

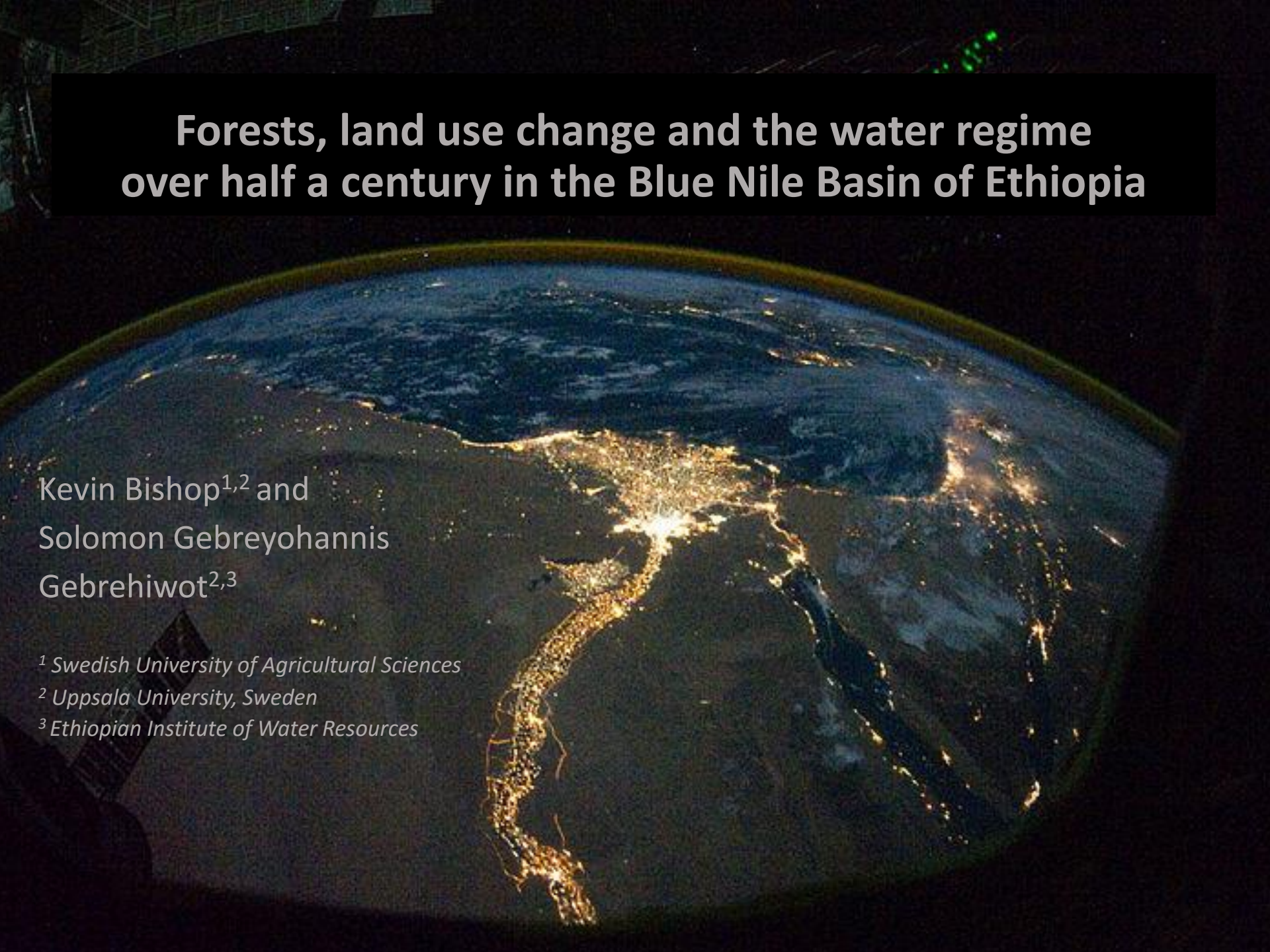
Forests, land use change and the water regime over half a century in the Blue Nile Basin of Ethiopia

