Understanding and predicting the impact of climate variability and climate change on land use and land cover change via socio-economic institutions in southern Africa

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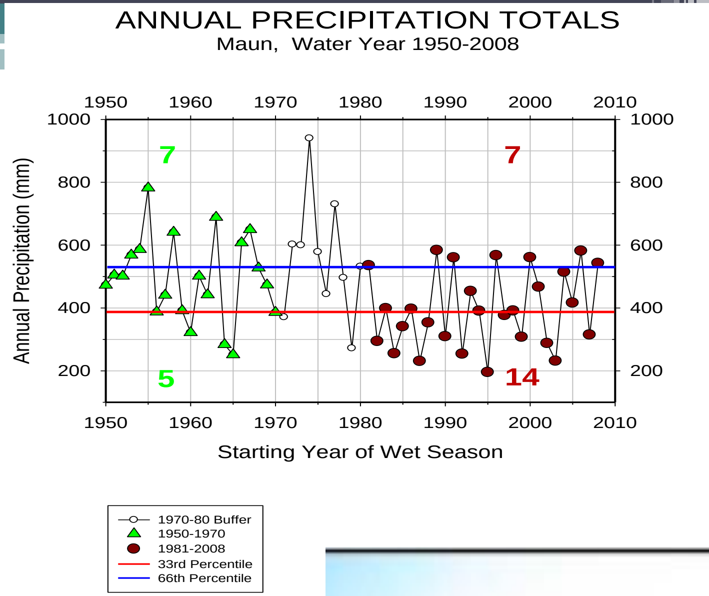
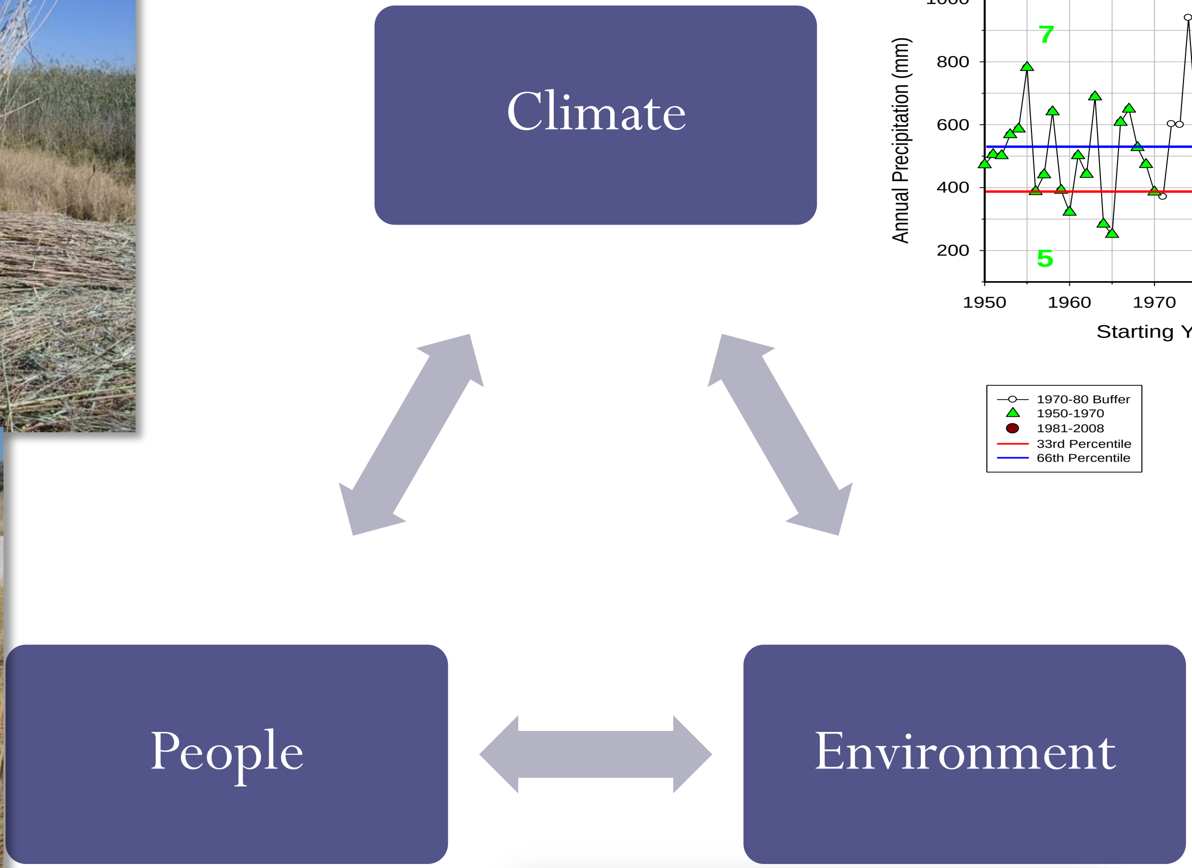
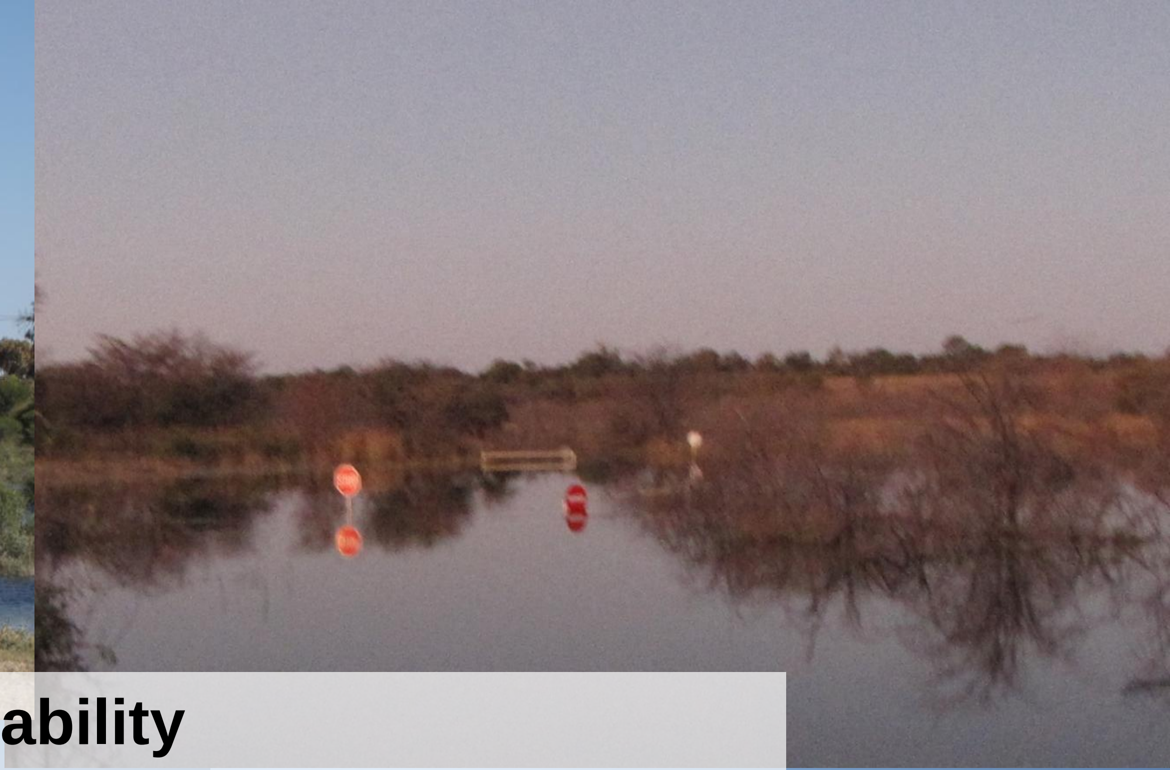


ANNUAL PRECIPITATION TOTALS
Maun, Water Year 1950-2008
Annual Precipitation (mm)
Starting Year of Wet Season
1950
1960
1970
1980
1990
2000
2010
1000
800
600
400
200
7
7
5
14
1970-80 Buffer
1950-1970
1981-2008
33rd Percentile
66th Percentile



