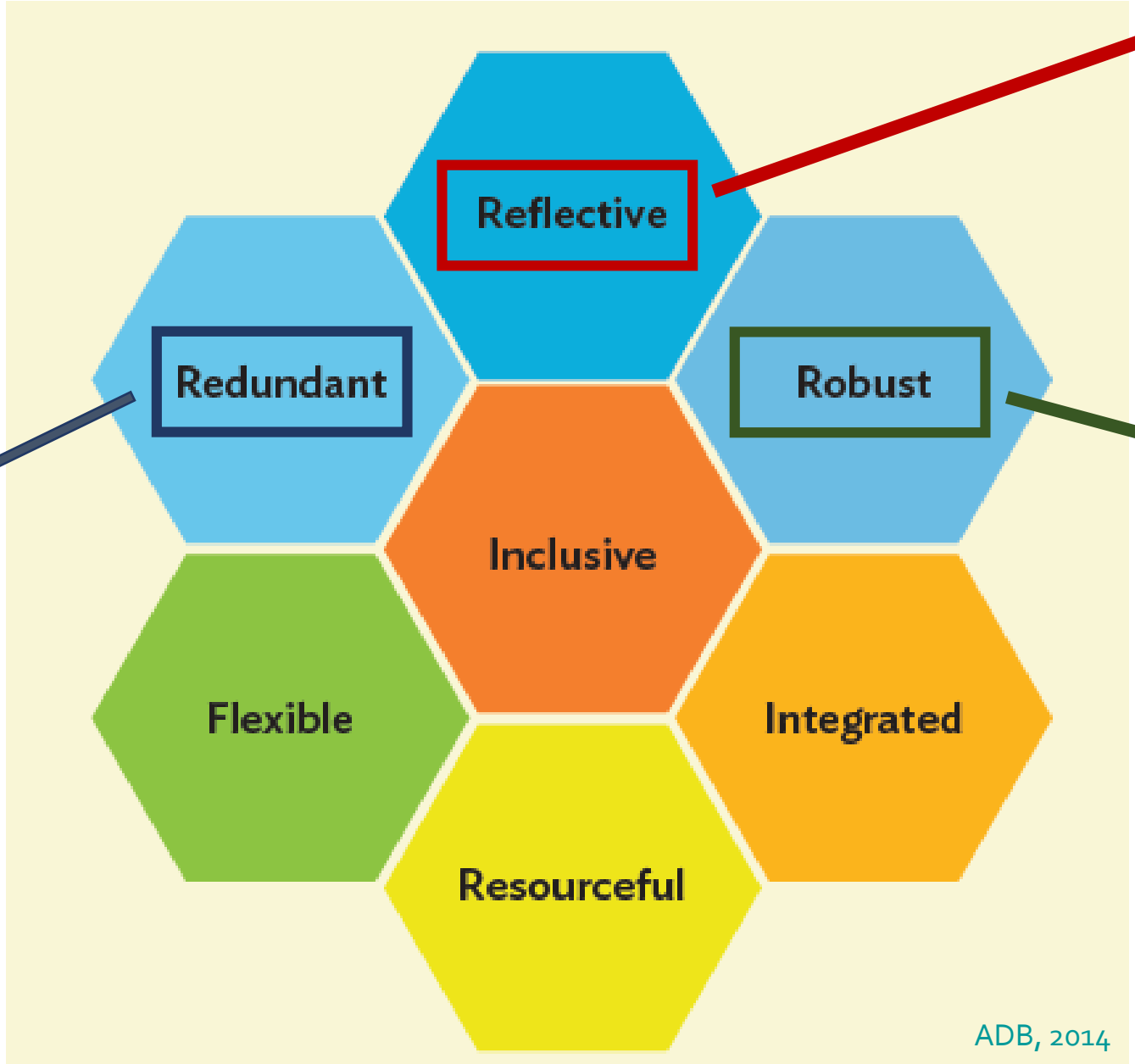
MOST SUSCEPTIBLE AREAS

fragile systems

large populations of the socially or economically marginalized

RESILIENCE qualities

if one component of the system fails, other pathways or substitutable components can meet essential functional needs

