WATER AND RESILIENCE OF AGRICULTURAL LANDSCAPES

2 CASES AT 2 SCALES

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I. HUMAN MODIFICATIONS OF GLOBAL VAPOR FLOWS

II. LAND DEGRADATION IN MAKANYA, TANZANIA

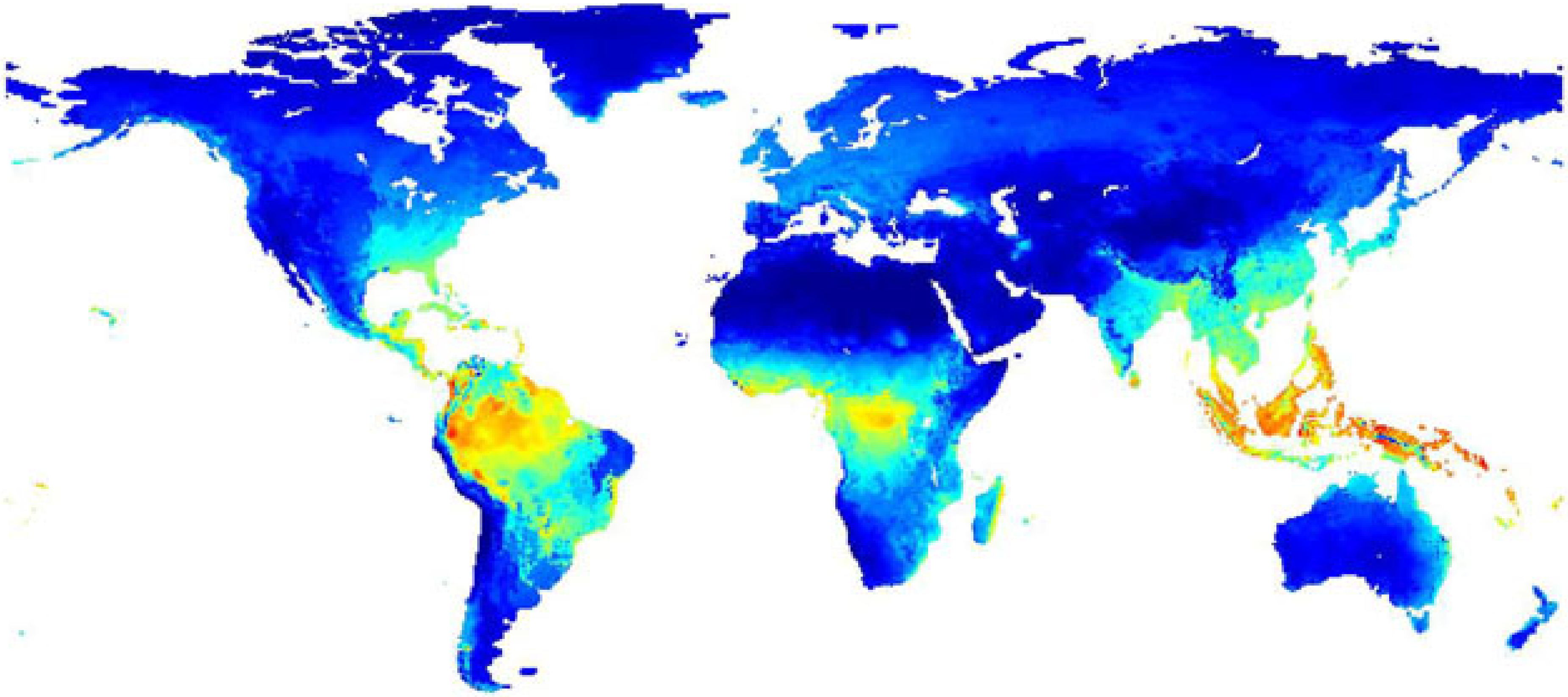
Human Modification of Global Vapor Flows From the Land Surface

Global Model of 0.5° by 0.5° Grid Cells

Understanding human impact (mainly from agricultural activities) on the terrestrial part of the hydrological cycle

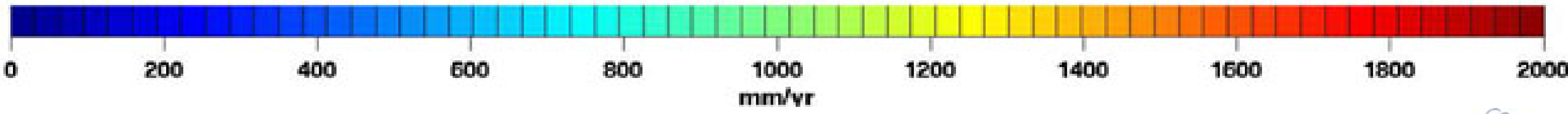
Comparing vapor flows from present vegetation with vapor flows from potential vegetation

