# *Wetlands, Water, and Climate Perspective from Southern Africa*

**Richard Beilfuss**
**International Crane Foundation**


**Kai Krause 2012**

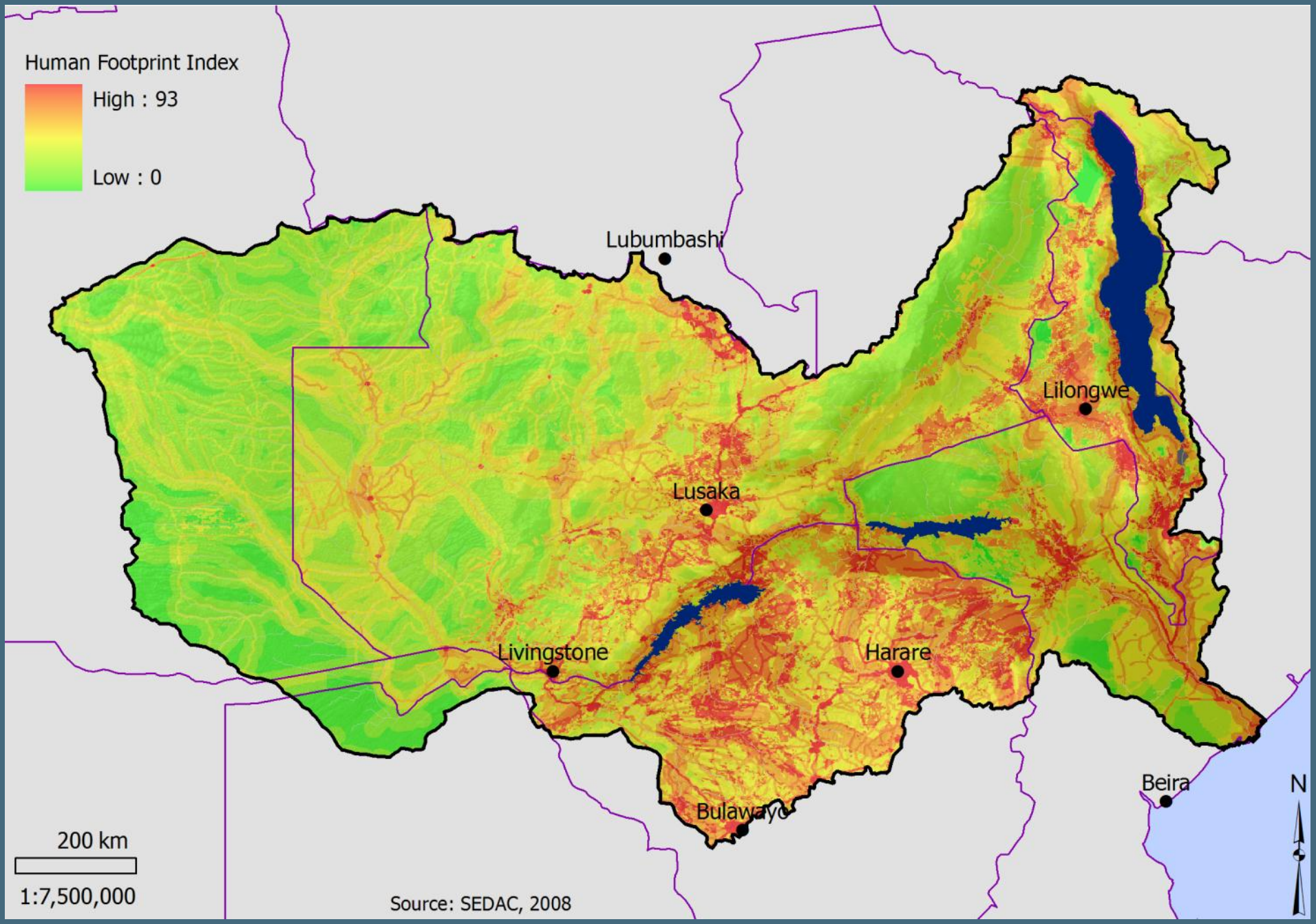

A2-NAB

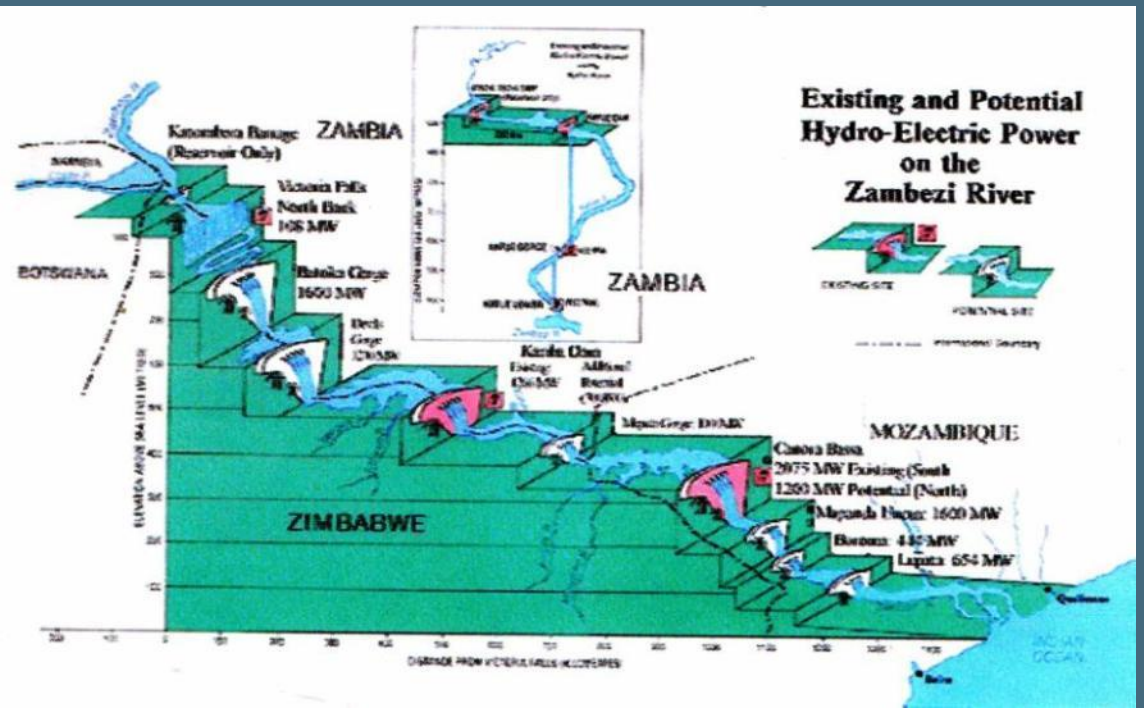

Eight basin countries – 1.4 million km$^2$

Busanga Swamps
Chobe Swamps
Kafue Flats
Liuwa Plain
Lower Zambezi
Mana Pools
N&S Luangwa
Zambezi Delta

Eight *Wetlands of International Importance*--Ramsar Convention


LEVI STRAUSS


Human Footprint Index
High : 93
Low : 0
Lubumbashi
Lilongwe
Lusaka
Livingstone
Harare
Beira
Bulawayo
200 km
1:7,500,000
Source: SEDAC, 2008
N