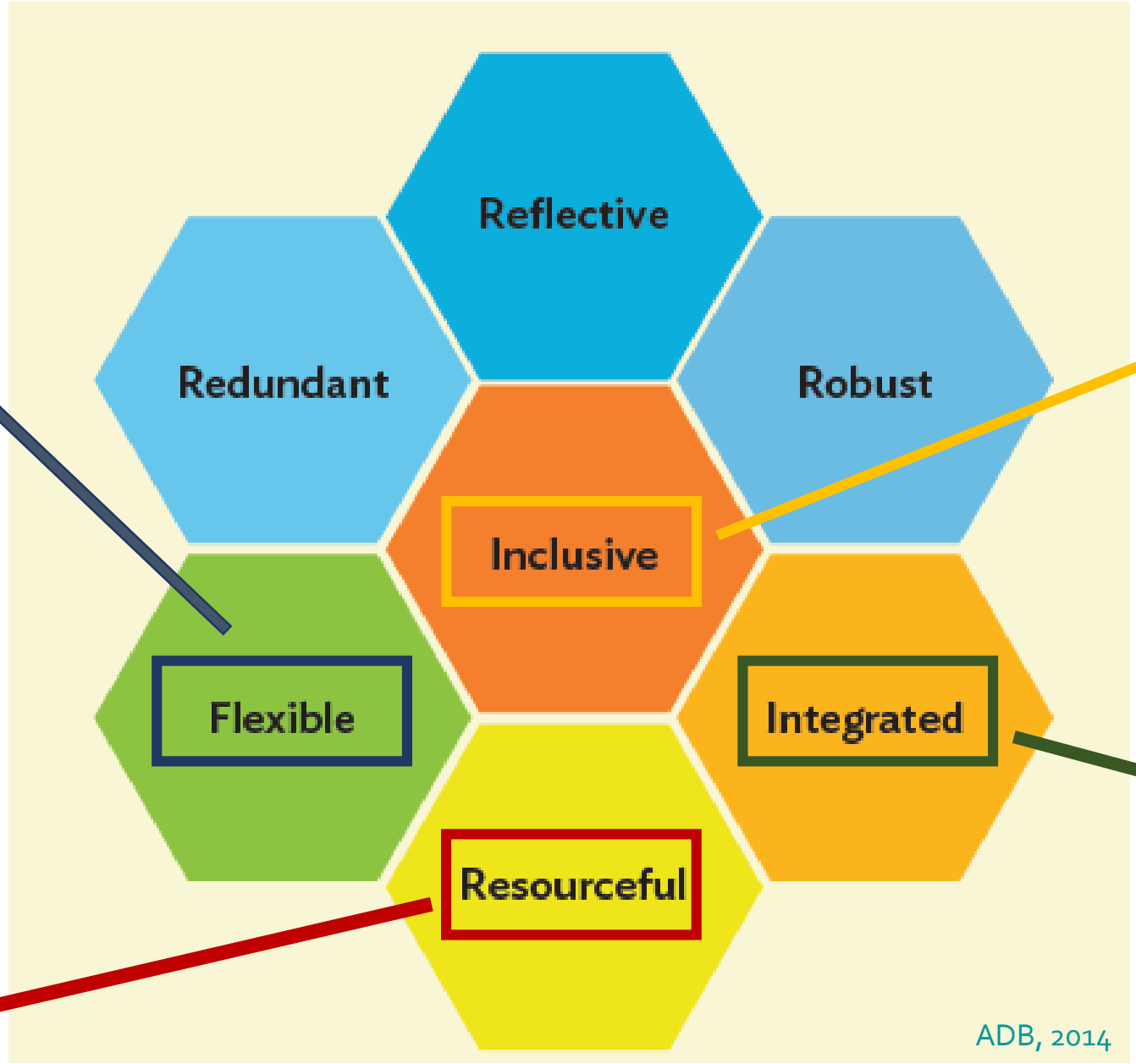


- systematical learning from experience,
- mechanisms to continuously modify standards

- withstanding the impacts of extreme conditions,
- avoiding a catastrophic collapse of the city from the failure of a single element
- anticipating system failures,
- maximizing predictability and safety

RESILIENCE qualities

- systems that can change, evolve, adopt alternative strategies
- favoring the decentralization of conventional infrastructure

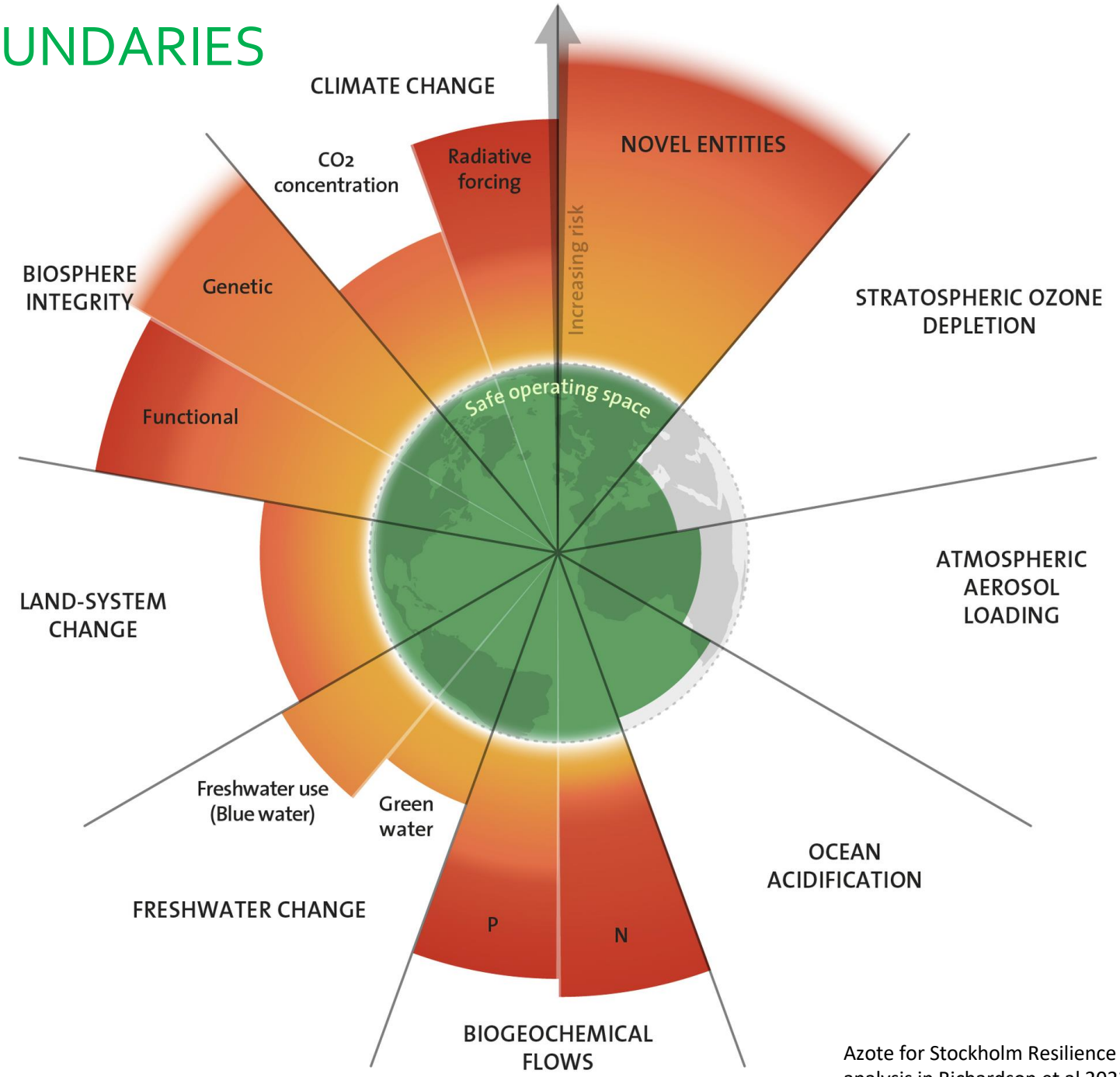


including the consultation and engagement of communities, particularly those who are vulnerable

investing in capacity to anticipate future urban conditions, set priorities, mobilize and coordinate the resources