Climate
People
Environment

Climate variability
-impassable, flooded roads



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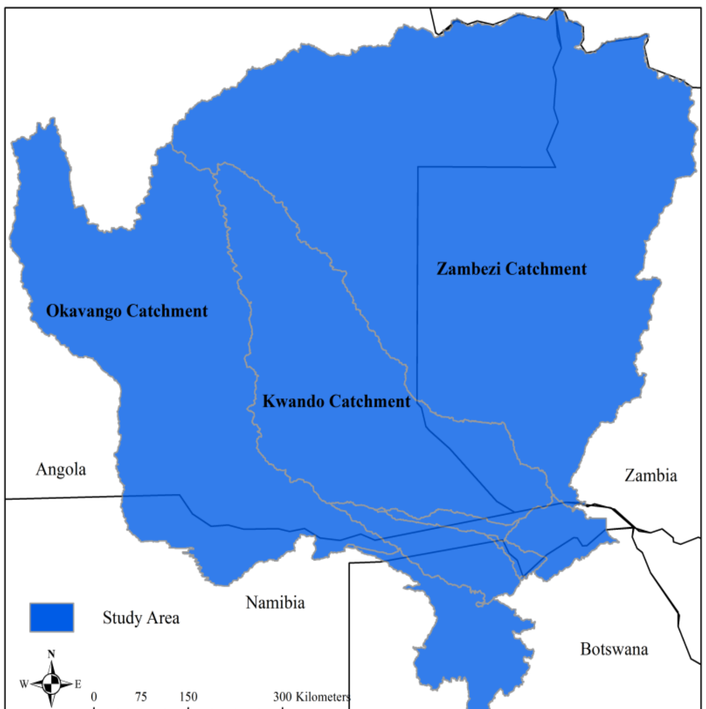
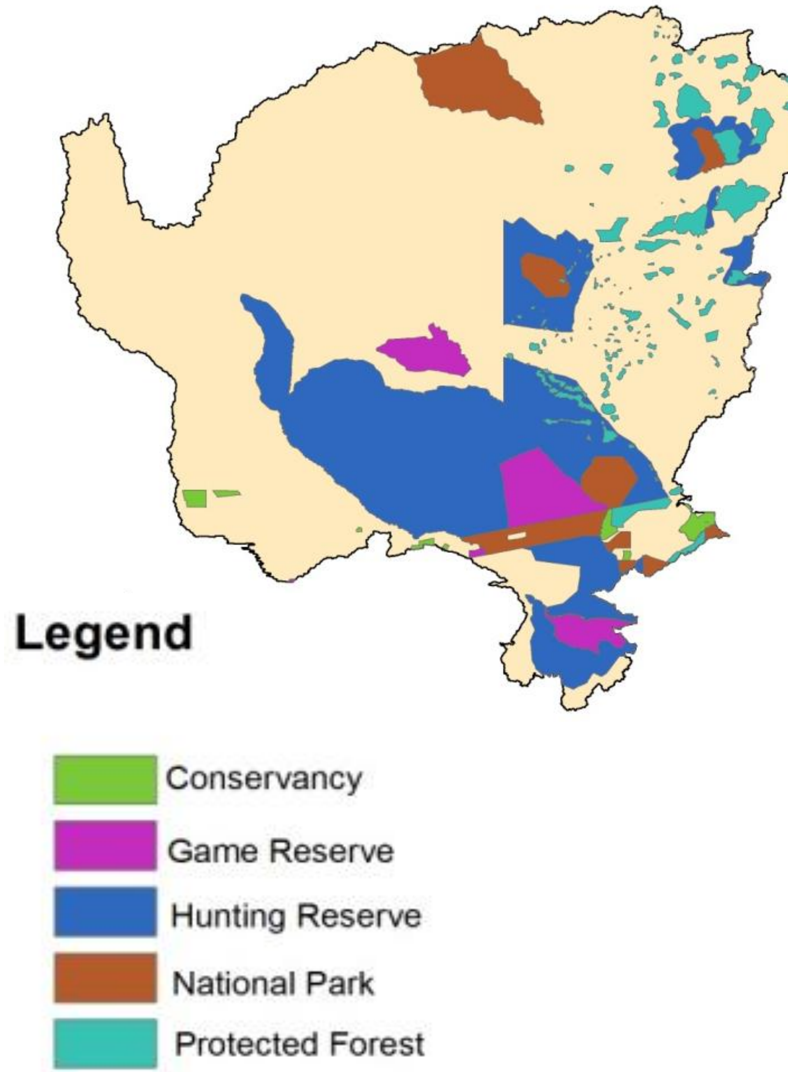
~800,000 km^2

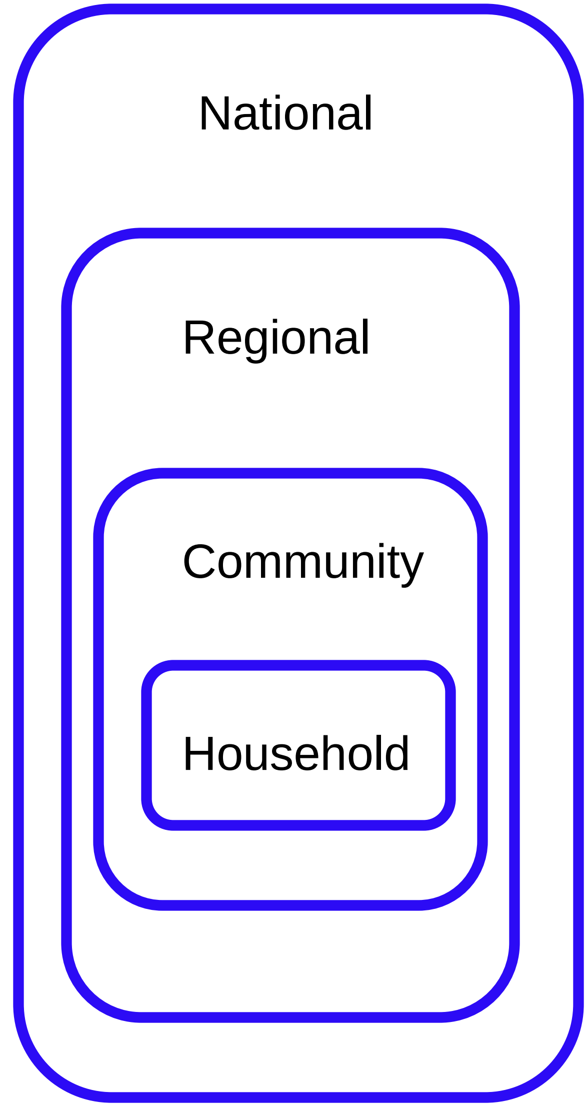
New Mexico, Colorado, Kansas



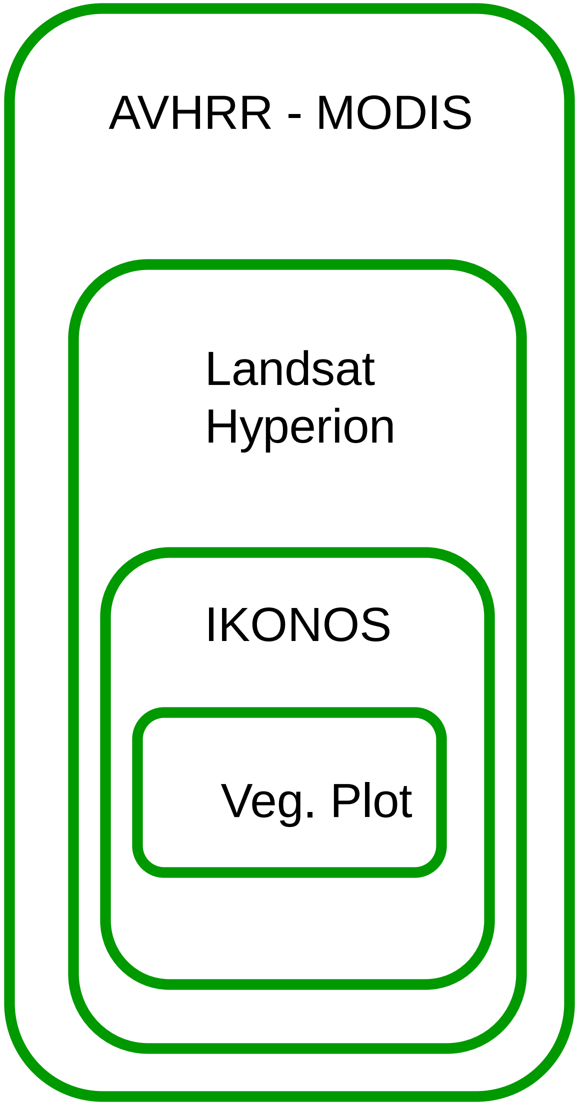


Social data

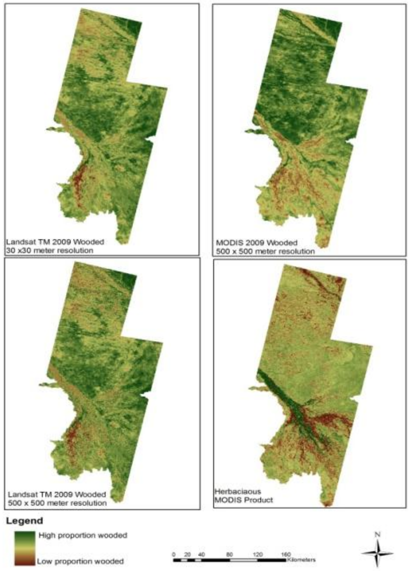
- Governance
- National policy
- Management
- Parks
- Tenure
- Boundaries – fences

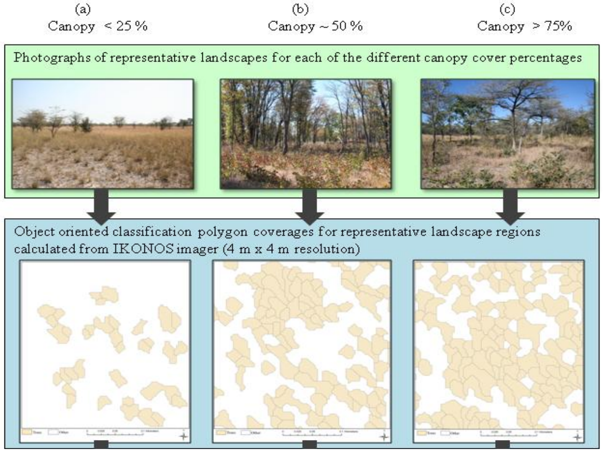


Remote Sensing & Biophysical data



- Multi-scalar
- Vegetation components
- Vegetation indices
- Hyperspectral
- OOC
  - Fields
  - Trees
- LMM
  - Woody
  - Grass
  - Soil





