Hydrologic partitioning and vegetation response in selected moist zone catchments of Ethiopia: analyzing spatiotemporal variability

(Fasil T. Worku and Guiling Wang)

Presenter

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Outline

- Introduction
- Problem statement and objective
- Study area
- Methodology
- Results and Discussion
- Conclusion and Recommendations

Introduction

- Water budget and vegetation are closely coupled. How?
  - Terrestrial vegetation is a first-order control on the water budget of catchments (Brutsaert, 1988).
  - Seasonal variability of vegetation impacts the seasonality hydrologic cycle (Kim and Wang, 2005).
  - Changes in climate affects terrestrial ecosystem structure and functions (Zhou *et al*., 2003; Alo and Wang, 2008).

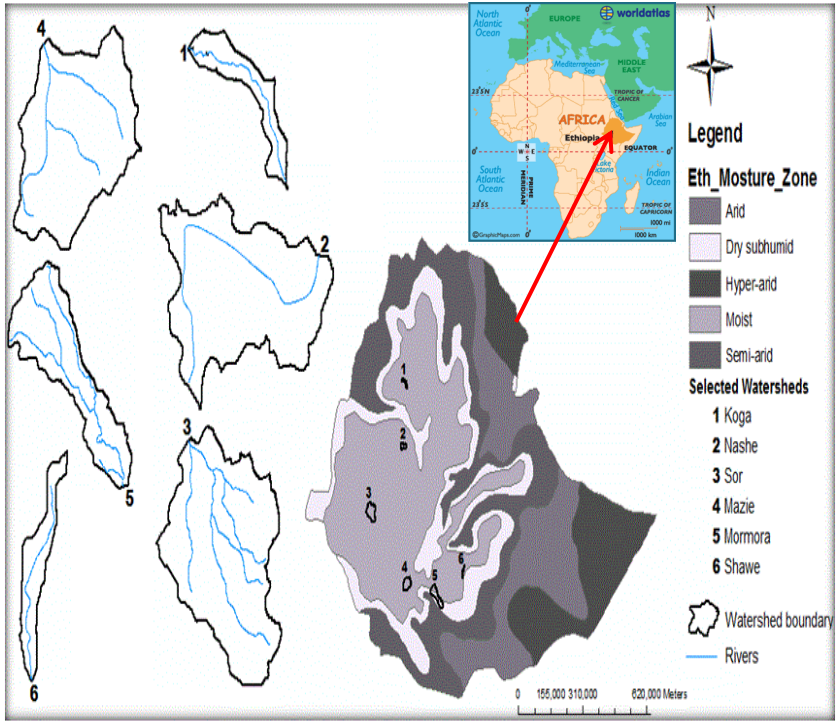
Introduction … cont'd

- Why understanding this coupling is important?
  - Functional relationships using water budget parameters as predictor of vegetation response (Mora and Iverson, 1997).
  - Spatial patterns of vegetation may offer a lens through which to investigate scale dependence of hydrology (Thompson *et al.,* 2011b).
  - Differences and developments of space time patterns among various biomes (Rodriguez-Iturbe, 2000).

Problem statement and objective

- Problem:
  - Ethiopia – strong spatiotemporal variability of both vegetation and hydrologic budget
  - However, little has been done to understand vegetation-water budget interlink which is important for better catchment management.
- Objective:
  - To quantify water budget and vegetation greenness index, explore their correlation, and analyze their variability

Study areas and data



Study catchments		*Koga*	*Nashe*	*Sor*	*Mazie*	*Mormora*	*Shawe*
Drainage area (km^2)		244	350	1622	937	1375	161
Elevation, a.m.s.l, (m)	Low	1926	2074	1550	932	1617	1416
	High	3048	2663	2621	3452	3017	3522
Mean daily discharge (m^3/sec)		5.61	7.52	46.40	5.54	18.61	2.85
Mean annual precipitation (mm)		1434	1604	1872	1136	1113	885
Rainfall seasonality		unimodal	unimodal	unimodal	bimodal	bimodal	bimodal
Mean annual temp. (°C)	Max	26.7	23.4	24.9	30.3	23.7	24.4
	Min	10.2	10.9	11.7	15.0	10.9	11.0
Major landuse / landcover		cultivatd	cultivatd	evergreen forest	grassland and bushland	evergreen forest	evergreen forest

