‘Exploiting linkages between soil quality, biodiversity and agricultural production’

Andrew Gillison

Center for Biodiversity Management

Queensland, Australia

Theme 1.1

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Limitations to African Agriculture

- Prime land occupies about 9.6%
- Lands with high potential 6.7%
- Medium-low potential 28.3%
- Deserts & areas with severe constraints 55%
- Marginal lands with nomadic grazing are stressing environment
- Problems balancing output with input

Source: Eswaran et al. 1997;

Agricultural inputs and outputs

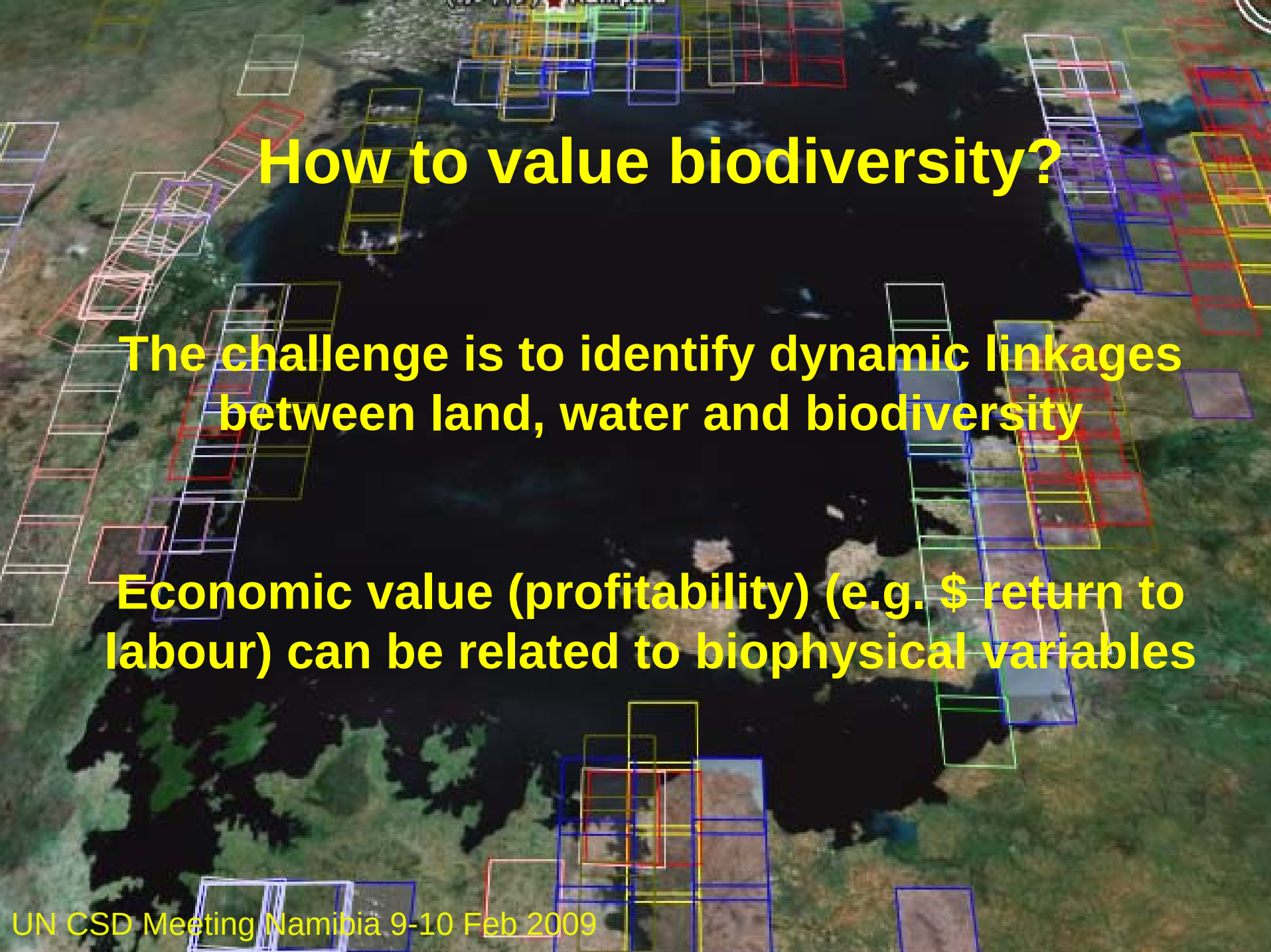
- Organic farming not a global solution[1] but vital for small farmers in remote areas
- Small inputs of chemical fertilizer can raise productivity significantly – but cost limited[1] (Biodiversity-based alternatives..IPM etc)
- Trade-off (input-output) models are needed for adaptive management
- Policy interventions require access to natural resource baseline information

[1]Source FAO Ann. Rep. 2007

“Farmers are essentially driven not by environmental concerns, but by economics”
(UNEP/CBD 2001)

Biodiversity benefits agriculture

- **Improvements in yield,and reduction in yield variance**
- **Confers resilience and resistance to environmental change**
- **Enhanced pollination, protection from pests and pathogens (IPM) 'insurance hypothesis'**
- **Ecosystem services: improved soil, water quality**
- **Reduced management costs and improved options for adaptive management**



How to value biodiversity?

The challenge is to identify dynamic linkages between land, water and biodiversity

Economic value (profitability) (e.g. $ return to labour) can be related to biophysical variables

Measuring policy relevant biodiversity

- Species counts alone are not policy relevant
- **Species combined with plant functional traits and vegetation structure** provide a baseline for adaptive agroecosystem management
- Gradient-based sampling of land use intensity improves environmental representativeness
- Standard protocols allow comparisons within and between regions (‘biodiv..sans frontières’)
- Links with soil fertility enable economic valuation

Assessing biodiversity

Two levels of biodiversity:

1. **Conceptual:** Biodiversity is " the variety of life on earth expressed in terms of gene, species and ecosystem". (*cf*. Heywood & Baste, 1996)

2. **Operational:** The number and composition of species and functional types recordable in any area. (Gillison, 2001).