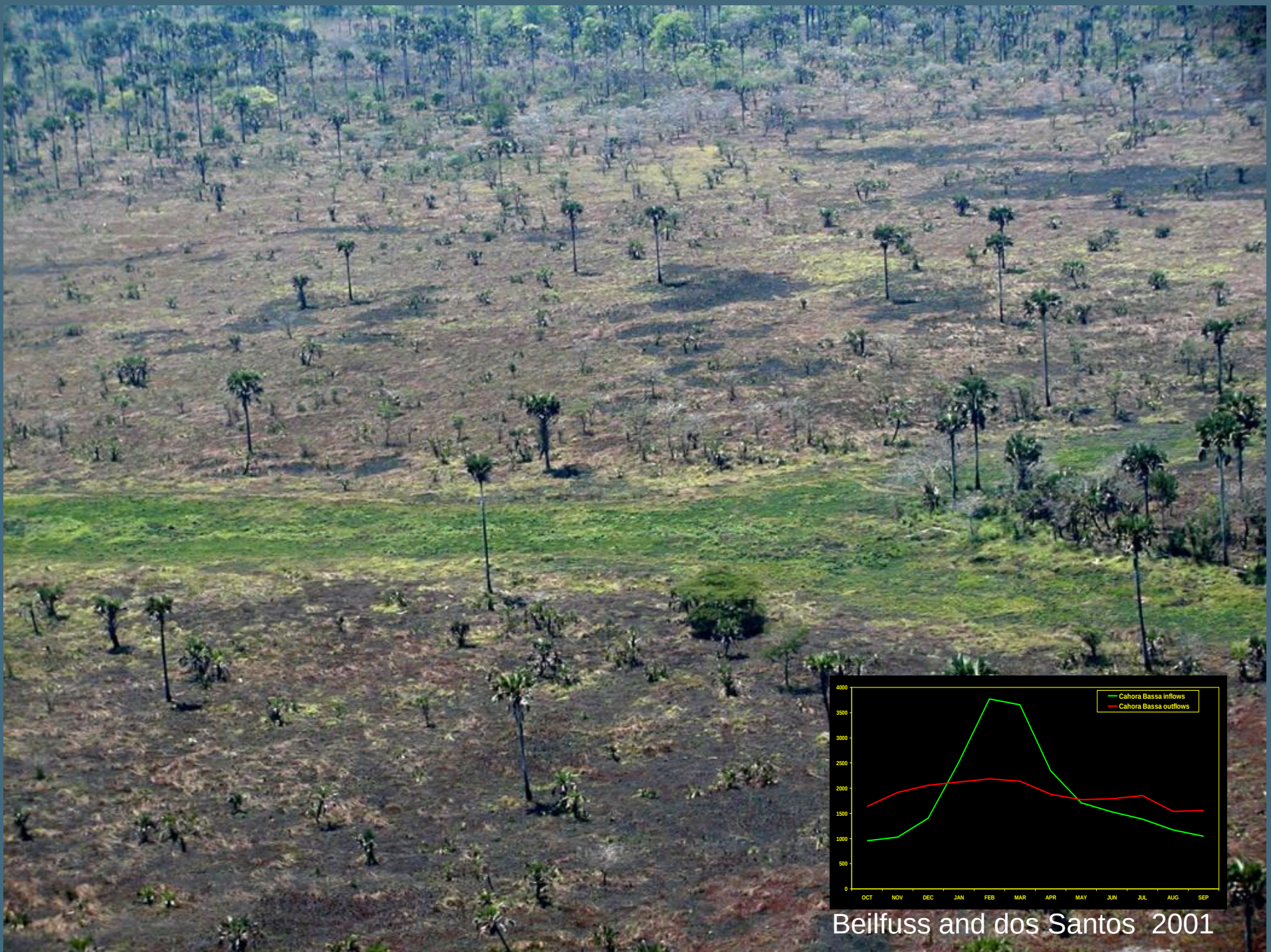

Installed

3530 MW (mainstem)

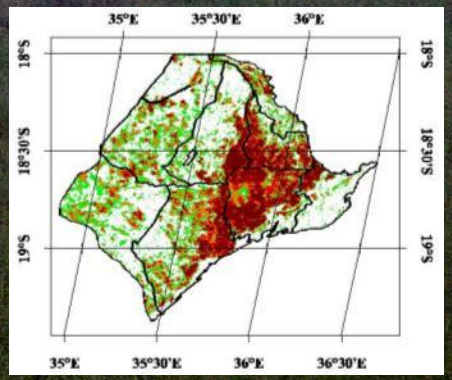