Kevin Bishop^{1,2} and
Solomon Gebreyohannis
Gebrehiwot^{2,3}

¹ *Swedish University of Agricultural Sciences*

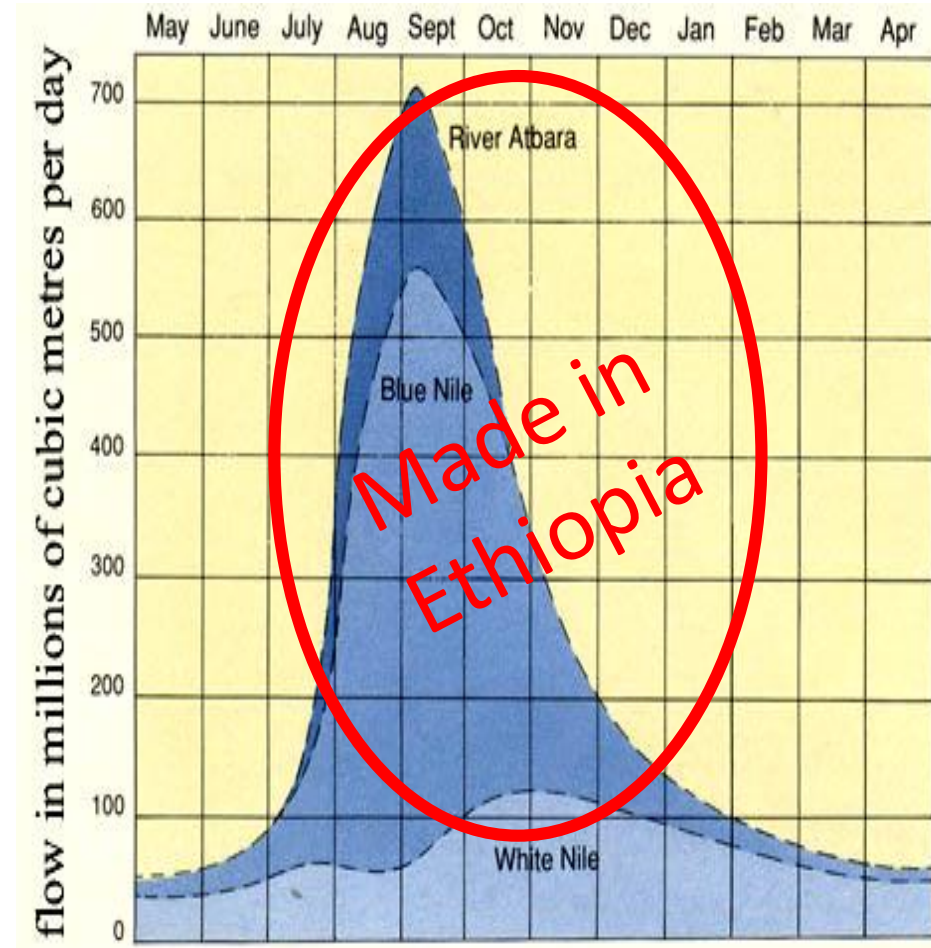
² *Uppsala University, Sweden*

³ *Ethiopian Institute of Water Resources*



The Nile at Cairo

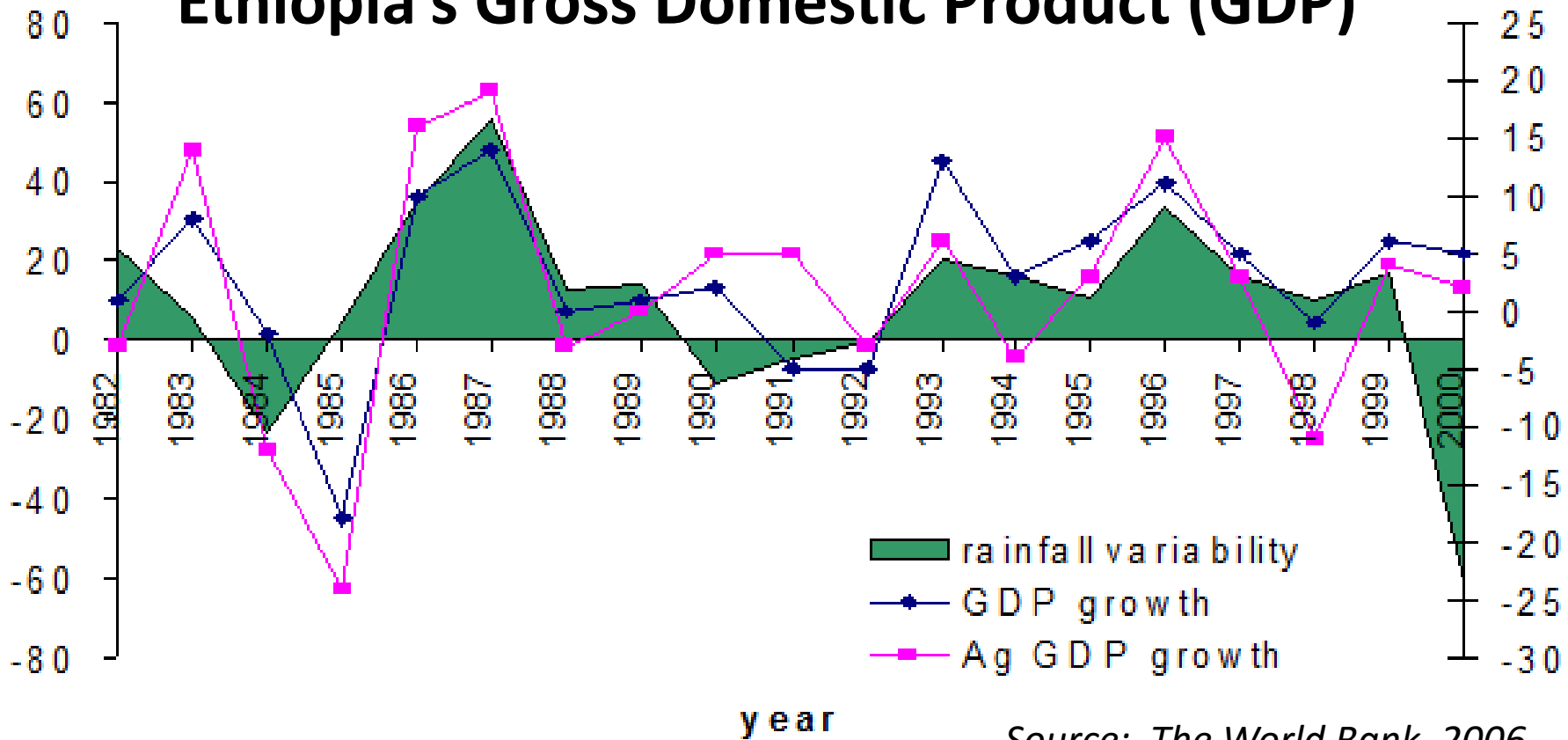
- 100% of Egypt's Water
- 80% from Ethiopia
- 8% of Nile Catchment



