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Compatible fusion of nature-based and innovative solutions for improving resilience of water infrastructure

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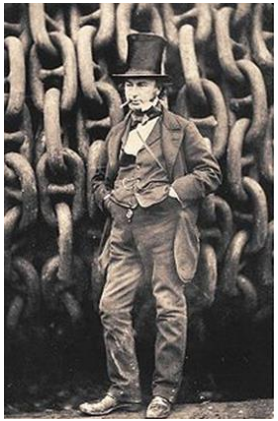
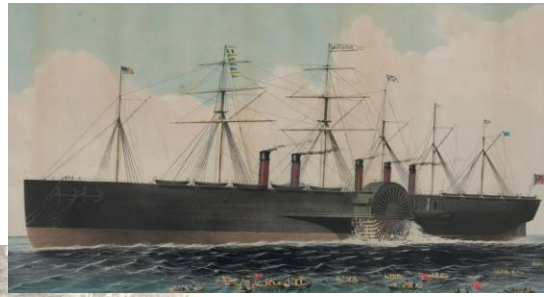
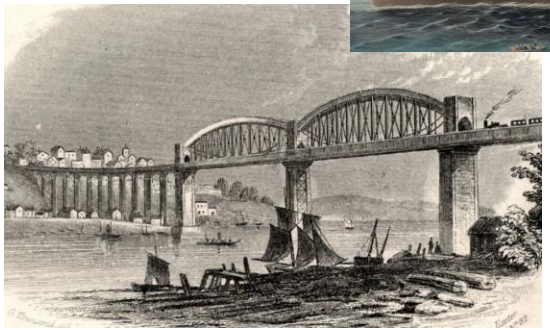
Who was Isambard Kingdom Brunel?

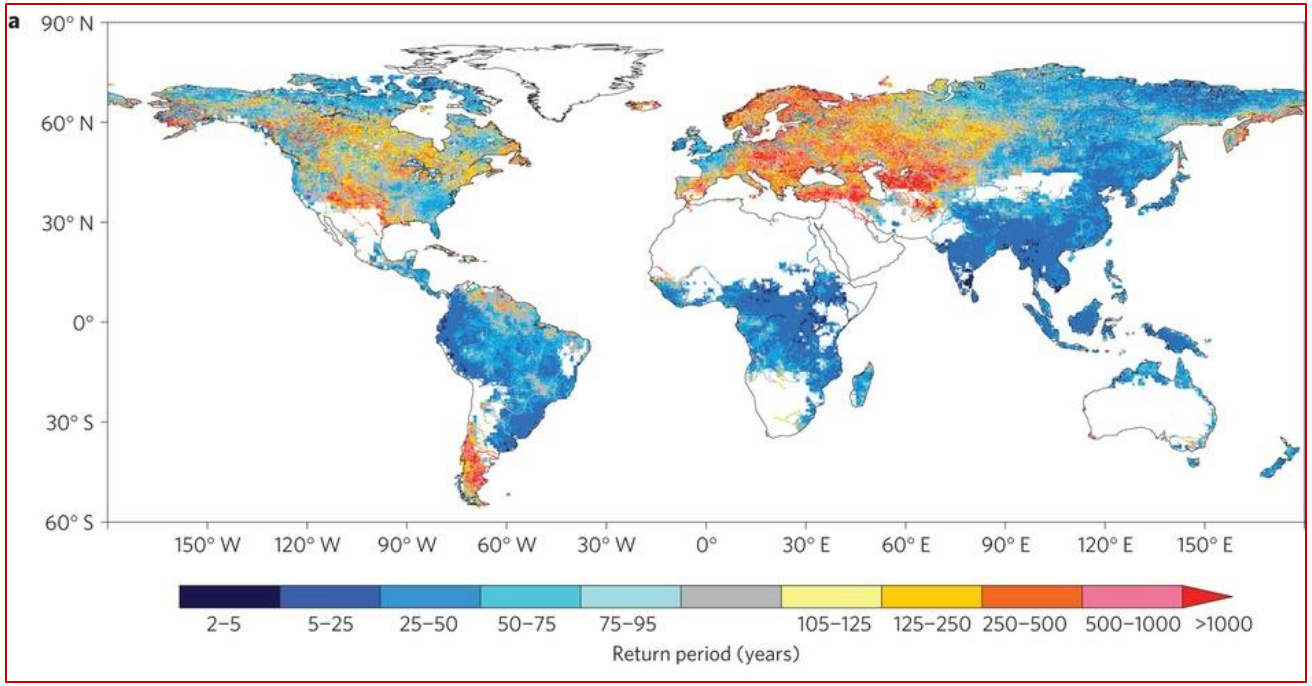


- British engineer, 1806-1859
- Famous for designs of bridges, railways, steamships