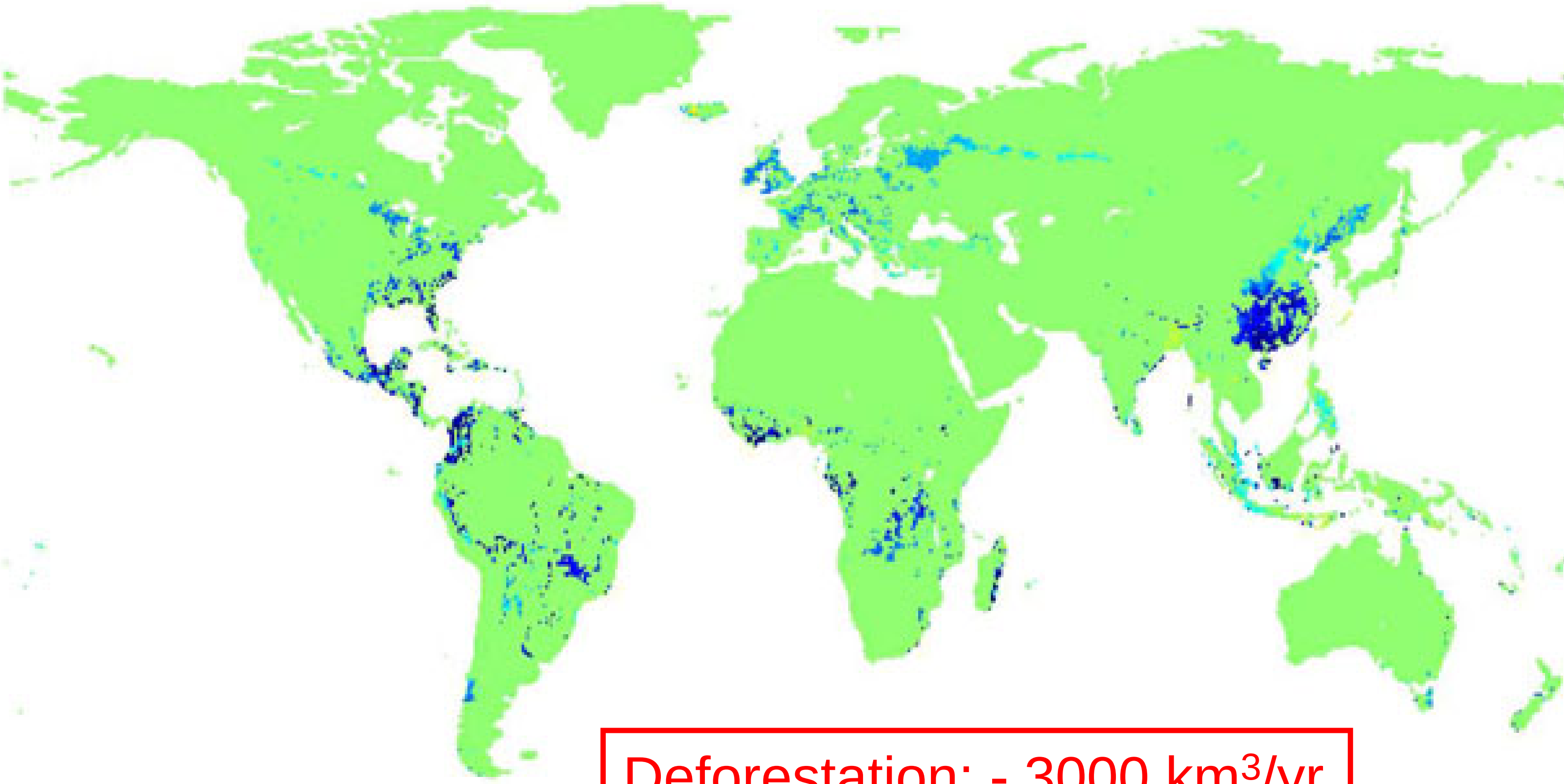
Focus on deforestation and irrigation



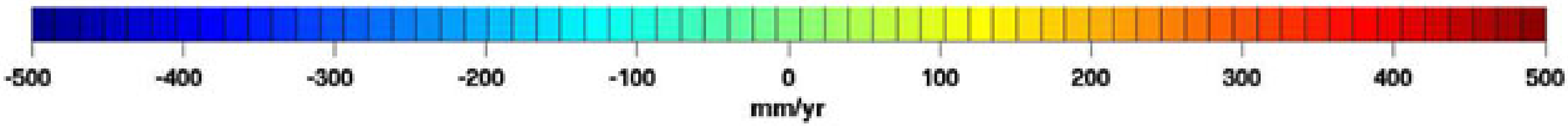
GLOBAL ANNUAL VAPOUR FLOWS (mm/yr)