>5000 MW (basinwide)

Potential

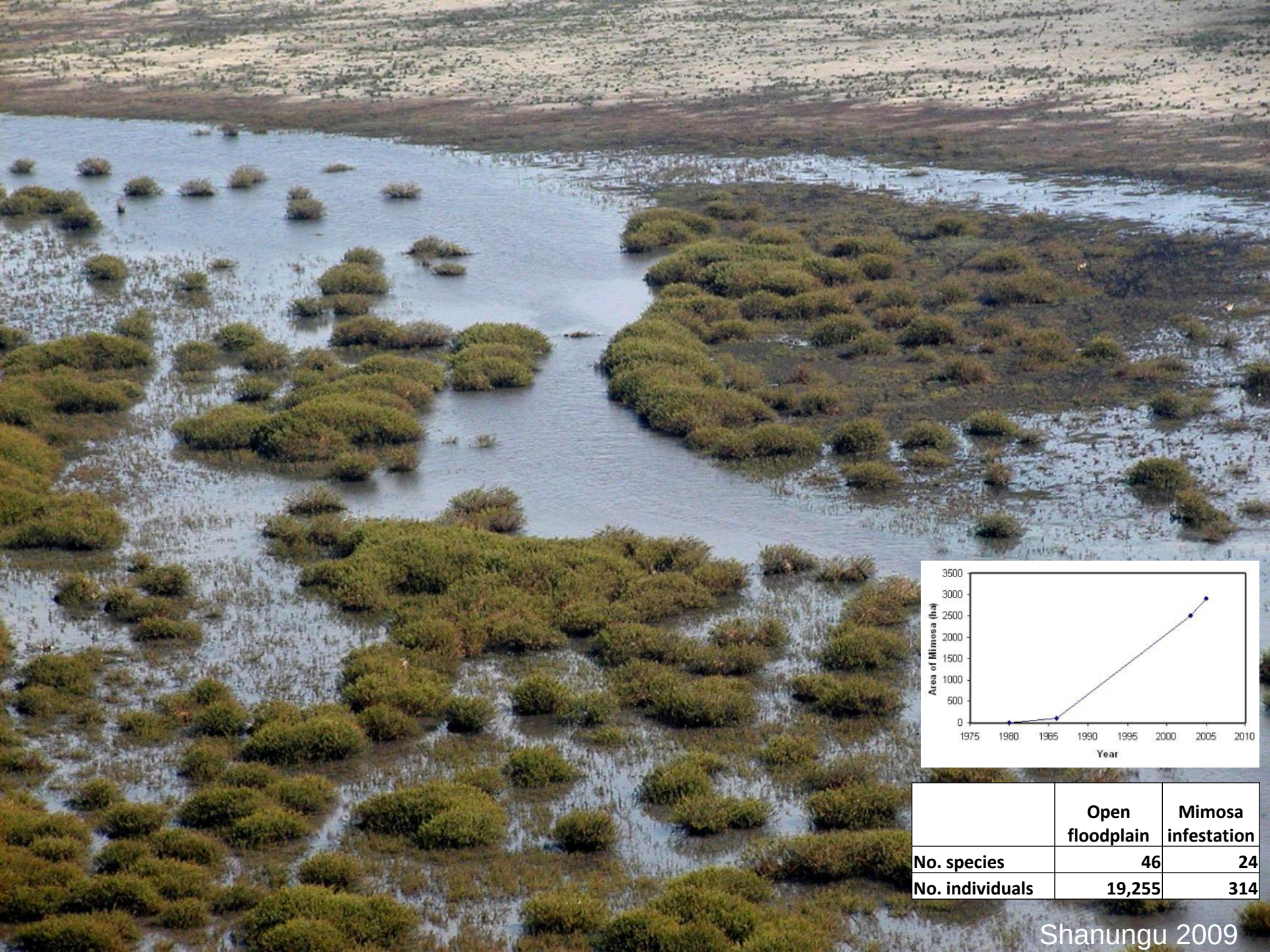
>13000 MW (basinwide)