Subsistence Farming, Ethiopian Highlands



Annual Rainfall Variation, Agriculture and Ethiopia's Gross Domestic Product (GDP)



Source: The World Bank, 2006

Husbanding the Rainfall: A Land Use Issue

- Reduce Floods
- Reduce Erosion
- Retain Water
for the Dry Season



Highland landscapes: Deforested and Degrading



Are new forests part of the answer?

- **Popular Belief**
- **National Policy**

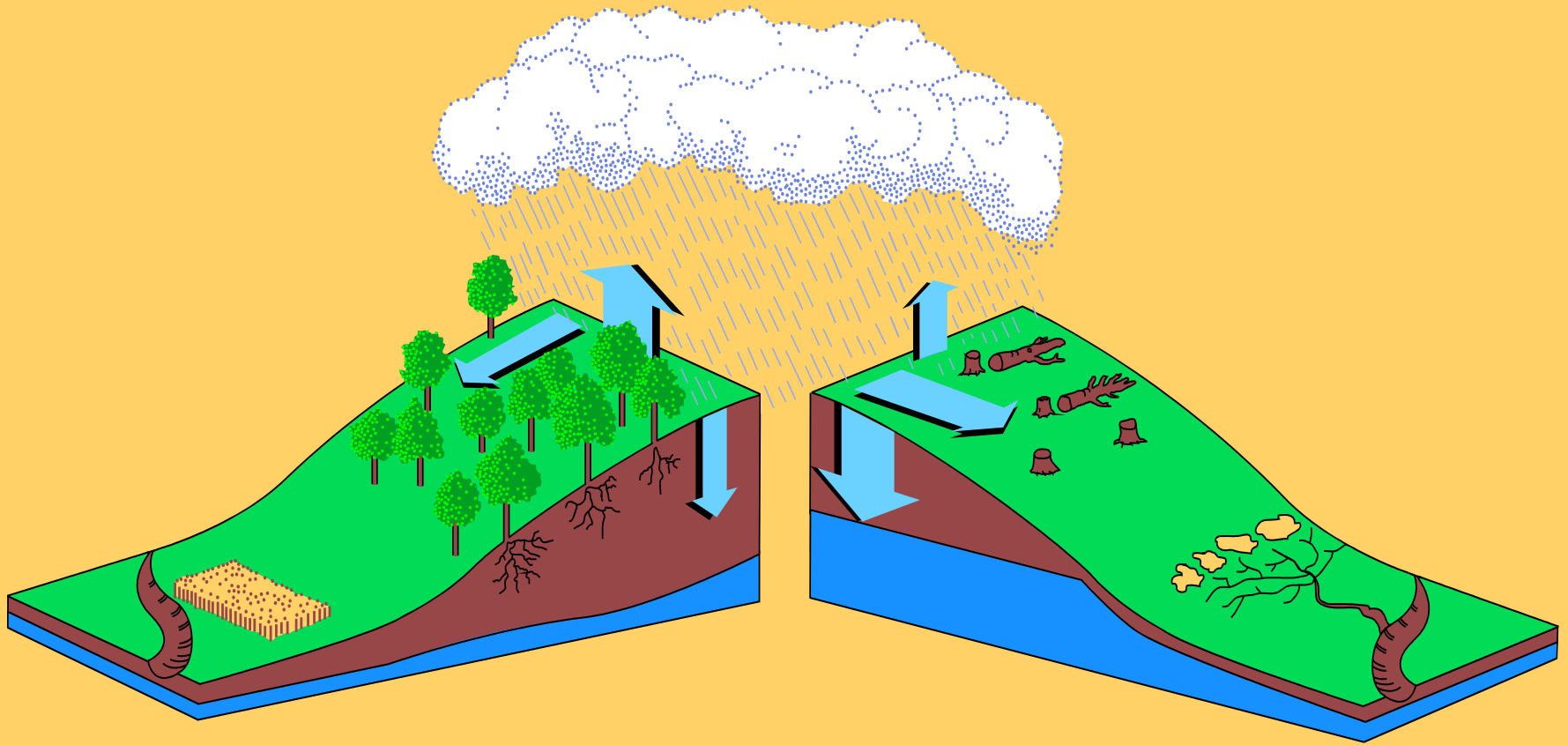
Ethiopia's Climate-Resilient Green Economy