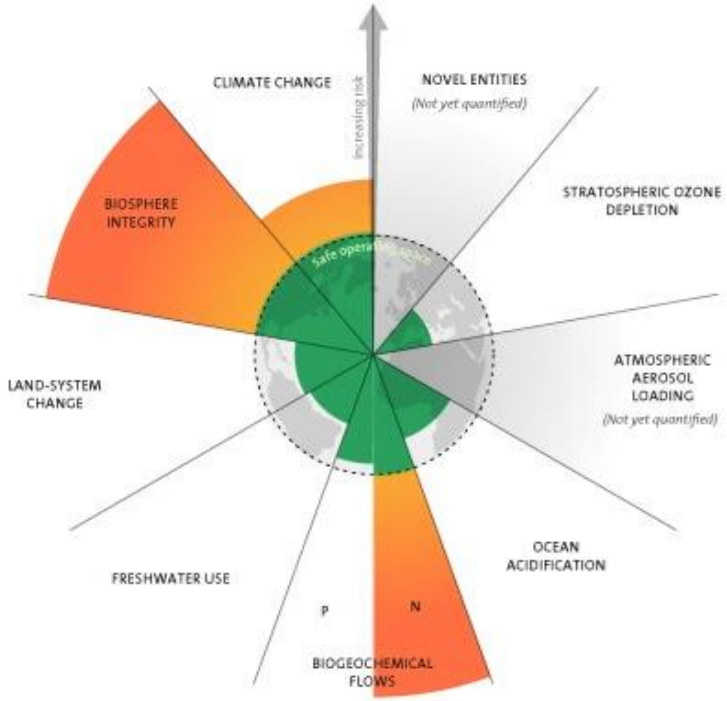
- city systems, decision making, investments mutually supportive of a common outcome,
- requires ongoing feedback system for collection of information and response

PLANETARY BOUNDARIES



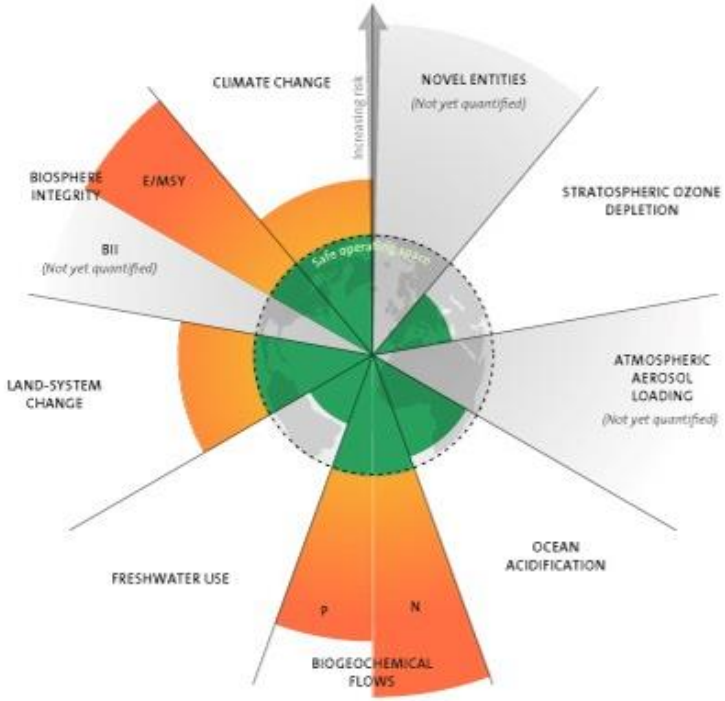
Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2023

2009



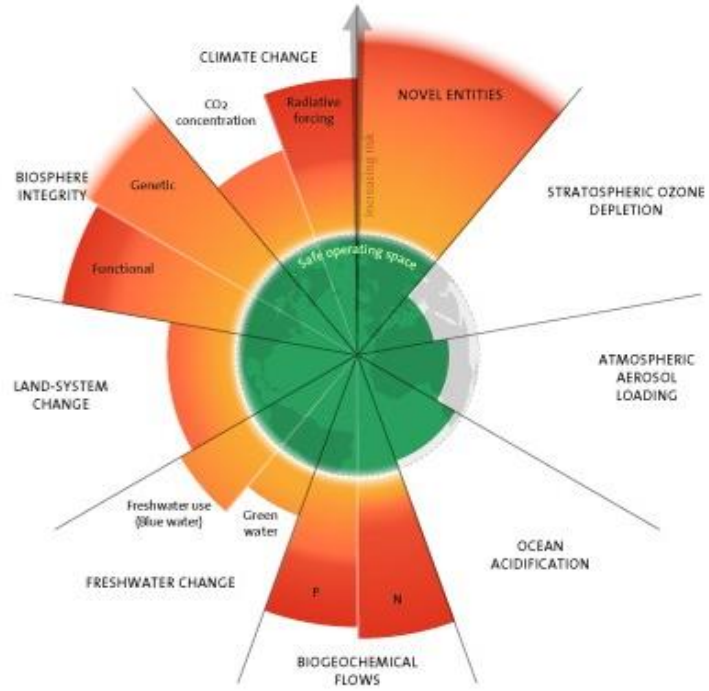
3 boundaries crossed

2015



4 boundaries crossed

2023



6 boundaries crossed

Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2023; Steffen et al. 2015, and Rockström et al. 2009

Loss of Biosphere Integrity

ARUP 2021

75%

of the world's food comes from just twelve plant and five animal species.[9]

1 million plant and animal species are at risk of extinction

- Visible impact
Water Hyacinth invasion in South Africa

lower functional diversity

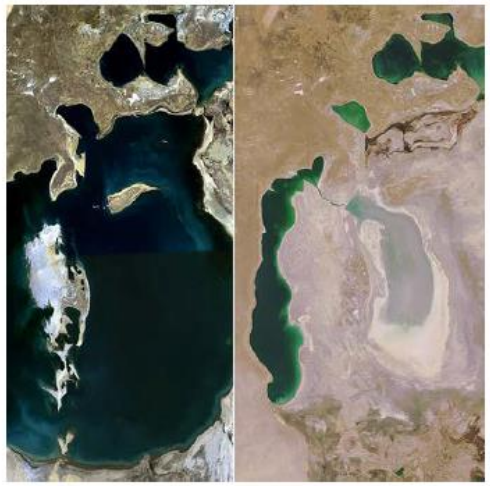
- Expansion of cities fragments habitats;
- Urban development destroys biodiversity hotspots;
- Urban areas favour invasive species;
- Polluted waterways and soil cannot support life.