Beilfuss and dos Santos 2001

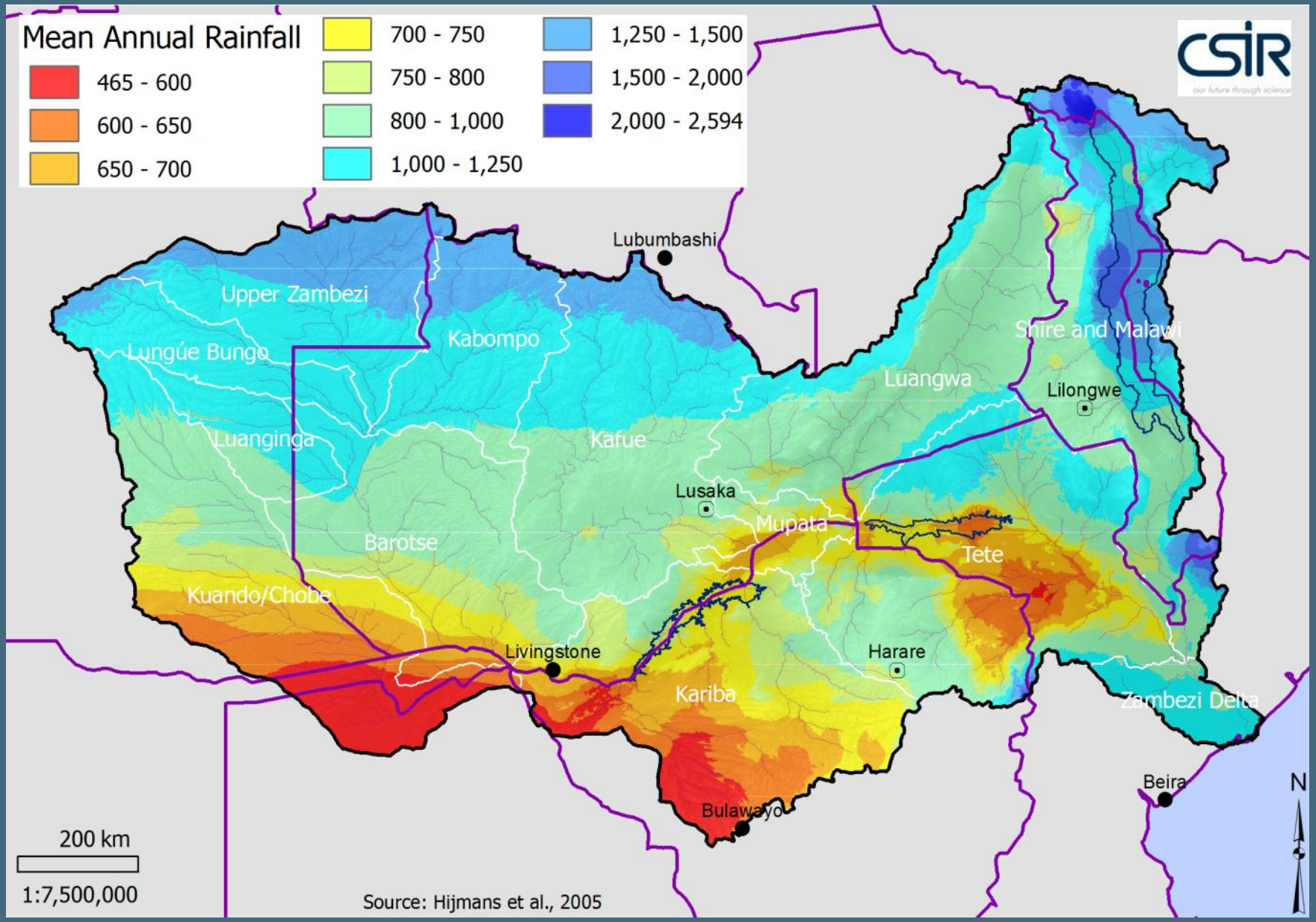



Rebelo and Beilfuss 2010

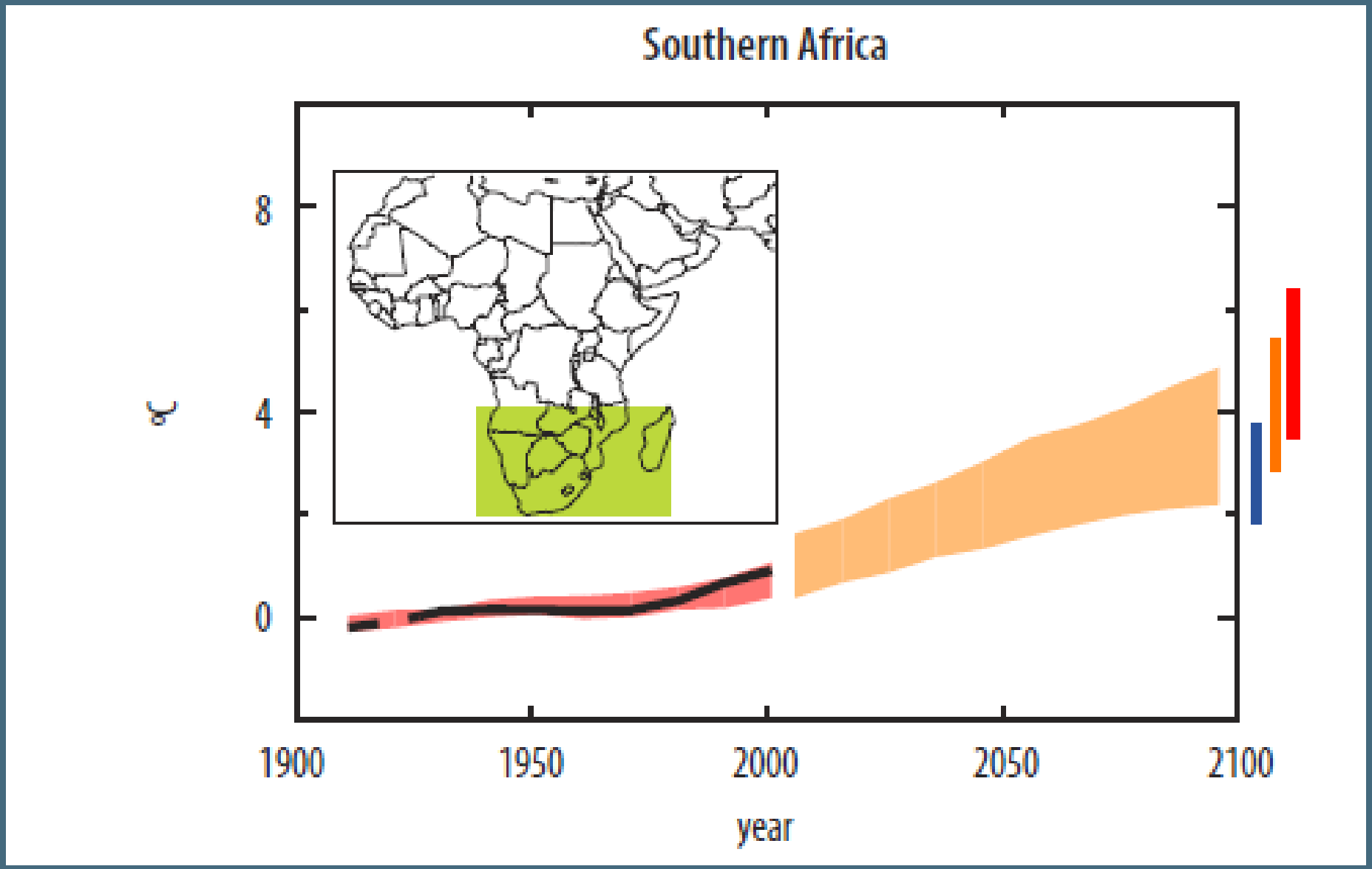



| | Open floodplain | Mimosa infestation |
|---|---|---|
| No. species | 46 | 24 |
| No. individuals | 19,255 | 314 |