[**Functional types** are sets of organisms showing similar responses to environmental conditions and having similar effects on the dominant ecosystem processes.]

(Diaz, 1998).

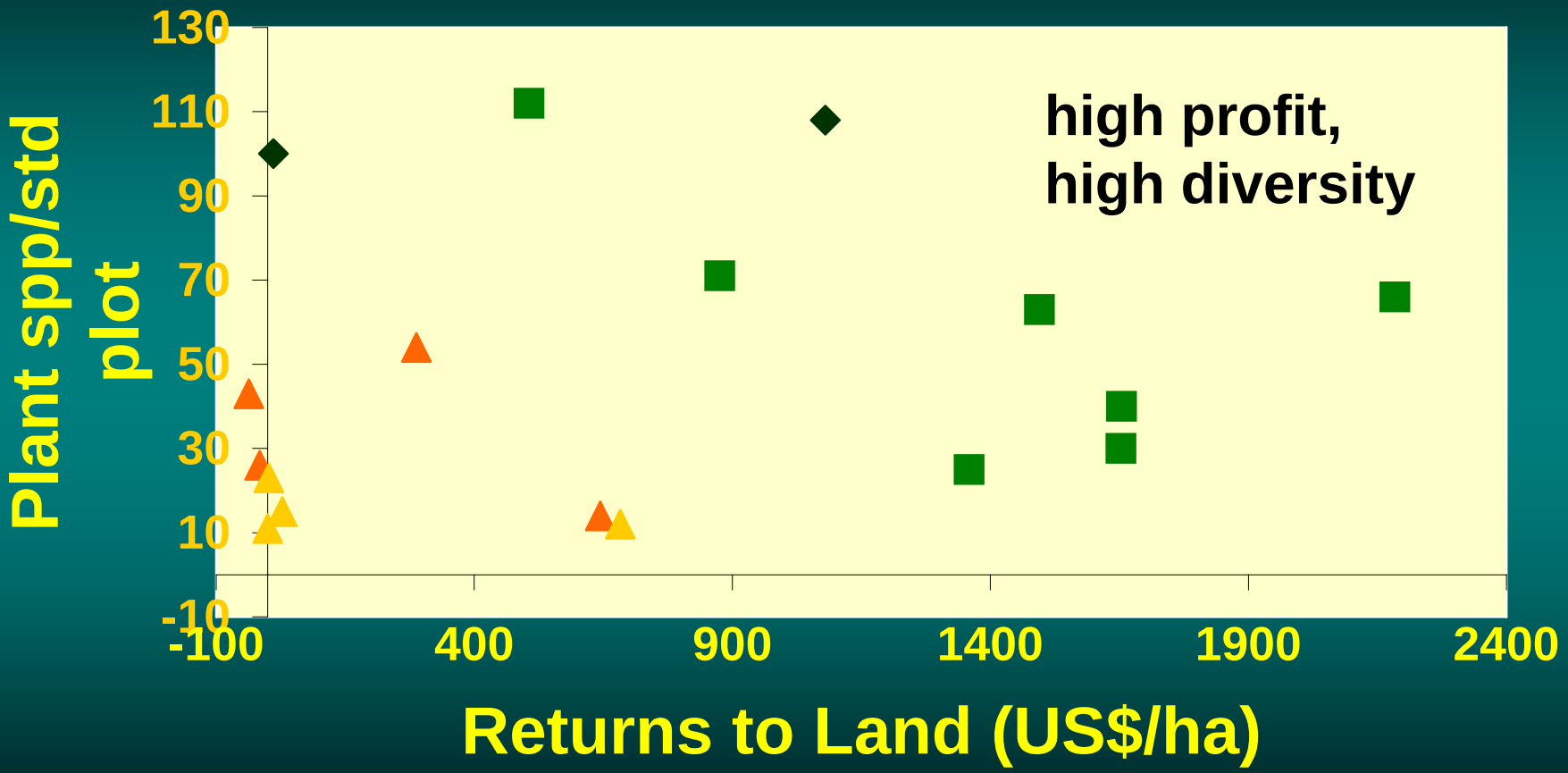
Water

Light (energy)	High	Medium	Low
High			
Medium			
Low			

Plant response along a moisture gradient

CBM

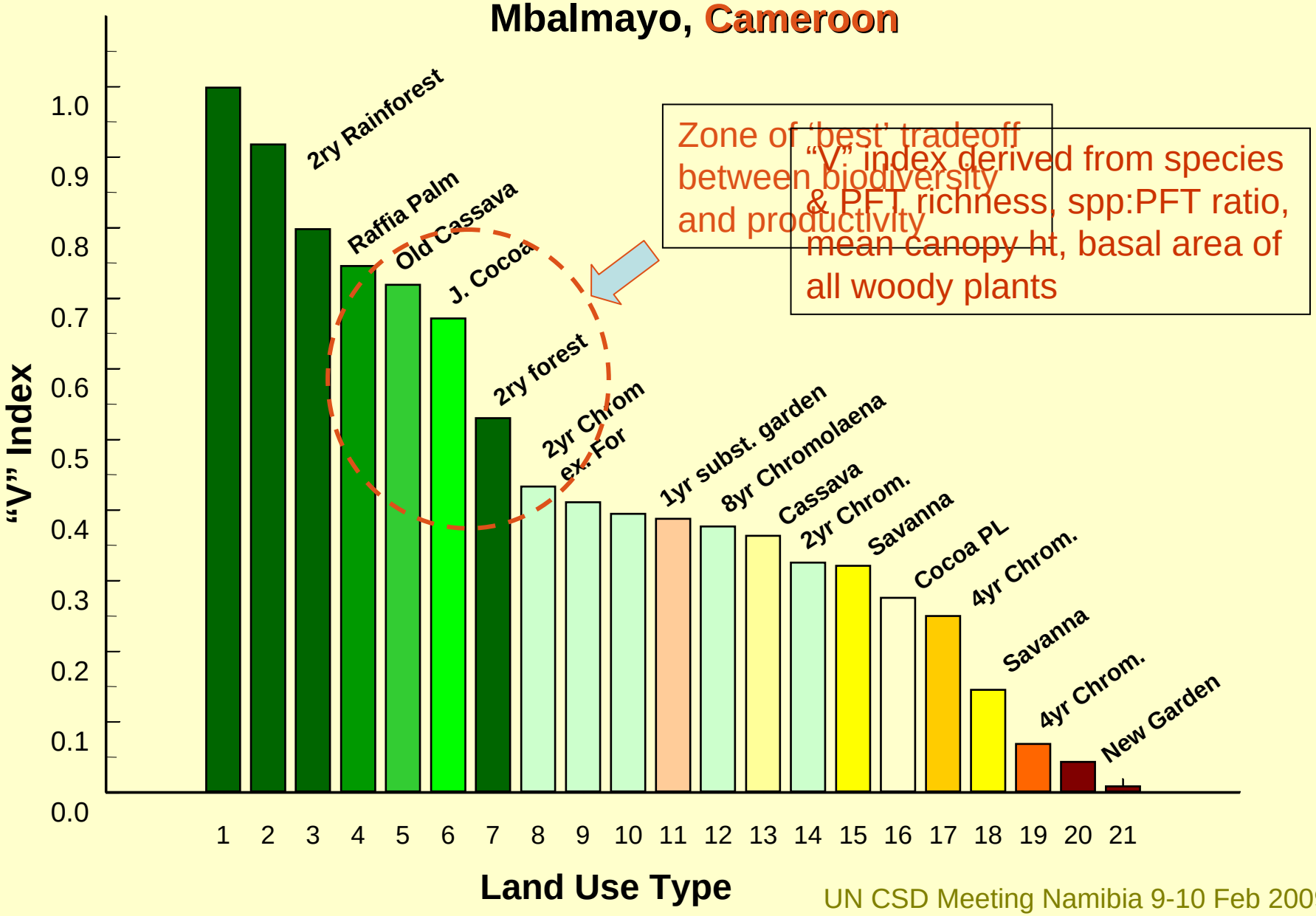