Green economy strategy



FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA





**Are Forests Good for Water Resources?
A myth according to some (Calder)**

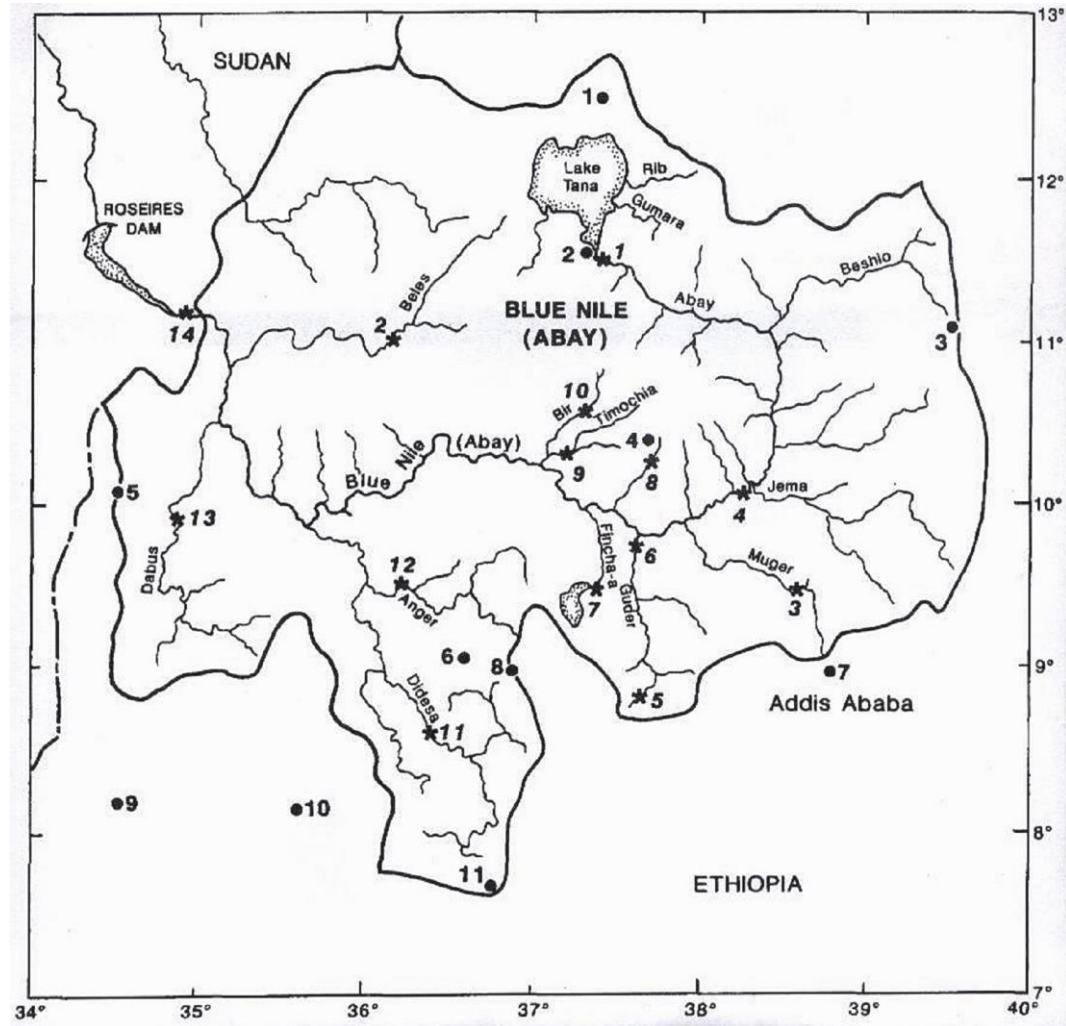
Deforestation and the Water Regime: What has science proven?

- **Total flow:** usually increases
- **Peakflow:** usually increases
- **Low Flows:** Unclear
- **Reversibility of Deforestation:** Unclear