Regeneration

- Enhanced connectivity of habitats;
- Restoration of degraded ecosystems;
- Improved efficiency of existing modified land: reduced need for further land conversion.

Freshwater use

ARUP 2021



- Visible impact
The disappearing Aral Sea

- Visible impact
Tehran sinking from groundwater depletion

56 % of endemic fish species in the Mediterranean are endangered due to unsustainable water management.

- High water consumption in cities;
- Impervious urban surfaces;
- Illegal pumping (wells).

- Changing global water cycle
- Food security (irrigation)
- Water sources are disappearing: 90% of cities rely on forested watersheds for supply.
- Water quality is deteriorating

Regeneration

- Smart agricultural practices;
- Water governance;
- Water cycle as part of urban planning.

Ocean Acidification

ARUP 2021

- Visible impact
Great Barrier Reef Decline

The rate of calcification (growth) of the Great Barrier Reef declined by 14% between 1990 and 2005.

- Interference with the formation of shells and skeletons of marine organisms;
- Worsening physiological functions;
- Altered ecosystem function and food chains.

- Cities - consuming 2/3 of global energy and accounting for over 70% of emissions. The main sources are TRANSPORTATION, ENERGY PRODUCTION, and BUILDINGS.
- Sewage and urban runoff contribute to coastal acidification.

Regeneration

- To reduce CO_2 emissions and increase sequestration is the only global solution;
- Locally - algae and seagrasses: metabolize dissolved CO_2, provide food for fish;
- Urban environment (especially coastal cities): education, awareness, community engagement (against unsustainable fishing, excessive surface water runoff ...).

Stratospheric Ozone Depletion ARUP 2021

the ozone layer protects against UV-C&B radiation

- Visible impact
Antarctic ozone hole

- Visible impact
Phytoplankton photosynthesis reduction

A 6-12% reduction in phytoplankton photosynthesis in Antarctica due to the ozone hole.

- ODS in air conditioners: many products continue to slowly release harmful compounds;
- Illegal use of ODS persists.

Regeneration

- Coordinated global action and binding international agreements;
- CFC gas is destroyed by incineration in special furnaces that break down the molecules.

Land-System Change

ARUP 2021

70% of rainfall is generated by rainforests themselves.

- Cities are major resource sinks;
- Fragmentation of forested areas.

- Forests regulate the water cycle, temperature;
- Forests capture and store carbon;
- Forests support biodiversity: 30% of the surface = 80% of biodiversity.

- Visible impact
Decreased rainfall in deforested Borneo

Regeneration

- city growth boundaries,
- better utilization of already modified surfaces,
- improved planning of transportation routes.

Biogeochemical Flows

ARUP 2021

Human impact on the global nitrogen (N) and phosphorus (P) cycle

- Visible impact

Gulf of Oman dead zone

- Agriculture relies on non-renewable N and P;
- Excess N and P in aquatic ecosystems lead to eutrophication

- Cities drive demand for food, biofuels, cotton … escalating industrial nutrient use.
- Sewage: loaded with N and P from waste and detergents - most wastewater treatment plants do not remove nutrients.
- Landscaping runoff: parks, lawns, and gardens are often heavily fertilized.
- Burning fossil fuels increases N pollution.

Eutrophication: excessive growth of algae and phytoplankton – when they decay, CO_2 is released, and oxygen is consumed - "dead zones."

In the oceans, there are more than 400 major dead zones (such as the Gulf of Oman).

Regeneration

Reuse of nutrients in agriculture, greater efficiency, bioremediation.

- Urban infrastructure is critical in redirecting flows: rain gardens, meanders;
- Sustainable food production (local, hydroponics, aquaponics).

Atmospheric Aerosol Loading

ARUP 2021

- Visible impact
South Asian monsoon disruption

- Aerosols alter cloud formation,
- influence Earth's temperature,
- lower air quality.

- Heating, cooling, transportation, industry: inefficient burning of fossil fuels, biomass, coal;

- Construction and demolition: dust emissions.

Year 2016: 91% of the world's population lived in places that did not meet the WHO guidelines for air quality.

Regeneration

- Improving forest land management;
- Clean energy;
- During the transition period: reducing energy consumption, equipping existing power plants with particle removers;
- Reducing dust emissions during demolition;
- Temporary greening of vacant lots.