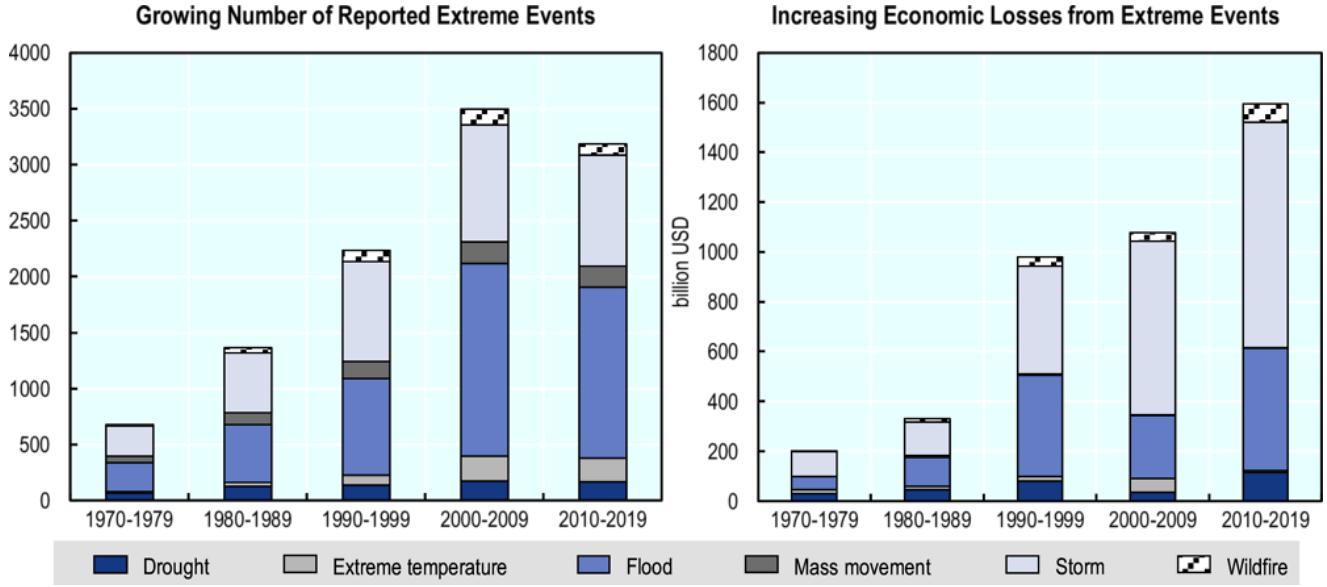


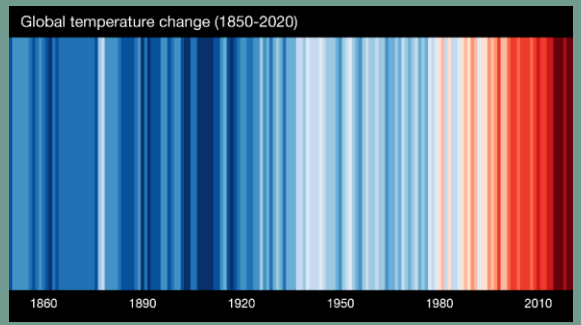
Flood risk context (end of 21st Century RI of a 100-year event in 2000)



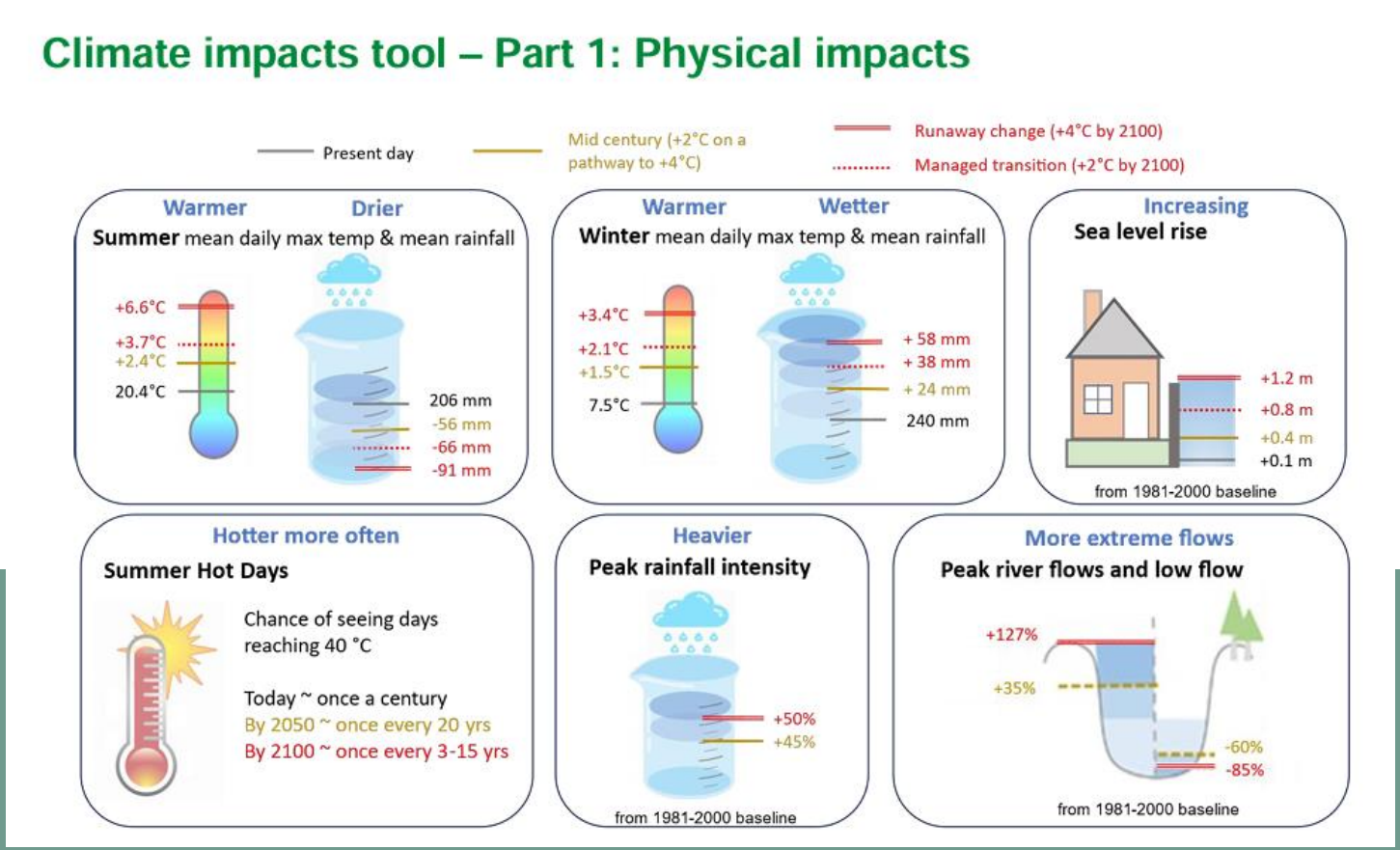
Hirabayashi et al., 2013

Global hazard context





UK climate impacts



Environment Agency, 2023

UK climate impacts

Climate impacts tool – Part 2: Wider physical and systemic impacts

"Storms and floods impact emergency responder access and resources"

"Intense rainfall impacts staff safety, especially when working outside or travelling"

"Sea level rise and increasing storminess threaten coastal communities"

"High temperatures and drought increase wildfires risk or fire risk at regulated sites"