Data: Rainfall, temperature, river discharge, and MODIS MCD43A4

Methodology

a. Infilling missing stream flow and quality assessment

b. Hydrograph separation

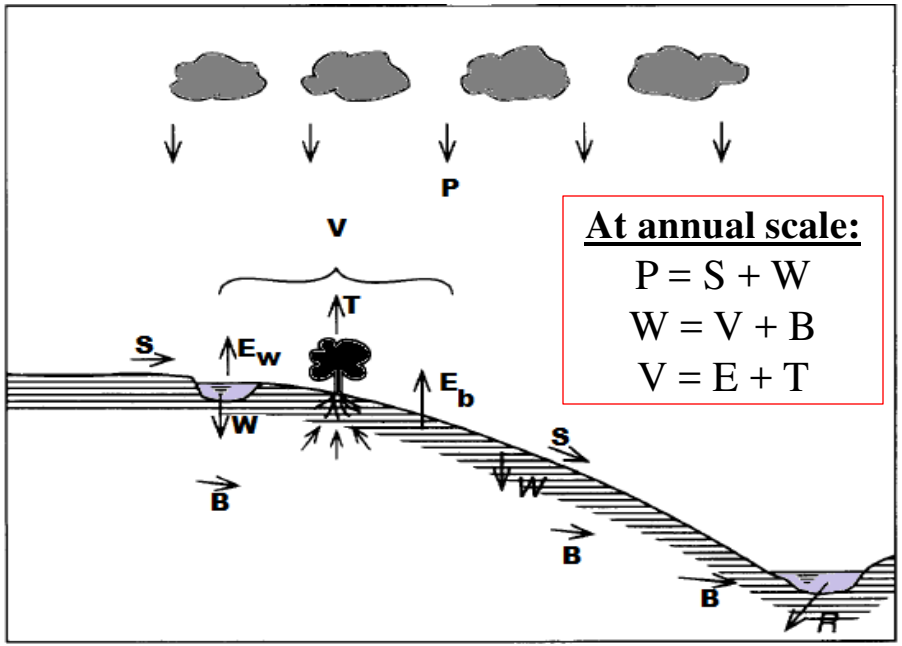
- Baseflow and quick flow
- One parameter recursive filter (Nathan and McMahon,1990)

$$S_t = \alpha S_{t-1} + \frac{(1+\alpha)}{2}(Q_t - Q_{t-1})$$

$$B_t = Q_t - S_t$$

Methodology … cont'd

c. Hydrologic partitioning (L'vovich,1979)



At annual scale:

P = S + W

W = V + B

V = E + T

d. Hydrologic indices

- Horton index $HI = \frac{V}{W}$
- Humidity index $HuI = \frac{P}{PET}$

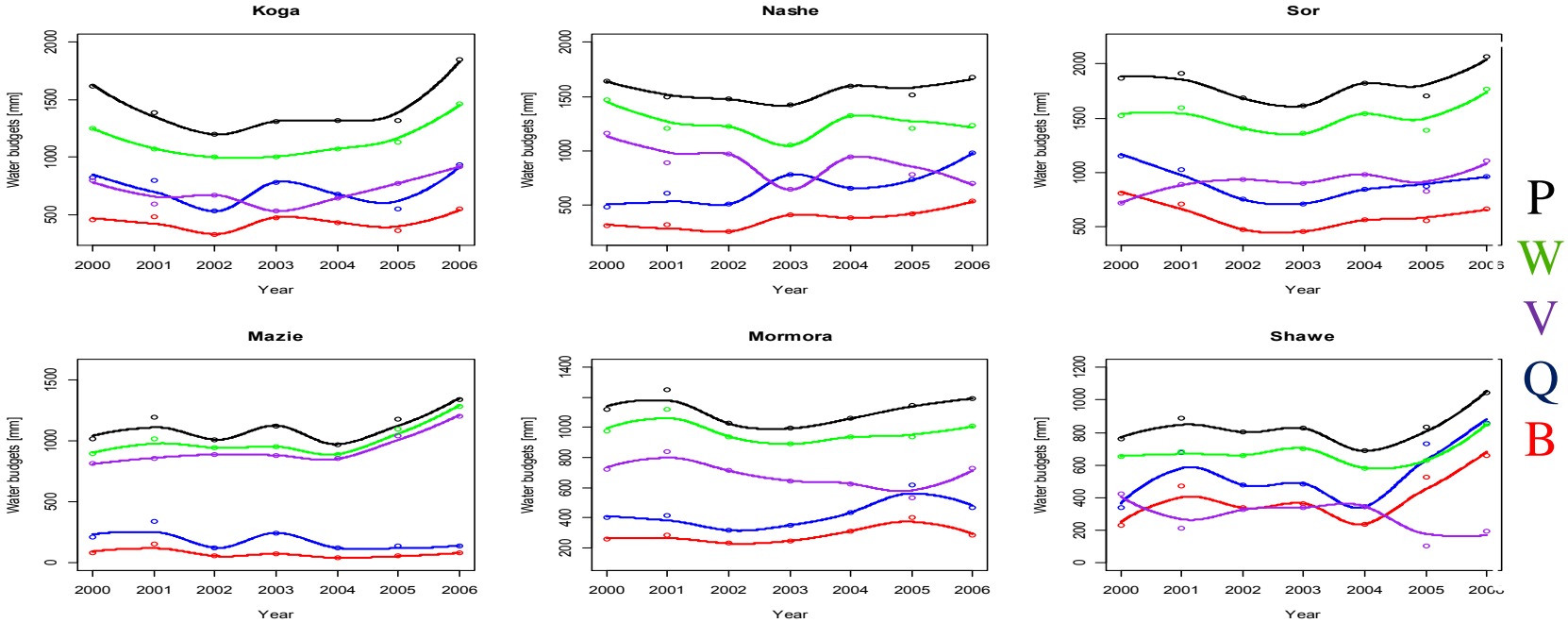
$$PET = 0.0023Ra(Tm + 17.8)\sqrt{Td}$$

e. Vegetation index

$$NDVI = \left[\frac{Band\ 2 - Band\ 1}{Band\ 2 + Band\ 1}\right]$$

Results and Discussion

a. Catchment-scale hydrologic partitioning variation



Results and Discussion … cont'd

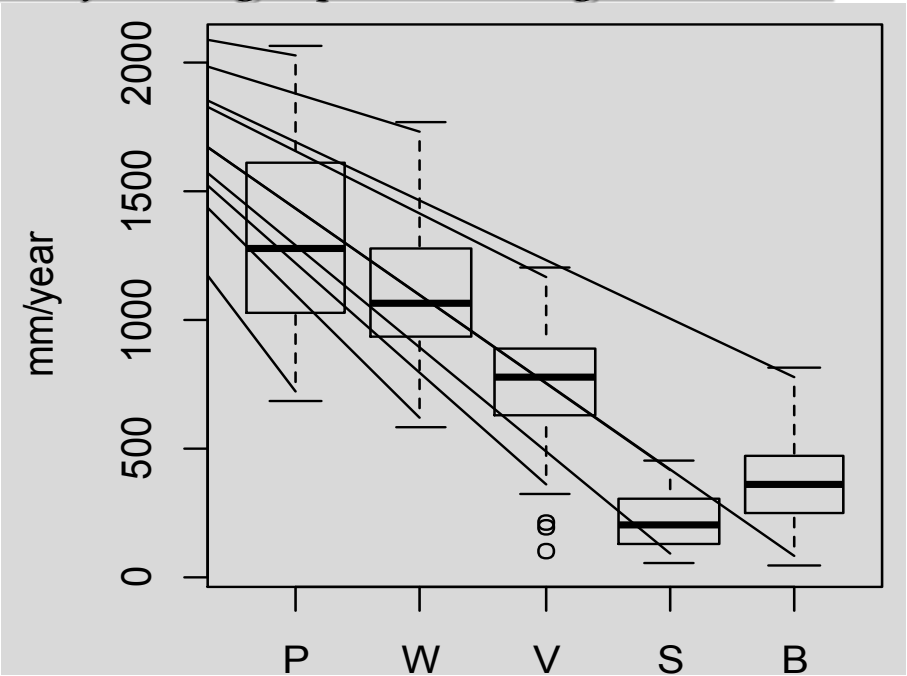
a. Catchment-scale hydrologic partitioning variation

Mean (STD) of hydrologic budget over 2000-2006

Water budgets (mm/year)	Study catchments					
	Koga	Nashe	Sor	Mazie	Mormora	Shawe
Precipitation (P)	1428 (225)	1546 (95)	1811 (157)	1117 (129)	1113 (92)	836 (113)
Total flow (Q)	726 (149)	678 (171)	903 (156)	186 (83)	427 (97)	559 (200)
Baseflow (B)	439 (76)	374 (90)	603 (129)	77 (38)	287 (58)	403 (158)
Wetting (W)	1141 (165)	1242 (128)	1511 (145)	1008 (139)	973 (75)	680 (85)
Vaporization (V)	702 (133)	868 (177)	908 (122)	931 (139)	686 (96)	277 (111)