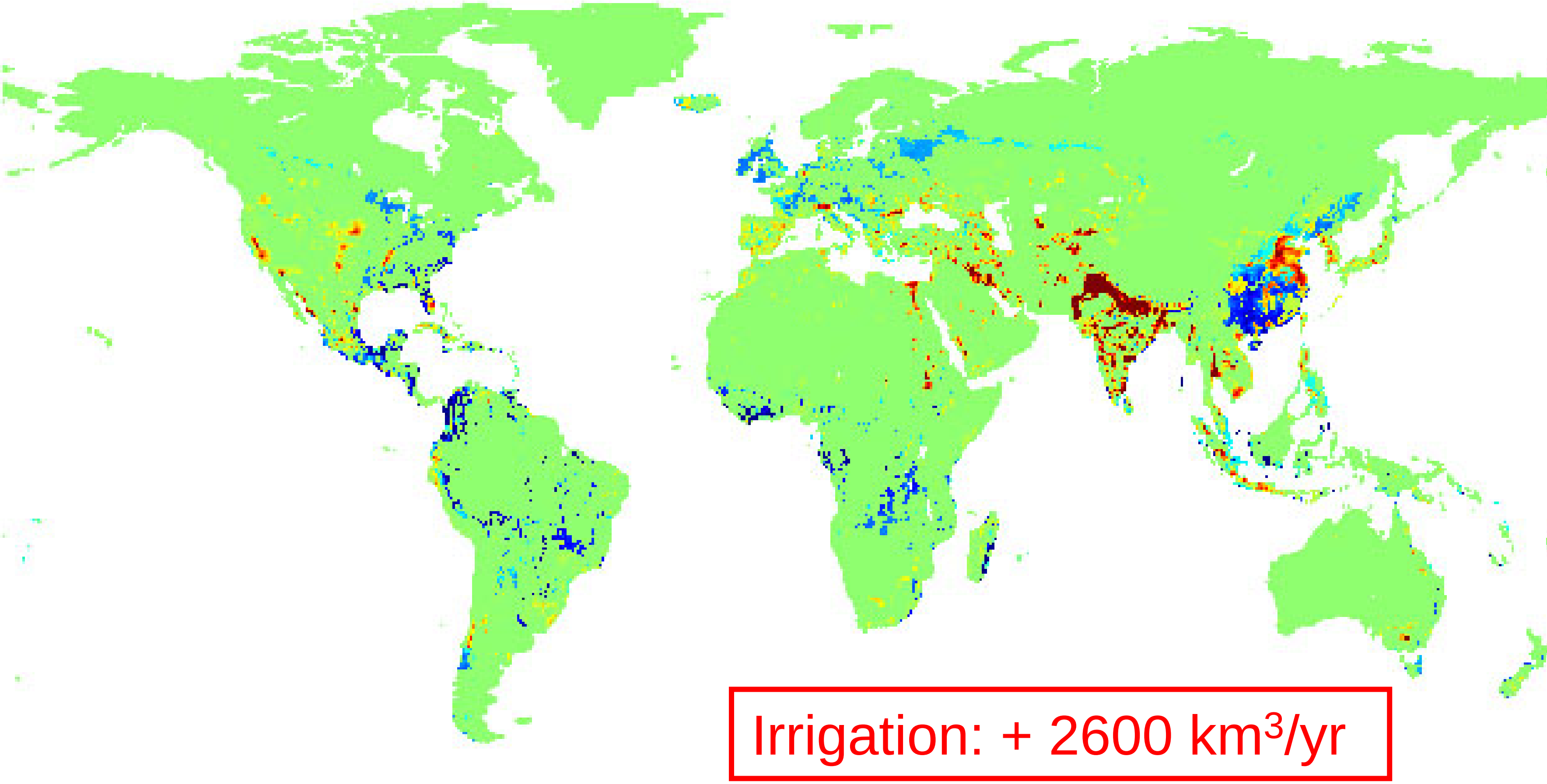
Global Total: 67 000 km^3/yr



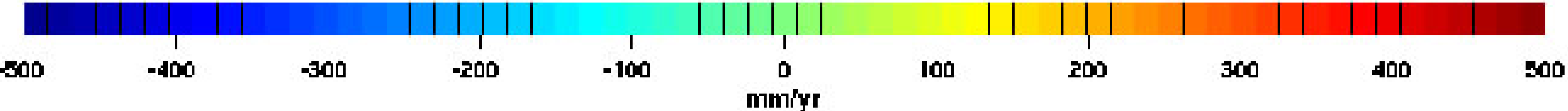


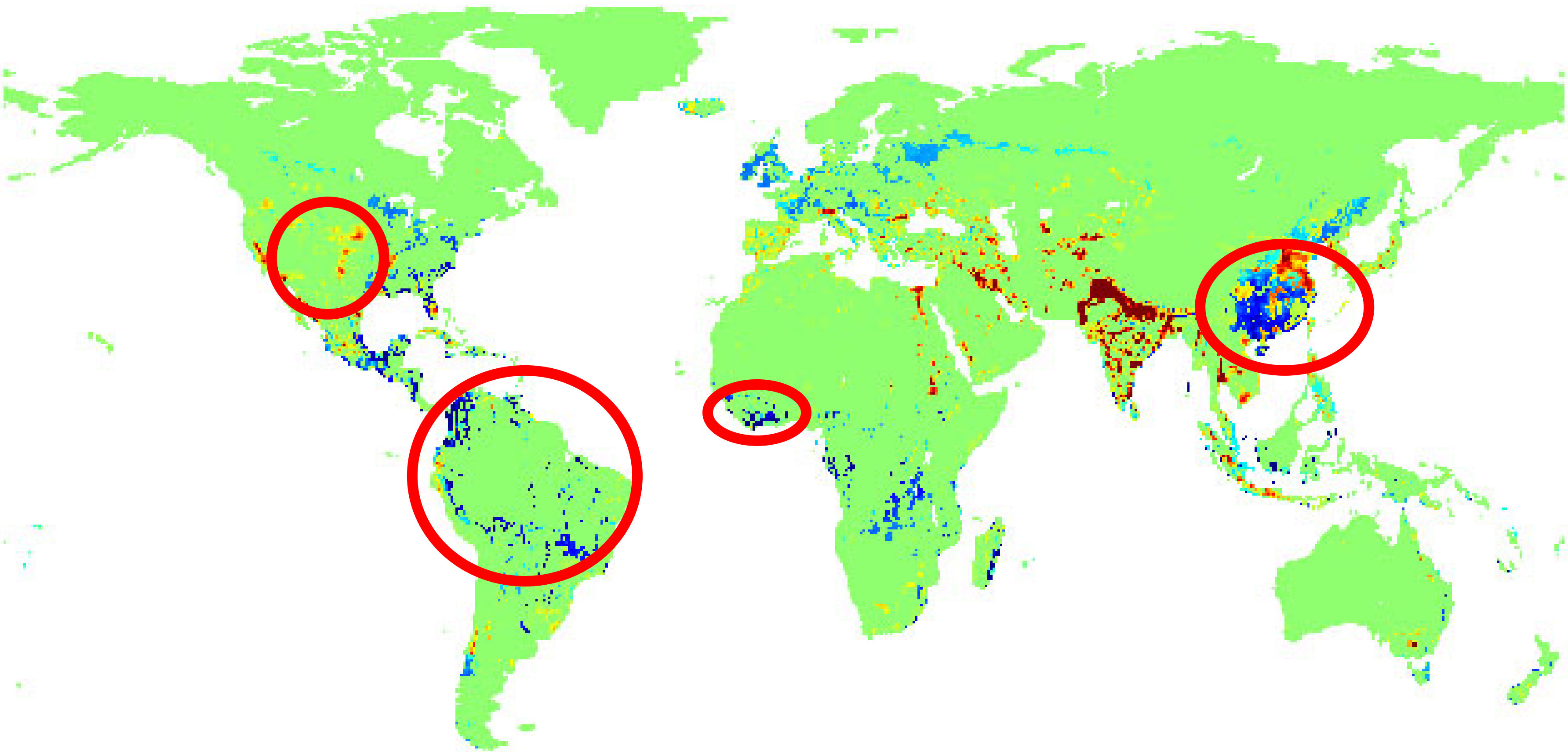
CHANGES IN GLOBAL VAPOR FLOWS DUE TO DEFORESTATION



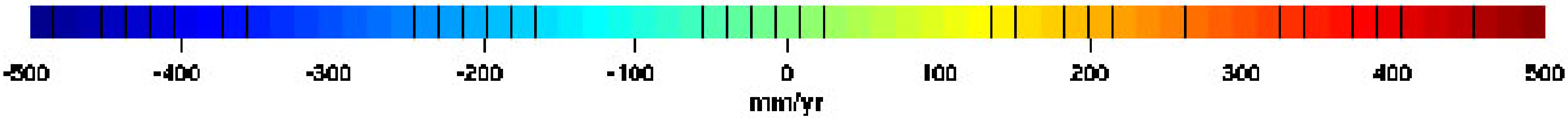


CHANGE THROUGH DEFORESTATION AND IRRIGATION

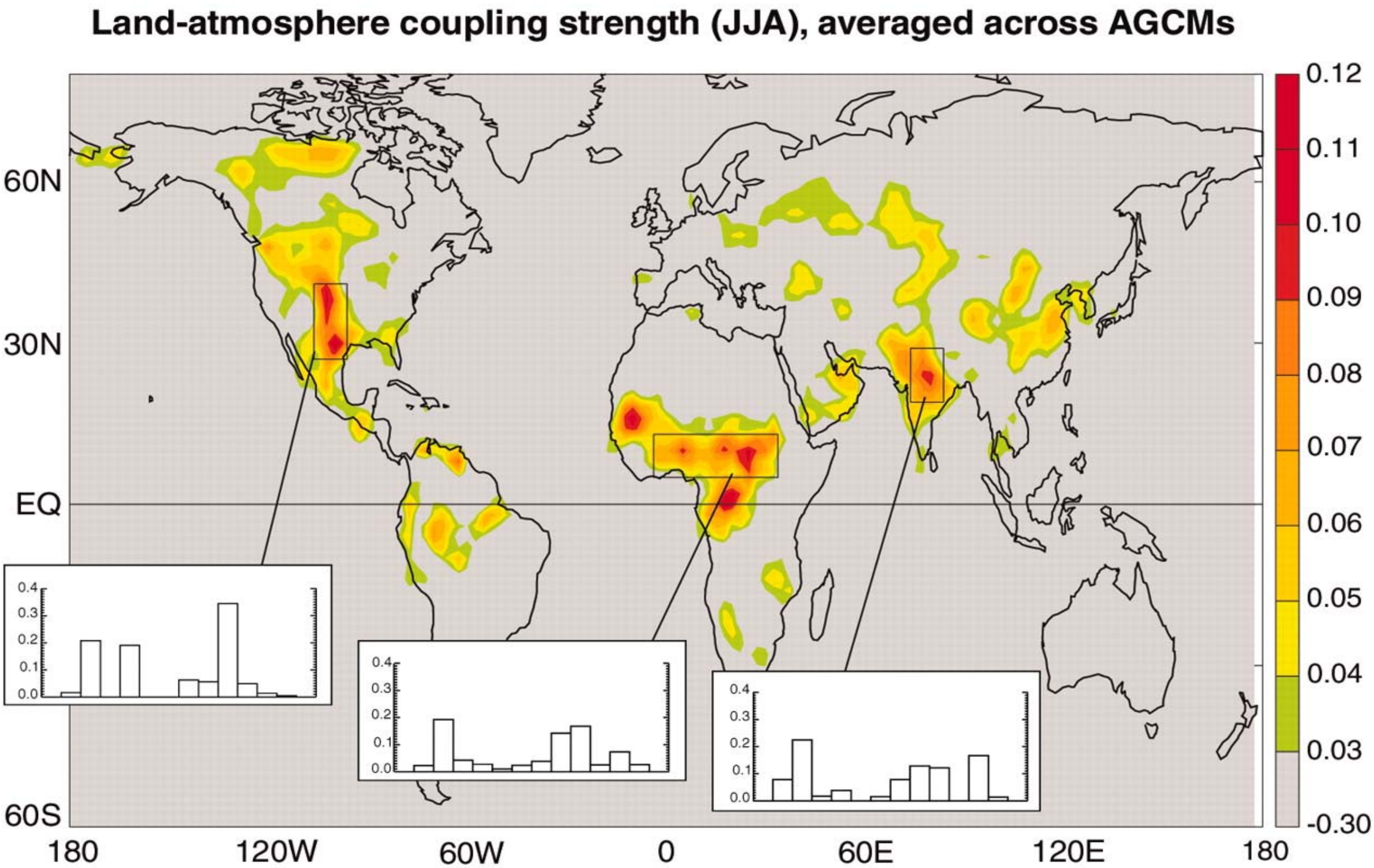




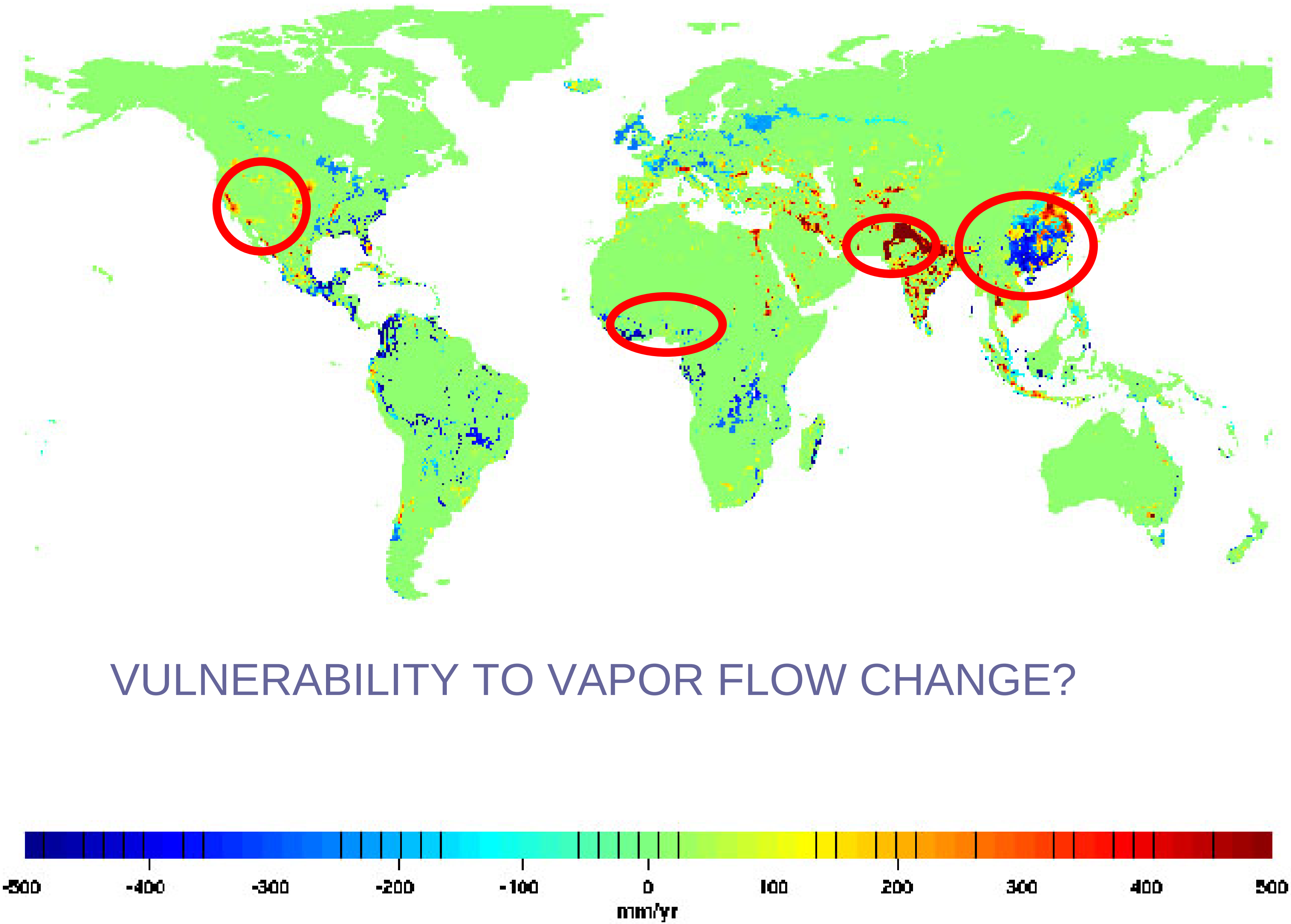
CHANGE THROUGH DEFORESTATION AND IRRIGATION



Estimated Areas of Strong Land Atmosphere Couplings



(Koster et al 2004)



VULNERABILITY TO VAPOR FLOW CHANGE?

CONCLUSIONS:

Increased vapor flows from irrigation has almost compensated for deforestation at a global scale but the global average masks regional differences