Profits vs Biodiversity



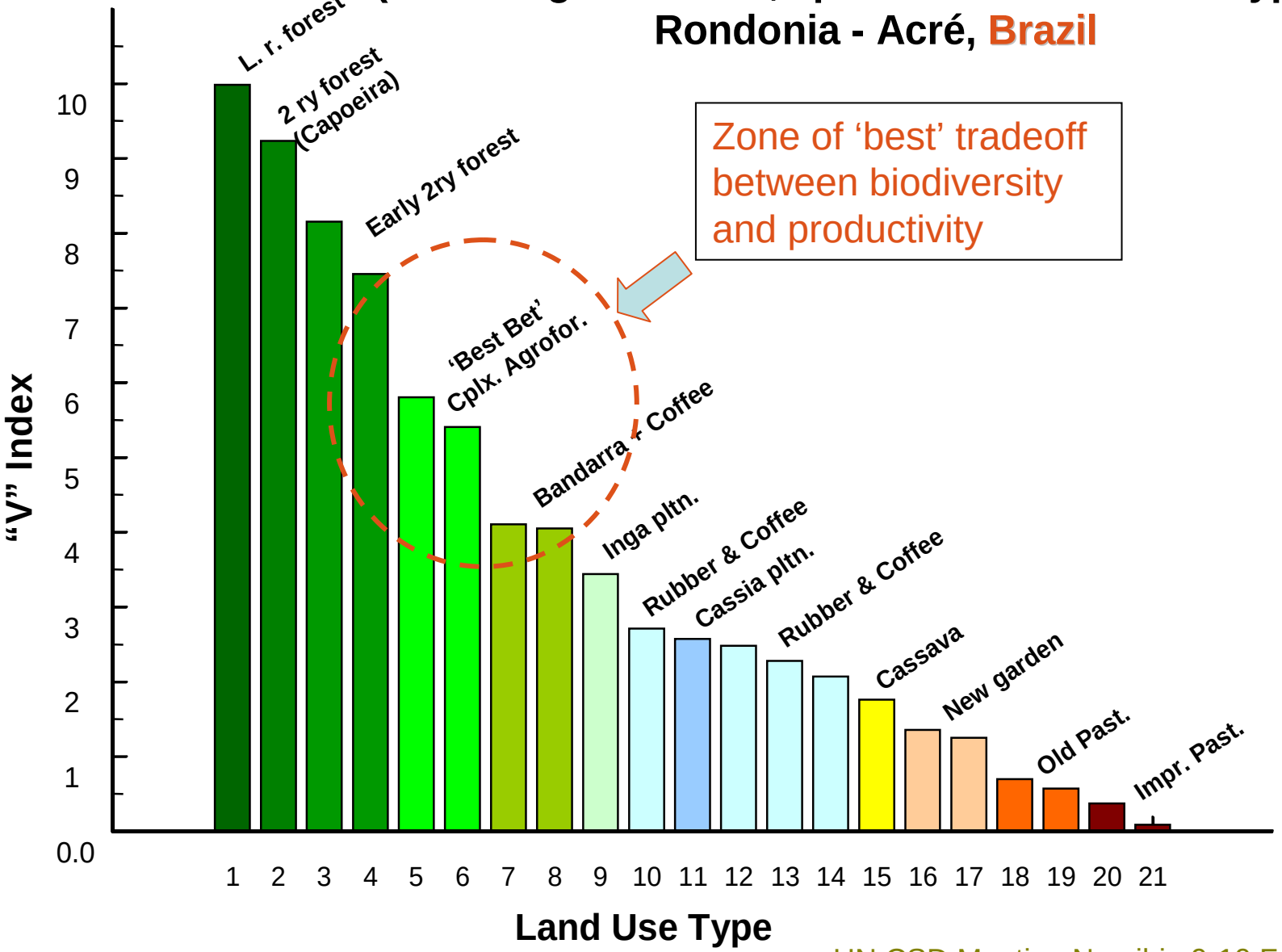
Biodiversity and land use

- Land use intensity gradients provide a context for modelling biodiversity and agricultural productivity response to environmental change
- Characterizing land use types by a vegetation or “V” index can assist in modelling tradeoffs between biodiversity and productivity