Novel Entities

ARUP 2021

- Visible impact
DDT and bird shell thinning

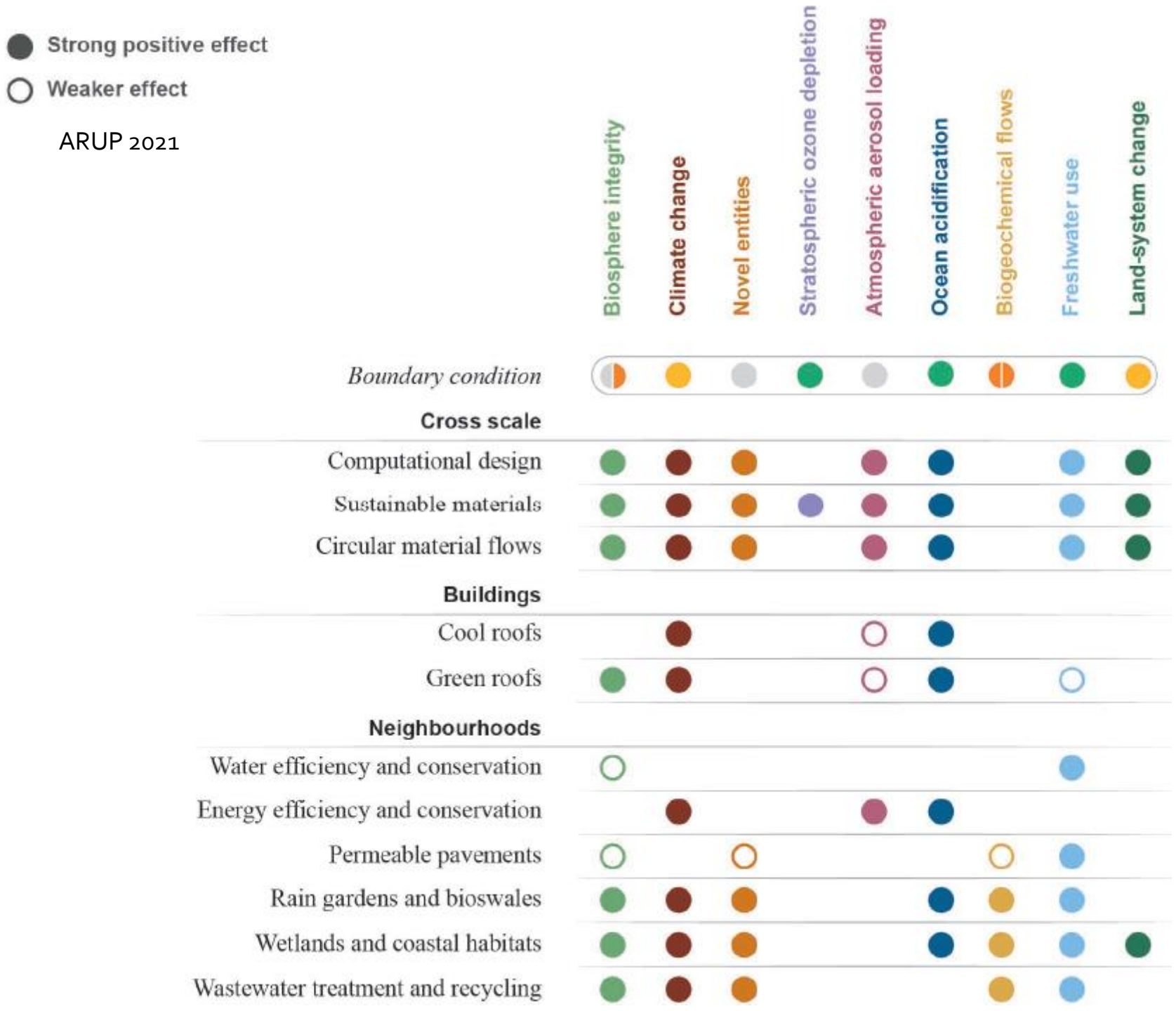
90% of the population in the USA has detectable levels of bisphenol A (BPA), which is associated with fertility issues and heart disease.

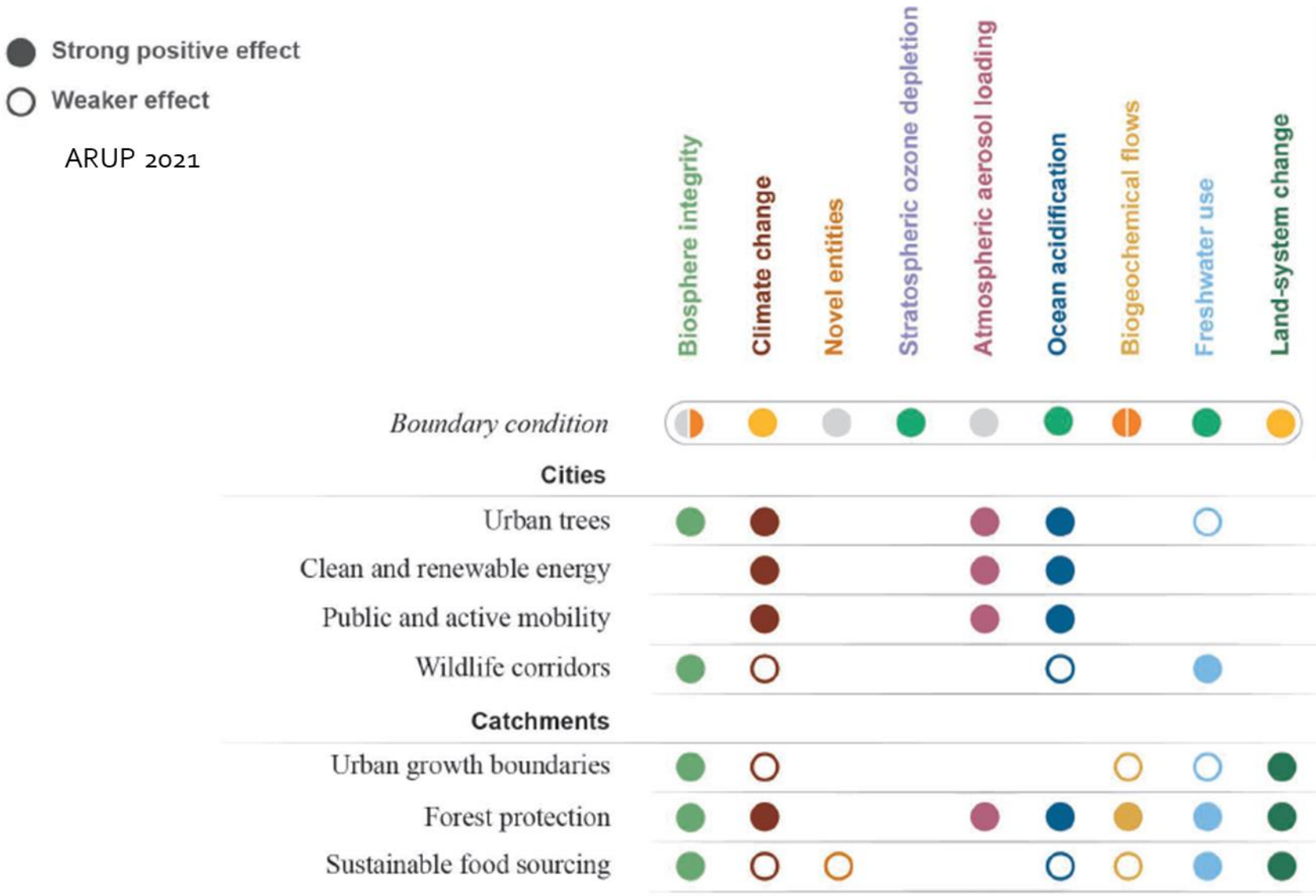
- Chemicals spread through air, water, plastic, and food chains;
- Interactions are uncertain and hazardous.