Results and Discussion … cont'd

a. Catchment-scale hydrologic partitioning variation



Results and Discussion … cont'd

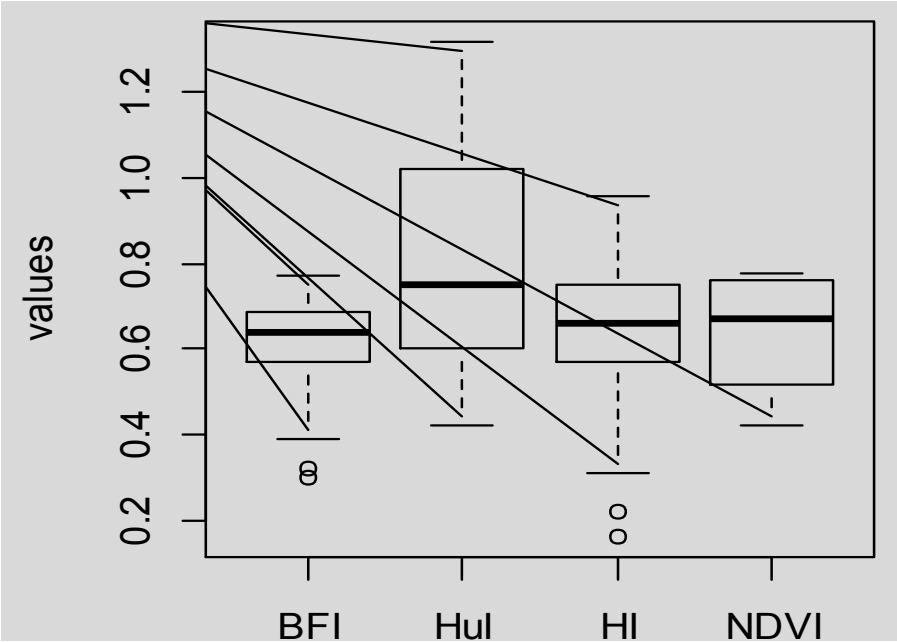
b. Catchment-derived hydrologic and vegetation indices variation

Mean (STD) of hydrologic and vegetation indices over 2000-2006.

Indices	Study catchments					
	Koga	Nashe	Sor	Mazie	Mormora	Shawe
BFI	0.61(0.03)	0.55(0.05)	0.66(0.03)	0.42(0.09)	0.68(0.04)	0.72(0.03)
HuI	0.80(0.15)	1.05(0.07)	1.11(0.12)	0.58(0.07)	0.73(0.06)	0.52(0.09)
HI	0.61(0.06)	0.69(0.09)	0.60(0.07)	0.92(0.04)	0.70(0.07)	0.42(0.19)
NDVI	0.44(0.01)	0.51(0.02)	0.76(0.01)	0.56(0.03)	0.71(0.02)	0.77(0.01)