AVHRR - MODIS

Landsat

IKONOS

Veg. Plot

Climate Variability
1900s-current

Climate Change
2020's

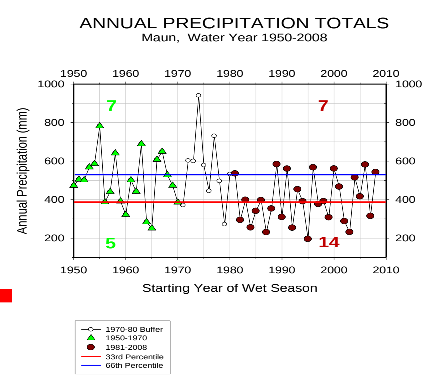
Resilience
Sustainability
Vulnerability

National

Regional

Community

Household



QnD

Human responses to
Climate variability
-Adaptation strategies
-Social resilience

Savanna

Spatial landscape model

Responds to climate, herbivory, fire, management

AVHRR - MODIS

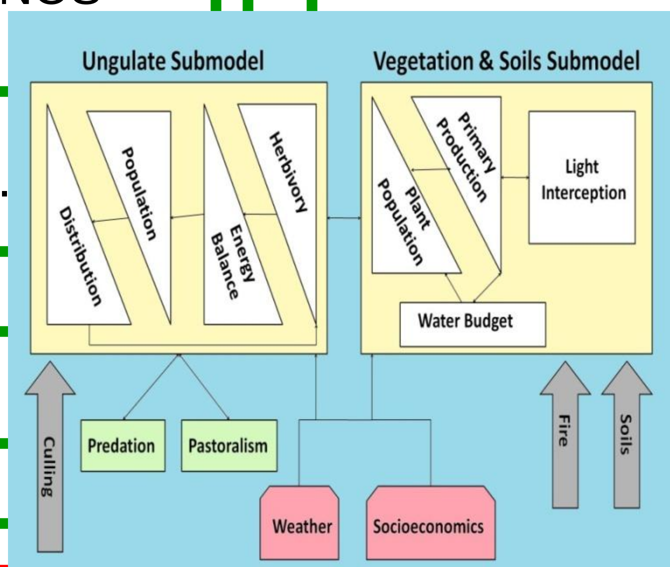
National

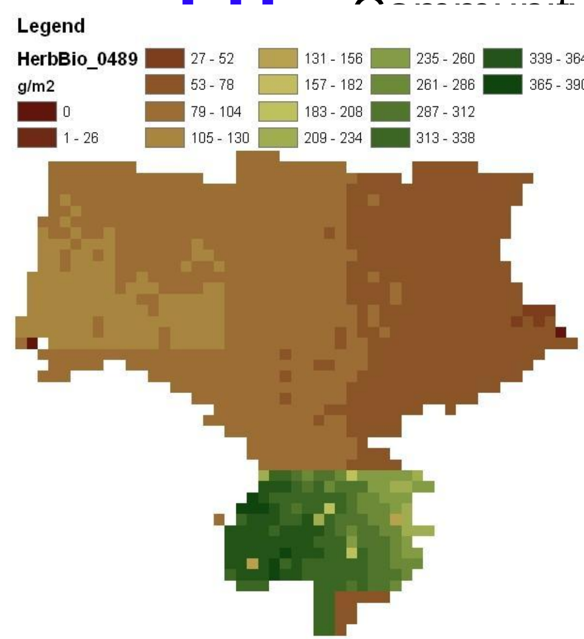
Landsat

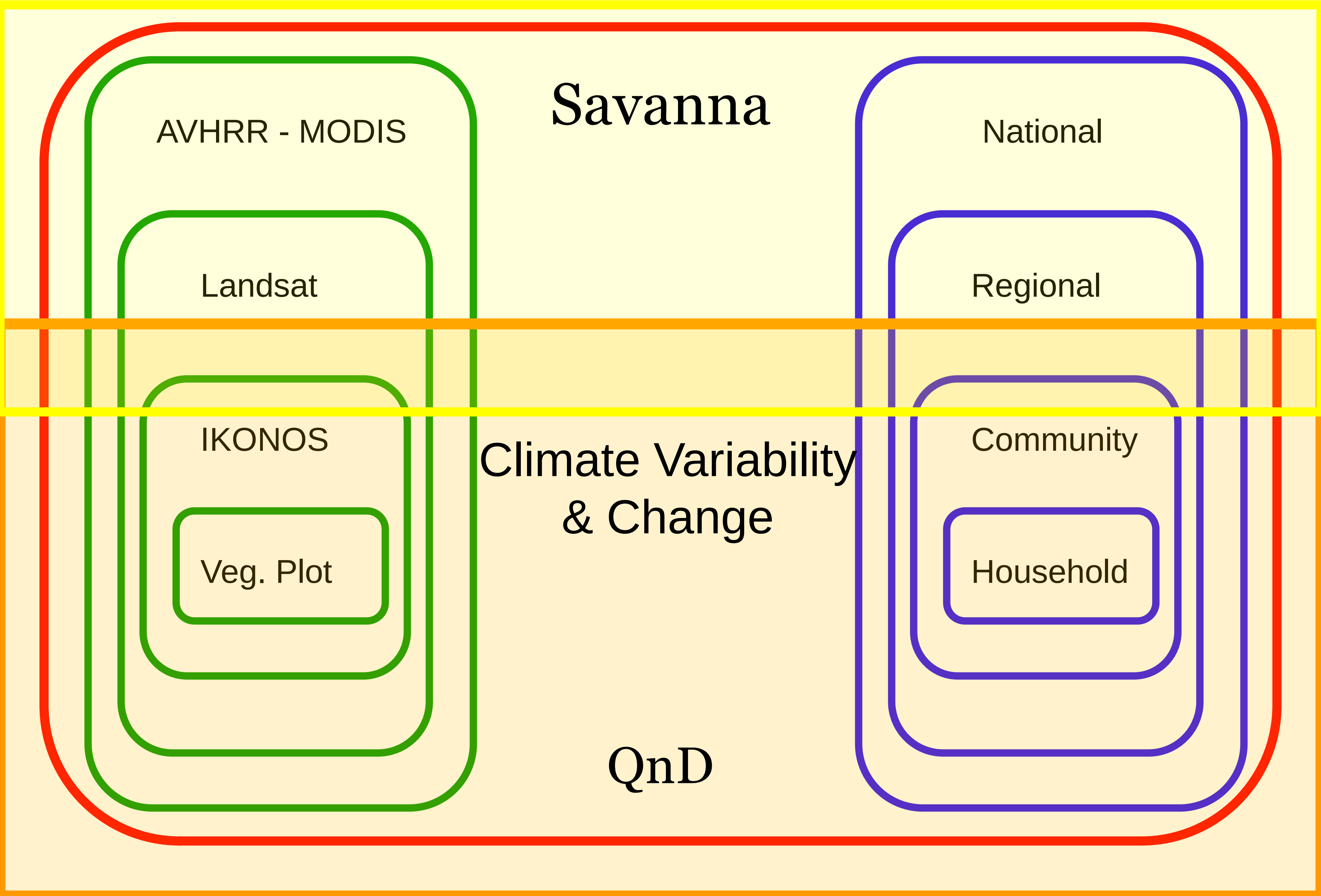
Regional

IKONOS

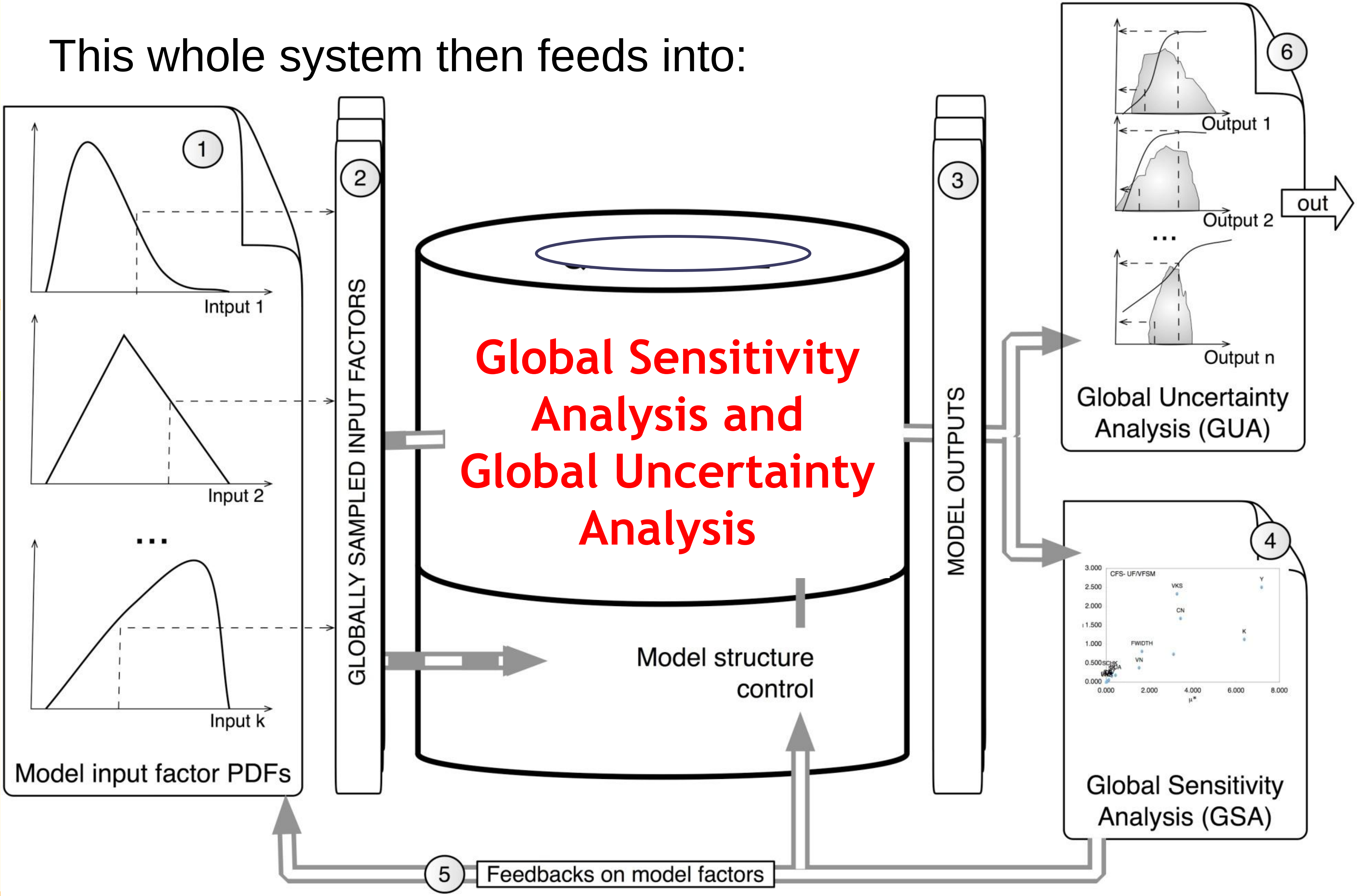
Veg.