Land Use Types ranked against “V” Index (from: veg. structure, species and functional types) Mbalmayo, Cameroon



Land Use Types ranked against "V" Index (from: veg. structure, species and functional types) Rondonia - Acré, Brazil



Zone of 'best' tradeoff between biodiversity and productivity

Coupling biodiversity with land use and productivity

- Rapid, gradient-based surveys along geo-referenced, land use intensity gradients
- Standard recording protocol includes plant species, functional types, vegetation structure and site physical variables
- Links with soil and remote sensing
- Harmonized data collection allows informed comparison within and between countries and ecoregions –> guide to policy intervention

Natural resource baseline information is needed to:

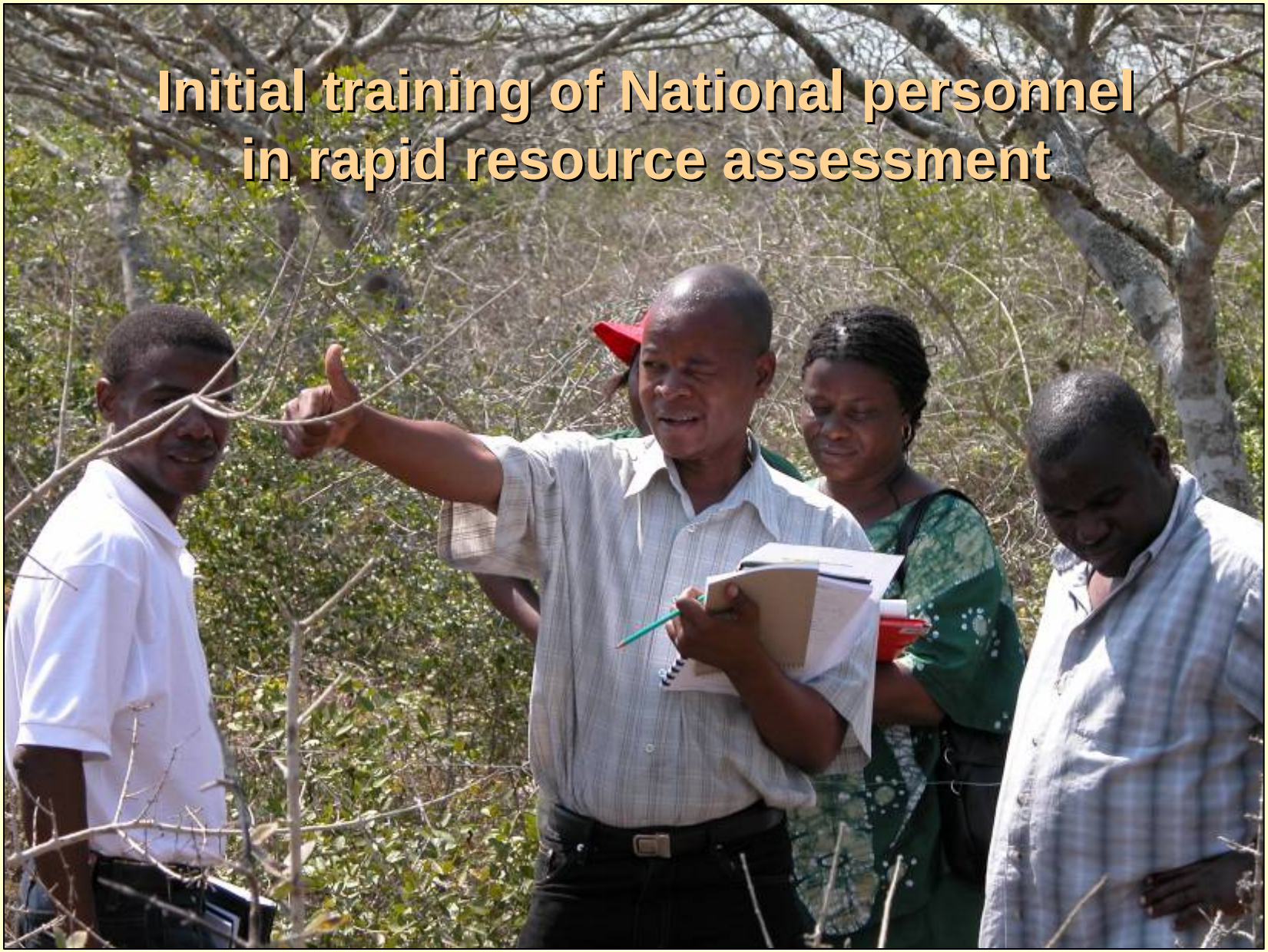
- Understand agroecosystem response to environmental change
- Quantify linkages between agri- and natural biodiversity and productivity/ profitability (private and social benefits)
- Forecast effects of land use practices on productivity and biodiversity
- Plan for adaptive management