Extraction of ecosystem services locally can compromise the flow of goods and services at a different temporal and spatial scale

Changing freshwater regimes may not be seen until they cause abrupt changes in ecosystems

Need to understand the relative role of climatic change / change in vapor flows - need to include biospheric feedback in global modeling

Analyzing resilience in dryland ecosystems:

a case study of the Makanya catchment in Tanzania over the past 50 years

Enfors and Gordon, in prep

UNIVERSITY OF KWAZULU-NATAL

UNESCO-IHE Institute for Water Education

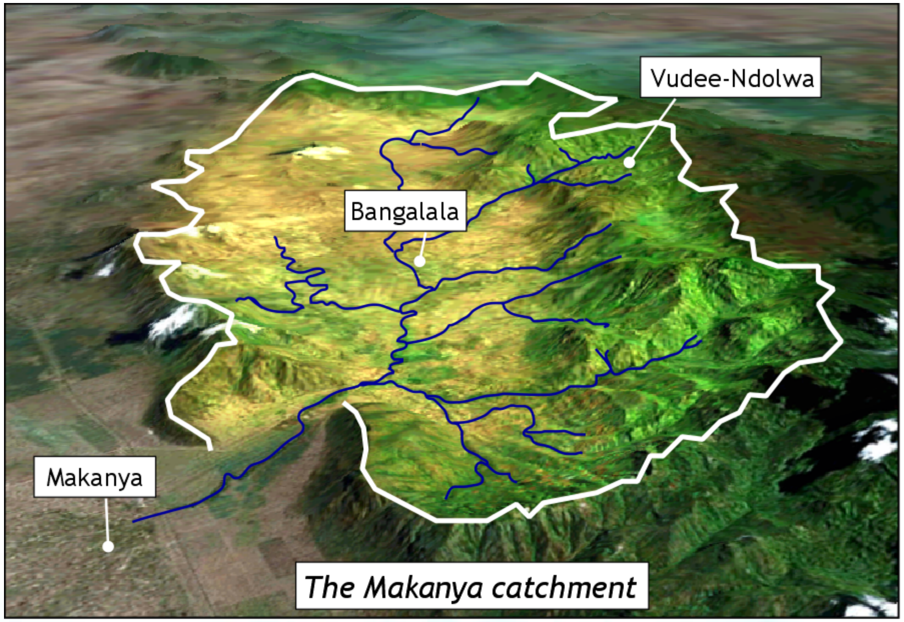
IWMI International Water Management Institute