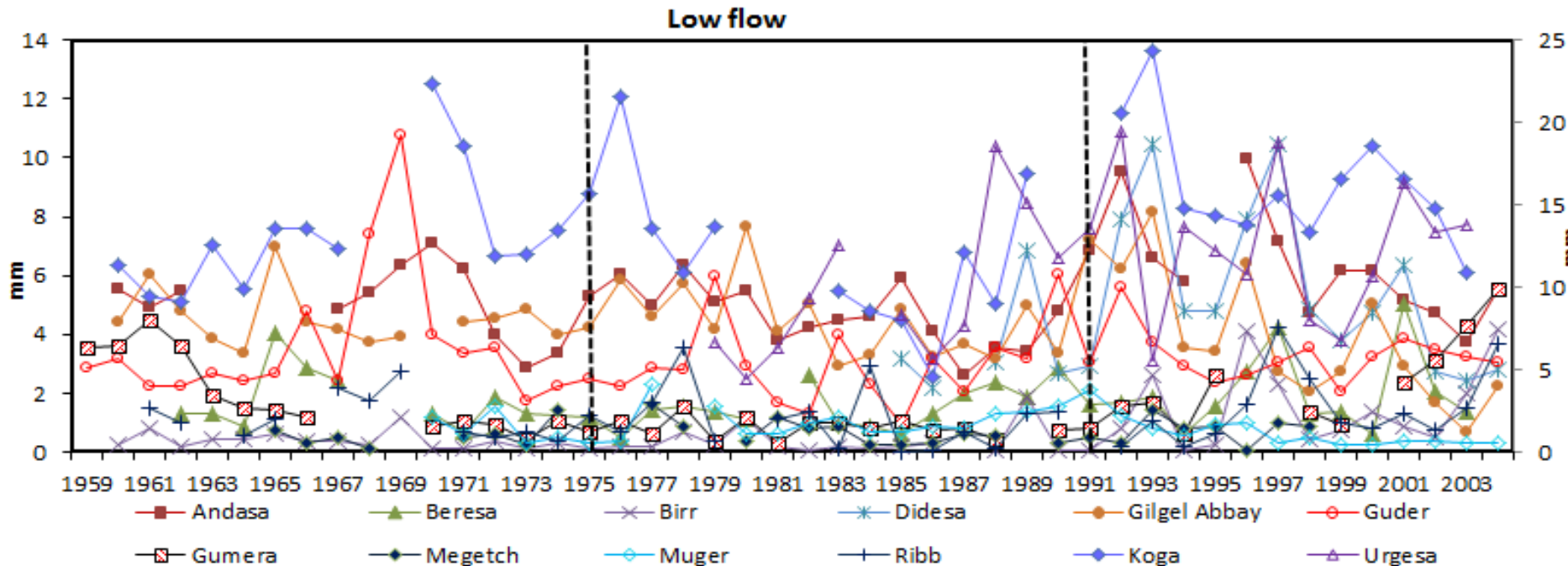
Region-specific knowledge needed

Highlands have River gauging 1960-



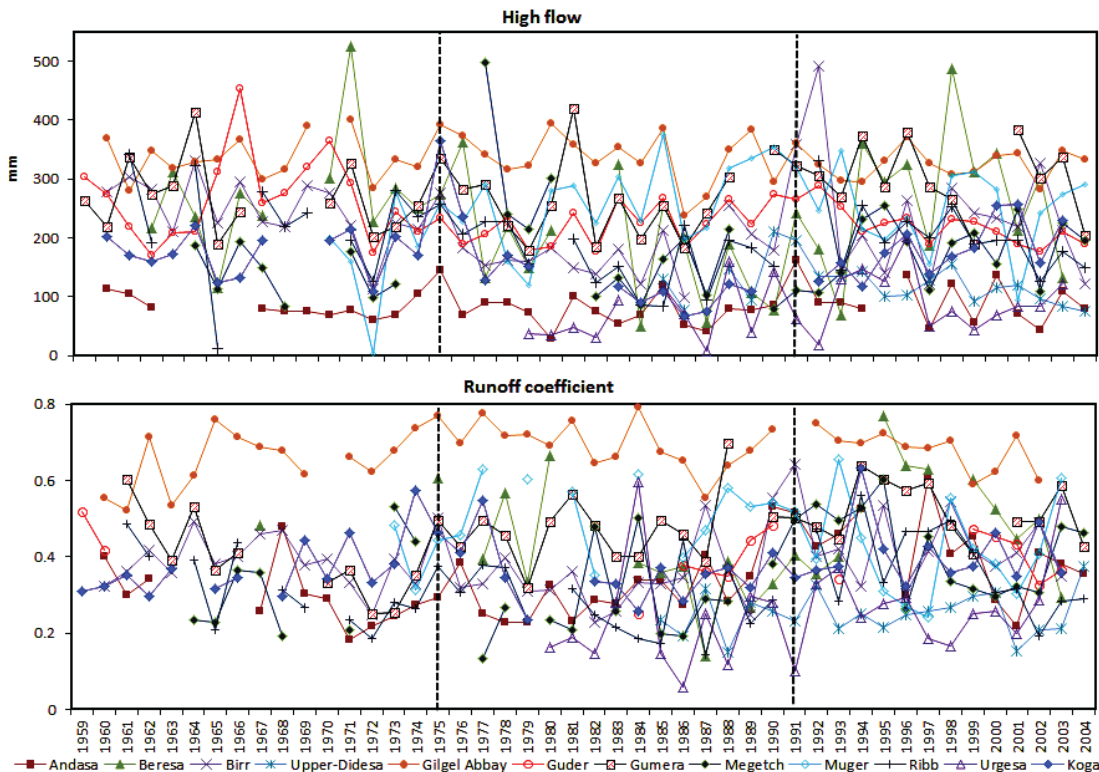
30 Daily time-series 1960-2014

- Flows – Annual, Peak, Base
- Runoff Coefficient, Base Flow Index
- Air Photos, Satellites



