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Climate-Forest-Water-People relations from tree to earth system scales:

A. Biophysical Basis of Climate-Forest-Water-People relations

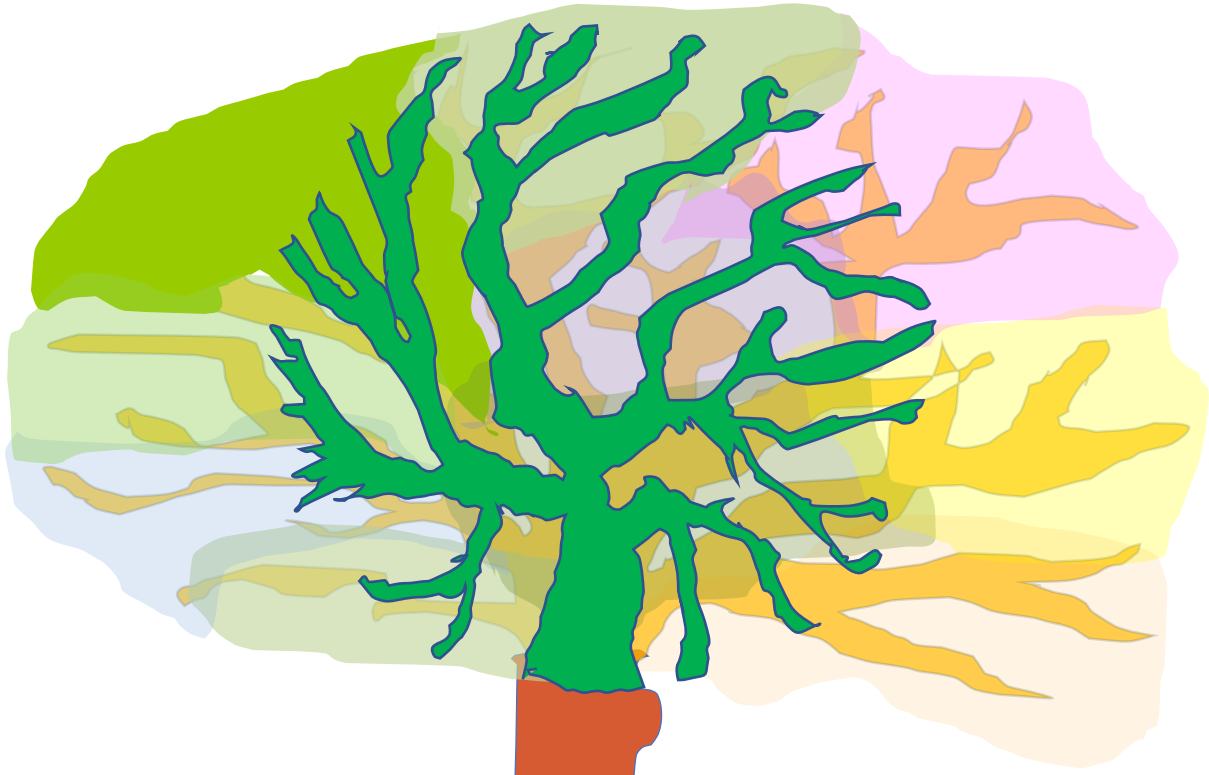
Meine van Noordwijk

World Agroforestry 40

WAGENINGEN UR
For quality of life

Brawijaya University
Research Group of
Tropical Agroforestry

B. Clumsy Governance of a Wicked Nexus



Now: **Climate-Forest-Water-People**

Monday: Forests and Climate Change

Tuesday: Biodiversity, Ecosystem Services

Wednesday: Forests and People

Friday: Production Forests

Now: **Climate-Forest-Water-People**

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New data show that atmospheric moisture recycling ratios are higher than we thought a few years ago, downwind impacts may…

Science

People care about water, why can't climate policy be rooted in local knowledge & concerns?

Policy

So forest-climate debates need to start with water so that people understand and align