"Air quality changes could impact people and the environment, for better or worse"

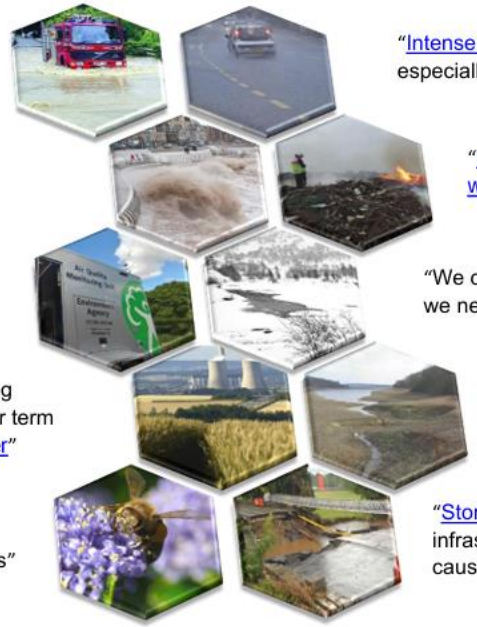
"We could still see extreme winter cold – we need to remain prepared!"

"Heat and drought impact industrial cooling systems and agriculture – adding to longer term impacts of warming on land, soil and water"

"Prolonged dry weather impacts water quality, resources and ecosystems"

"A warming climate impacts biodiversity, its vulnerability and the threat of invasive species"

"Storms, erosion and subsidence impact infrastructure (our assets and those of others) causing cascading impacts that could affect our work"



"Climate impacts are increasing, becoming more frequent and more severe – we need to act now to manage the risks!"

Environment Agency, 2023

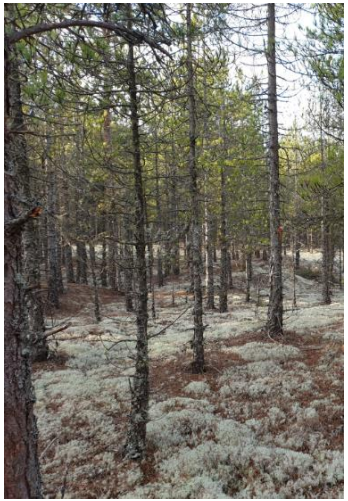
Restoring landscapes: what is natural?

Types of river restoration (Brookes and Shields, 1996)

Term	*Definition*
Full restoration	Complete structural and functional return to a pre-disturbance state
Rehabilitation	Partial return to a pre-disturbance structure or function
Enhancement	Any improvement in environmental quality
Creation	Development of a resource that did not previously exist at site

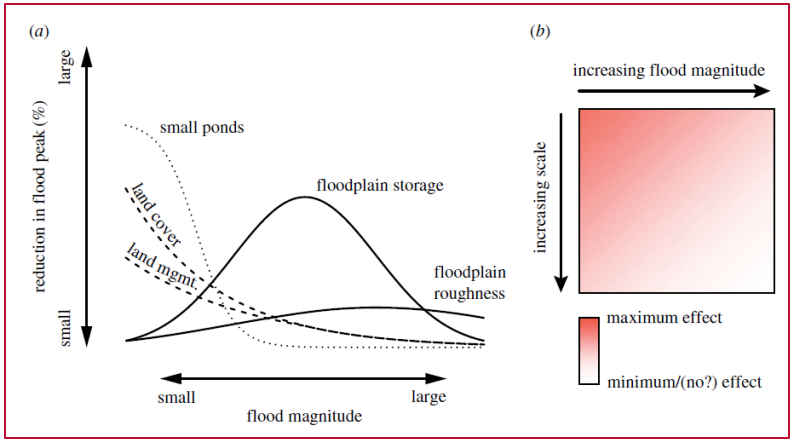
Restoration or enhancement: Kallang River, Singapore

Enhancement: Culbin dunes, Scotland

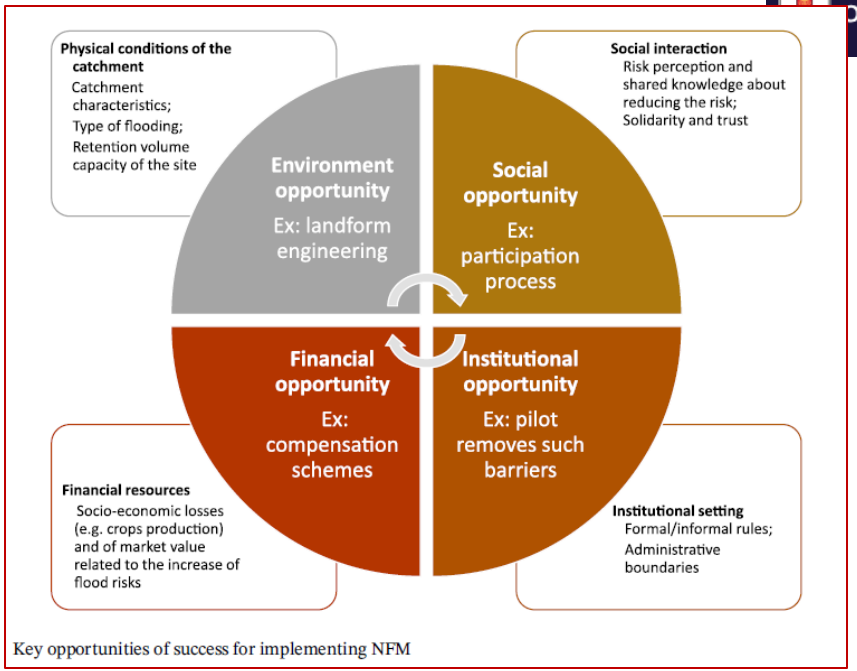


- 28 km^2 forest – since 1950
- Naturally unstable sand dunes
- New habitats created and now protected

Effectiveness of Natural Flood management (NFM)