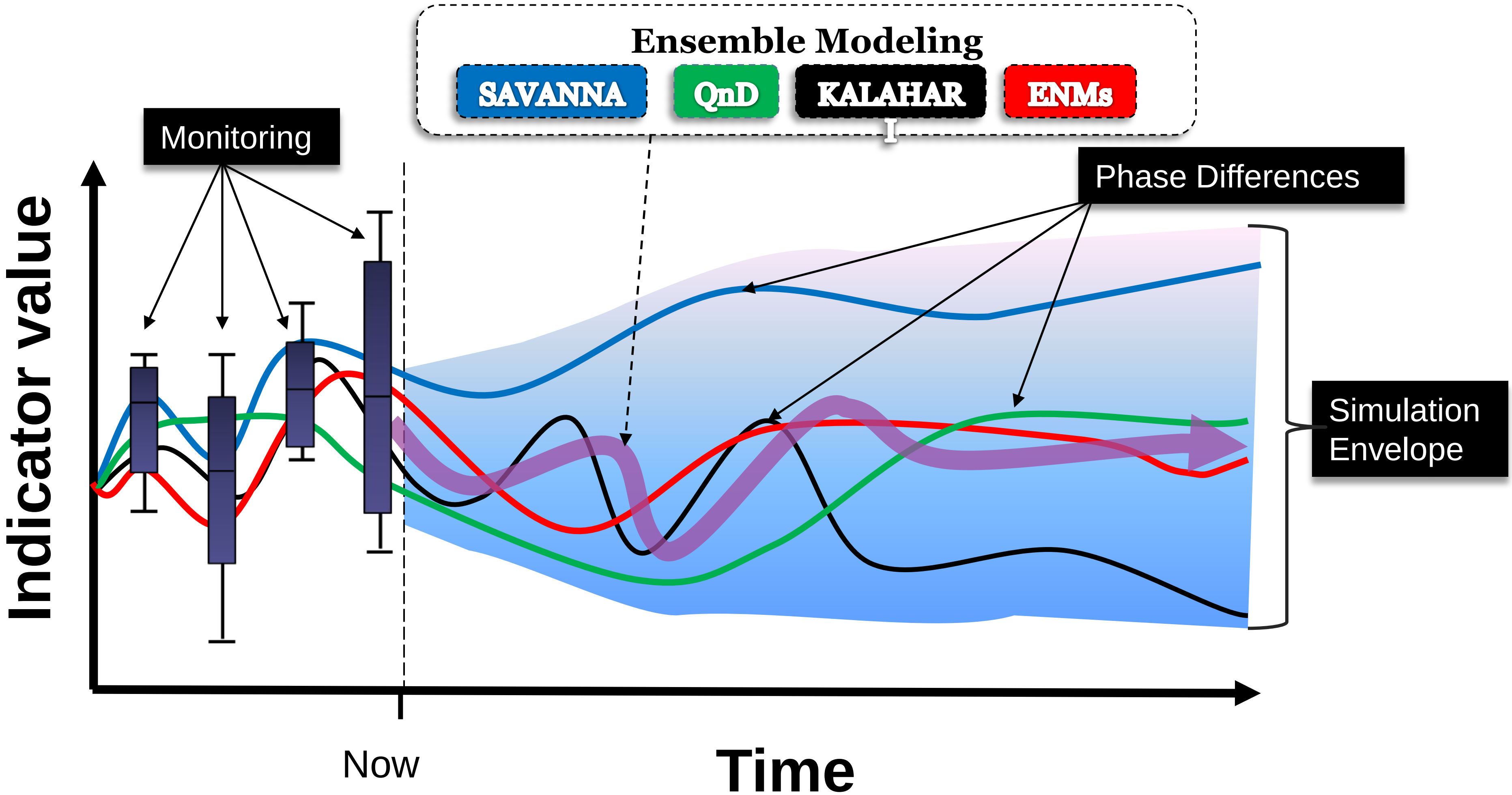


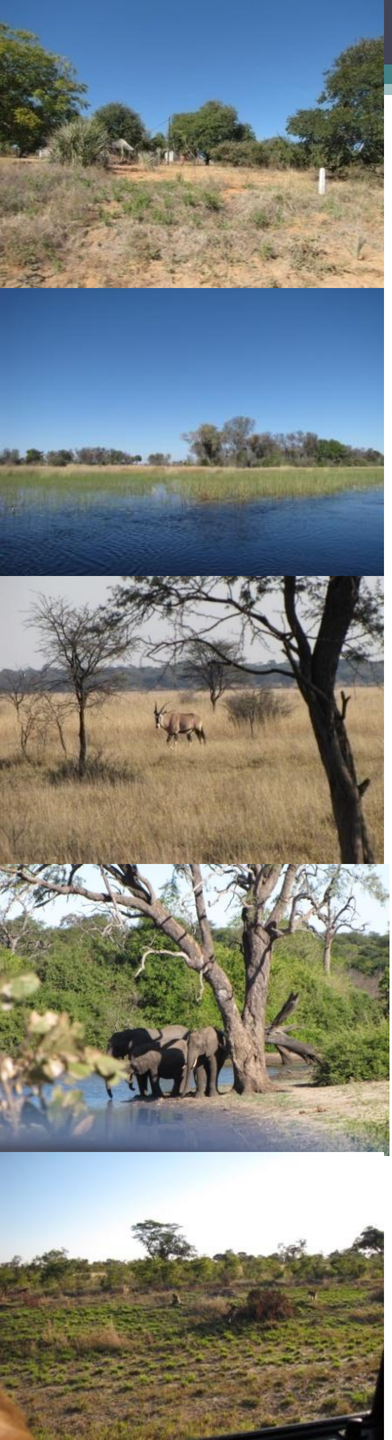

Savanna
AVHRR - MODIS
Landsat
IKONOS
Veg. Plot
National
Regional
Community
Household
Climate Variability & Change
QnD

This whole system then feeds into:



The Future? Ensemble modeling allows simulation and combination of models in uncertain futures





avanna col ogy

- 'semi-arid savanna' refers to those regions of the world, which, in their natural state, have a predominant continuous grass cover, with scattered to numerous trees and shrub
  - Gradations in landscape relate to composition
    - i.e. amount grass-tree-shrub
- Comparison of the dynamics of various savanna and other natural systems leads to the conclusion that the resilience of the systems decreases as their stability increases
- So highly heterogeneous landscape = resilient
    - Walker et al. 1981

Landscape dynamics

Grasses dominate

Increasing vegetation amount

Shrubs dominate

Increasing vegetation amount

Woodland dominates

Social Science Research Overview

- OBJECTIVE:
  To understand how households cope with climate variability and what factors lead to greater resilience in the face of anticipated variability

- HYPOTHESIS:
  Socioeconomic institutions are the main instruments of human adaptation to climate variability and change, and the observable outcomes of these adaptations are expressed as land use and land cover change

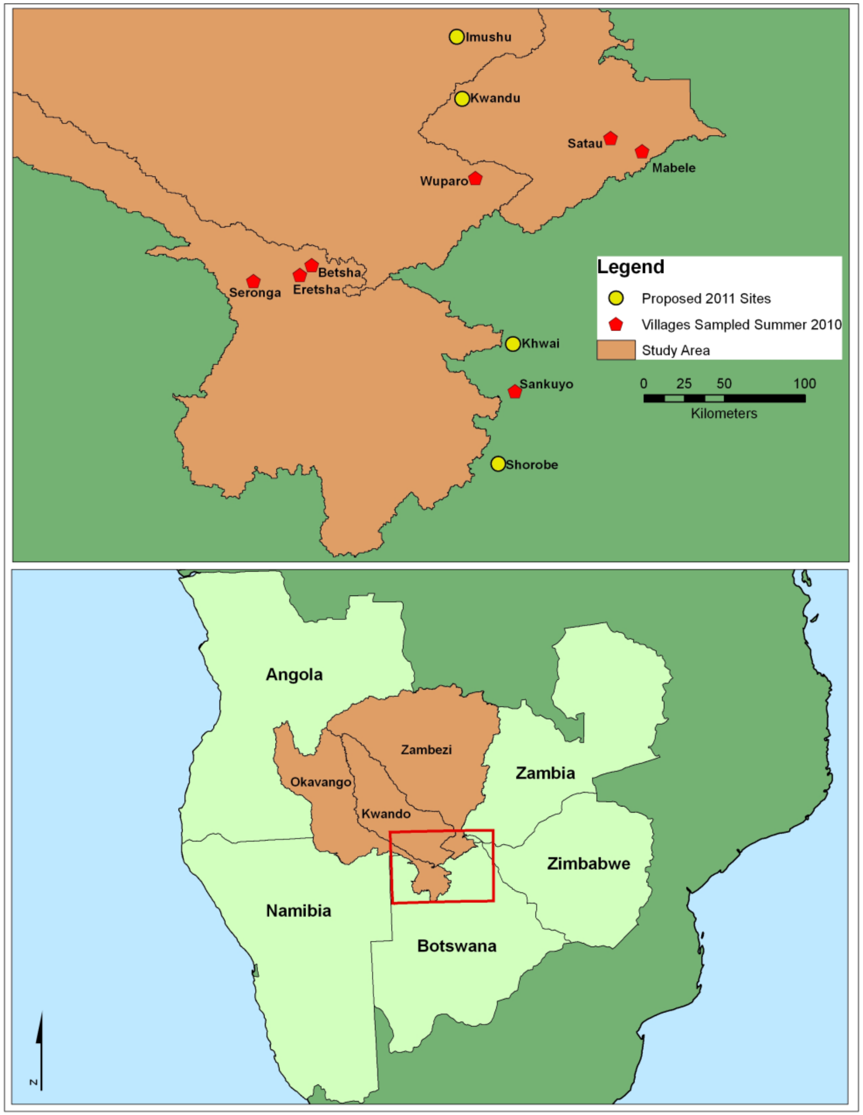
Do alternatives to land-based livelihoods enhance resilience to climate variability?