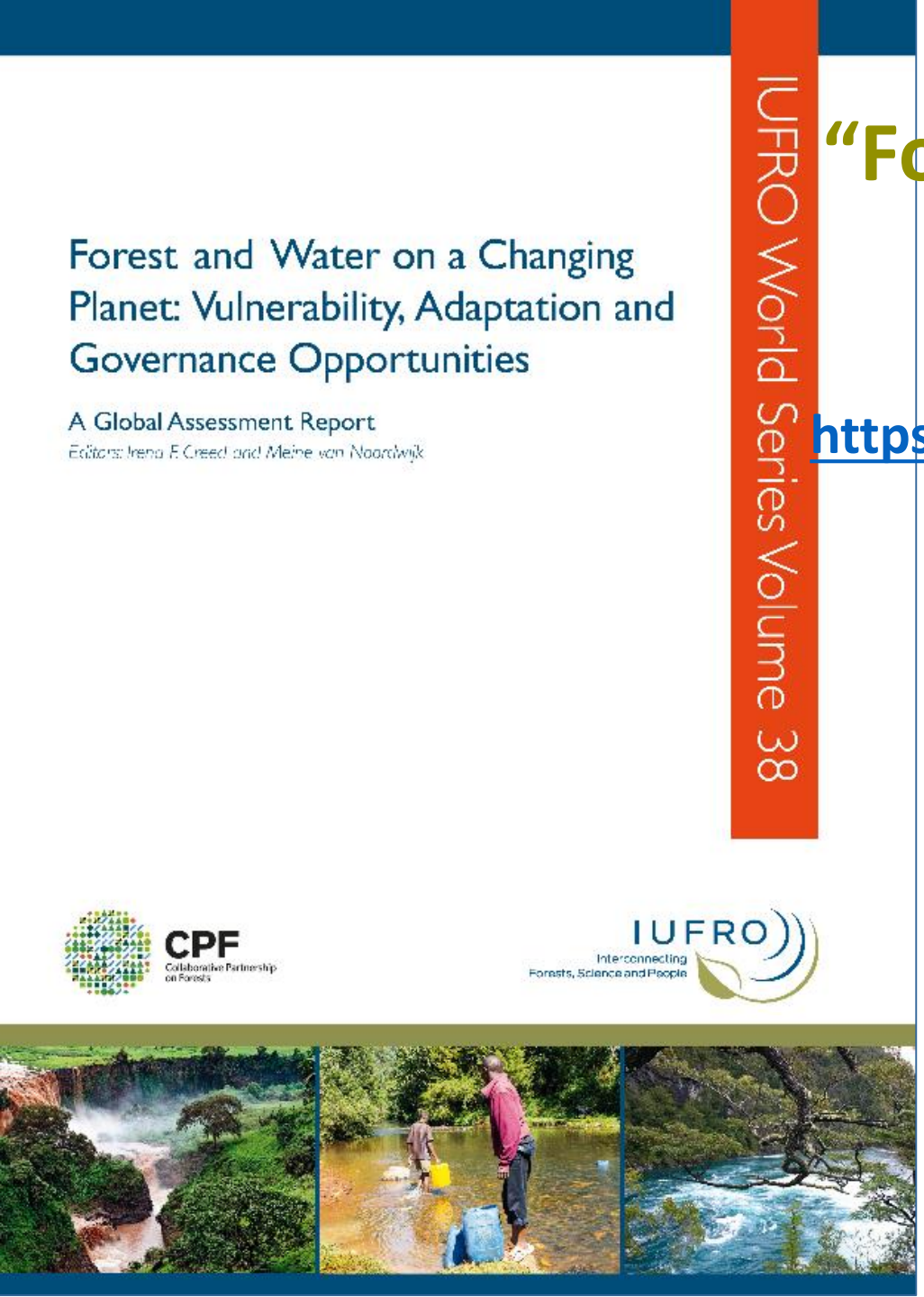
Empty seats for other stakeholders…

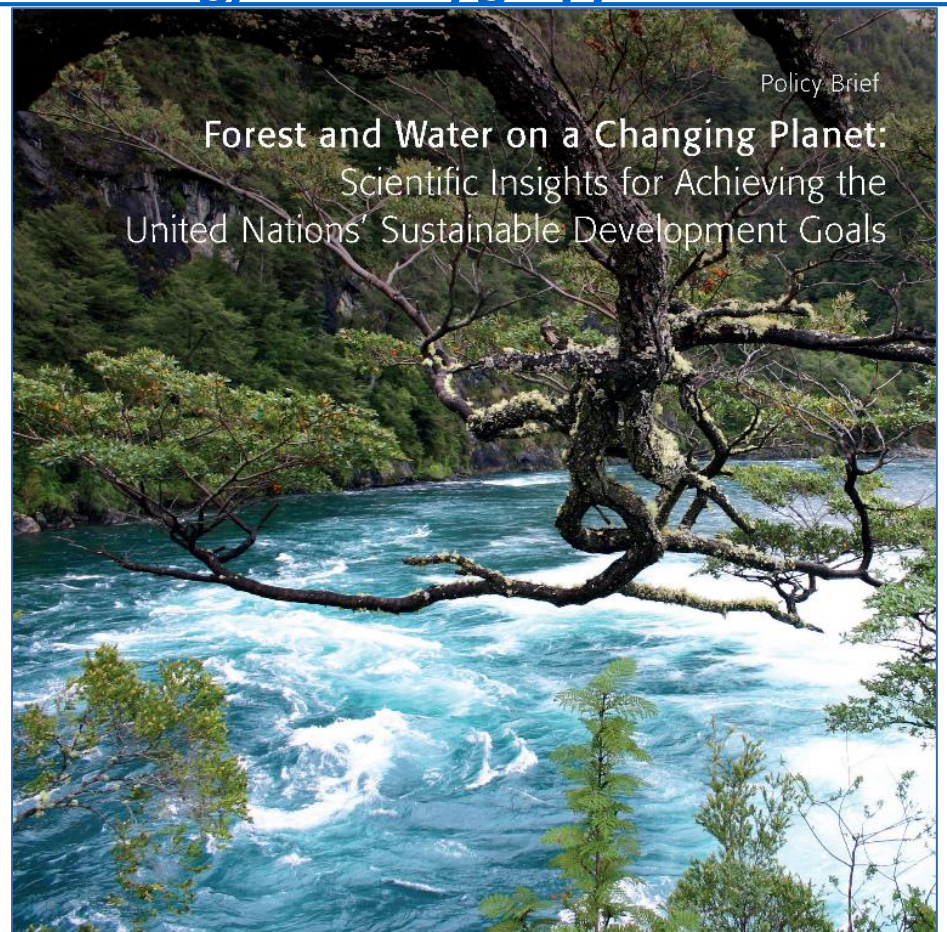
GFEP

“Forest and Water on a Changing Planet”

The report and policy brief are available at the official website of GFEP on Forests and Water

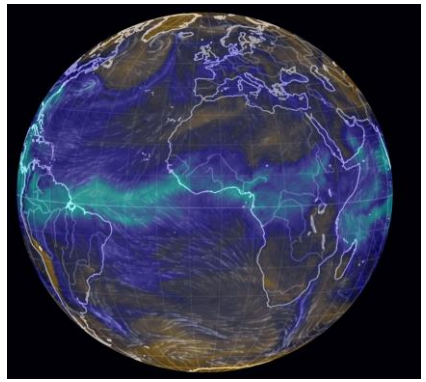
https://www.iufro.org/science/gfep/forests-and-water-panel/





Global climate dependence and influence of forest-water relations via carbon cycle

Upwind dependency



and downwind effect in precipitationshed

Missing link in governance

SDG13

SDG15,16 Forest governance

SDG1,15

people

Climate

Governance

Forest

People

Water

Forest – water relations

Streamflow

SDG2,3,6,7,9

SDG6,15,16 Water governance

“More trees, less water”

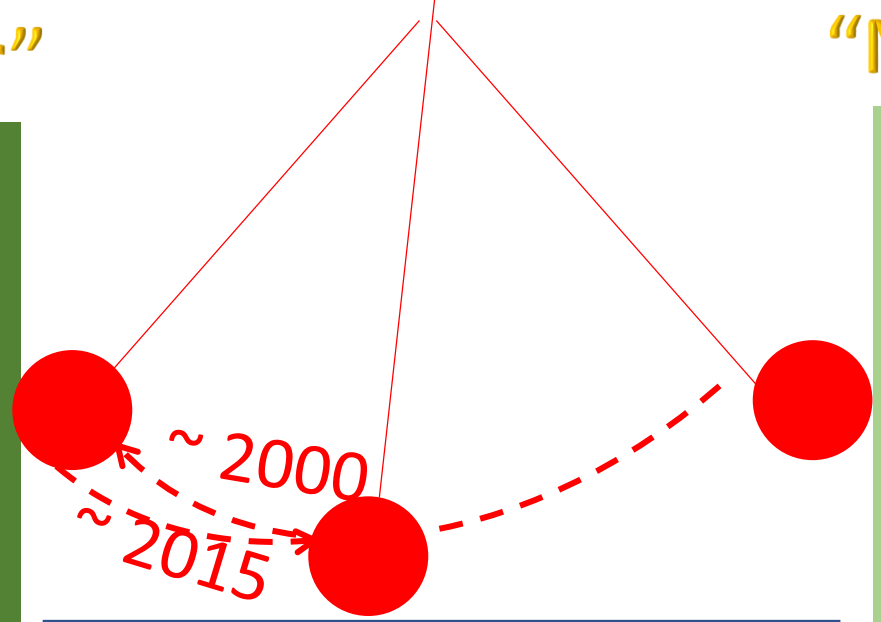
“No forest, no water”

Blue vs green water tradeoff

Tree water use competes with streamflow, hydrological functions depend on scale

Paradise lost

All problems of too much or too little water are caused by deforestation, tree planting is the universal remedy



Catchment hydrology

Full hydrological cycle

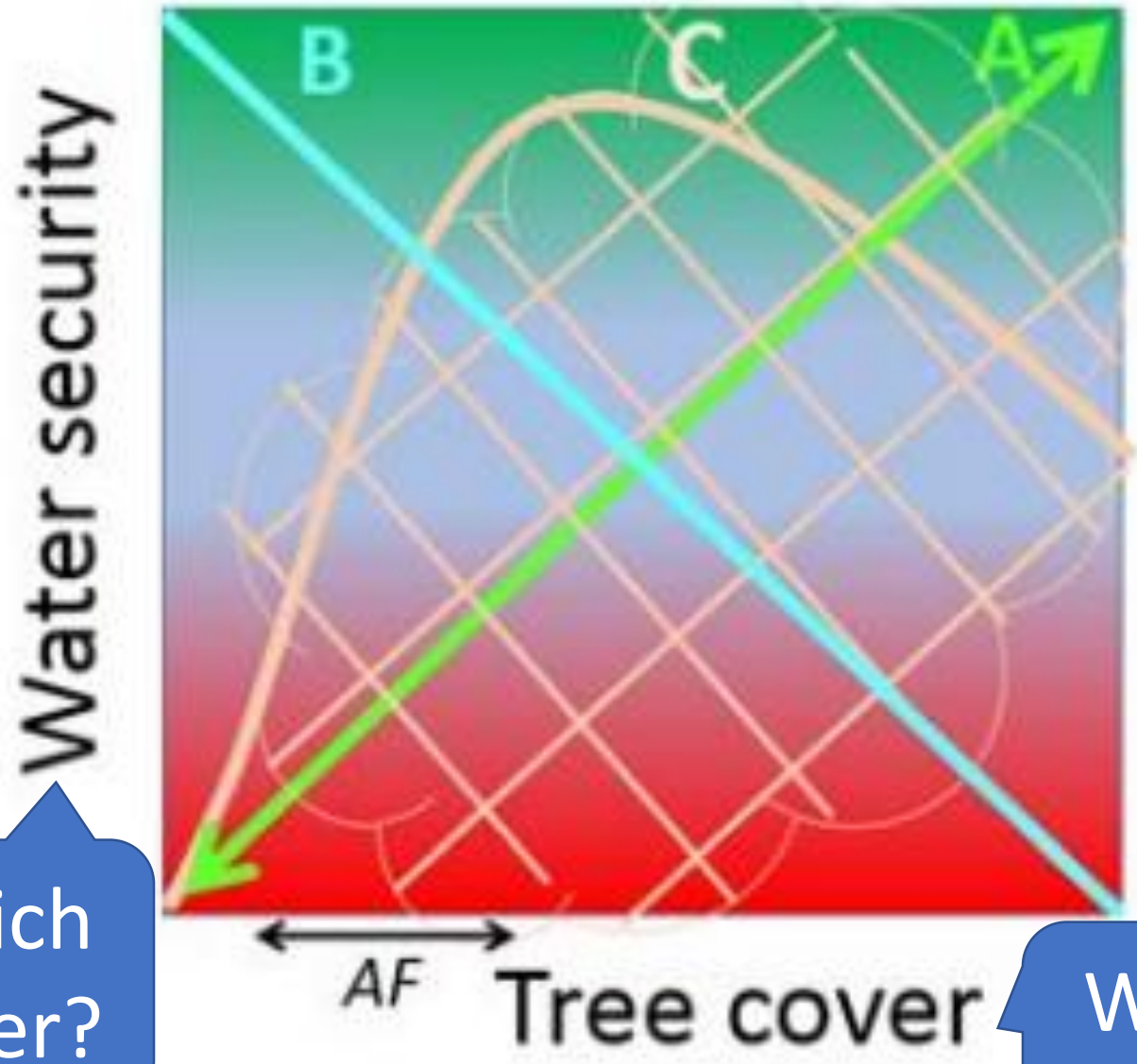
Forests and fast-growing trees use (recycle) more water (10-20% of PET) than other vegetation