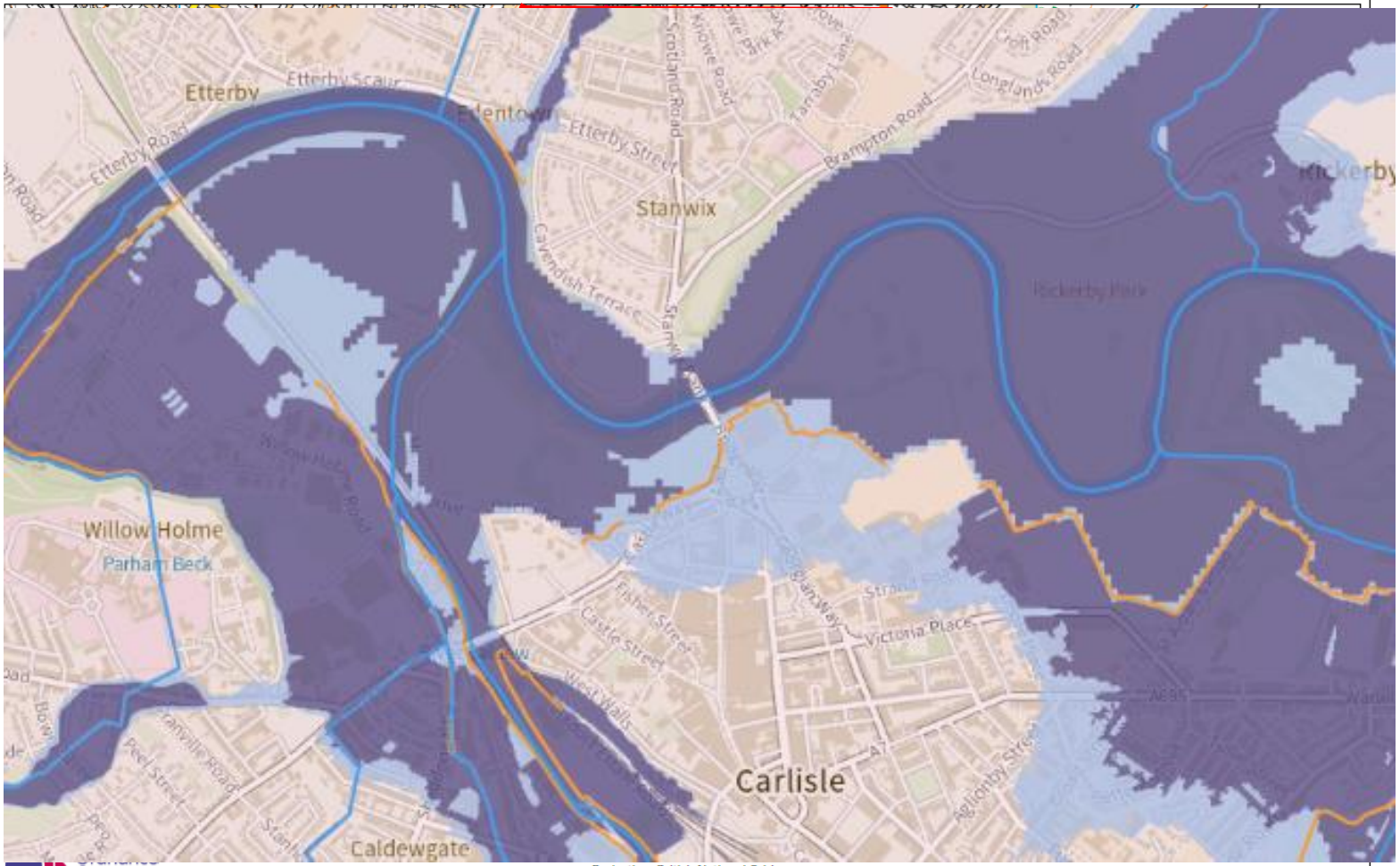
Dadson et al., 2017 http://dx.doi.org/10.1098/rspa.2016.0706