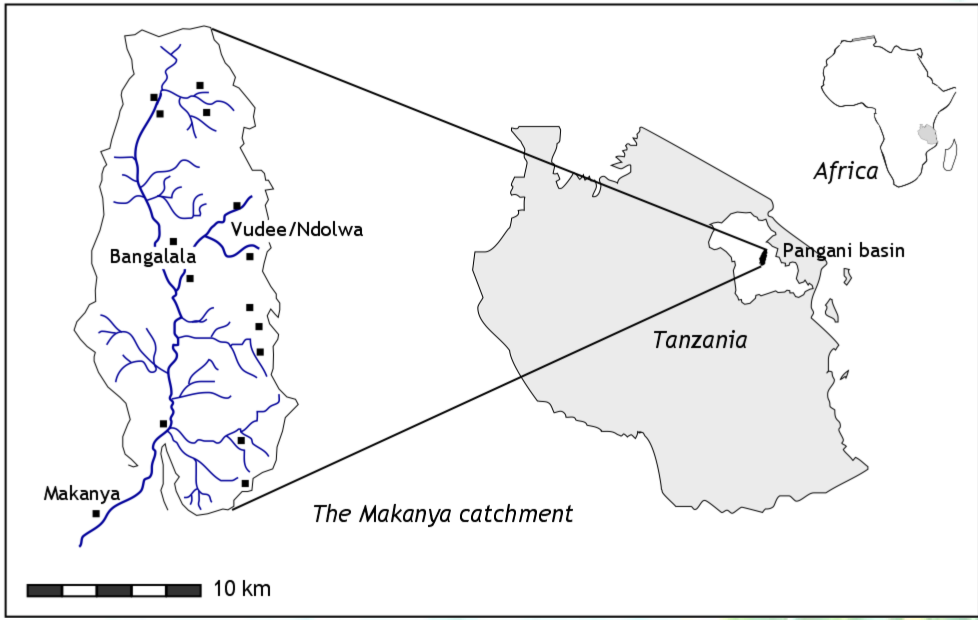
Research goals

Analyzing the changes in resilience of the agro-ecosystem, including the societies that depend on them, in the Makanya catchment, Tanzania, over the past 60 years including the driving forces behind them

Developing a conceptual framework for analyzing resilience of smallholder subsistence agro-ecological systems in semi-arid tropics

Makanya, South Pare Mountains, Tanzania





Resilience

the capacity of a social-ecological system to cope with change and reorganize afterwards, without loosing its essential functions

• Social-ecological systems can have multiple stability domains

• Low resilience increases the probability for shifts between these

• Most systems are robust over a certain range of conditions but respond strongly when key variables approached certain thresholds

• There are a few variables that determine the resilience of the system

Interpretation for the Makanya agro-ecosystem

The main function of agro-ecosystems is to generate food and other ecosystem services needed by the population

Two alternative states are envisioned *for this system*: one ‘productive’ (biophysical capacity to sustain the population over time), one ‘degraded’

We propose that “soil water index” and “ecosystem insurance capacity” are two of the key variables in this system

The two key variables

Soil water index

a) amount water (per cap) theoretically available on arable lands

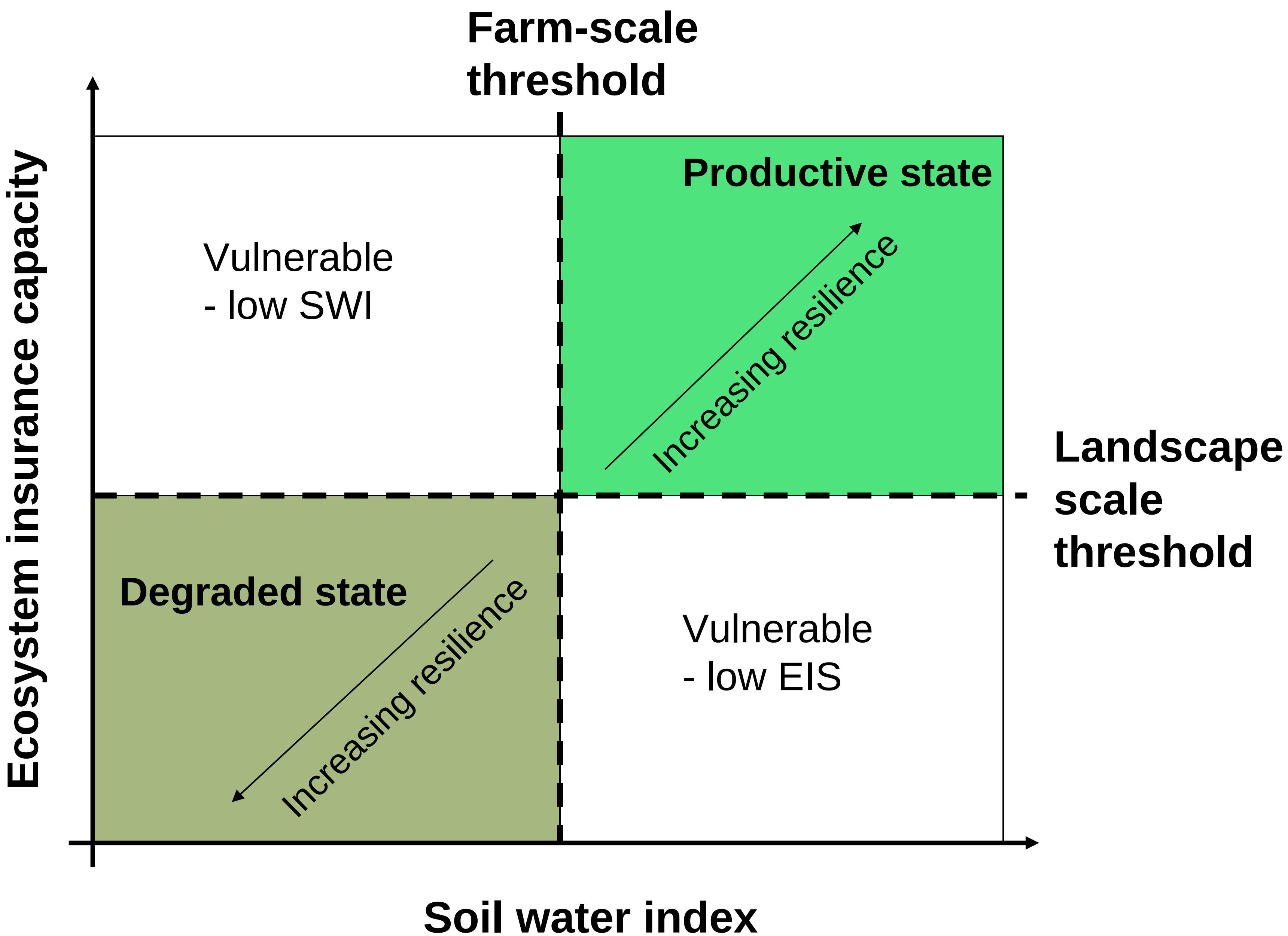
b) probability of receiving this amount, (e.g. risks of dry-spells, droughts and non-access to irrigation)

c) on-farm soil properties (infiltration, water holding capacity, plant uptake capacity)