- Excessive use of medications (improper disposal), batteries, pesticides, construction materials;
- Industrial areas are often polluted.

Regeneration

- International agreements on the use and management at the end of life;
- Improving pollution indicators;
- Transition to a circular economy: radically reducing pollution (extraction and disposal);
- Urban environment: use of bioremediation measures, monitoring, sustainable building materials.


Strong positive effect
Weaker effect
ARUP 2021
Biosphere integrity
Climate change
Novel entities
Stratospheric ozone depletion
Atmospheric aerosol loading
Ocean acidification
Biogeochemical flows
Freshwater use
Land-system change
Boundary condition
Cross scale
Computational design
Sustainable materials
Circular material flows
Buildings
Cool roofs
Green roofs
Neighbourhoods
Water efficiency and conservation
Energy efficiency and conservation
Permeable pavements
Rain gardens and bioswales
Wetlands and coastal habitats
Wastewater treatment and recycling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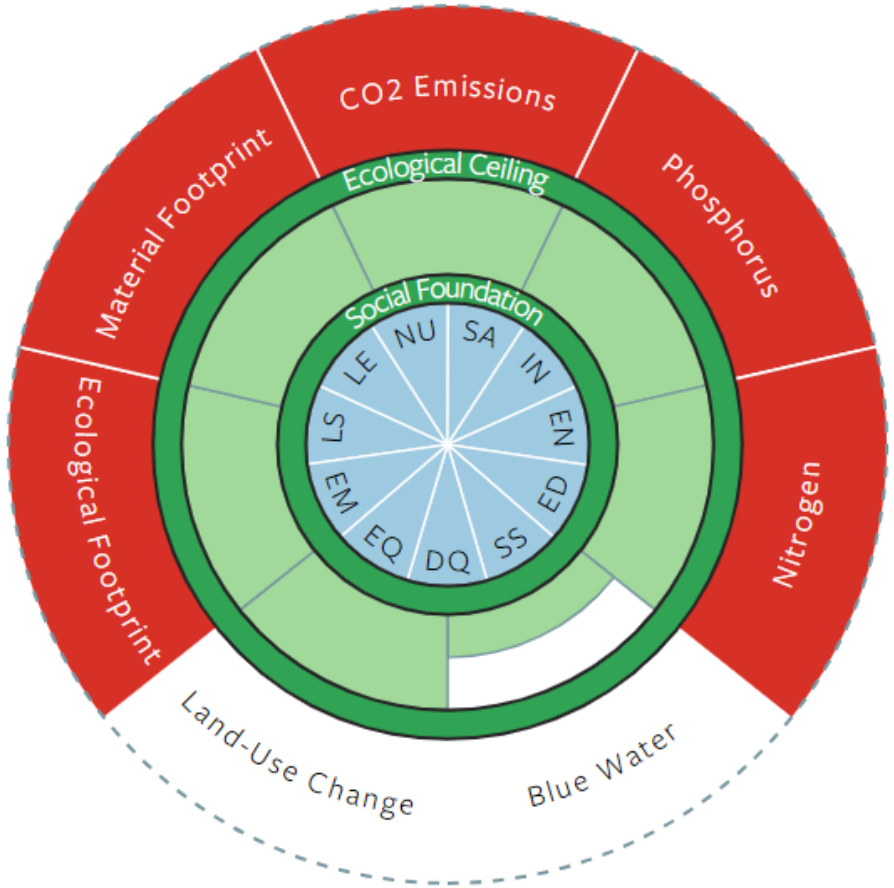
Biogeochemical flows
Freshwater use
Land-system change
Boundary condition
Cities
Urban trees
Clean and renewable energy
Public and active mobility
Wildlife corridors
Catchments
Urban growth boundaries
Forest protection
Sustainable food sourcing

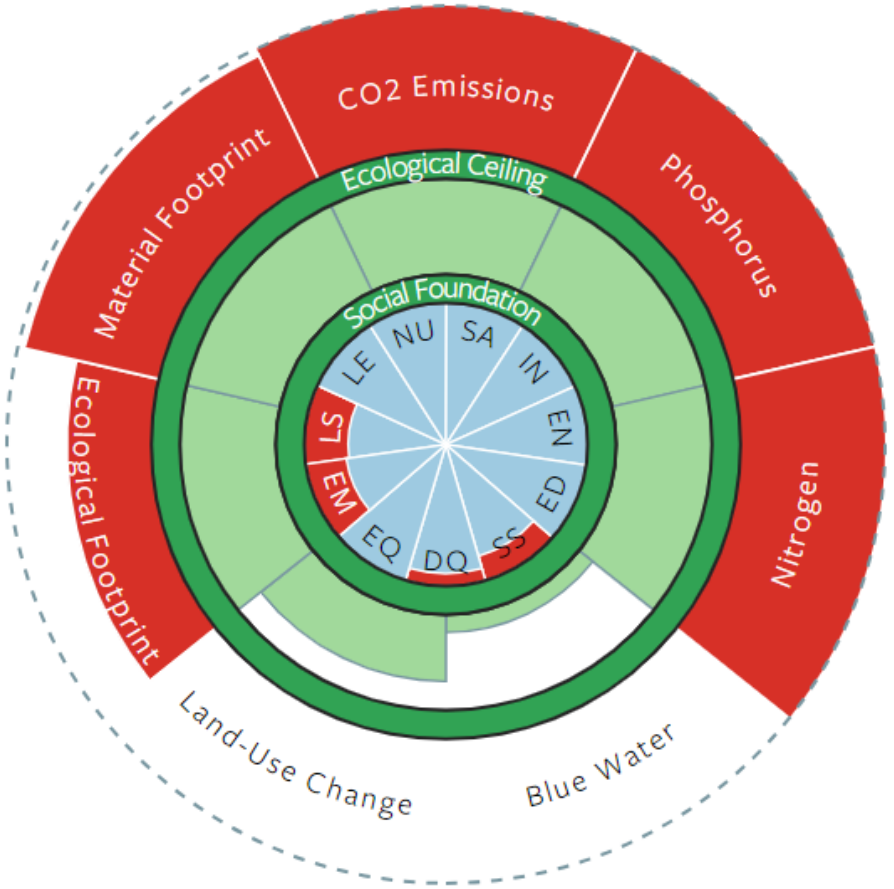
Country Comparison (2011)