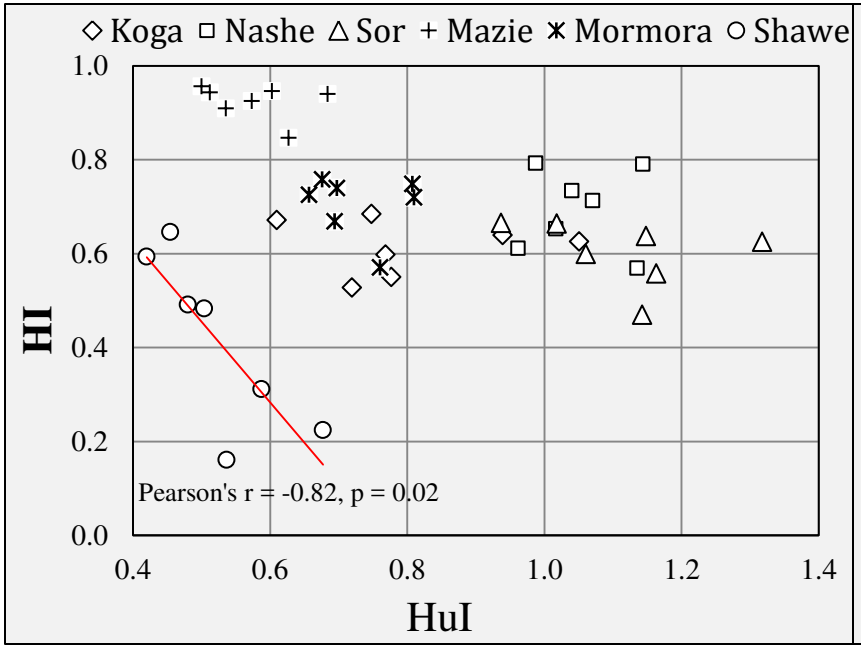
Results and Discussion … cont'd

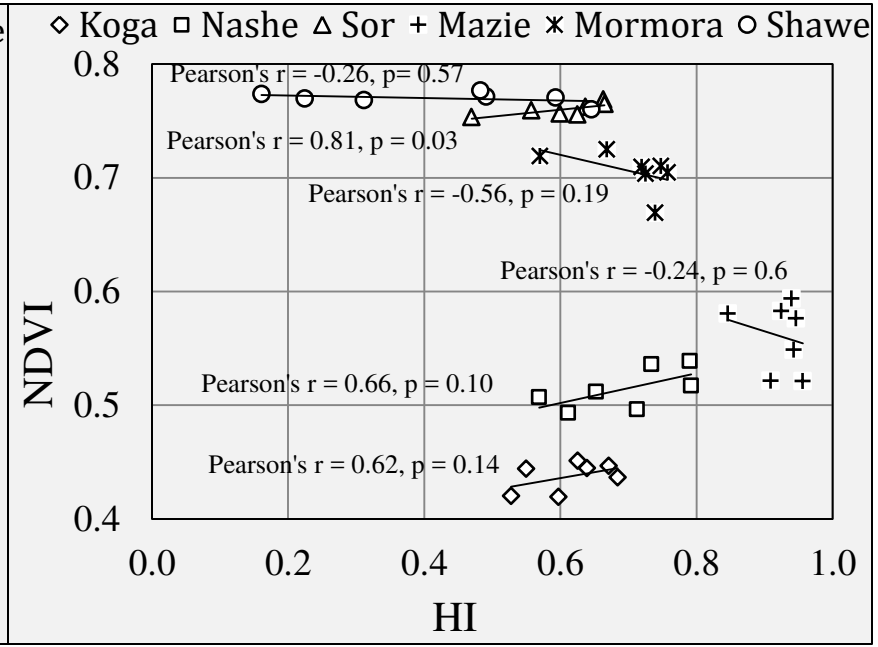
b. Catchment-derived hydrologic and vegetation indices variation



Results and Discussion … cont'd

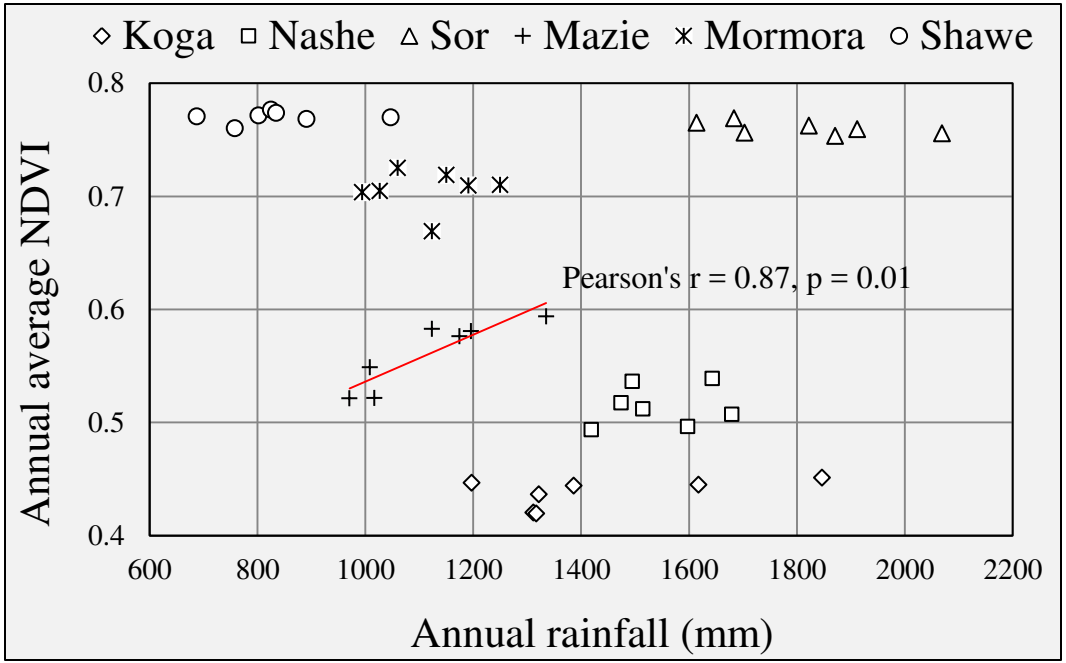
b. Catchment-derived hydrologic and vegetation indices variation