Key opportunities of success for implementing NFM

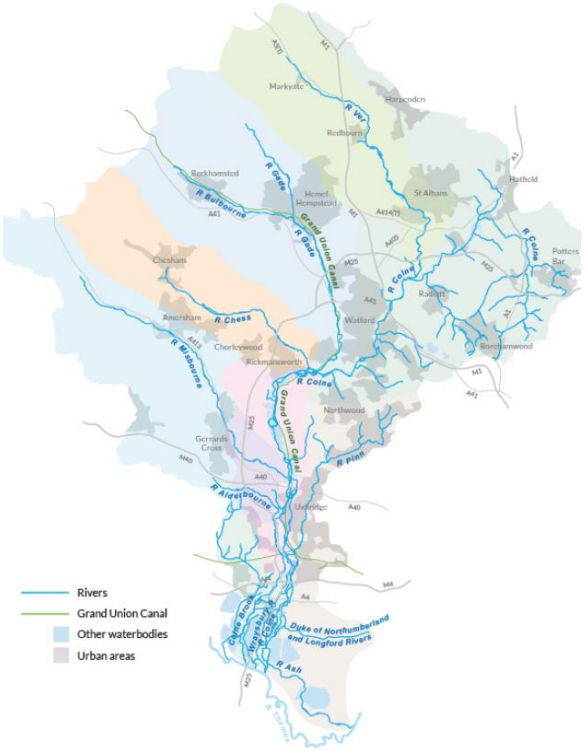
Thaler et al., 2023 10.1002/wat2.1637

Carlisle



Maps from Professor Lee Bosher, University of Leicester

Rivers as catchments and continua



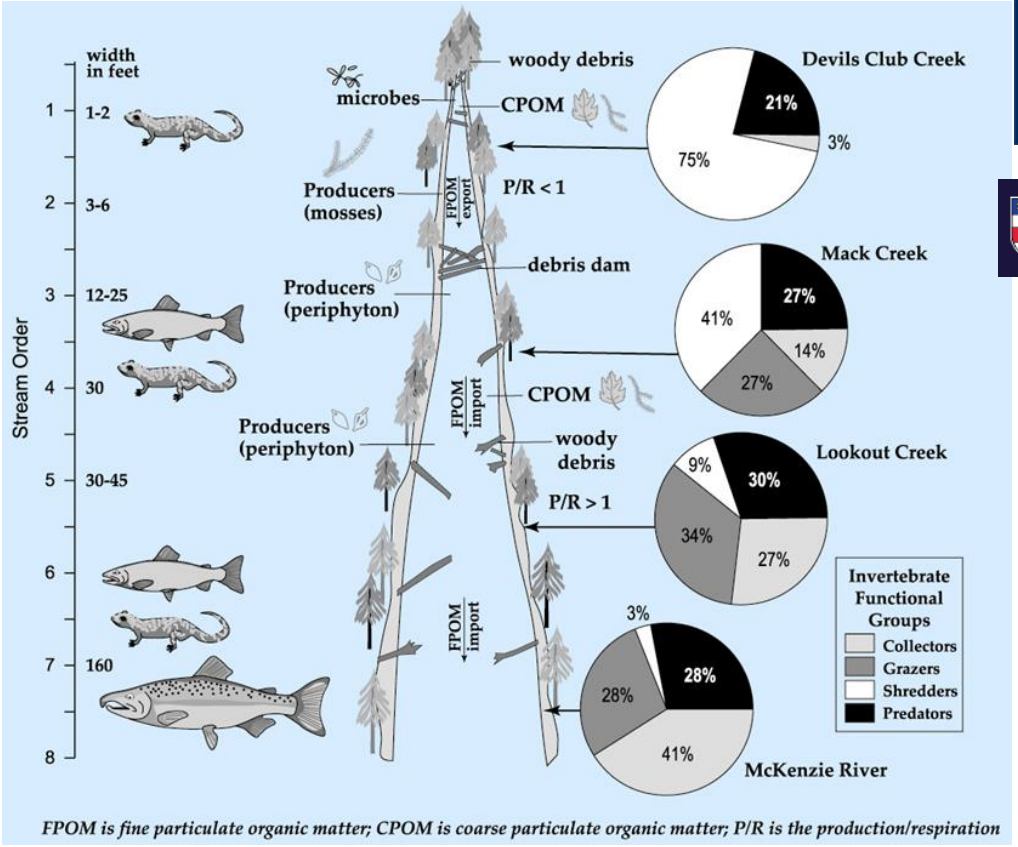


Image from Long term Ecological Research Network

Climate change and boundary conditions

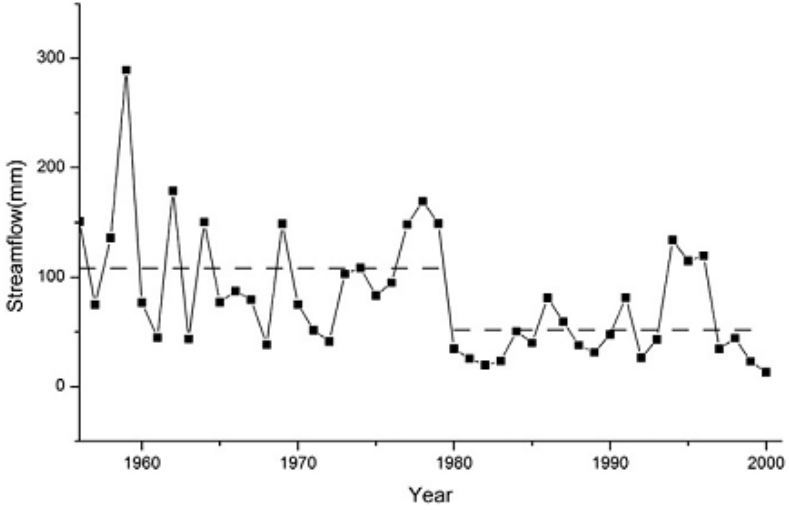


Fig. 4. Changes of annual streamflow from 1956 to 2000 in Luan River basin.

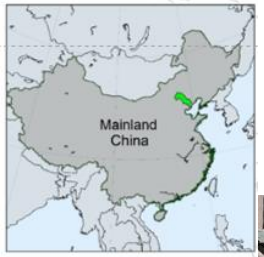
Contributions to change:

- Climate 41%
- Human activity 59% [reservoir 39%; land-use change 20%]

Wet season climate effect = 44%; dry season = 7%

Wang et al 2016, *Catena* 136, 182-8

Luanhe River Basin China



国立研究開発法人
科学技術振興機構
Japan Science and Technology Agency

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Loughborough University

IGES SDGs Aspiration to Action

UKRI Natural Environment Research Council

Land use change scenarios

“Trend”

Follows the Middle of the Road shared socioeconomic pathway (SSP2), which is a pathway of socio-economic trend does not shift markedly from historical patterns, with relatively low commitment to achieve development goals

“Expansion”

Follows the fossil-fueled development shared socio-economic pathway (**SSP5**), where people exploit abundant fossil fuel resources, the global economy grows at the highest speed.

“Sustainability”

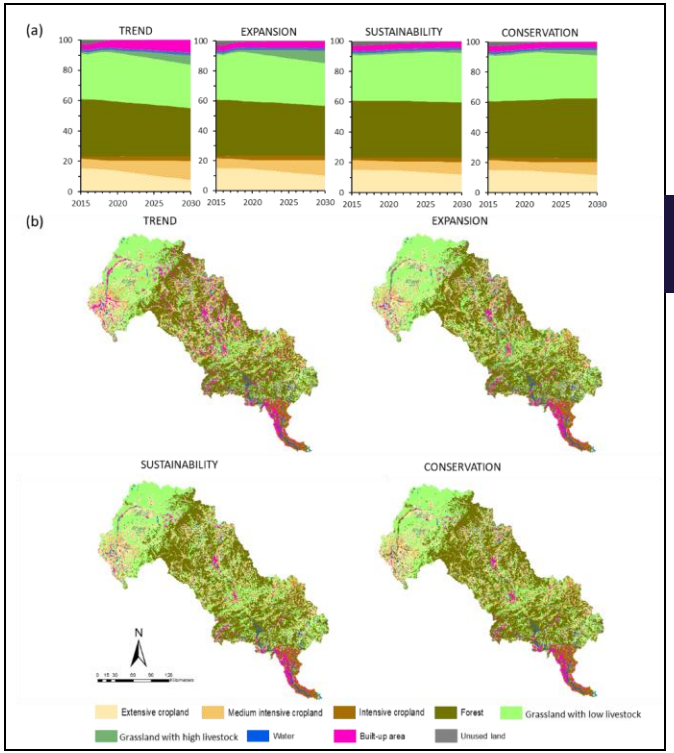
Follows the Sustainable shared socioeconomic pathway (SSP1)