Austria

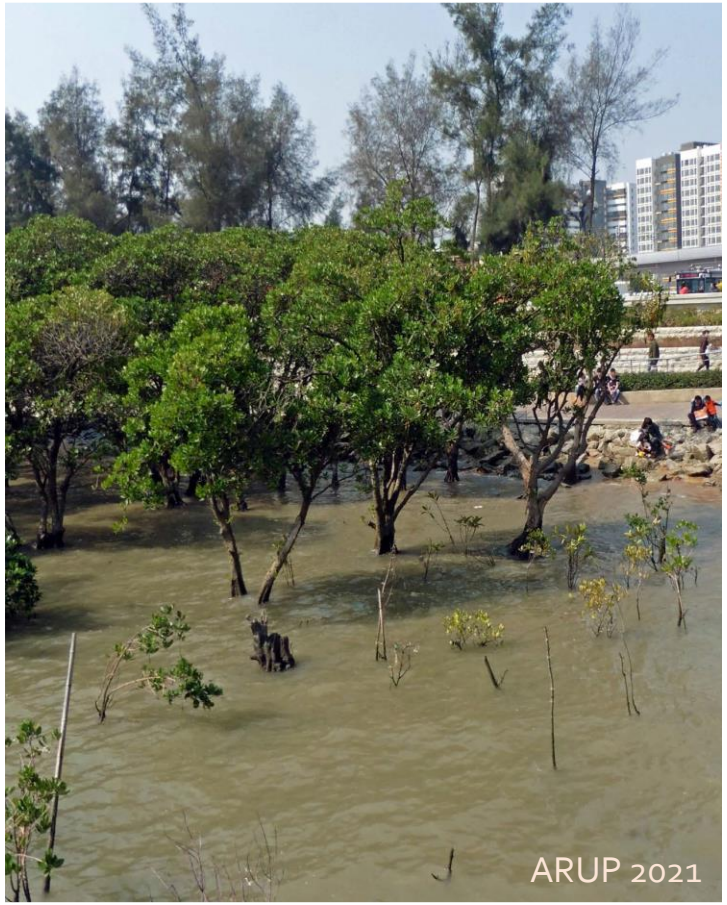


LS - Life Satisfaction
LE - Healthy Life Expect.
NU - Nutrition
SA - Sanitation
IN - Income
EN - Access to Energy
ED - Education
SS - Social Support
DQ - Democratic Quality
EQ - Equality
EM - Employment

Croatia



https://goodlife.leeds.ac.uk/countries/



Shenzhen: 51 hectares of coastal mangroves restored—reestablishing local habitats for stabilizing urban coastlines (storms, erosion). Mangroves absorb 8 times more CO_2 than other ecosystems and also regulate temperature