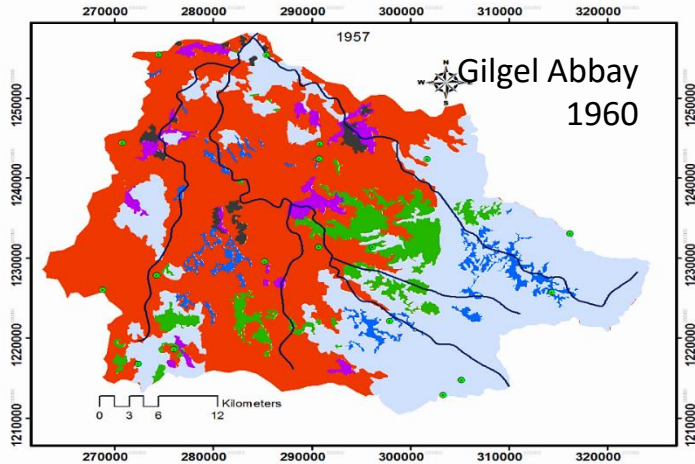
Detect Changes in Flow Regime and Land use

- Long-term trends
- Decadal Step Changes
- Model Parameter Changes



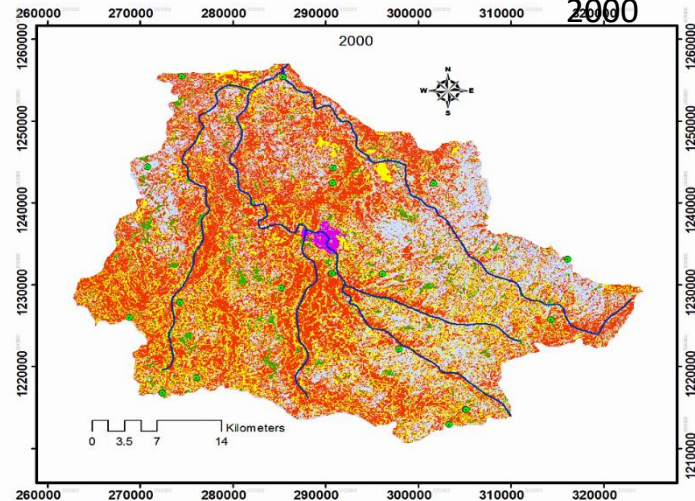
Solomon a decade ago

Forest Cover Change 1960-2000



Gilgel Abbay

2000



Examples:

- 90% natural forest to 45% (Upper Didessa, SW highlands)
- 27% natural forest to 10% (Birr)
- 7% natural forest to 18% Eucalyptus (Gilgel Abbay)



Gebreyohannis, Bishop et al., 2013a
Regional Environmental Change

Change detection – statistical

Trends and decadal step-changes over 45 years (3x15 years)

- 288 Separate Tests
- 46 Significant changes (29 expected by chance)
- No consistent changes in the hydrological regime
- No relation to land use

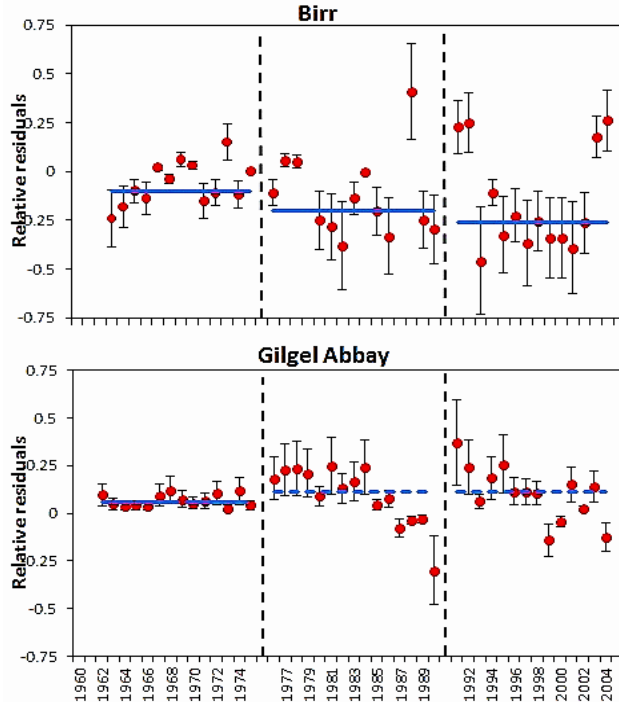
Rivers	Trend	Step-wise change from		
		P1 to P2	P1 to P3	P2 to P3
P (rainfall)	2-	1-	NS	NS
Qt (total flow)	1+, 1-	1+, 3-	1-	5+
Qh (high flow)	1-	3-	2-	1+, 1-
C (runoff coefficient)	2+	1+	3+	4+
Ql (low flow)	1+, 2-	1-	1+	1+, 2-
LFI (low flow index)	1+, 1-	1-	1+	2+, 1-