Ecosystem Insurance Capacity

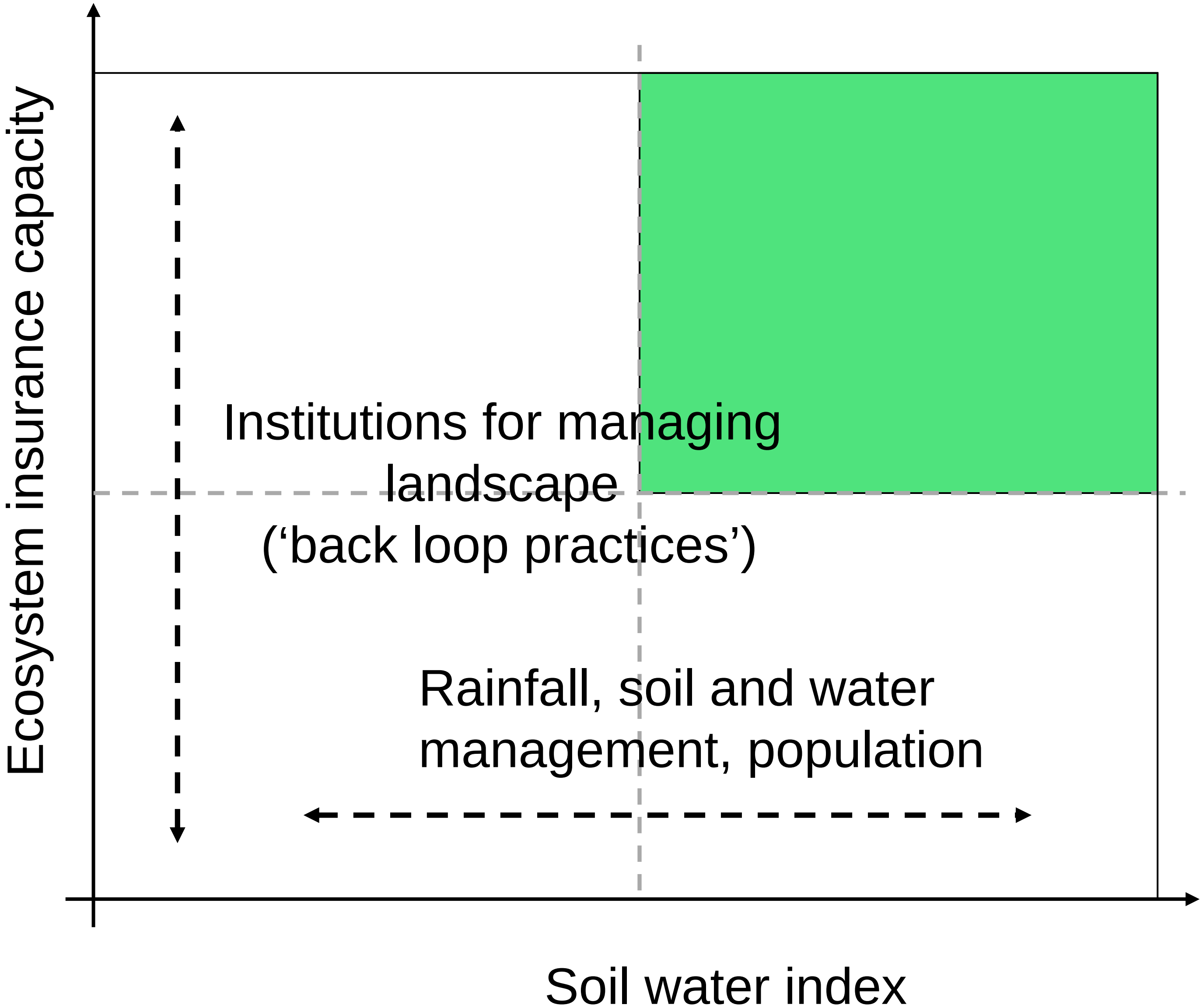
a) Increase of use of ES when failed or decreased yields

b) the recovery capacity of ecosystems after such a period

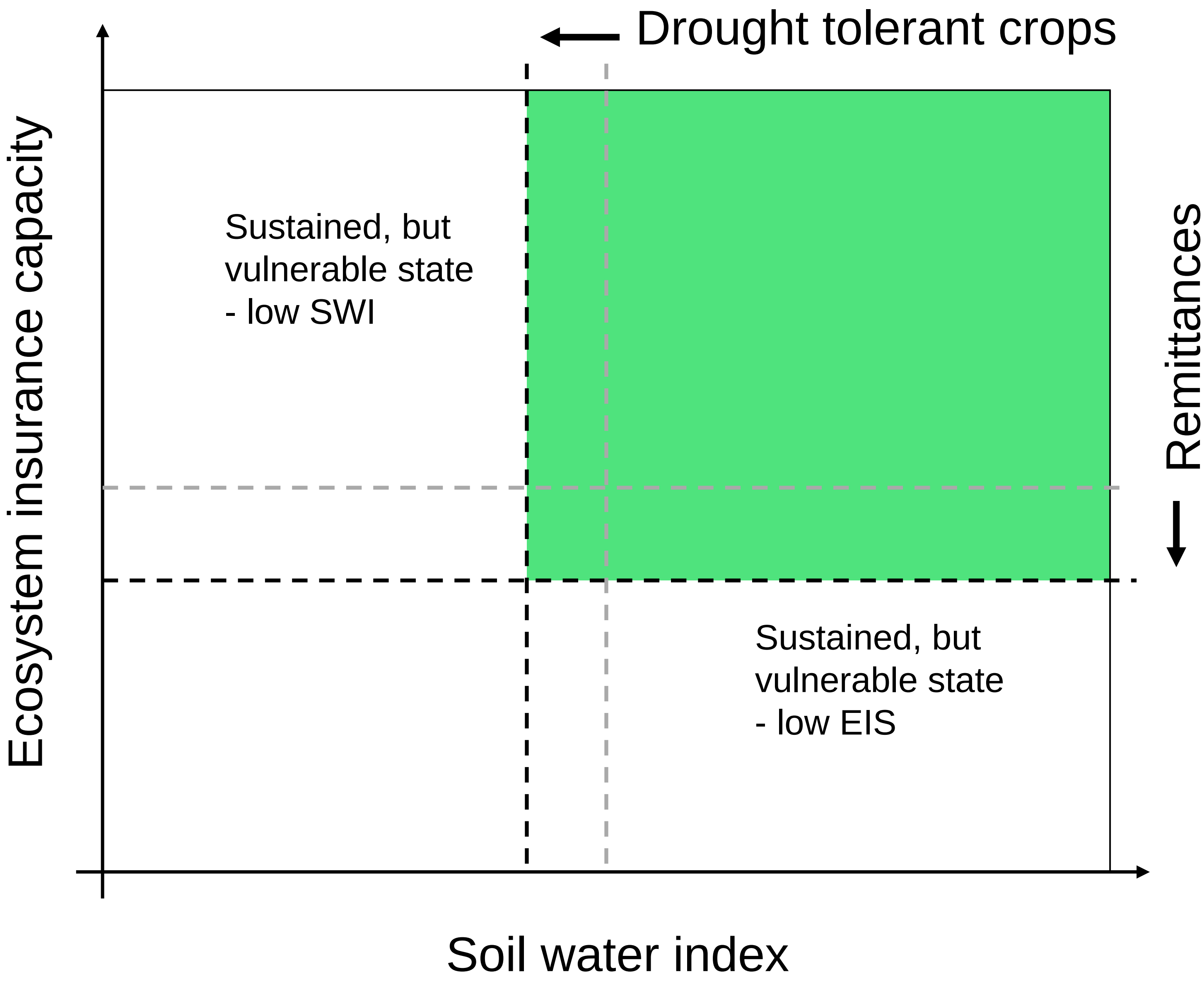


Farm-scale threshold
Productive state
Increasing resilience
Vulnerable
- low SWI
Landscape scale threshold
Degraded state
Increasing resilience
Vulnerable
- low EIS
Ecosystem insurance capacity
Soil water index