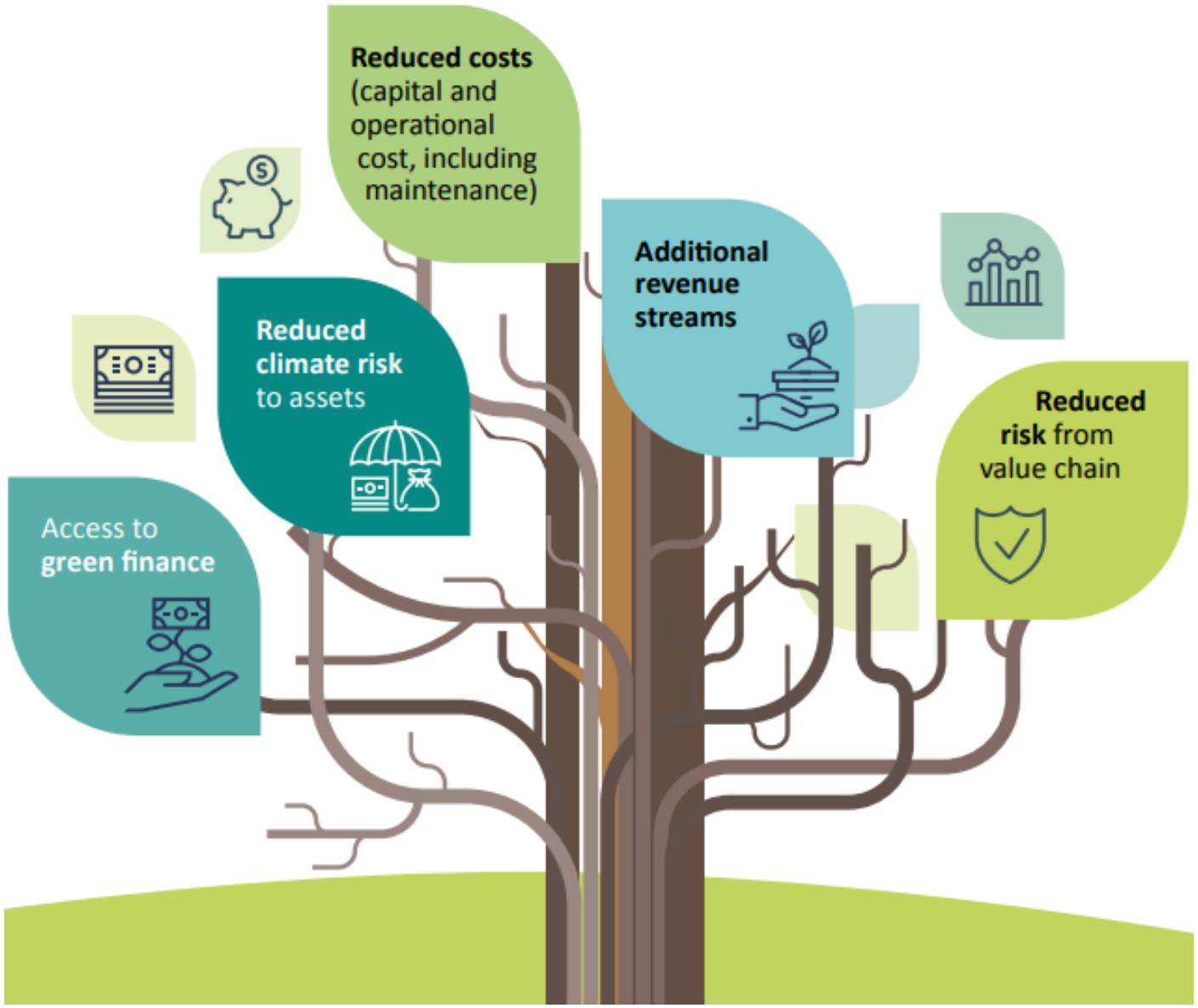
UNEP, 2023

Bandung, Indonesia

New York, USA

Local and national governments should work together to craft the right mix of incentives and regulation to create a supportive environment for the widespread application of NbS.

UNEP, 2023



UNEP, 2023

Munich, Germany

Measure: Improve energy efficiency of buildings and infrastructure

- **Planetary Boundary:** Climate Change, Resource Use (e.g., reduced materials needed for new infrastructure)
- **Co-benefits:** Lower energy costs, reduced greenhouse gas emissions

https://www.iberdrola.com/sustainability/sustainable-green-buildings

Measure: Promote sustainable transportation (public transit, cycling, walking)

- **Planetary Boundary:** Climate Change, Air Pollution
- **Co-benefits:** Reduced traffic congestion, improved air quality, healthier population

https://momentummag.com/makes-city-great-bicycling/

Measure: Protect and restore natural areas within the city (urban parks, green roofs)

- **Planetary Boundary:** Biodiversity Loss, Climate Change
- **Co-benefits:** Improved water quality, reduced urban heat island effect, habitat for pollinators

https://medium.com/mark-and-focus/green-roofs-a-sustainable-solution-for-urban-development-f639a1a39dc1

Measure: Promote urban agriculture and local food systems

- **Planetary Boundary:** Land-System Change, Biodiversity Loss, Climate Change
- **Co-benefits:** Reduced food transportation emissions, increased food security, community engagement

https://greenheartsc.org/urban-farm-at-enston-home/

Measure: Implement sustainable water management practices (rainwater harvesting, greywater reuse)

- **Planetary Boundary:** Freshwater Use, Biodiversity Loss
- **Co-benefits:** Reduced reliance on freshwater resources, improved water security, reduced pressure on natural ecosystems

https://www.treehugger.com/beginners-guide-to-rainwater-harvesting-5089884

Measure: Implement green infrastructure solutions to manage stormwater runoff and reduce pollution

- **Planetary Boundary:** Biodiversity Loss, Water Pollution
- **Co-benefits:** Improved water quality, reduced flooding risk, habitat creation

https://en.wikipedia.org/wiki/Bioswale

Measure: Encourage sustainable consumption practices and support local businesses

- **Planetary Boundary:** Resource Use (e.g., reduced extraction of raw materials), Climate Change
- **Co-benefits:** Reduced environmental footprint, economic benefits for the local community

https://agriculture.ny.gov/farmers markets

Measure: Promote product life extension initiatives (repair, reuse)

- **Planetary Boundary:** Resource Use, Climate Change, Novel entities,
- **Co-benefits:** Reduced waste generation, conservation of resources, potential for job creation

https://www.bikeradar.com/advice/workshop/essential-bike-maintenance-tips

Measure: Promote environmental education and awareness programs for citizens

- **Planetary Boundary:** All Planetary Boundaries (informed public for better decision-making)
- **Co-benefits:** Increased public support for sustainability measures, behavior change

https://www.pca.state.mn.us/air-water-land-climate/long-term-biological-monitoring-of-rivers-and-streams

https://participatorysciences.org/

CONCLUSIONS

Understanding Local Impacts:

- Risk Assessment: Identify climate threats, analyze their potential impact on infrastructure, ecosystems, and communities.
- Planetary Boundaries: Assess how urban activities affect crucial boundaries, focus on areas exceeding safe limits.

Building Resilience:

- Nature-Based Solutions: Parks, bioswales, and urban forests to manage stormwater, reduce heat stress, and enhance biodiversity.
- Infrastructure Upgrades: Strengthen critical infrastructure to withstand future climate events. Promote flood protection in vulnerable areas.

Promoting Equity and Transition:

- Community Engagement: Involve citizens, identify vulnerable communities disproportionately affected by climate change and prioritize their needs.
- Just Transition: Invest in green jobs and retraining programs, ensure affordable housing and access to public transportation for all residents.

Continuous Improvement:

- Monitoring and Evaluation: Regularly monitor progress, evaluate the effectiveness of implemented strategies and adapt them as needed.
- Knowledge Sharing: Collaborate with other cities and share best practices.

THANK YOU

ADB, 2014: Urban climate change resilience
(https://www.adb.org/publications/urban-climate-change-resilience-synopsis)
ARUP, 2021: Designing for Planetary Boundaries
(https://www.arup.com/-/media/arup/files/publications/d/designing_for_planetary-boundary-cities.pdf)
UNEP, 2023: Smart, Sustainable and Resilient Cities
(https://wedocs.unep.org/bitstream/handle/20.500.11822/36586/SSRC.pdf?sequence=1&isAllowed=y)