- Δ (seasonal) Leaf Area Index
- Δ Surface litter, sealing
- Δ Rooting depth
- Δ Macroporo-sity formation
- Δ Rainfall

“The combined effects of trees depend on location”

Atmospheric moisture recycling,
Tele-coupled hydroclimates,
Scale- dependent buffering

Three competing paradigms:



A. “No forest, no water”

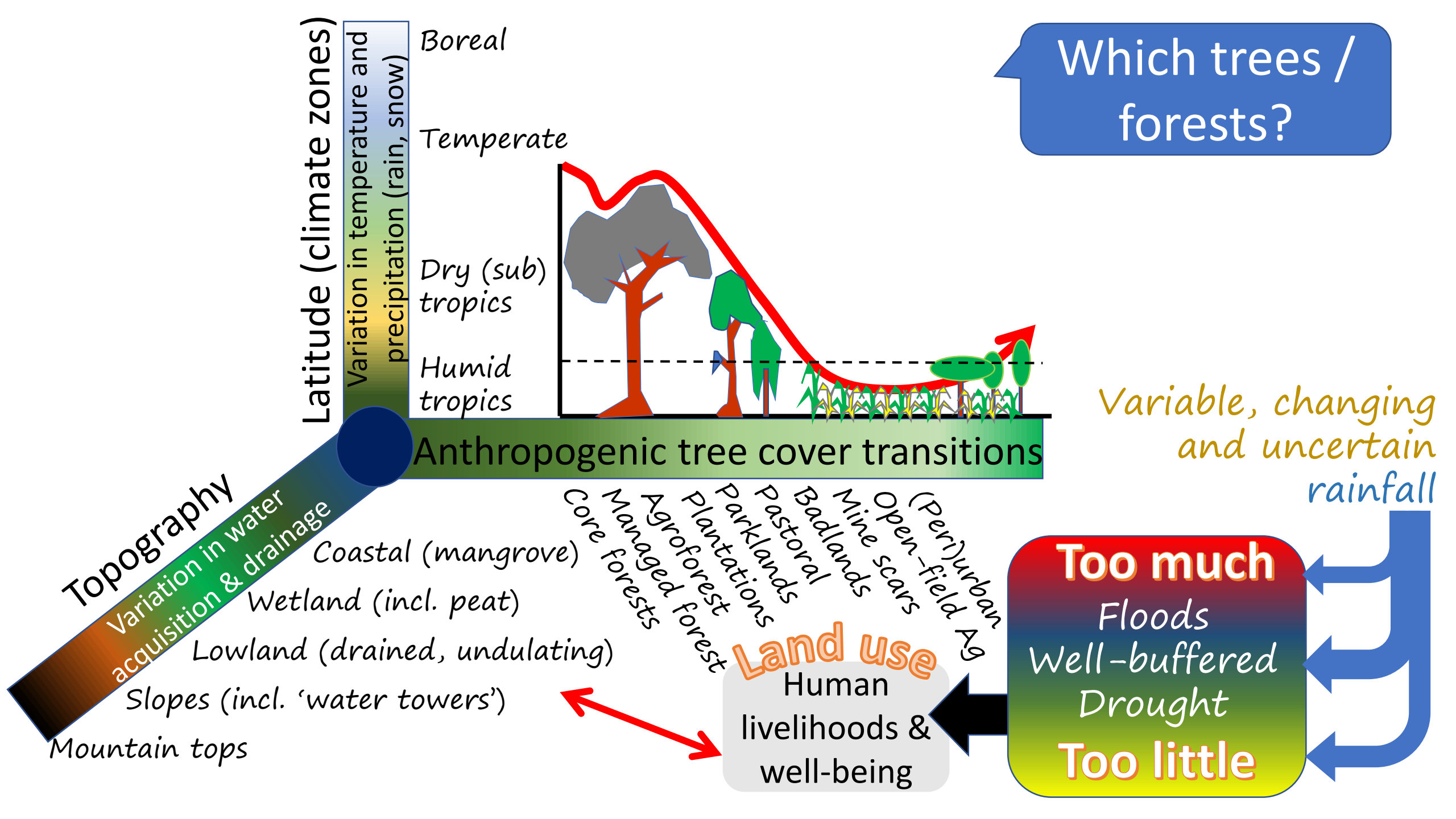
B. “More trees, less water”

C. “The combined effects of trees depend on location”

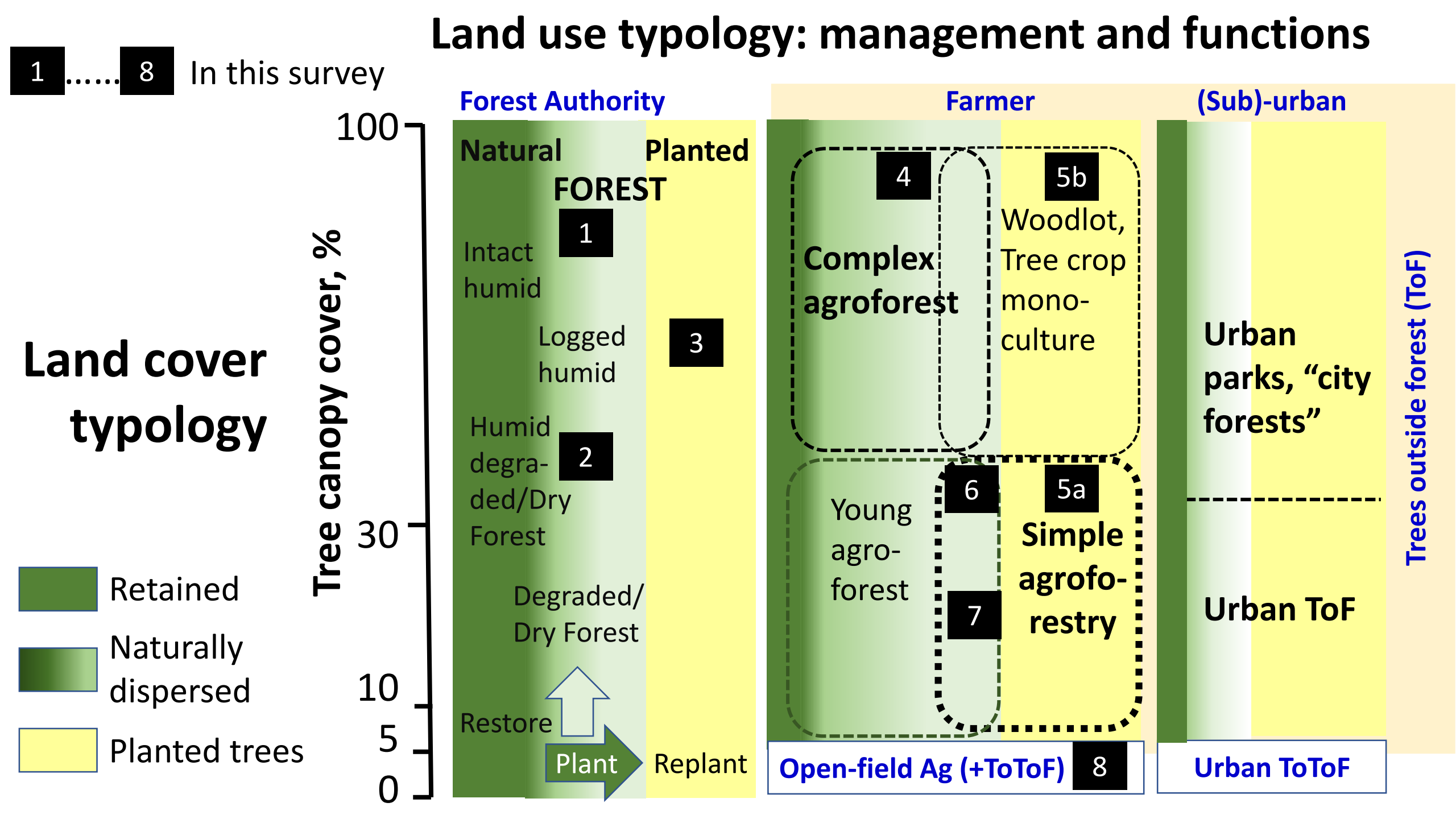
Which water?