Gebreyohannis, Bishop et al., 2013b
Regional Environmental Change

Change detection – modeling

HBV Model - Six calibrated parameters

Three 15-year periods to compare parameters, residuals

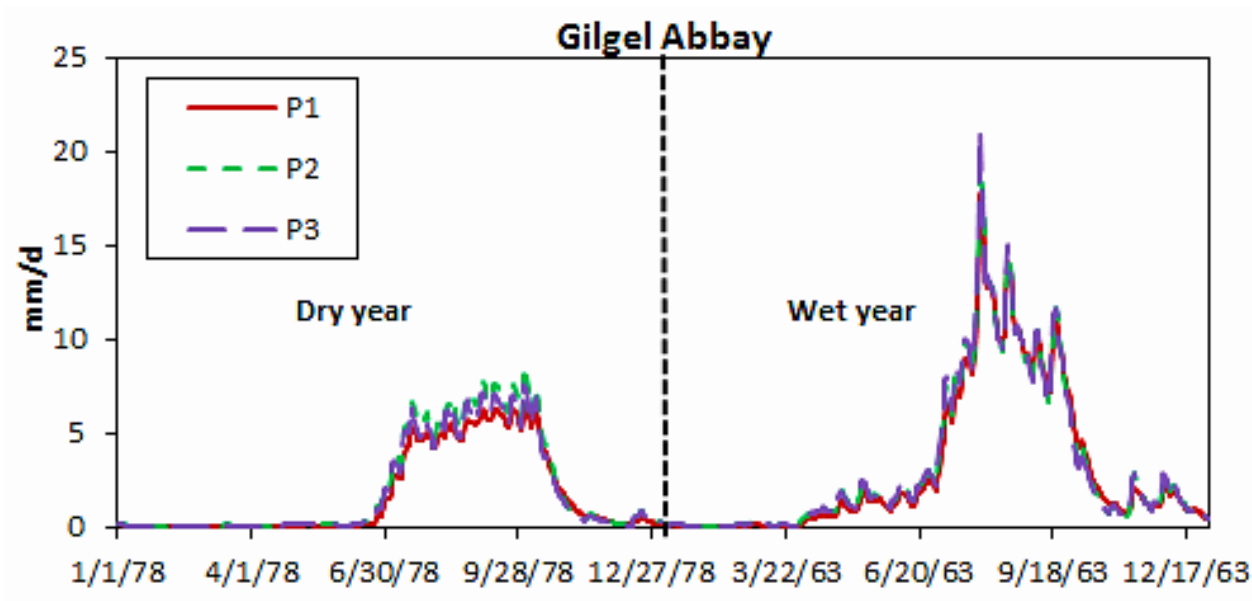


- Residuals changed between time periods
- Half the Parameters changed between time periods
- Eureka?

Gebreyohannis, Bishop et al., 2012a
Water Resources Research

Change detection modeling - Reality Check

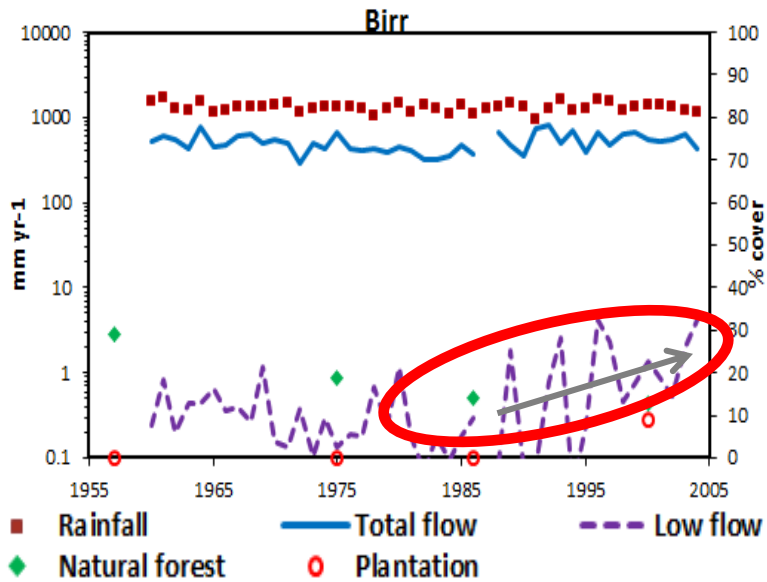
- Simulations didn't reflect parameter changes
- Compensation between parameters suspected



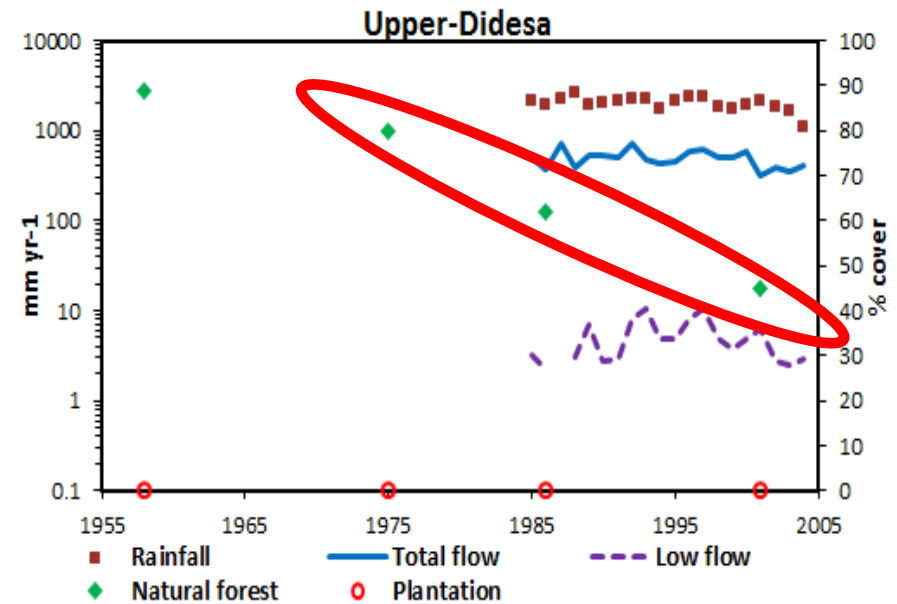
Gebreyohannis, Bishop et al., 2012a, *Water Resources Research*

Conclusion: No Consistent Regime Changes: But Clues and Ideas for the future

Riverine forest loss,
More baseflow?