<u>Hypotheses</u>

1. Households with cash income from wildlife/tourism will report less hunger months than households dependent on agriculture
2. Households closer to market centers will sell more of their crop
3. Households that have a member working in wildlife economy will purchase more food and other goods than households not directly involved in wildlife

1. Households more involved in off farm, cash economy will have less land in cultivation
2. Households headed by younger people with non-working age children will have more land under cultivation
3. Households in communities distant from tourism markets will have more land in cultivation.
4. Households in communities where financial benefits from wildlife are not shared will have more land in cultivation
5. Households that receive more subsidy from government and private companies will have less land in cultivation than households not receiving subsidy

Study Communities: 2010



- 340 Total Responses
- Total # Per Village:
  - Sankoyo: 40

Okavango Conservation Trust

- Seronga: 49
- Beetsha: 36
- Eretsha: 37

- Wuparo: 62

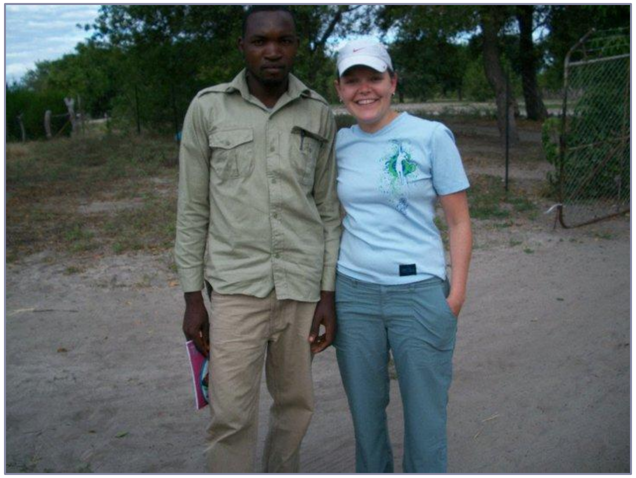
Chobe Enclave

- Satau: 56
- Mabele: 56

**4 surveys flagged, not included in analyses*

Methods

- Household Surveys
- Personal Interviews
  - Conducted with key informants:
  - Semi-structured interviews
  - Interview Themes:
    - Histories of migration
    - Population change
    - Agricultural practices
    - Vegetation and wildlife use
- Focus Groups



** We observed all confidentiality issues prior to administering interviews and the questionnaire: informed consent, freedom to ask questions, freedom to withdraw during the process*

Findings – initial for social

- Do alternatives to land-based livelihoods enhance resilience to climate variability? **YES, so far**

- Initial Statistics show:
  - Households deriving income from jobs in tourism are purchasing more goods and services
  - Households deriving income from jobs in tourism report less hunger
  - Households with jobs have more land under cultivation
  - Households with 3 or more subsidies have more land under cultivation

BUT, only half done with surveys. Summer 2011
Still linking to modeling, remote sensing etc.

nvironmental histories and land use

Environmental histories:

"when I was younger we used to have Teak, Erioloba, Giobortia, Terminalia ….. now we can only find Teak and Kiatt"

"now there are only shrubs and few trees, not many grasses"

Land use practices:

"more of these areas [shrub dominated lands] now, they are not good for grazing cattle and are dangerous"

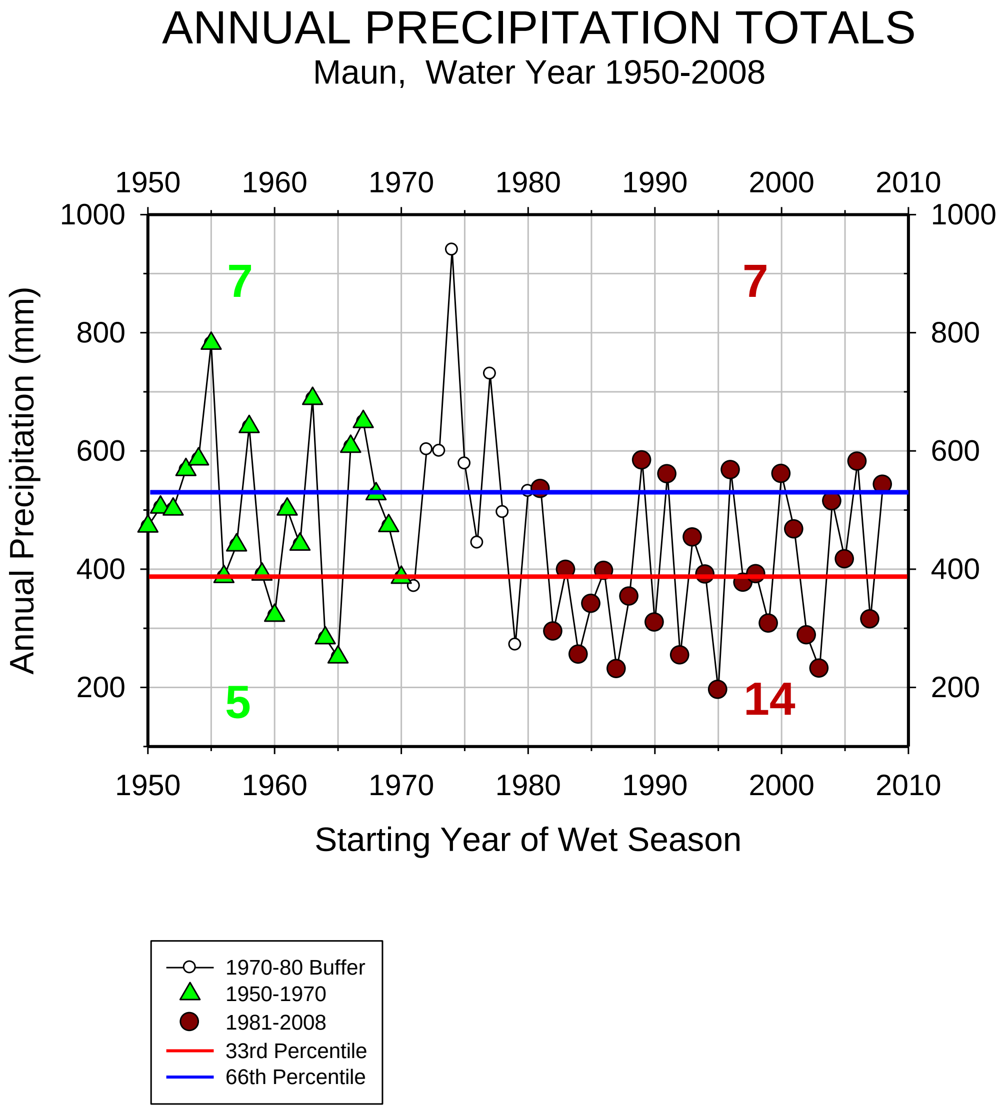
Time Series Analyses

- Multi temporal and spatial level analysis: 1982-2010, annual series
  - Precipitation monthly time series data (0.5 ◦ gridded dataset – Uni of Delaware,)
  - April and May as ideal months for studying long-term change
  - AVHRR Monthly data, 1982-2000
  - MODIS Monthly data, 2000-2009

- As such we can pull climate AND vegetation history into our landscape level studies – so providing CONTEXT, PERSPECTIVE and therefore potentially a useful FRAMEWORK for the larger research.

Main driver in this region = Precipitation

- Major climatic shifts have been found since the mid to late 1970's
  - A global climate shift
- Long term change, has 5 and 7 year cyclical events also, e.g., El Nino, Benguela current
  - Nicholson (2000).
- We treat this shift as a shock, ecologically
- We study post-shock landscape and changes by looking at NDVI, new equilibrium?



- **Mean-Variance Time-Series Analysis**
  - To characterize the spatio-temporal behavior of the RS vegetation index
    - Mean = amount of vegetation
    - Variance = degree of landscape heterogeneity
  - Post-event recovery can be assessed via malleability
    - Here our ‘event’ is the change in precipitation patterns, overall a decrease in precipitation amount since the 1970s

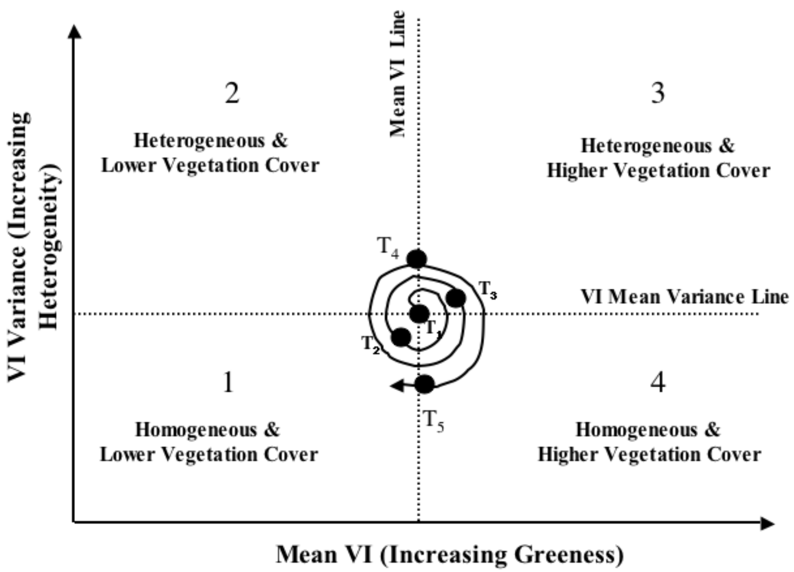


Figure: Hypothetical statistical phase portrait of the inter-annual mean-variance dynamics of an agricultural landscape’s vegetation index (VI).
T = time.