Which forests?

http://www.worldagroforestry.org/trees-on-farms


Which trees / forests?
Latitude (climate zones)
Variation in temperature and precipitation (rain, snow)
Boreal
Temperate
Dry (sub) tropics
Humid tropics
Anthropogenic tree cover transitions
Topography
Variation in water acquisition & drainage
Coastal (mangrove)
Wetland (incl. peat)
Lowland (drained, undulating)
Slopes (incl. 'water towers')
Mountain tops
Core forests
Managed forest
Agroforest
Plantations
Parklands
Pastoral
Badlands
Mine scars
Open-field Ag
(Peri)urban
Land use
Human livelihoods & well-being
Variable, changing and uncertain rainfall
Too much
Floods
Well-buffered
Drought
Too little

Land use typology: management and functions



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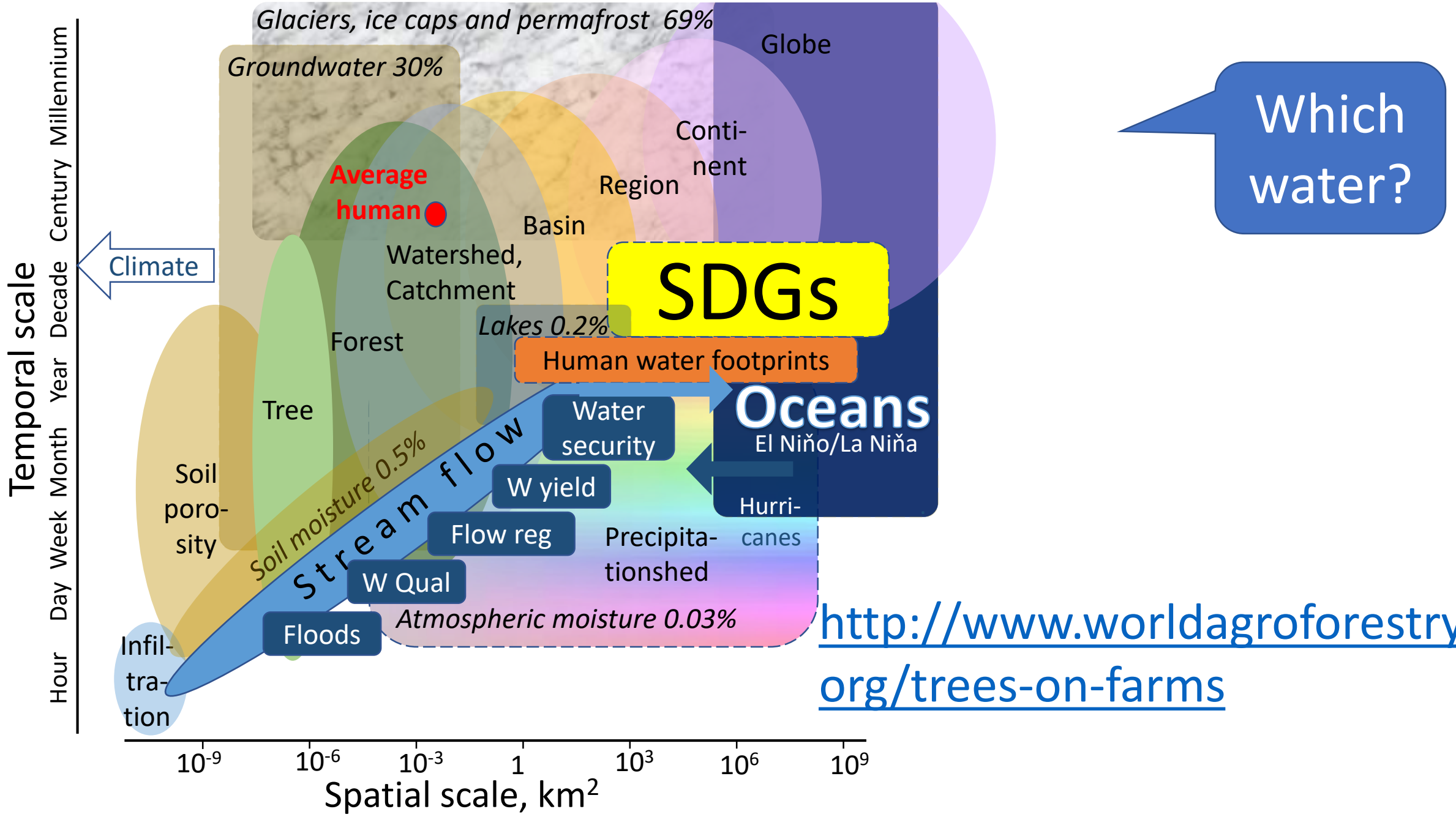


Which water?