Forest Loss 80% to 40%:
Stable flows



Focus on the Areas of Ongoing Deforestation in Southern Highlands



Alternative Data Sources:

Community perception from 1940s to 2000s

- Community believes land use influences hydrology
- Perception differs between watersheds, communities
- Communities recognized relationships as complex



Gebreyohannis, Bishop et al.,
GeoJournal, 2014

Move Across Scales:

Field Scale – Where crops are grown
and Land use influences documented

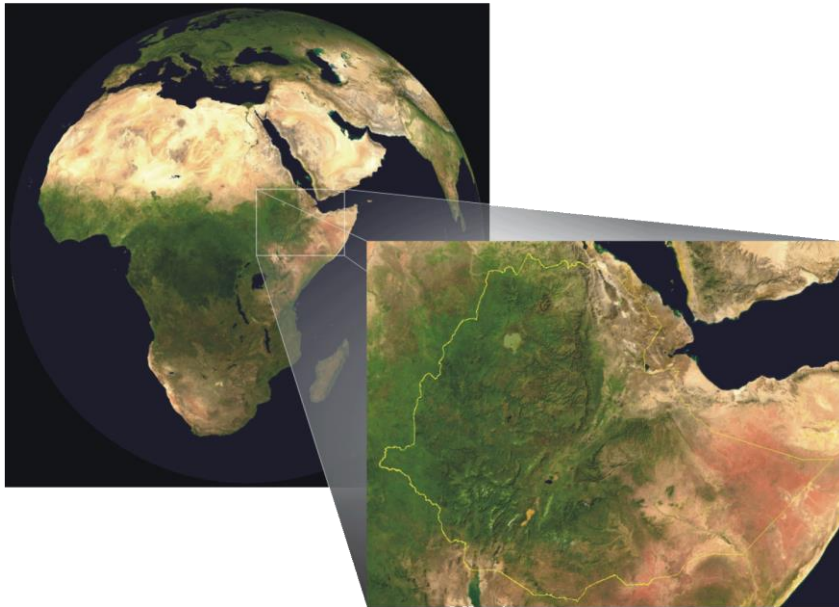


Hurni and colleagues
Steenhuis and colleagues

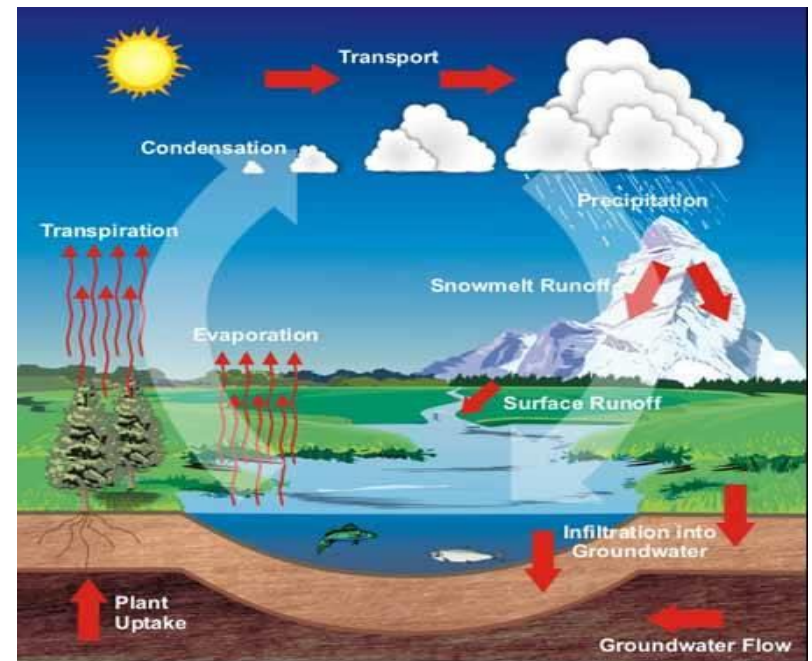
Move Across Scales:

Regional Tele-connections

Forests as rain suppliers



How much of Ethiopia's rain comes from West Africa's Rain Forests?



Ellison, Futter & Bishop, 2012
Global Change Biology

Forests + Flow Regimes = Complexity

Ethiopia and everywhere else

50 years is not enough

- More Good Data
- New Approaches
- Multiple Scales
- **More trained minds!**



ETHIOPIAN INSTITUTE OF
WATER RESOURCES