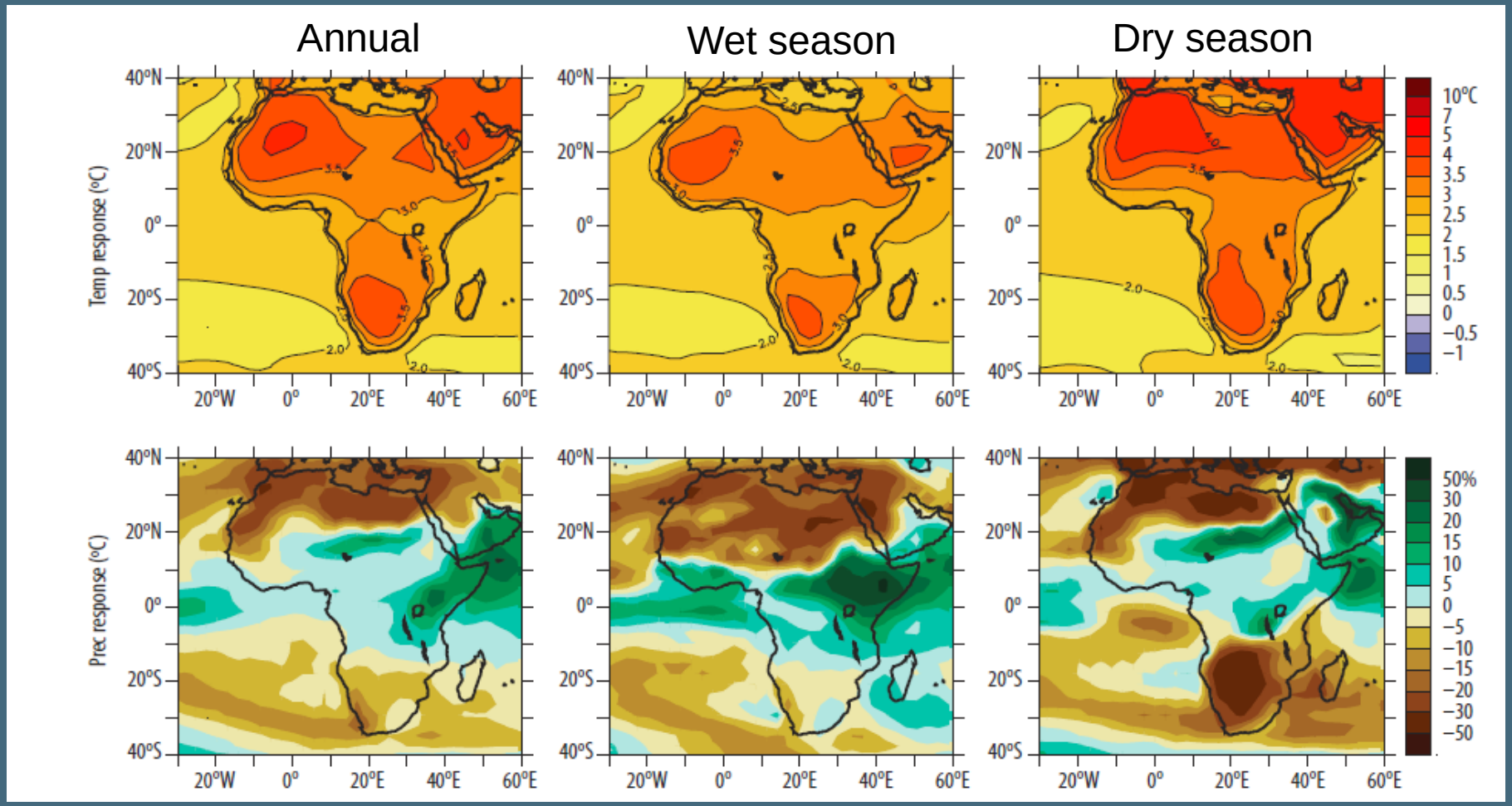
Shanungu 2009



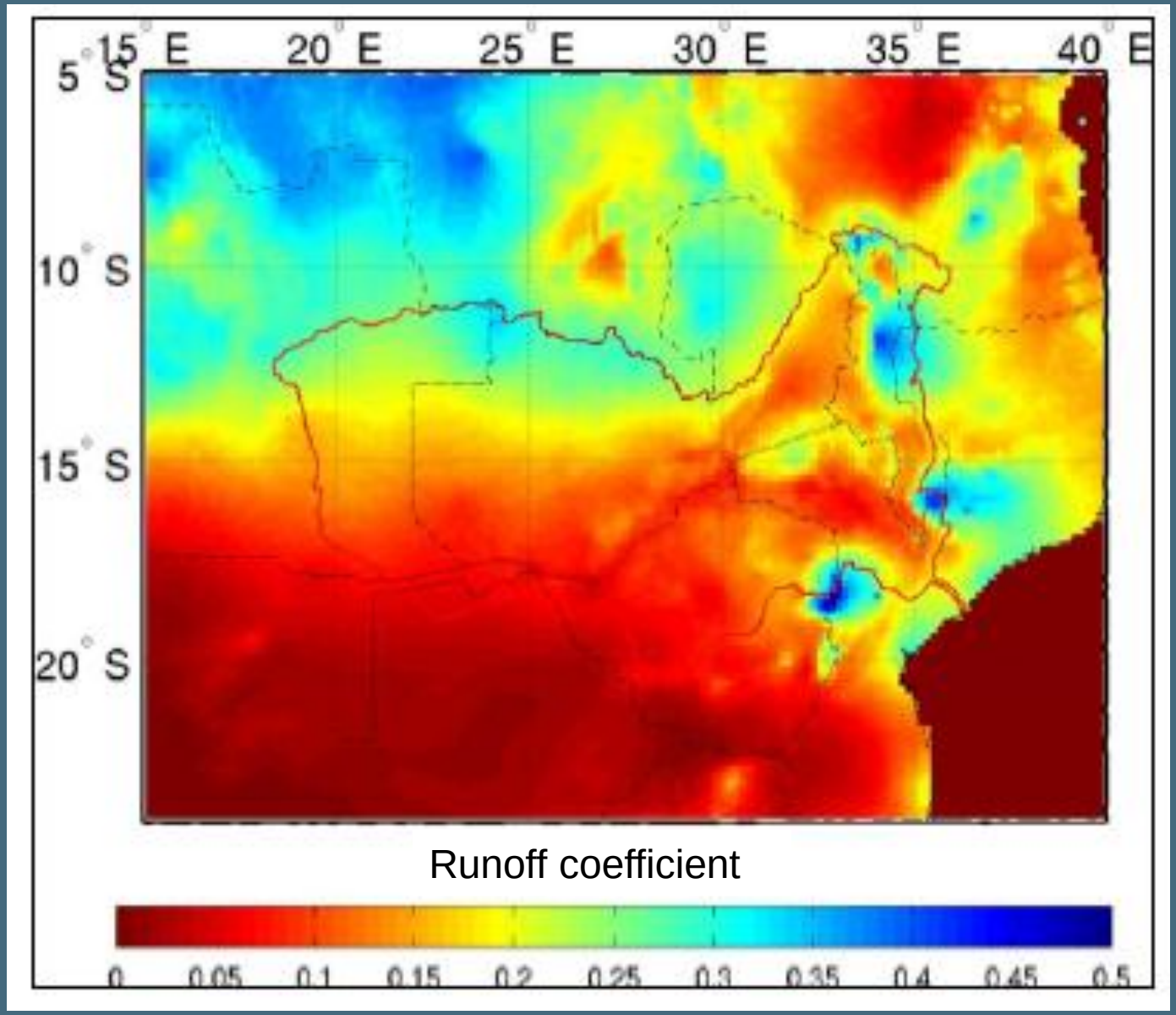

Rainfall highly variable across the basin and through time (season, annual, cyclical)—prone to frequent drought/flood