Results and Discussion … cont'd

c. Vegetation response to rainfall



Results and Discussion … cont'd

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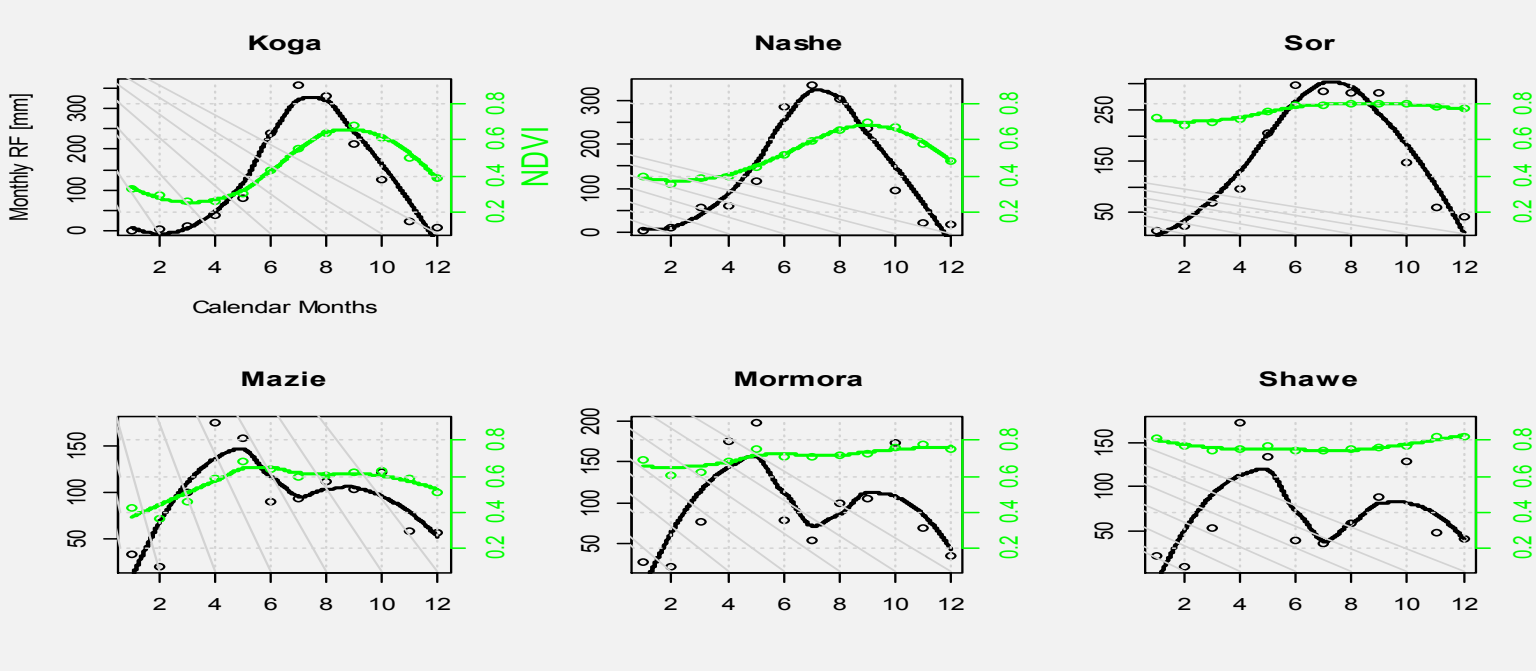

Conclusion and *Recommendations*

- Catchments within the same climate zone exhibit variable hydrologic partitioning and vegetation response behavior .
- Therefore, issues like catchment management and the impact of climate variability on catchment vegetation should be treated differently regardless of similarity in moisture regime of catchments.
- *We suggest future researches to include more representative catchments and longer analysis period*
- *In addition, performing the analyses at finer time-scale (e.g. seasonal) would be more convincing.*

Thank You!

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