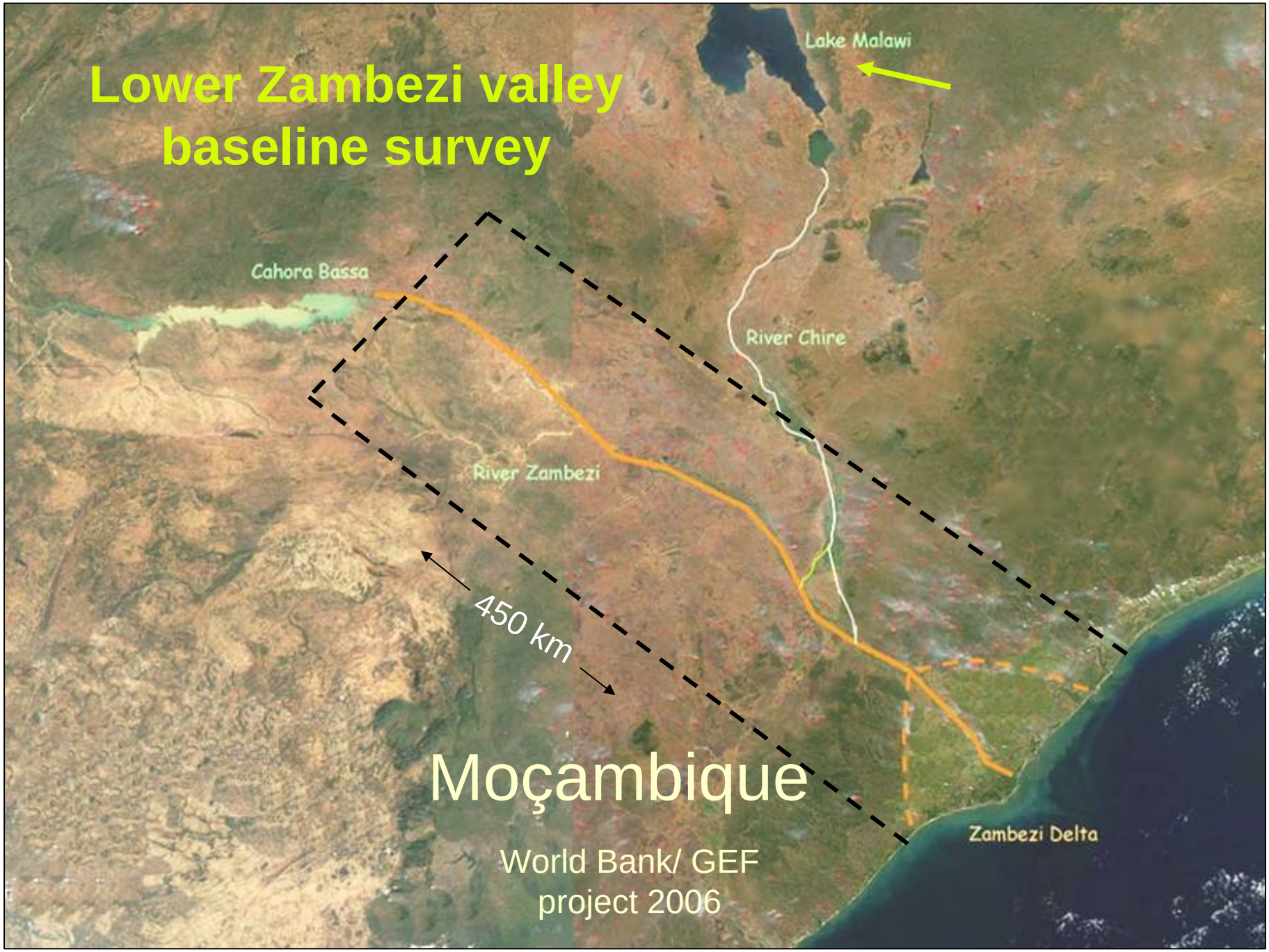
Capacity enhancement

- Training the trainers:
- Technology transfer in rapid resource appraisal methods
- Hands-on ‘real’ survey

Harmonized methods

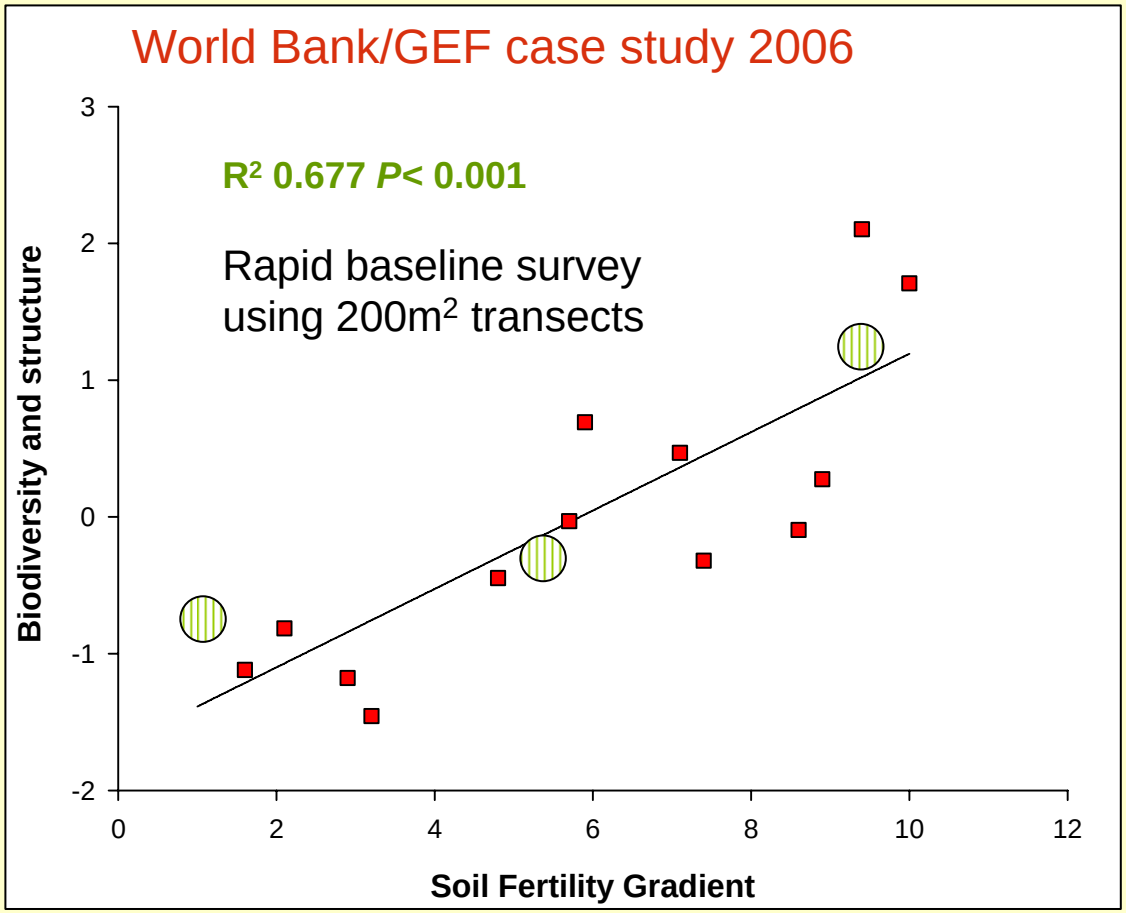
- Uniform survey protocols allow within and between regional comparisons of data
- Follow-up mentoring important