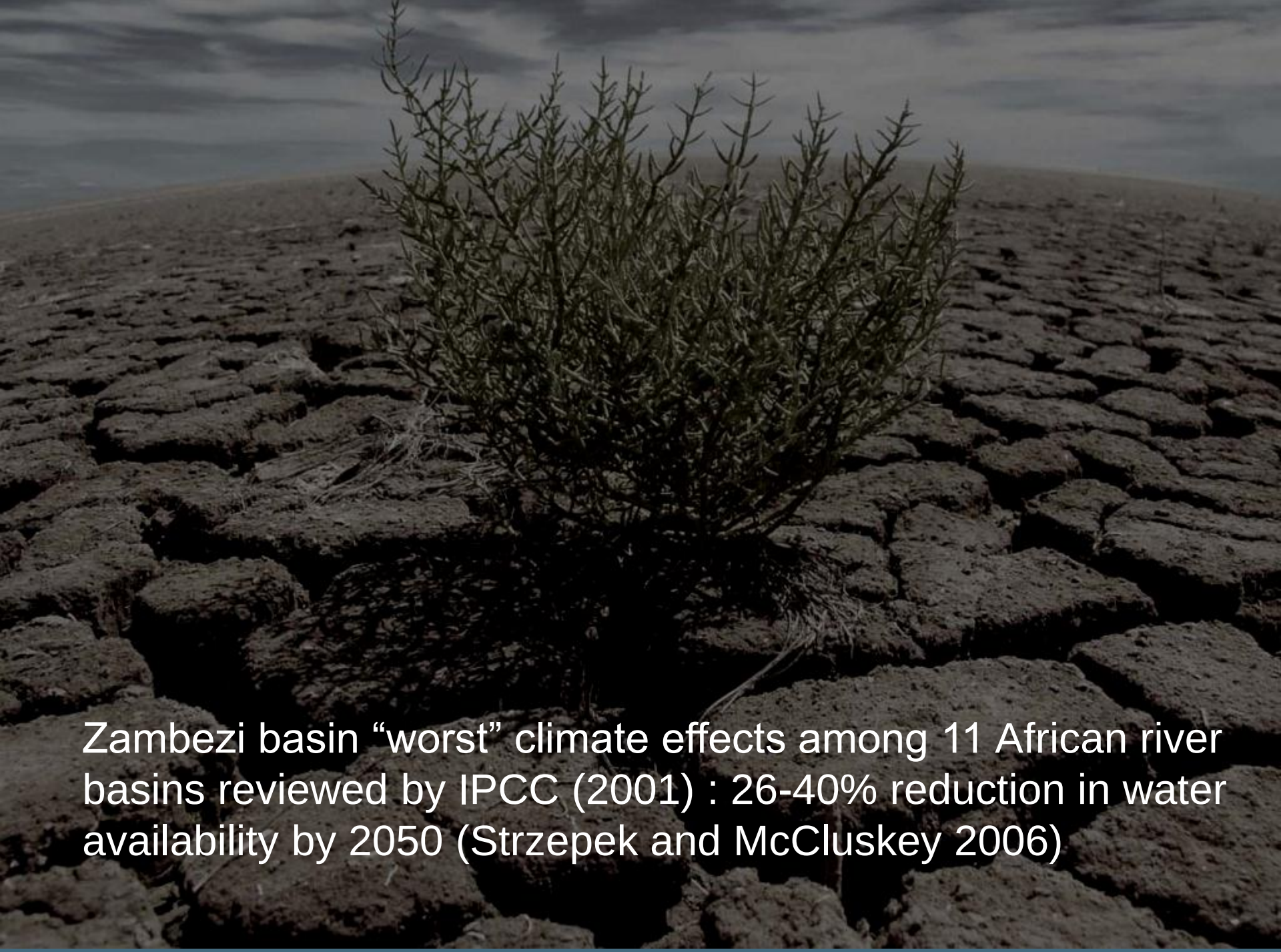

Trends in temperature for southern Africa, for the period 1906-1999 (observed) and 2001-2100 (forecast) (IPCC 2007).




Predicted temperature changes and annual & seasonal precipitation changes across Africa (IPCC 2007).




Low runoff coefficients, low drainage densities, and aridity indicate high vulnerability to changes in rainfall and temperature



Zambezi basin “worst” climate effects among 11 African river basins reviewed by IPCC (2001) : 26-40% reduction in water availability by 2050 (Strzepek and McCluskey 2006)

# Four reasons to be hopeful about wetlands & wildlife

- Water authorities and dam operators implementing environmental flows
- Local universities leading wetland research and monitoring
- Communities advocating for their wetland ecosystem services
- Governments committing resources to invasive species control and other wetland management

# Getting the water right

*Environmental flows* describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems **and** the human livelihoods and well-being that depend on these ecosystems. (Brisbane Declaration 2005)




# Wetland ecosystem services that sustain wetlands and wildlife

# Wetland ecosystem services that sustain human well-being

# Building research and monitoring capacity through local universities and agencies

UNIVERSIDADE EDUARDO MONDLANE

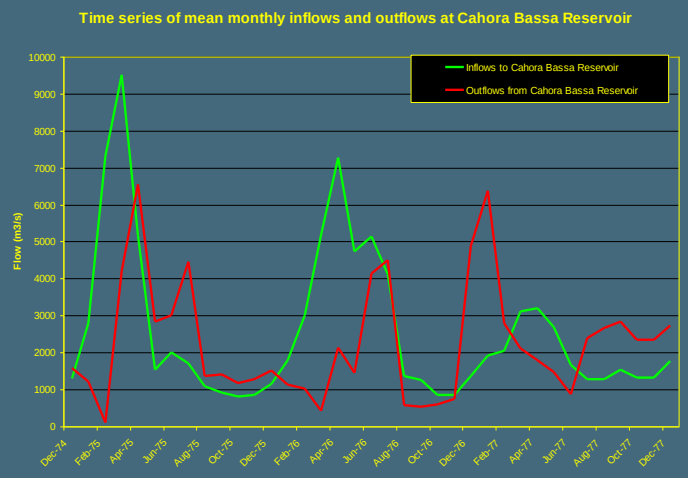
University Of Zimbabwe
knowledge - Diligence - Integrity