Source: Washington-Allen et al. 2008

egetation shifts in drylands ecosystem - possible vegetation states across our region

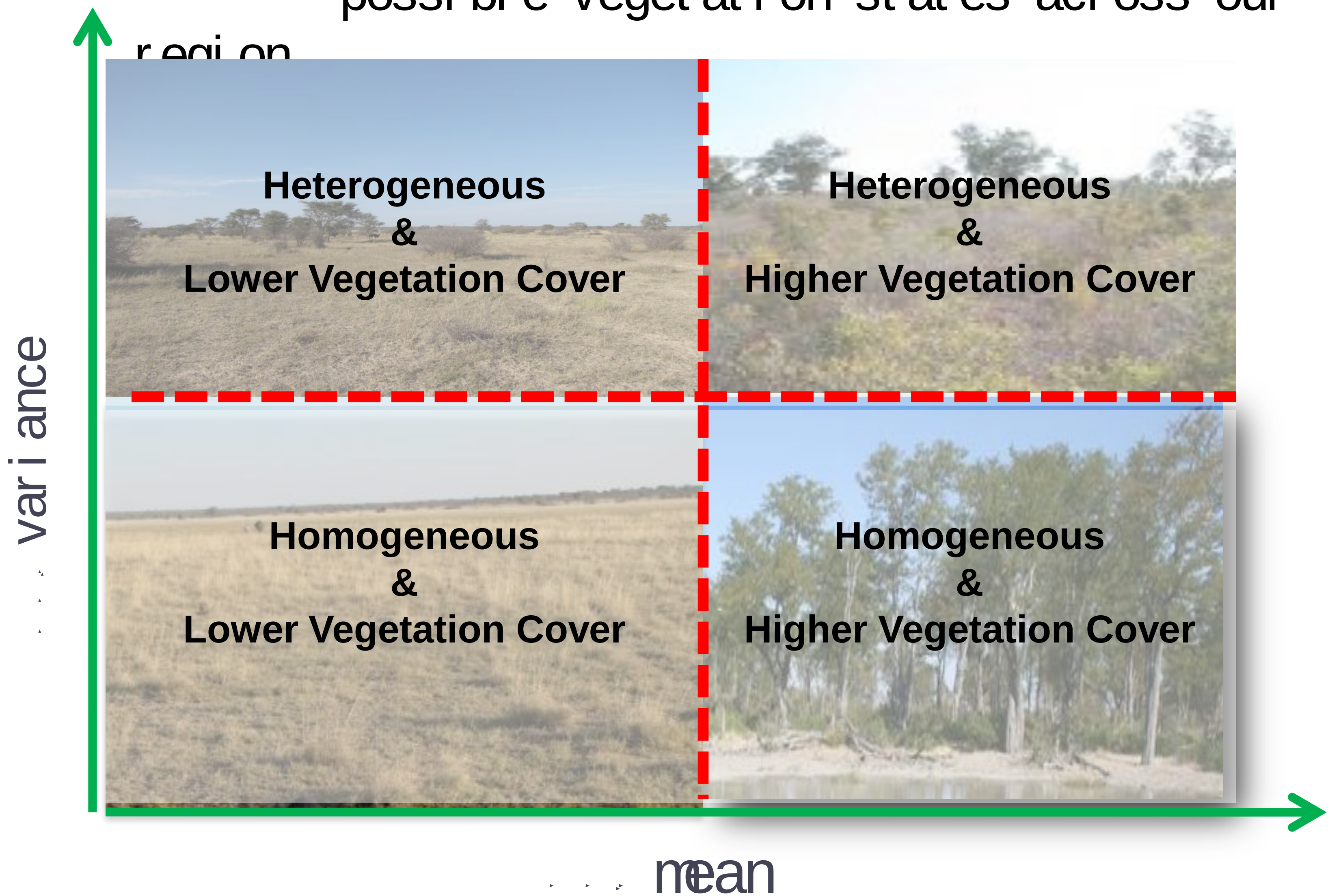
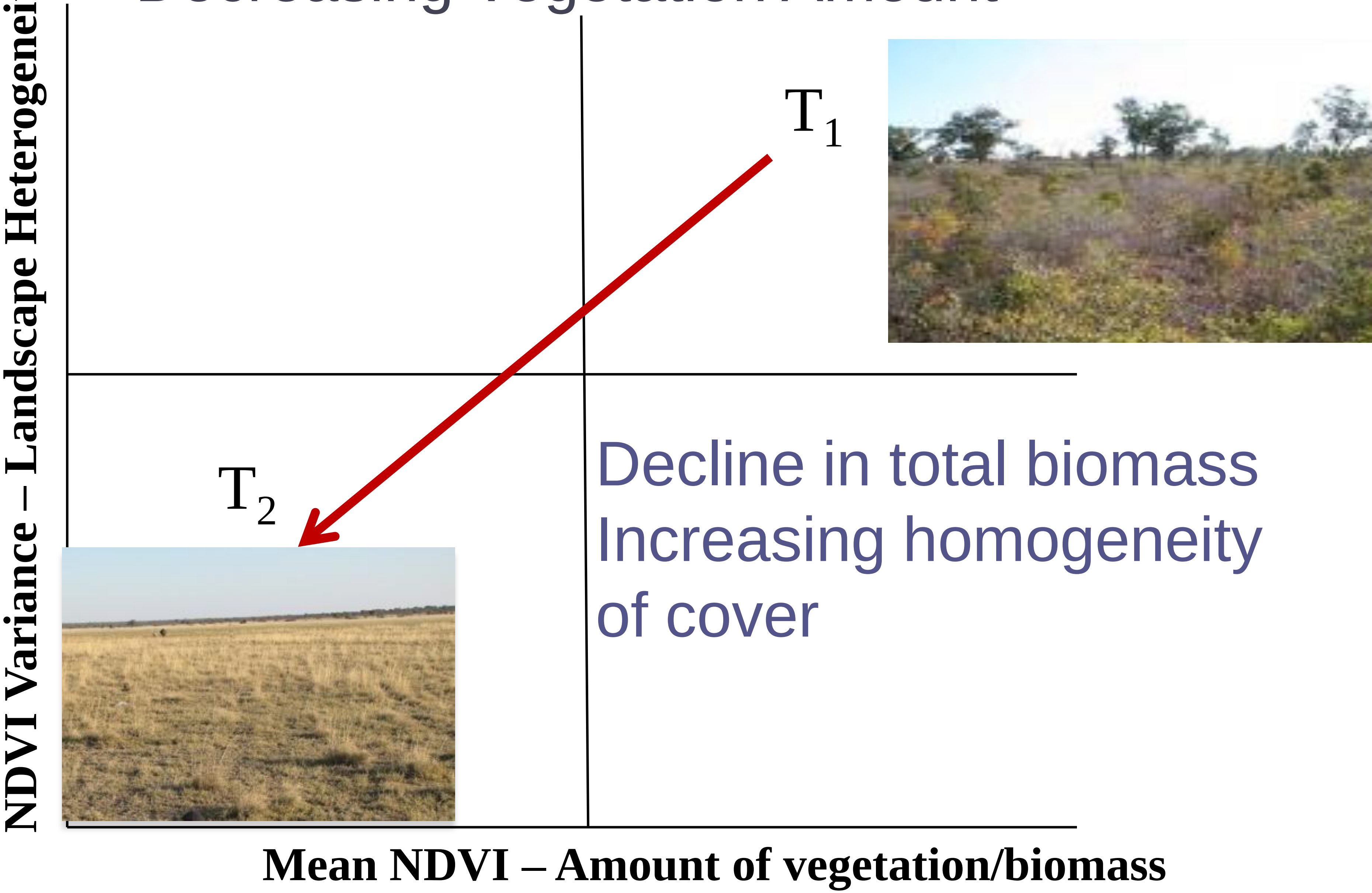
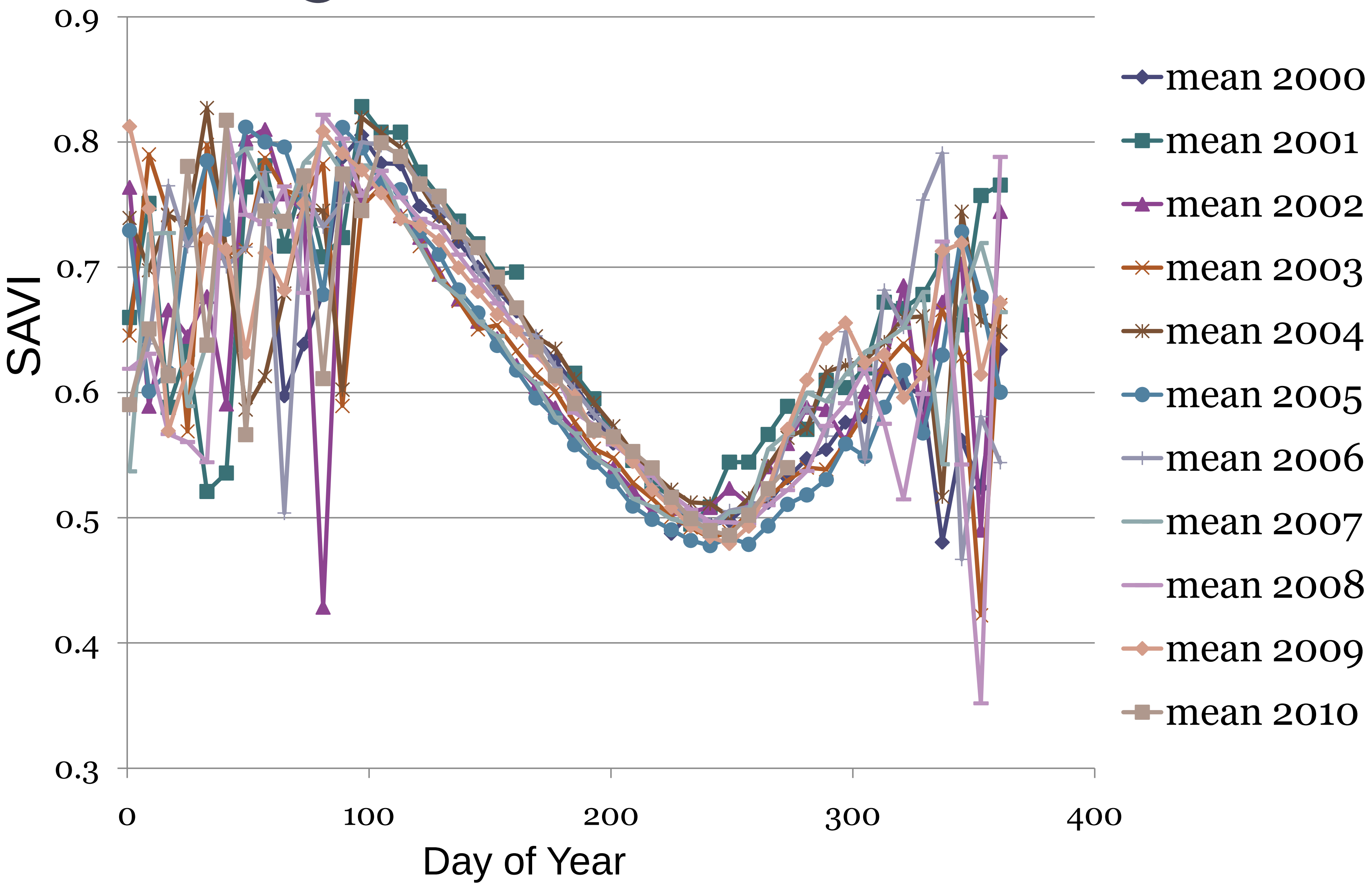