Moving the system



Moving thresholds



Methods

Interviews & construction of timelines with local farmers, extensionists and district level authorities

Aerial photo/satellite image interpretations of land cover change

Rainfall analysis

Population data

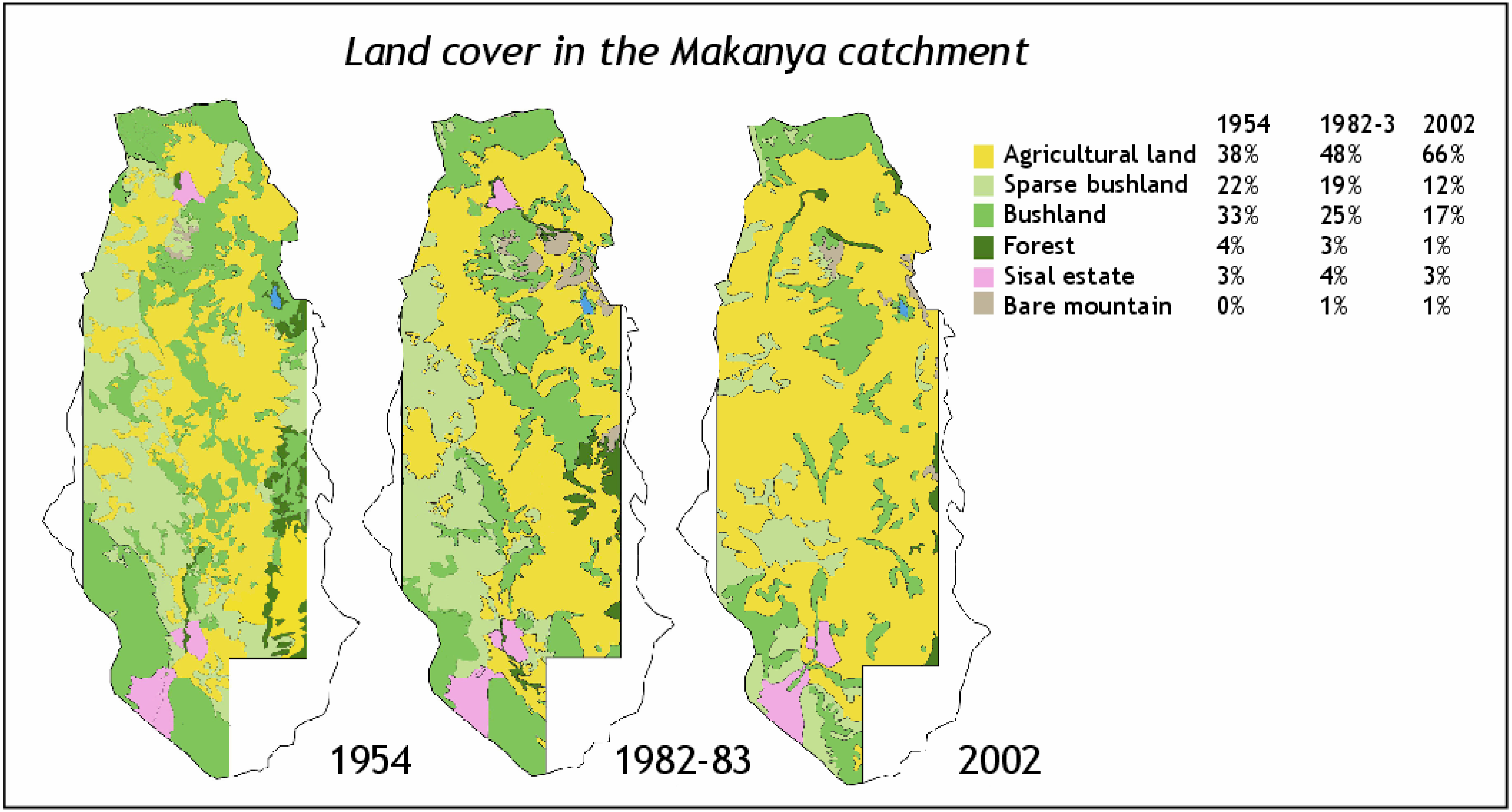
(also started soil sampling etc)

Based on field work done 2004-2005

	The Colonial period - 1961
Socio-political structure *(national scale driver)*	• Low population that live from subsistence farming • The colonial system rule through local chiefs • Imposed cash crop production
Natural resource management *(regional-local scale driver)*	• Colonial laws to protect land, water and forests exist parallel to local institutions for resource access/control • Local chiefs enforce these rules and laws
Local perceptions of agro-ecological conditions *(local outcomes)*	• Natural resources used in daily life readily available • More reliable rainfall • Only a small portion of the land used for farming - fallows used

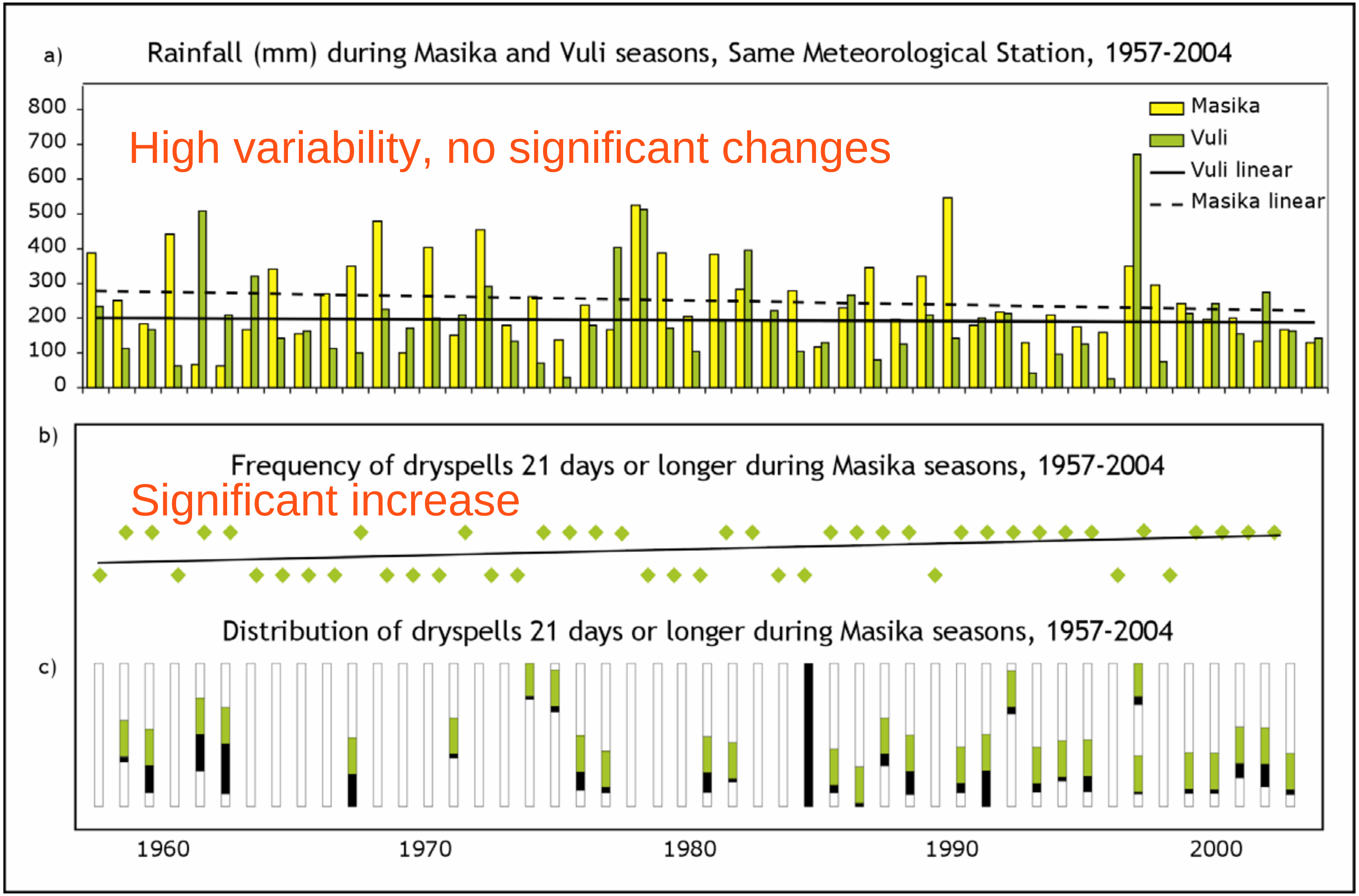
	The Development of independent Tanzania 1961-1985
Socio-political structure (national scale driver)	• Population growth, improved education & health care • Socialism, self-reliance and ujamaa national goals • Villagization (>50% of population) • Economic decline
Natural resource management *(regional-local scale driver)*	• Replacement of local chiefs leads to weaker protection of NR • Farming and livestock keeping more permanent • By-laws created to protect the environment
Local perceptions of agro-ecological conditions *(local outcomes)*	• Expansion of agr. land, farmers cultivate both seasons • Protected areas encroached upon • Decreasing forest / bush land cover • Disappearance of wildlife • Drier conditions