“National planning on medium- and long-term food security” (2008–2020) and “General Land Use Planning in Hebei Province (2006–2020)”

“Conservation”

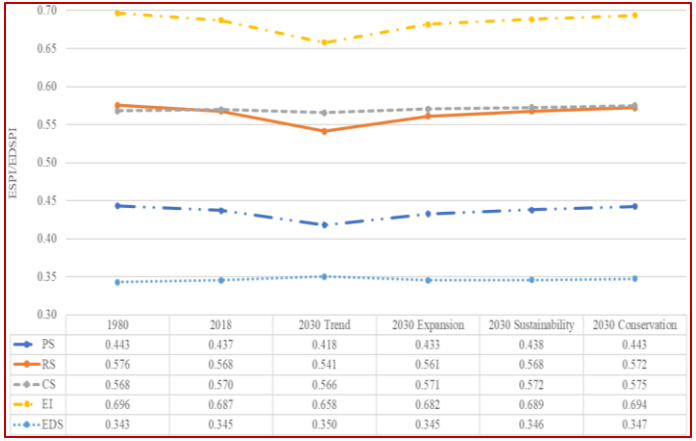
Sustainability scenario was used as a baseline, extended by the implementation of the ecological restoration and protection policy targets

A series of policies promoting afforestation have been implemented for biodiversity conservation and sand fixation.



Land use change from 2015 to 2030 in LRB under different scenarios. (a) Quantitative change. (b) Land system maps in 2030

Ecosystem services



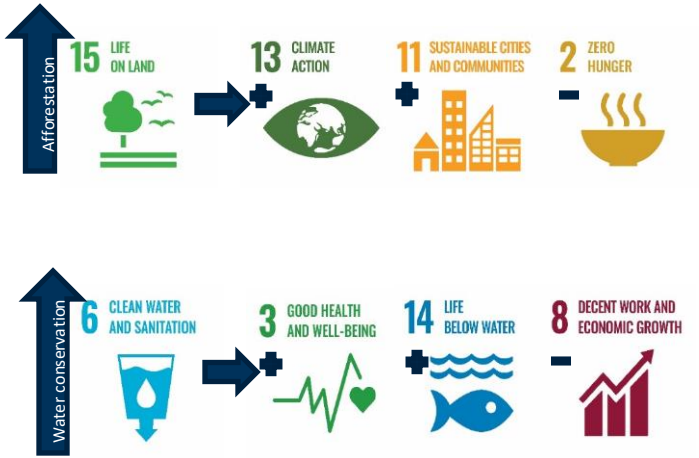
	1980	2018	2030 Trend	2030 Expansion	2030 Sustainability	2030 Conservation
PS	0.443	0.437	0.418	0.433	0.438	0.443
RS	0.576	0.568	0.541	0.561	0.568	0.572
CS	0.568	0.570	0.566	0.571	0.572	0.575
EI	0.696	0.687	0.658	0.682	0.689	0.694
EDS	0.343	0.345	0.350	0.345	0.346	0.347

ESPI of PS ($ESPI_{PS}$), RS ($ESPI_{RS}$), CS ($ESPI_{CS}$), EI ($ESPI_{EI}$) and EDSPI dynamic under past (1980), current (2018) and future (2030) land use

The ESPI of all the ESs declined from 1980 to 2018 and will continue to decline until 2030 without sustainable and conservational development strategy (i.e. *Sustainability* and *Conservation* scenarios).

Compared with the EDSPI in 1980, the EDSPI under all future scenarios in 2030 are projected to increase.