http://www.worldagroforestry.org/trees-on-farms

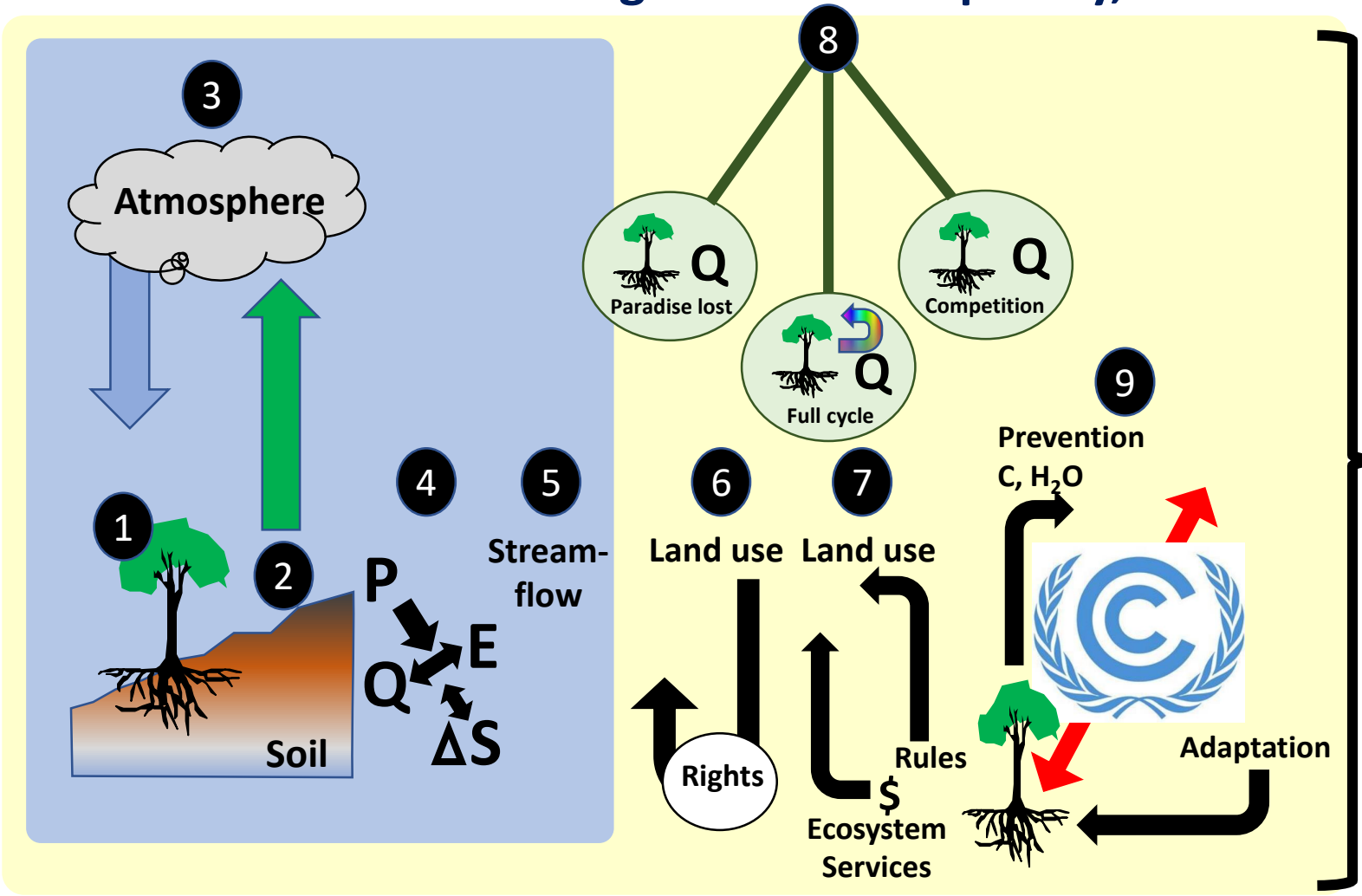
B.W. Abbott *et al.* 2019. Human domination of the global water cycle absent from depictions and perceptions. *Nature Geoscience* **12**, 533–540

STOCKS a) Major pools in the global hydrological cycle expressed in 10^3 km^3. For panels a and b, uncertainty is expressed in ± % based on the range of recent estimates.

FLOWS b) Major fluxes in the global hydrological cycle in 10^3 km^3 yr^{-1}. Human water appropriation is separated into Green , Blue , and Gray , water use.

http://www.worldagroforestry.org/trees-on-farms

The report reviews recent science for 10 nested scales, with increasing levels of complexity, to answer the three questions.

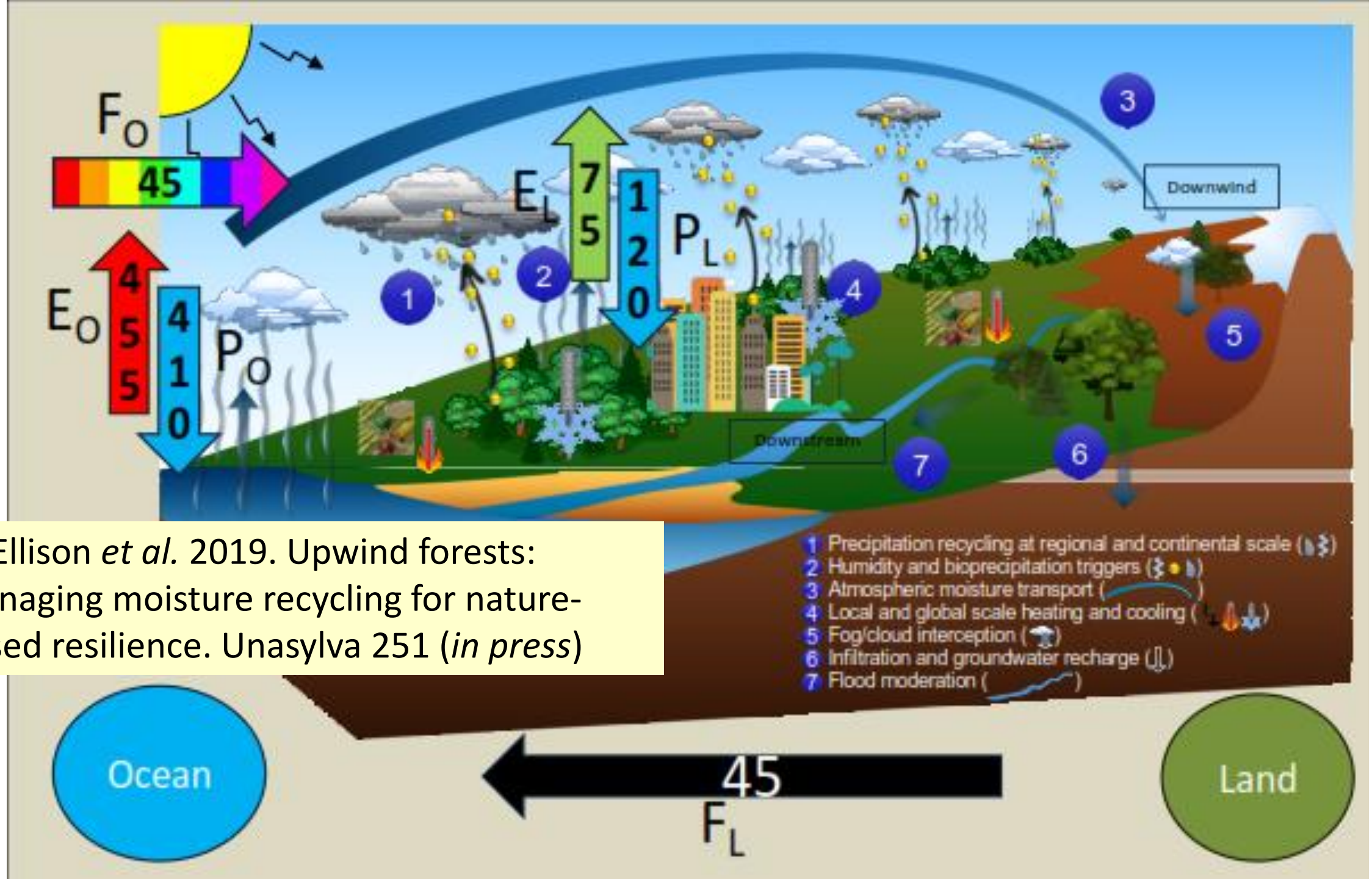


"Do forests matter?"