Initial training of National personnel
in rapid resource assessment


Lower Zambezi valley
baseline survey
Lake Malawi
Cahora Bassa
River Chire
River Zambezi
450 km
Moçambique
Zambezi Delta
World Bank/ GEF
project 2006

Hands-on field survey - measuring soil water infiltration – Lower Zambezi Valley survey

Biodiversity and vegetation structure can be readily used to estimate soil fertility in the lower Zambezi basin, Mozambique



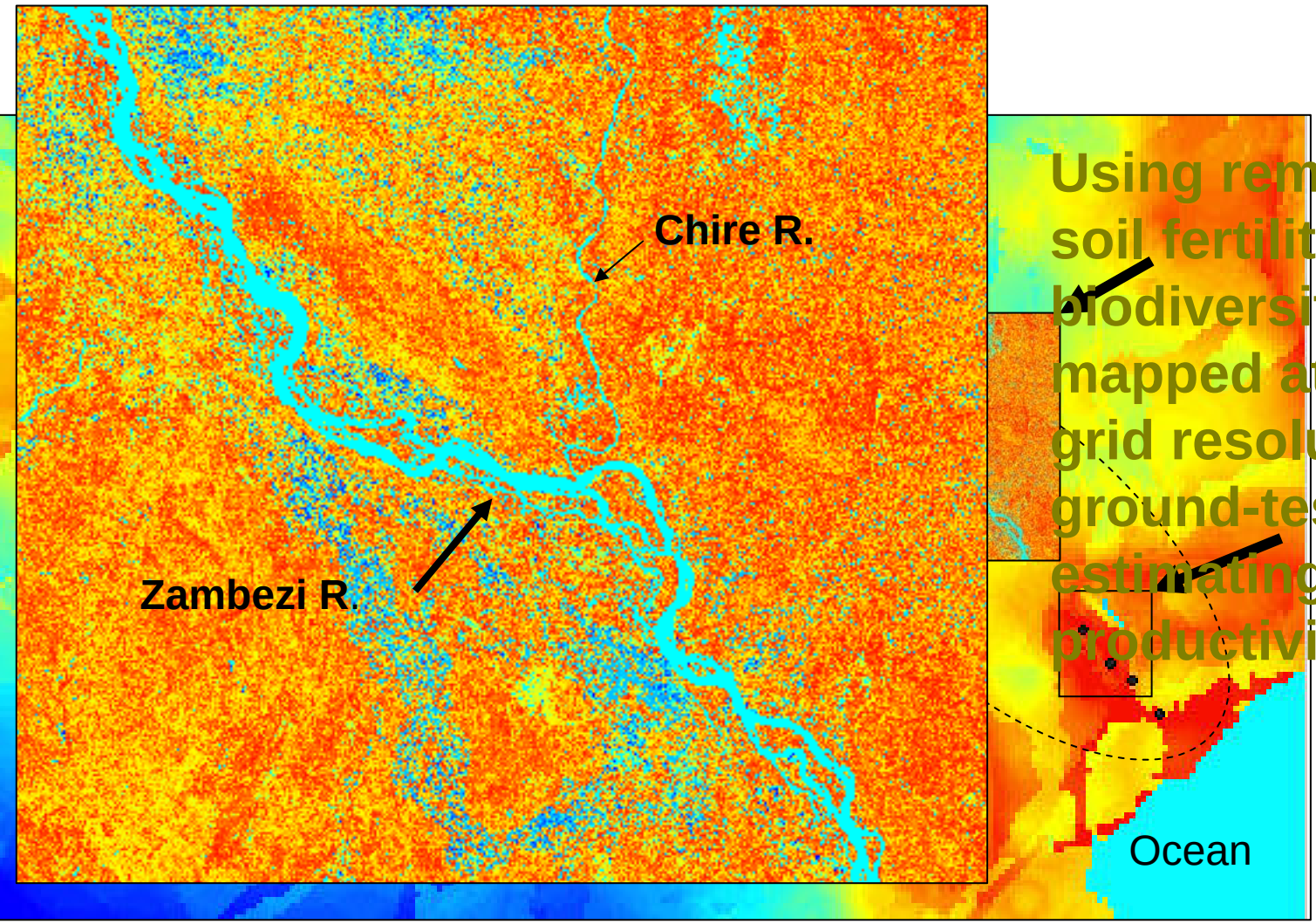
Potential agric. productivity

High (SFG8.9)

Medium (SFG5.6)

Low (SFG1.0)