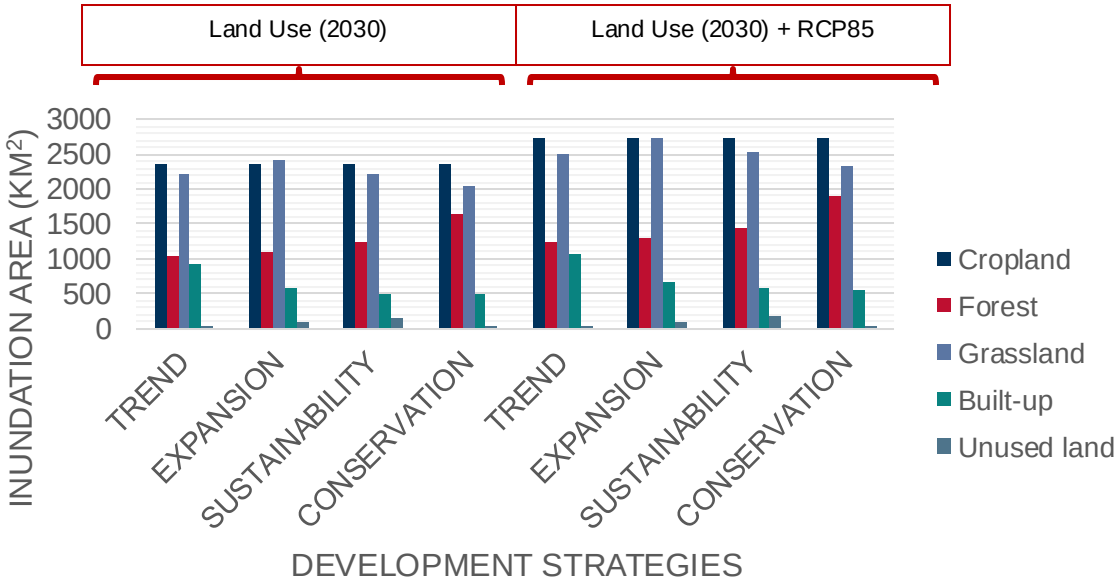
SDG synergies and tradeoffs



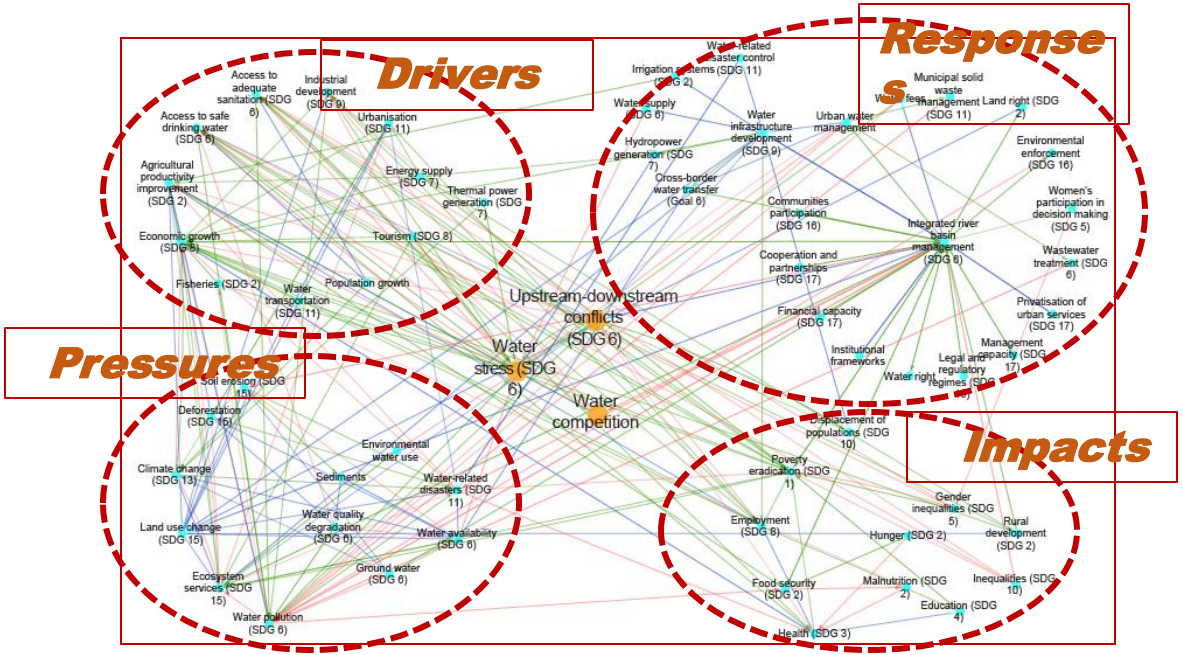
Flood risk assessment under different development strategies

A new framework based on a high-performance hydrodynamic flood model is developed to evaluate flood risk in LRB, considering the impacts from

- Land use change under different development strategies:
  - Trend; Expansion; Sustainability; Conservation
- Climate change:
  - RCP45; RCP85
- Key infrastructure development:
  - Shuangfengsi reservoir and Panjiakou reservoir



Qualitative assessment of the SDG interlinkages at the river-basin level based on expert judgement

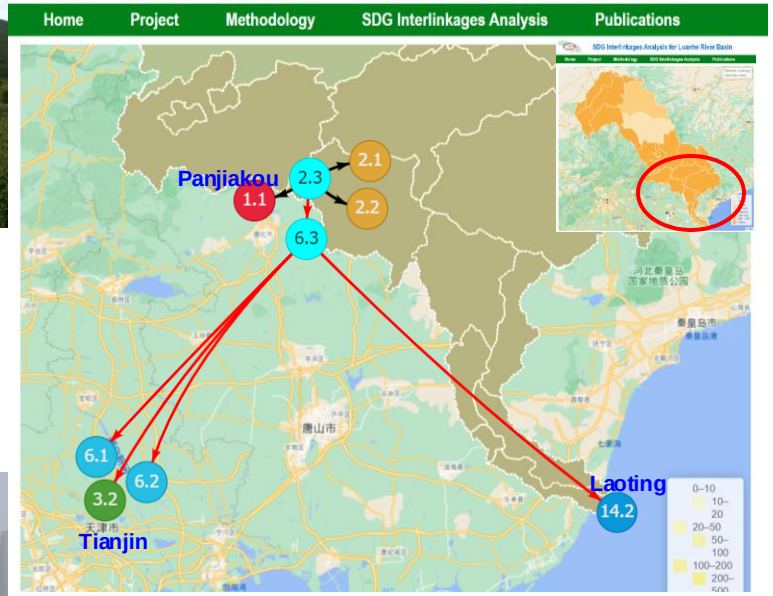


Colored edges:

- Positive linkage;
- Negative linkage;
- Either positive or negative.

Zhou et al., *Sustainability Science*
https://doi.org/10.1007/s11625-021-01065-z

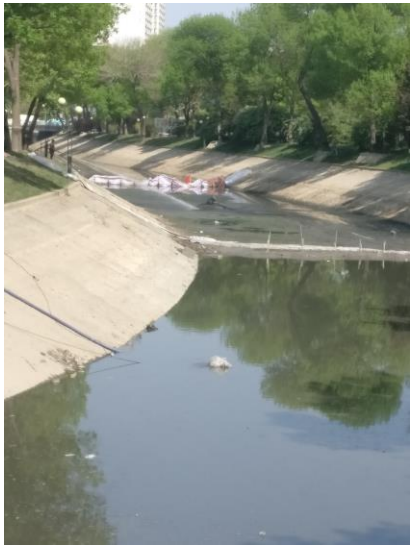
Downstream impacts of cage aquaculture in the midstream reservoirs, Luanhe River basin



- Midstream activity: Cage aquaculture in Panjiakou Reservoir (2.3)
- Midstream benefits: agriculture production (**2.3**), livelihood of small holders (**1.1**), food supply (**2.1**), nutrition (**2.2**), etc.
- Downstream impacts: water pollution (**6.3**), access to safe drinking water (**6.1**, **6.2**), health impacts (**3.2**), marine pollution (**14.2**), etc.