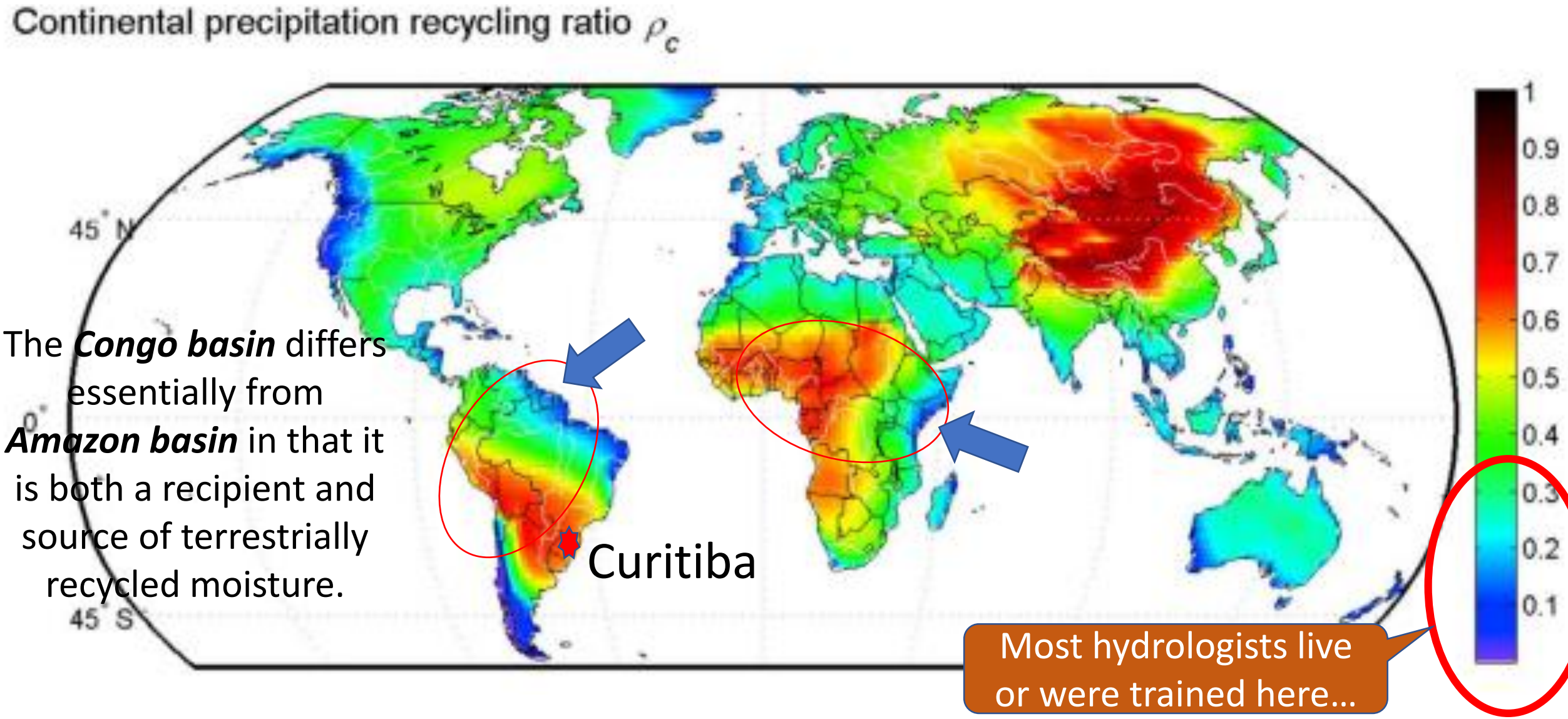
"Who is responsible and what should be done?"

"How can progress be made and measured?"

Forests modulate *supply* of blue water, but also influence *demand* for green water, and this implies recycling of atmospheric moisture.



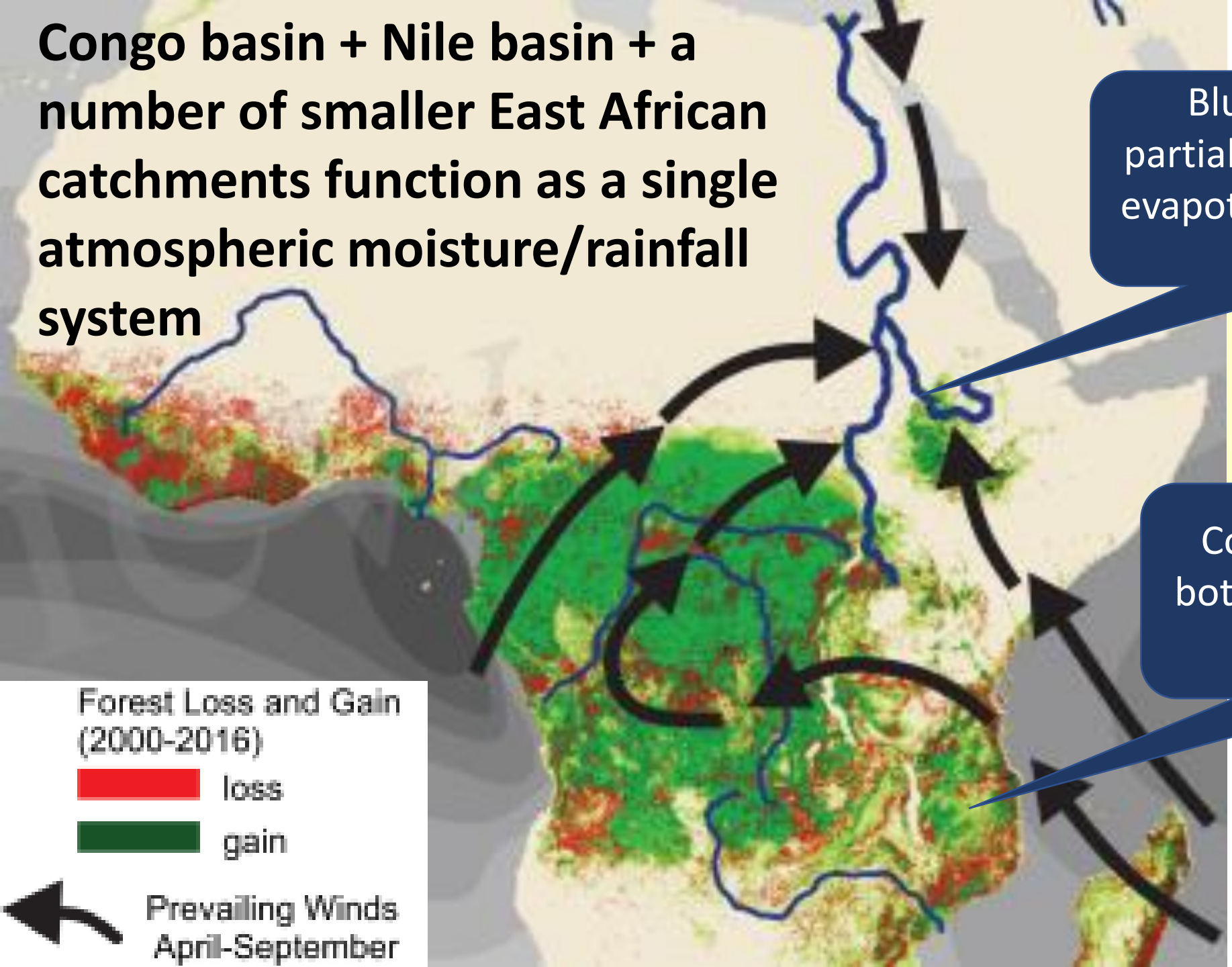
D. Ellison *et al.* 2019. Upwind forests: managing moisture recycling for nature-based resilience. Unasylva 251 (*in press*)



The ***Congo basin*** differs essentially from ***Amazon basin*** in that it is both a recipient and source of terrestrially recycled moisture.

precipitation recycling ratio or share of terrestrial evapotranspiration in precipitation (van der Ent et al., 2010)

Congo basin + Nile basin + a number of smaller East African catchments function as a single atmospheric moisture/rainfall system