Figure based on Washington-Allen et al. 2009

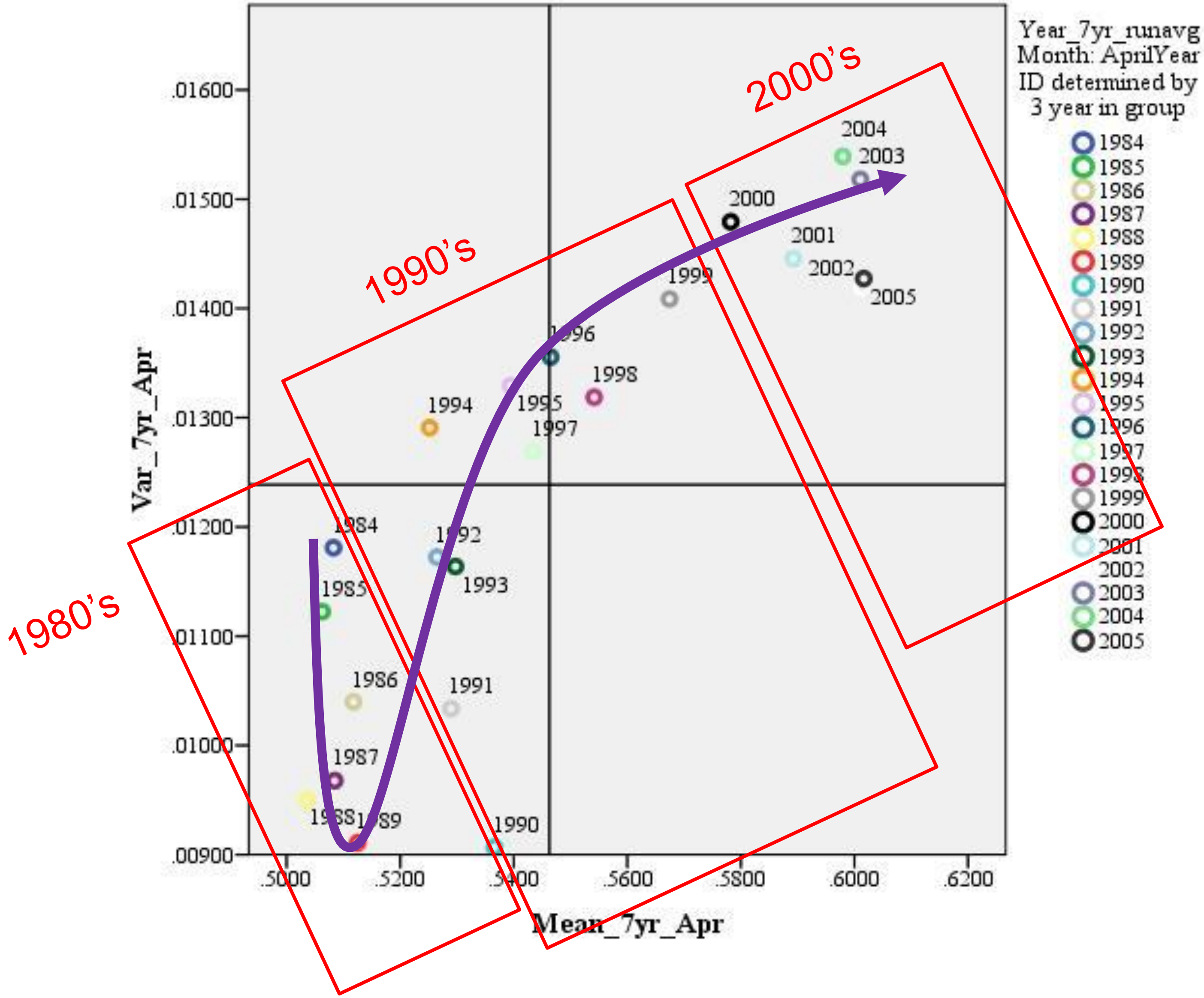
Decreasing Vegetation Amount



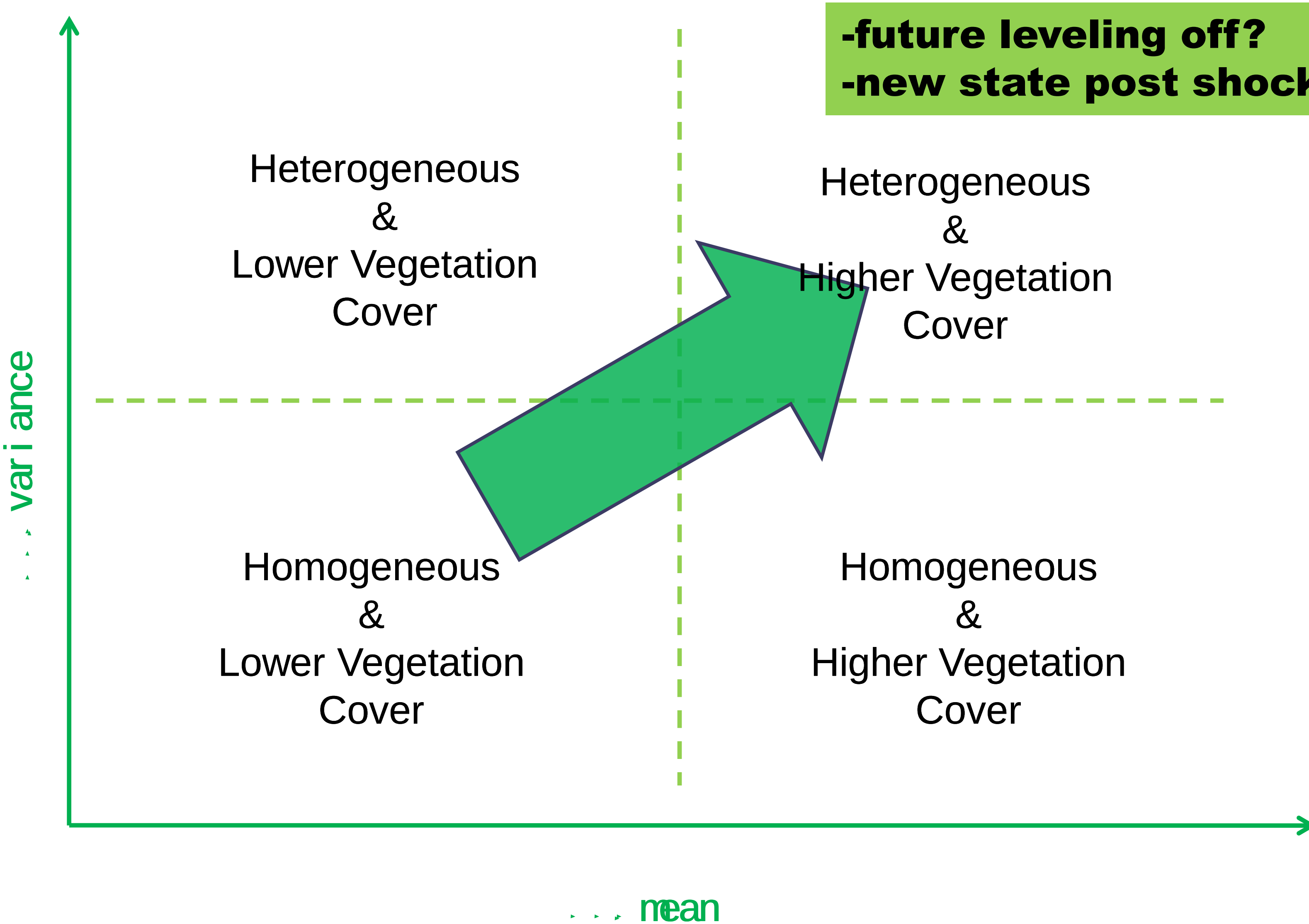
Timing matters!



