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

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

Meine van Noordwijk

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

Monday: Forests and Climate Change
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New data show that atmospheric moisture recycling ratios are higher than we thought a few years ago, downwind impacts may...

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

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

Science  Policy

Empty seats for other stakeholders...
“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

Climate

Forest

Water

Governance

People

Forest – water relations

Streamflow

SDG15,16 Forest governance

SDG1,15

SDG2,3,6,7,9

SDG6,15,16 Water governance
“More trees, less water”

Blue vs green water tradeoff
Tree water use competes with streamflow, hydrological functions depend on scale

“No forest, no water”

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

“The combined effects of trees depend on location”

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

Full hydrological cycle

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

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 forests?

Which water?

http://www.worldagroforestry.org/trees-on-farms
Latitude (climate zones)

- Boreal
- Temperate
- Dry (sub) tropics
- Humid tropics

Topography

- Variation in water acquisition & drainage
- Coastal (mangrove)
- Wetland (incl. peat)
- Lowland (drained, undulating)
- Slopes (incl. ‘water towers’)
- Mountain tops

Anthropogenic tree cover transitions

- Floods
- Well-buffered
- Drought

Variable, changing and uncertain rainfall

Which trees / forests?

Human livelihoods & well-being

Too much
- Agroforests
- Managed Forest
- Pastoral
- Badlands
- Mine scars
- Open-field Ag

Too little

- Core forests
- Forests
Land cover typology

Tree canopy cover, %

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

- Retained
- Naturally dispersed
- Planted trees

Forest Authority

Naturally dispersed
Retained Planted trees

Intact humid
Logged humid
Humid degraded/Dry Forest
Degraded/Dry Forest

Restore
Plant
Replant

Farmer

Complex agroforest
Woodlot, Tree crop monoculture

Young agroforest
Simple agroforestry

Open-field Ag (+ToToF)

Urban parks, “city forests”
Trees outside forest (ToF)

(Sub)-urban

In this survey

Forest Authority

1. Natural FOREST
2. Humid degraded/Dry Forest
3. Logged humid
4. Complex agroforest
5a. Simple agroforestry
5b. Woodlot, Tree crop monoculture
6. Young agroforest
7. Open-field Ag (+ToToF)
8. Urban ToToF
Which forests?

Which water?

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

**STOCKS a)** Major pools in the global hydrological cycle expressed in $10^3 \text{ km}^3$. 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 $10^3 \text{ km}^3 \text{ yr}^{-1}$. Human water appropriation is separated into Green , Blue , and Gray , water use.
Which forests?

Which water?

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.

1. “Do forests matter?”
2. “Who is responsible and what should be done?”
3. “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.
precipitation recycling ratio or share of terrestrial evapotranspiration in precipitation (van der Ent et al., 2010)

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

Most hydrologists live or were trained here...

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 White Nile.

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


A simple model of an ocean-inland gradient: reducing evapotranspiration (e.g. forest loss) will substantially reduce inland rainfall.
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,
WF6: Enhancing sediment filter strips in fields and across landscape matrix,
WF7: Protecting river banks, riparian zones and landslide-prone slopes,
WF8: Protecting springs, riparian zones and sources of domestic water,
WF9: Promoting multifunctional shade tree management for reducing pesticide and fertilizer uses,
WF10: Waste-water treatment to match biological recovery from (organic) pollutants.
The third side of the climate change coin

1. Mitigation
   - Atmospheric concentrations of short- and long-lived greenhouse gases
   - Fossil
   - Anthropogenic GHG emissions
   - Land use

Human actions

Energy use, Food, Transport

Human quality of life ↔ Vulnerability

5. Other LU effects on climate systems

Climate systems

Exogenous variability

Impacts of actual & predicted climate change on human and ecosystems

2. Adaptation
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.
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.
Managing Forests for Both Downstream and Downwind Water

Irena F. Creed, Julia J. Jones, Emma Archer Van Garderen, Marius Claassen, David Ellison, Steven G. McNulty, Meine Van Noordwijk, Bhaskar Vira, Xiaohua Wei, Kevin Bishop, Juan A. Blanco, Mark Gush, Dipak Gyawali, Esteban Jobbágy, Antonio Lara, Christian Little, Julia Martin-Ortega, Aditi Mukherji, Daniel Murdiyarso, Paola Ovando Pol, Caroline A. Sullivan, Jianchu Xu
Now, over to the policy perspective on this paradigm shift...