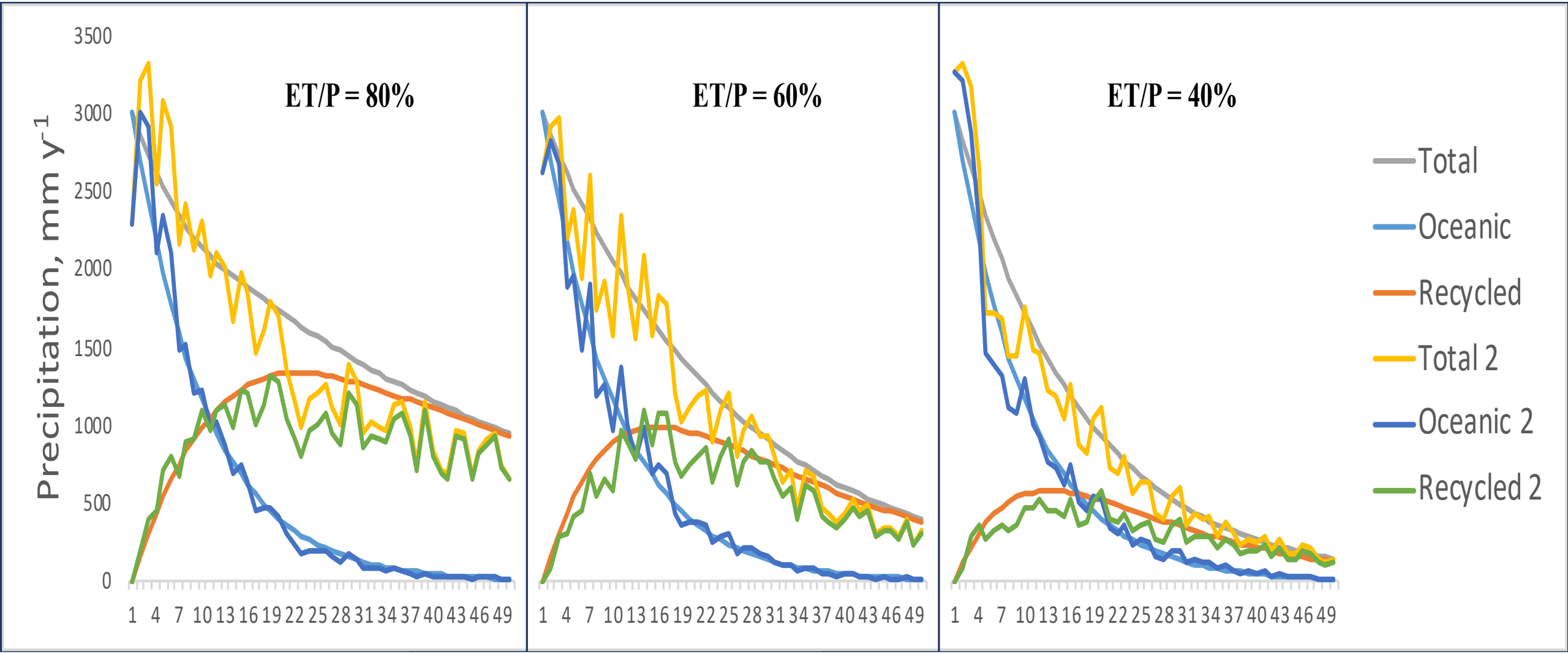
Blue Nile river flow is partially dependent on Sudd evapotranspiration, linked to WhiteNile

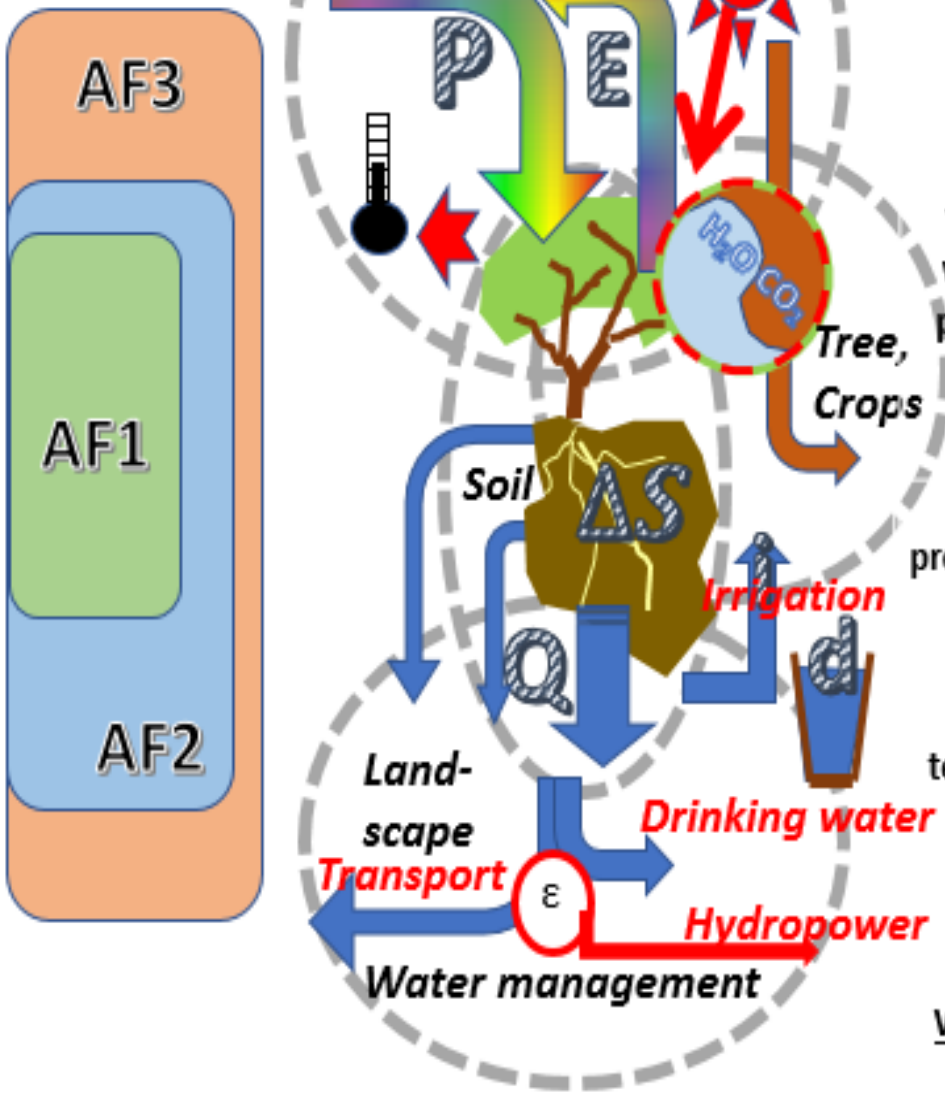
S.G. Gebrehiwot et al. 2018. The Nile Basin waters and the West African rainforest: Re-thinking the boundaries
doi.org/10.1002/wat2.1317

Congo basin receives rain both from the East and from the West

I.F. Creed *et al.* 2019. Managing Forests for Both Downstream and Downwind Water. Frontiers,

A simple model of an ocean-inland gradient: **reducing evapotranspiration (e.g. forest loss) will substaintially reduce inland rainfall**





Precipitation modifiers, biological rainfall generation

Water yield (WY): Annual blue-water yield versus green-water use (primary production, cooling + rainbow water)

Water use (WU): products in demand?

Water flow regime (WF): Flow persistence of blue water

Sediment load (WS): Controlling sediment load of streams and rivers

Water quality (WQ)

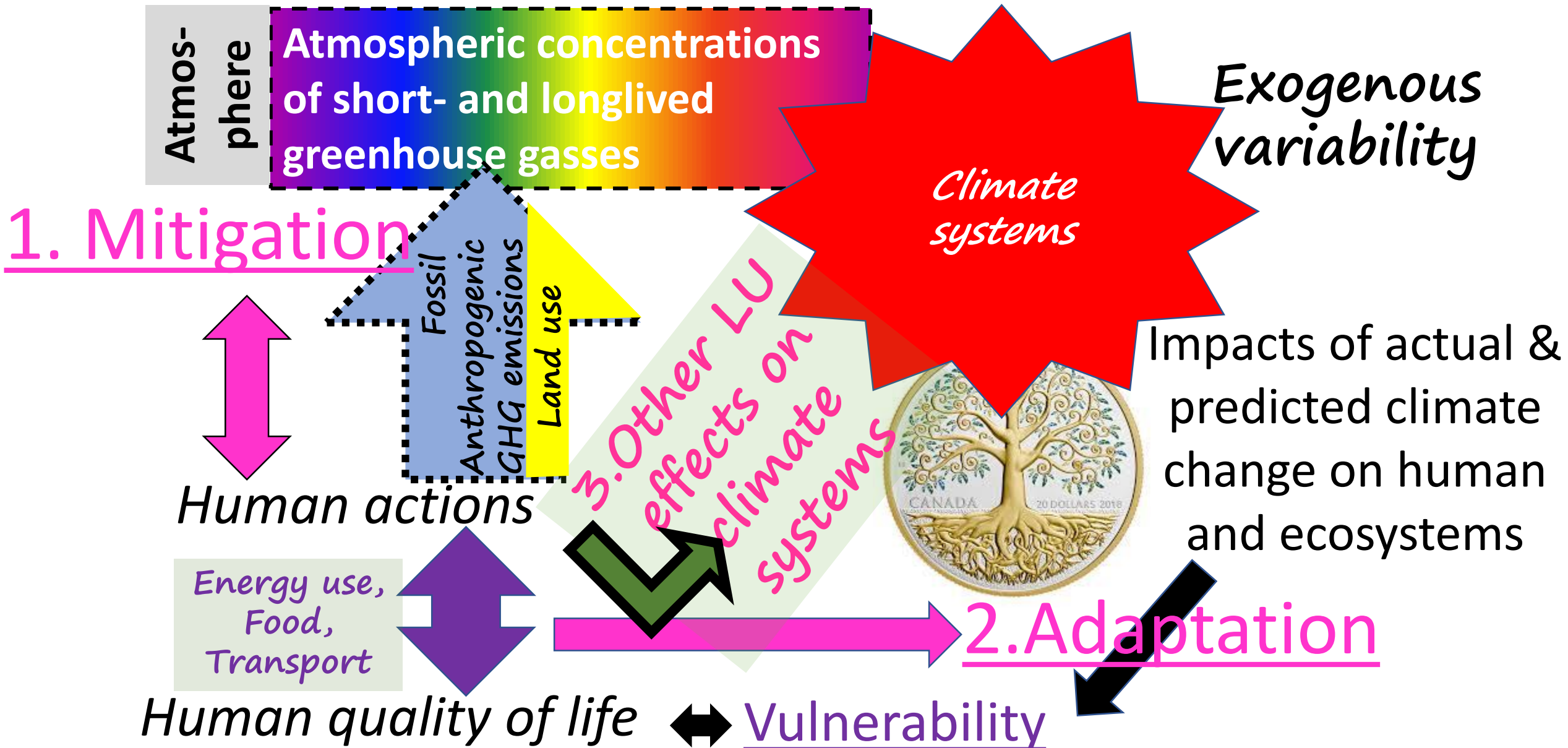
- W9 Rainfall triggering
- W7 Modified microclimate
- W0 Land cover, land use rights
- W1 Transmission
- W2 Flow buffering
- W3 Infiltration
- W5 Slope stability
- W6 Sedimentation/Erosion
- W8 Coastal protection
- W4 Quality for drinking water, aquatic life, a.o.