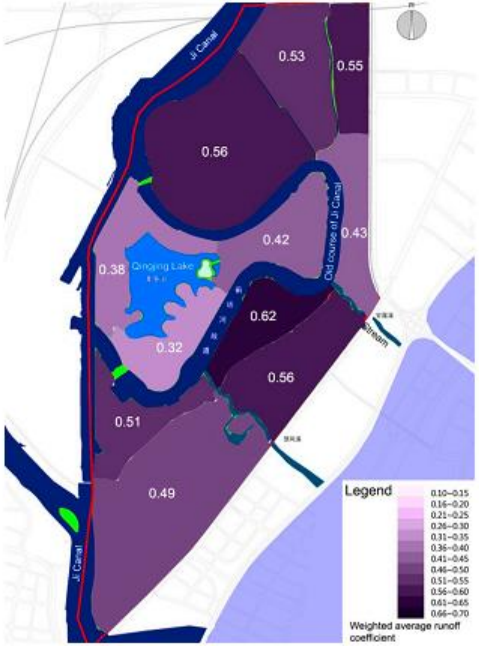
Source: " Luanhe Living Lab" river basin SDG tool. https://sdginterlinkages.iges.jp/luanhe/SDGInterlinkagesAnalysis.html

Downstream actions: designing the ‘sponge city’



Downstream actions: designing the ‘sponge city’

Figure 6. The planned surface water system in Tianjin Eco-City.

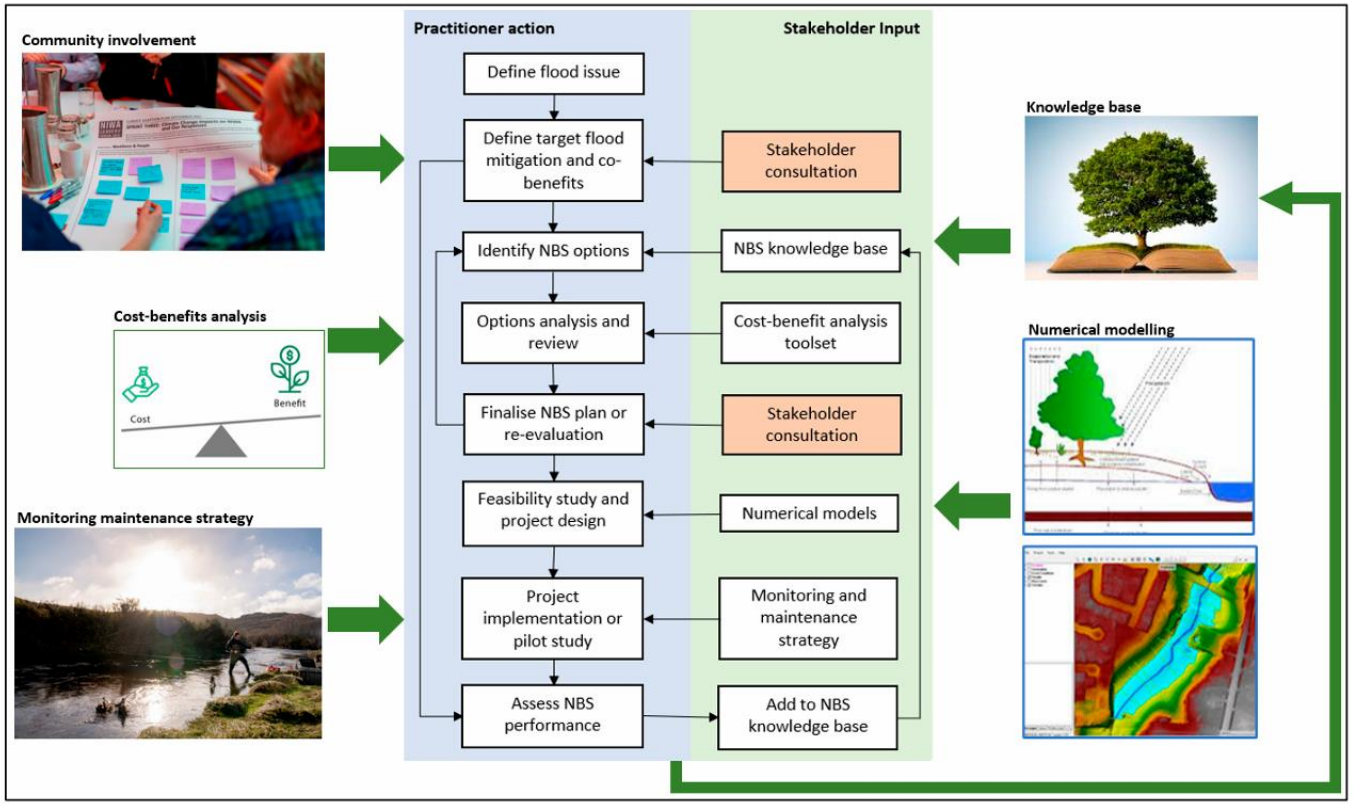


Weighted average runoff coefficient of each block in Tianjin Eco-City.

- to reduce flood risk, ensure connectivity between the pond and canal (creates additional storage capacity)

Zhou et al, 2015, doi:10.3390/su71013378

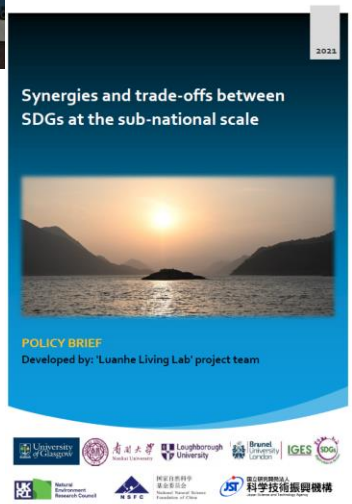
Downstream actions: designing the ‘sponge city’



Griffiths et al, 2024, *Water,* doi:10.3390/w16192802

Community engagement

- Engage at all scales: individuals to governments
- Active listening
- Participate, train and learn



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Conclusions

- Climate change requires innovative, scalable and effective responses
- The physical, biological, economic and social environments overlap and all need to be considered
- Scale depends on what the problem is: work at scales that control the natural environment (river catchments; coastal cells)
- Recognise synergies and trade-offs: be open about these and do not exaggerate the impact of interventions
- Consult and inform at all scales