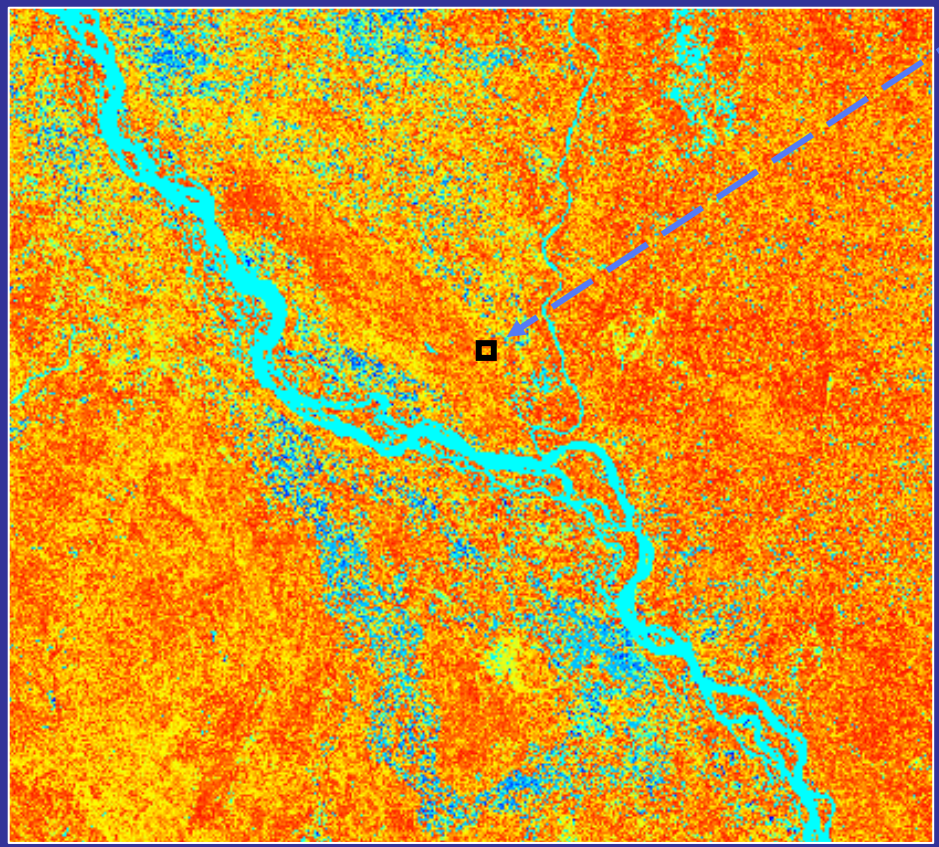
Soil fertility, actual and potential agricultural productivity can be linked with biodiversity and remote sensing



Using remote sensing, soil fertility and biodiversity can be mapped at 30m grid resolution (and ground-tested for estimating agricultural productivity)

Fertility high → → → → Low

Information on soil fertility, plant biodiversity, remotely sensed and other site values can be extracted from spatially-referenced data layers



Cell at 17.262S, 34.999E elevn 34m

Attribute	Value
Photosynthetic reflectance	605
Non-photosyn. reflectance	266
Bare ground reflectance	93
Soil fertility index	8.6
Plant species richness	19
Plant functional type richness	16
Plant functional complexity	116
Mean canopy height (m)	5
Basal area (m^2 ha^{-1})	1
Litter depth (cm)	0.2

Transect # 14 (40x5m) maize, rice

Resource baseline information for African agriculture

- Data collected, stored and accesed using different methods creates problems for policy development
- Standardized systems facilitate data exchange and bioregional planning
- Dynamic Information Framework (DIF) can be used for adaptive management through ‘live’ database
- Ongoing DIF development in Mozambique and riparian countries of Lake Victoria may provide a useful template for other countries