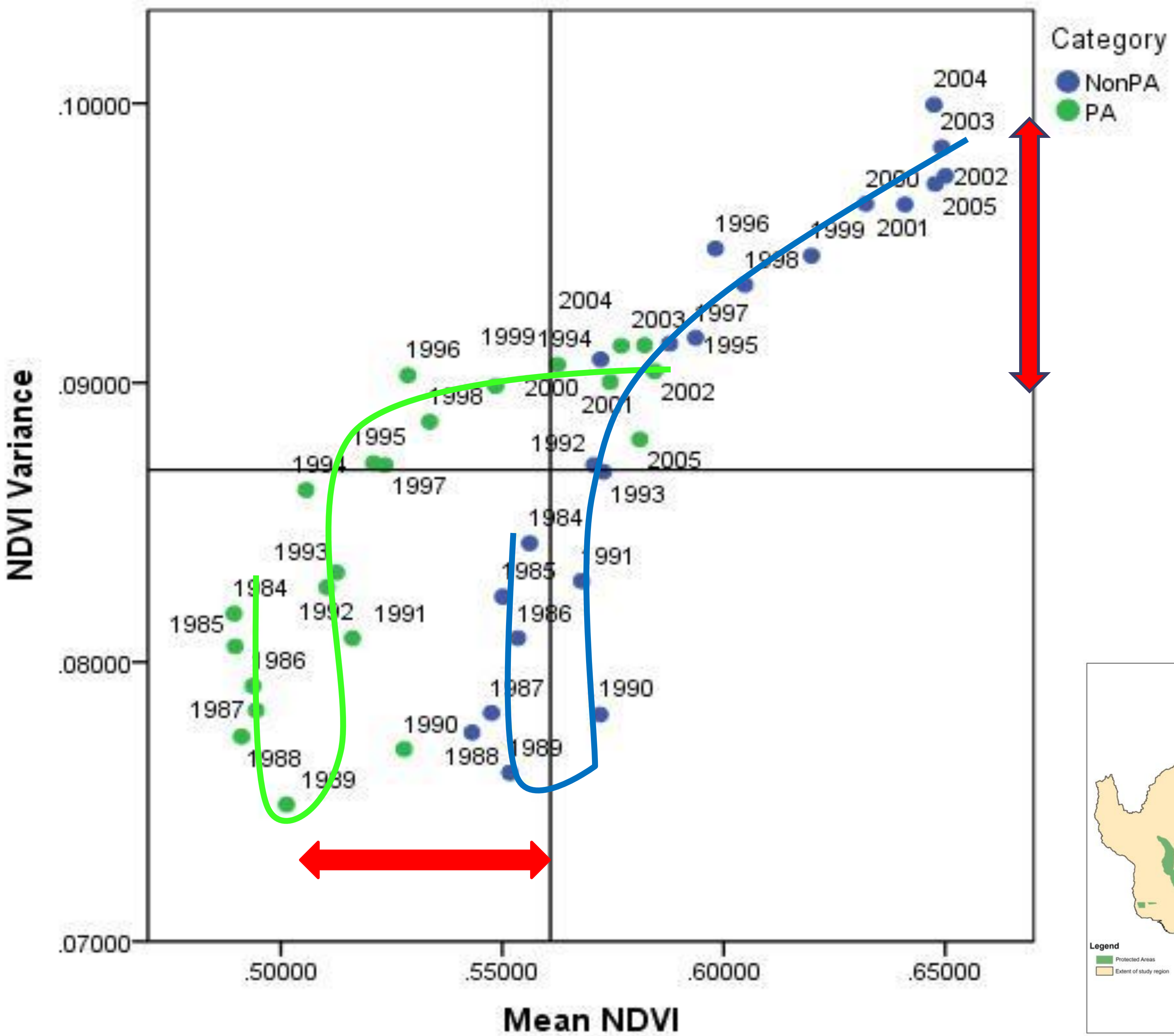
Precipitation on known 5-7 years cycles, so to determine the long-term changes produced a 7-year running mean of the NDVI input



-future leveling off?
-new state post shock?



Overall trend is one of increasing vegetation cover and increased spatial variance of vegetation


Category
NonPA
PA
NDVI Variance
Mean NDVI
.10000
.09000
.08000
.07000
.50000
.55000
.60000
.65000
2004
2003
2002
2005
2001
1999
1996
1998
1997
1995
1994
1992
1993
1984
1985
1986
1987
1988
1989
1990
1991
2000


Legend
Protected Areas
Extent of study region

Persistence analysis.

- direction of change (i.e. increase or decrease in NDVI) relative to the reference state (1982) is determined using the following nomenclature:

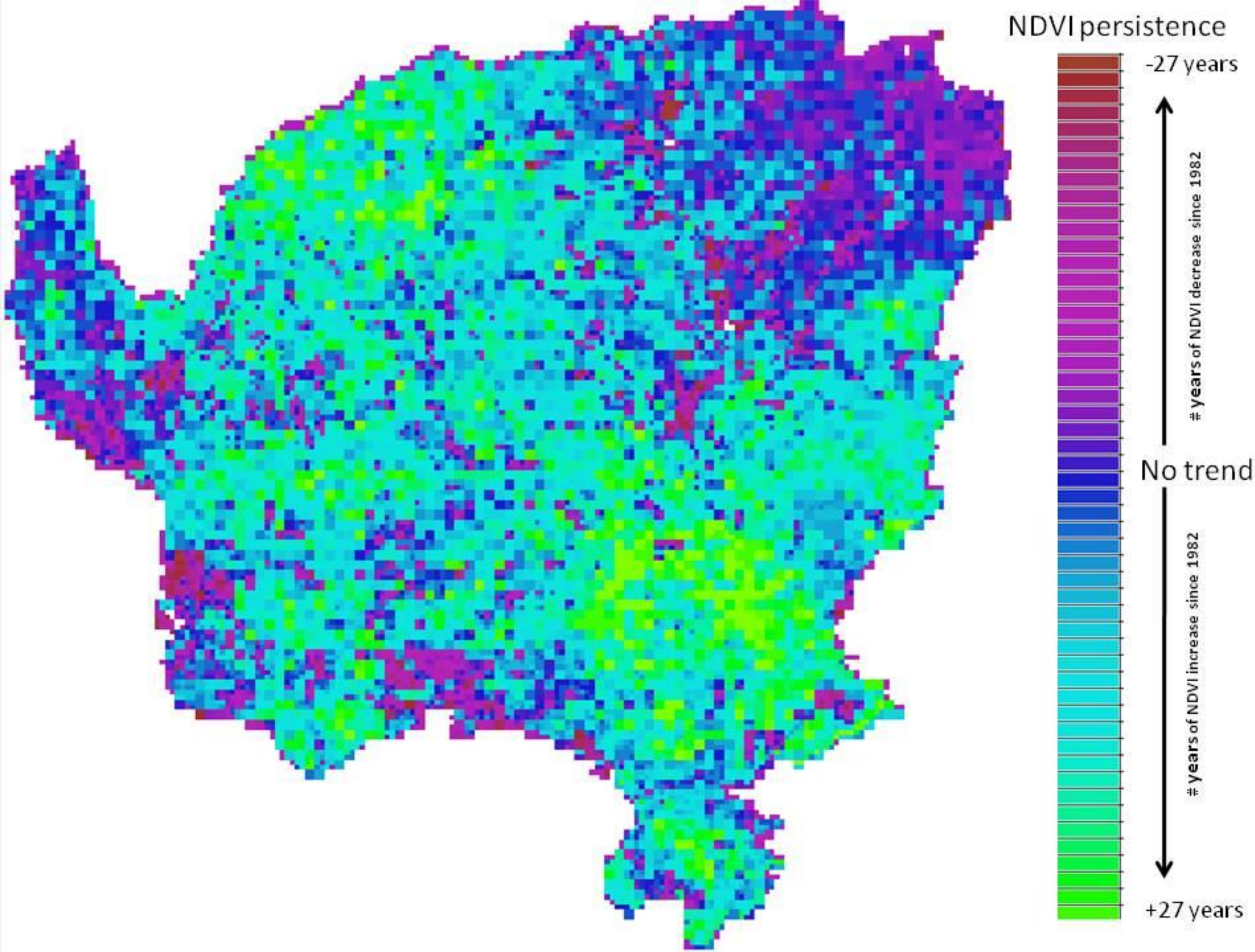
  $t < t_i$ = +1 [increase in NDVI]

  $t > t_i$ = - 1 [decrease in NDVI]

  $t = t_i$ = 0 [no change]

- cumulative persistence layer is then calculated by summing each of the persistence maps.

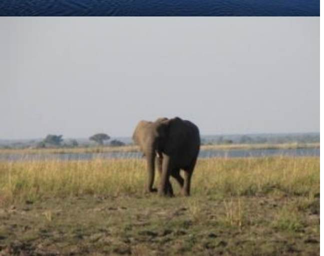
- Summed overall change in NDVI calculating the total amount of change



NDVI persistence
-27 years
years of NDVI decrease since 1982
No trend
years of NDVI increase since 1982
+27 years





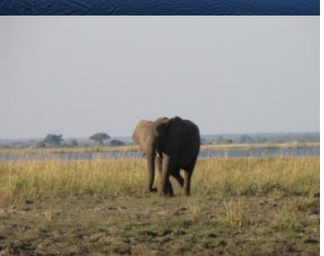



So far

- Significant shifts across this landscape once inter-annual variability accounted for:
  - In terms of 'resilience' we appear to be in higher mean and variance phase for savanna in our study region overall
    - a more RESILIENT landscape?
    - Also persists spatially





- Highlights need to place studies into a real landscape context in terms of spatial and temporal patterns
  - Can now place finer scale social-economic analyses into broader context
  - Select sites based on contrasting trends
  - Separate out park and land management types
  - Incorporate people and their adaptation, resilience and vulnerability

Future Directions?

- Field season summer 2011
  - Social and ecological data capture
  - Remote sensing method validation
- Model output and assessment
- Continued integration of social and ecological
- Global Sensitivity Analysis initiated on model output


Thank you