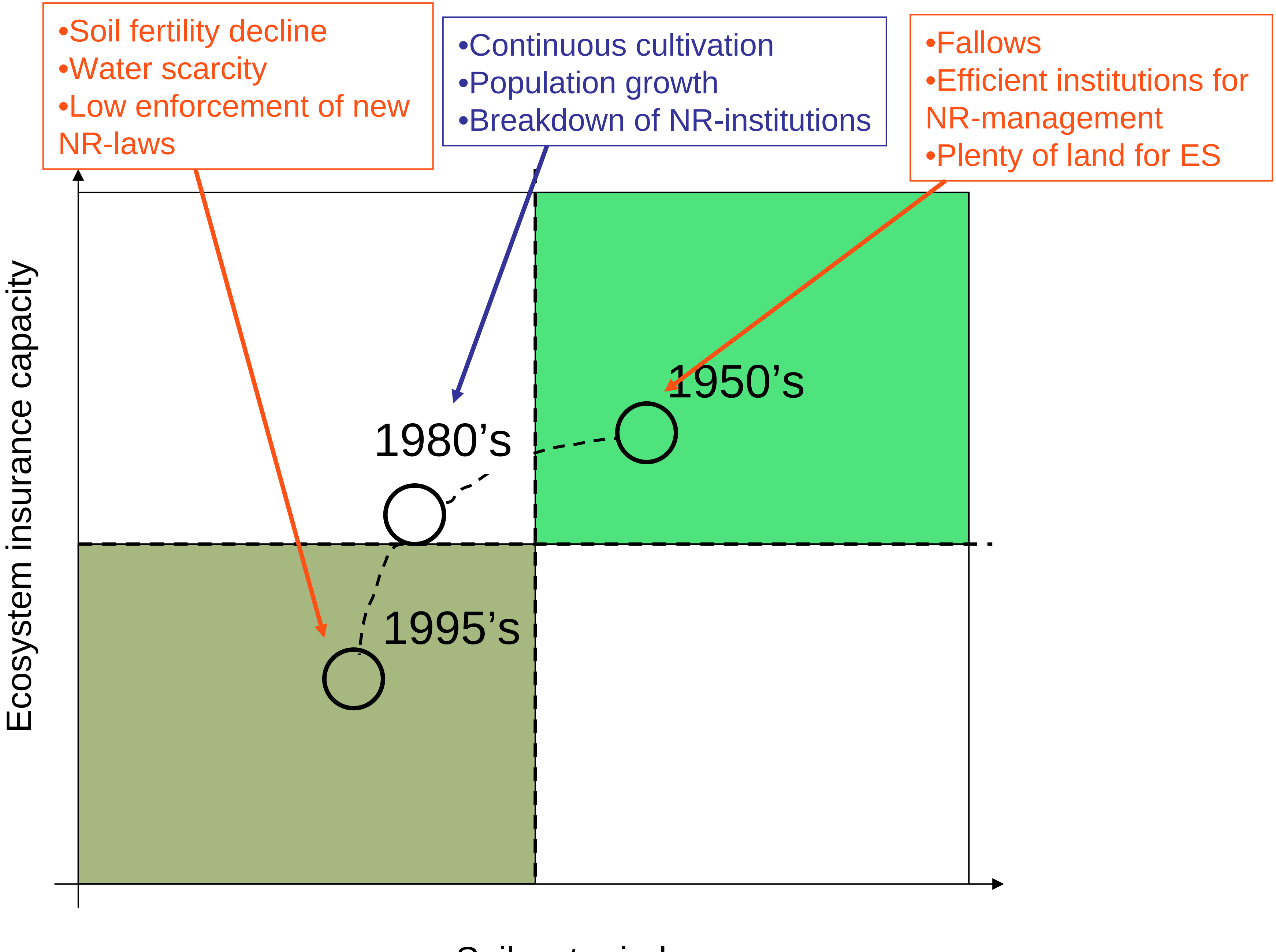
	The economic liberalization period 1985-
Socio-political structure (national scale driver)	• Economic crisis leads to reforms and SAP • Multi-party system adopted • NGOs important actors in rural development and participation on the agenda • From ‘efficiency governance’ to good governance
Natural resource management *(regional-local scale driver)*	• By-laws for environmental protection inefficient • Far reaching policy changes make alternative forms of NRM possible
Local perceptions of agro-ecological conditions *(local outcomes)*	• Lack of farming land in spite of expansion, low soil fertility • Illegal logging - large scale problem • Natural resources used in daily life increasingly difficult to find • Low rainfall and pop. growth seen as reasons behind this change



Narratives on agro-ecological change and land cover change analysis largely support each other

Analysis of rain data




•Soil fertility decline
•Water scarcity
•Low enforcement of new NR-laws
•Continuous cultivation
•Population growth
•Breakdown of NR-institutions
•Fallows
•Efficient institutions for NR-management
•Plenty of land for ES
1950's
1980's
1995's
Ecosystem insurance capacity
Soil water index

Summary

• Considerable land use/cover change causing a loss of ecosystem services. ‘Soil health’ has declined. Increasing dry-spell frequency, increased competition over NDIVA water

• Driven by huge re-organisation of society where strategies for natural resource management ‘did not keep up’, at the same time that population growth escalated

Potential for reversing a negative trend

- New local organizations and institutions are developing
- Local action is made possible and encouraged, including decreasing knowledge gaps
- The issue of land degradation is on the agenda both locally and globally due to a perceived crisis
- Higher availability of innovative farming techniques