The Zambezi Dynamic Information Framework

(ZambeziDIF) Version 1

Zambezi SLM Project

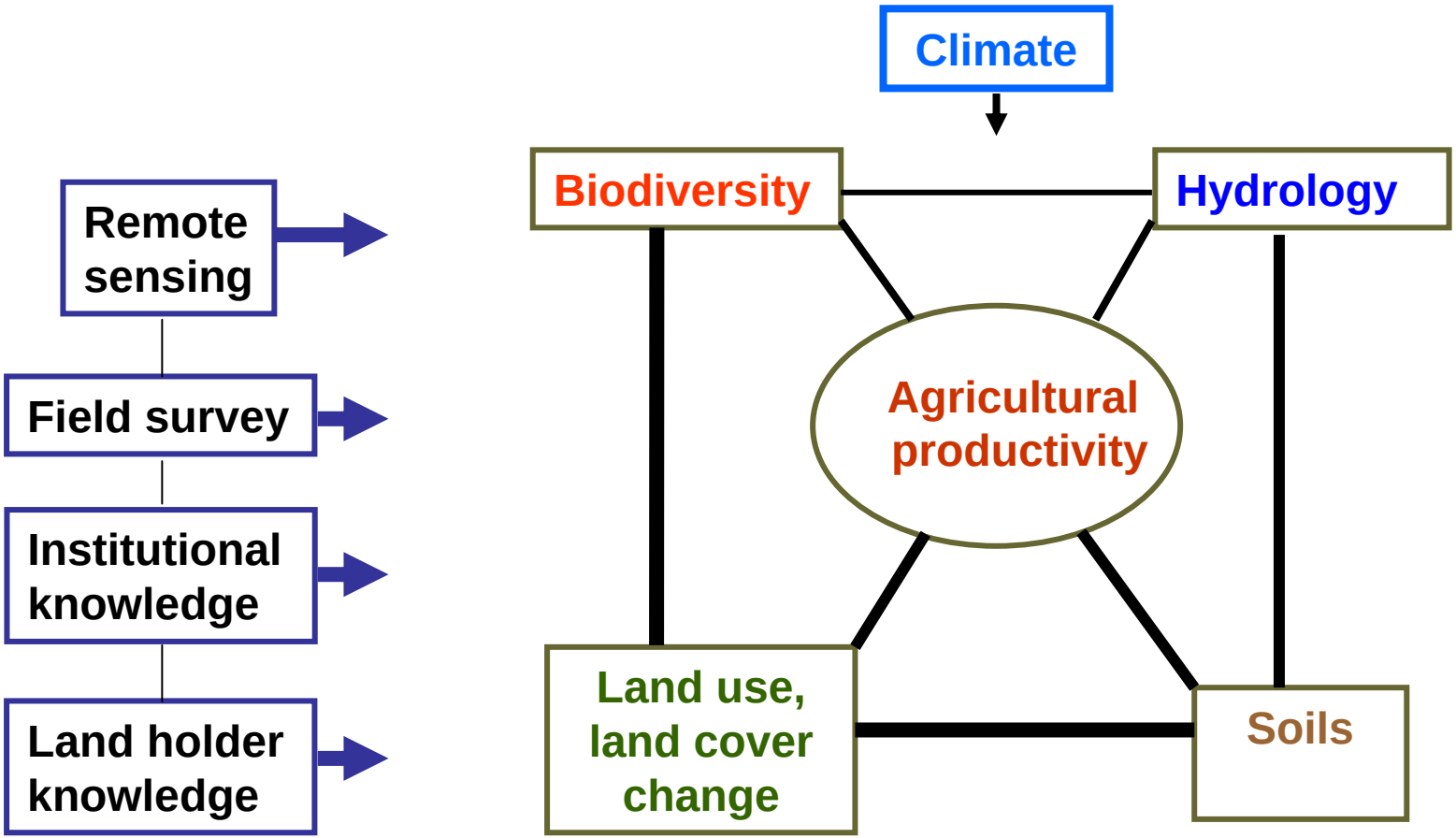
SLM Project Baseline study description

People and Places of the SLM Districts

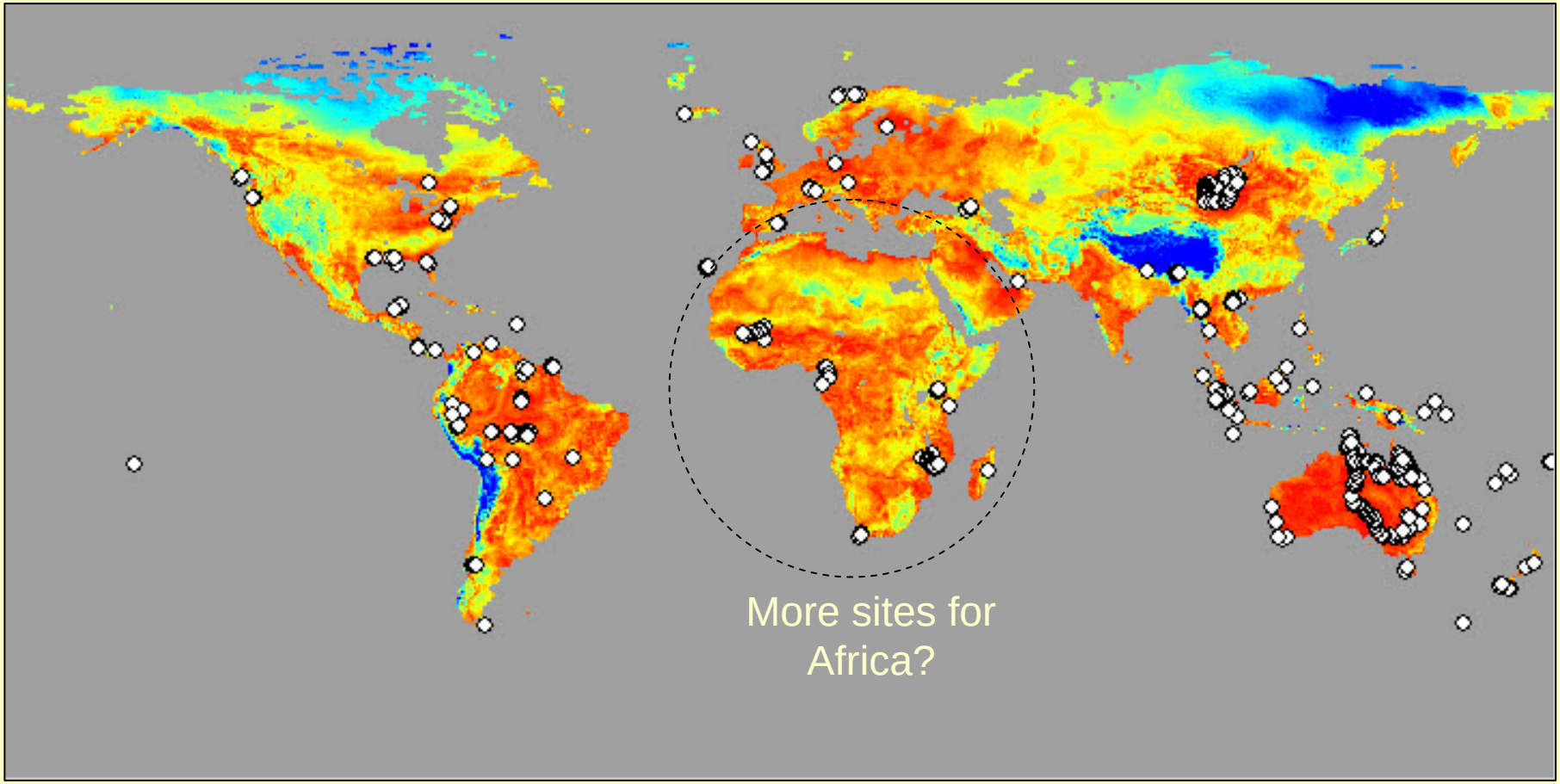
- **Images**
- **Maps** from Biodiversity and survey transects

ArcIMS Accessible Data Layers

- **Zambezi Basin Boundaries**
- **Soil Properties**
- **Southern Africa Landcover**
- **Landcover and Landuse**
- **Basin %Landcover**
- **Surface Climate and Water Distributions**



Relative strengths of current baseline information linkages with agricultural productivity (Africa, SE Asia, Brazil)



DOMAIN similarity levels

- > 99%
- 95-9
- 92-94
- 88-92
- < 88
- no value

Comparing African biophysical data at global scale.

Uniform methods of data collection provide ready comparison between global sites. DOMAIN similarity mapping of global subset of 950 VegClass transect sites based on Elevation, Total annual precipitation, Minimum temperature of coldest month, Annual total actual evapotranspiration. (Approx. 1800 transects recorded as at 25 Jan 2009)

Conclusions

- **Biodiversity without economic value has only a limited future**
- **Biodiversity linked with soil fertility and agricultural productivity facilitates economic valuation**
- **Spatial modelling permits mapping and testing outcomes for policy intervention**
- **Standardized, cost-effective methodology facilitates adaptive management**
- **The technology is readily transferable**