Prototype PES-worthy activities

WY1: Restoring vegetation-level water use to natural ET to maintain ecological flows & aquatic life,
WY2: Replacing fast-tree plantations with low-ET species of high utility,
WY3: Maintaining green water use as contribution to atmospheric recycling;
WF4: Increasing deep rooted trees; promoting litter layers and agricultural practices that increase infiltration and soil water storage,
WF5: Modifying operating rules for reservoirs and hydropower schemes;
WS6: Enhancing sediment filter strips in fields and across landscape matrix,
WS7: Protecting river banks, riparian zones and landslide-prone slopes;
WQ8: Protecting springs, riparian zones and sources of domestic water
WQ9: Promoting multifunctional shade tree management for reducing pesticide and fertilizer uses,
WQ10: Waste-water treatment to match biological recovery from (organic) pollutants.

AF-concepts → Eco-hydrological system structure & functions → SDGs → Metrics → Intervention options

The third side of the climate change coin



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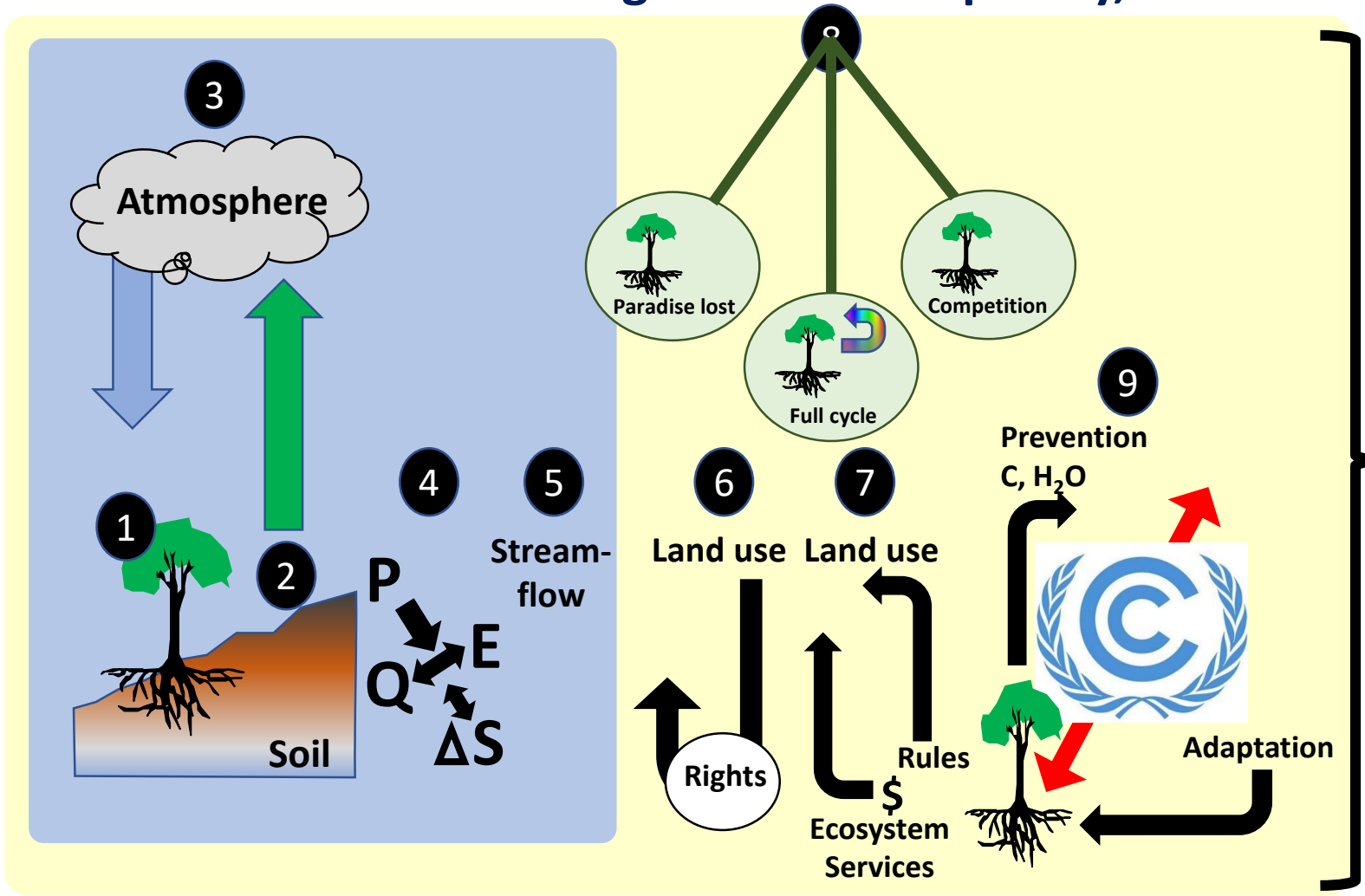

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- Trees and forests link local to regional and global water cycles through their modification of infiltration, water use, hydraulic redistribution of soil water and roles in rainfall recycling.
- In current understanding of forest (and tree) water relations in public discourse three paradigms clash:
  - ‘**paradise lost**’, emphasizing multitude of local benefits of tree cover,
  - ‘blue-green water competition’, central to catchment hydrology and **downstream** impacts of large-scale tree plantations,
  - ‘full hydrological cycle’, clarifying **downwind** climate impacts.
- The forest-climate debate and policies can be re-anchored in water relations, so that local concerns and actions align with global needs.

frontiers

Frontiers in Forests and Global Change

Managing Forests for Both Downstream and Downwind Water

Irena F. Creed[1*], Julia J. Jones[2], Emma Archer Van Garderen[3], Marius Claassen[3], David Ellison[4, 5], Steven G. McNulty[6], Meine Van Noordwijk[7, 8], Bhaskar Vira[9], Xiaohua Wei[10], Kevin Bishop[4], Juan A. Blanco[11], Mark Gush[12], Dipak Gyawali[13], Esteban Jobbágy[14], Antonio Lara[15, 16], Christian Little[16, 17], Julia Martin-Ortega[18], Aditi Mukherji[19], Daniel Murdiyarso[20, 21], Paola Ovando Pol[22], Caroline A. Sullivan[23], Jianchu Xu[24]

Now, over to the policy perspective on this paradigm shift…