UNIVERSITY OF ZAMBIA

ARA-Zambeze
Administração Regional de Águas do Zambeze

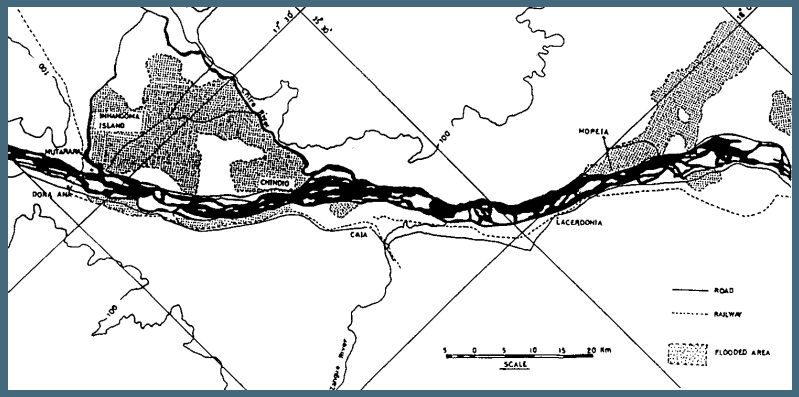
The University of Malawi CHANCELLOR COLLEGE

ZAMBIA WILDLIFE AUTHORITY



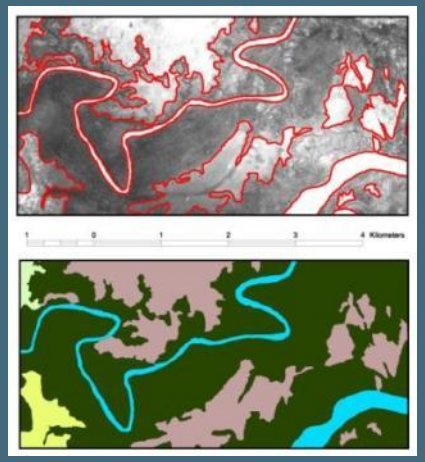

# Linking Zambezi waters to wetland inundation patterns

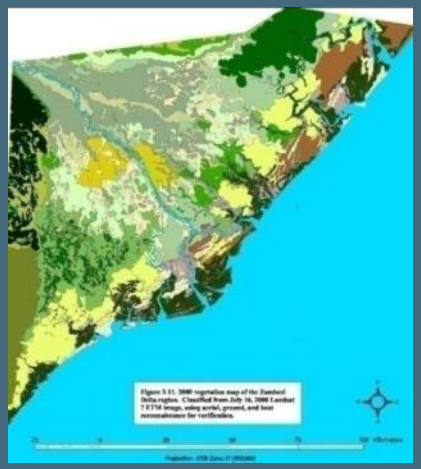
- Reconstituted 100-year flow series (1908-2007)
- Correlated Zambezi flows to patterns of wetland inundation (magnitude, timing, duration)
- Quantified changes in ecologically-meaningful water conditions
    - Mean annual runoff
    - Dry season onset, minimum, duration
    - Flood season onset, peak, volume, duration
- Flood frequency analysis



# Linking Zambezi waters to wetland dynamics

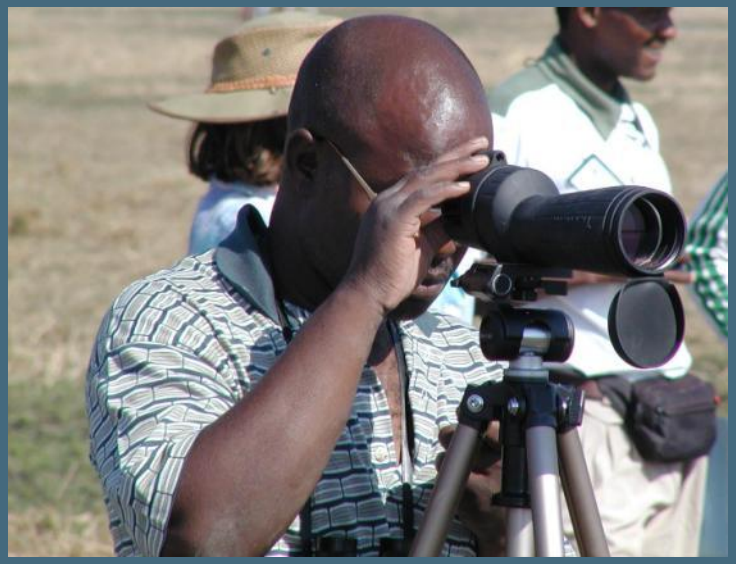
- Changes in vegetation cover over time using field sampling, aerial surveys, archival aerial photography, and remote sensing
- Permanent vegetation transects
- Factors affecting vegetation change at different scales—flood, fire, grazing regimes





# Linking Zambezi waters to wetland-dependent wildlife

- Waterbird breeding & feeding ecology as function of flooding patterns
- Large mammal status and ecology in relation to floodplain condition
- Total inventory plots of biodiversity



## Vulnerable Wattled Cranes

- ~80% population emigration/decline
- Reduction in main food source (Eleocharis rush tubers)
- Increased nest vulnerability to fire
- Shift in breeding grounds from floodplain to escarpment

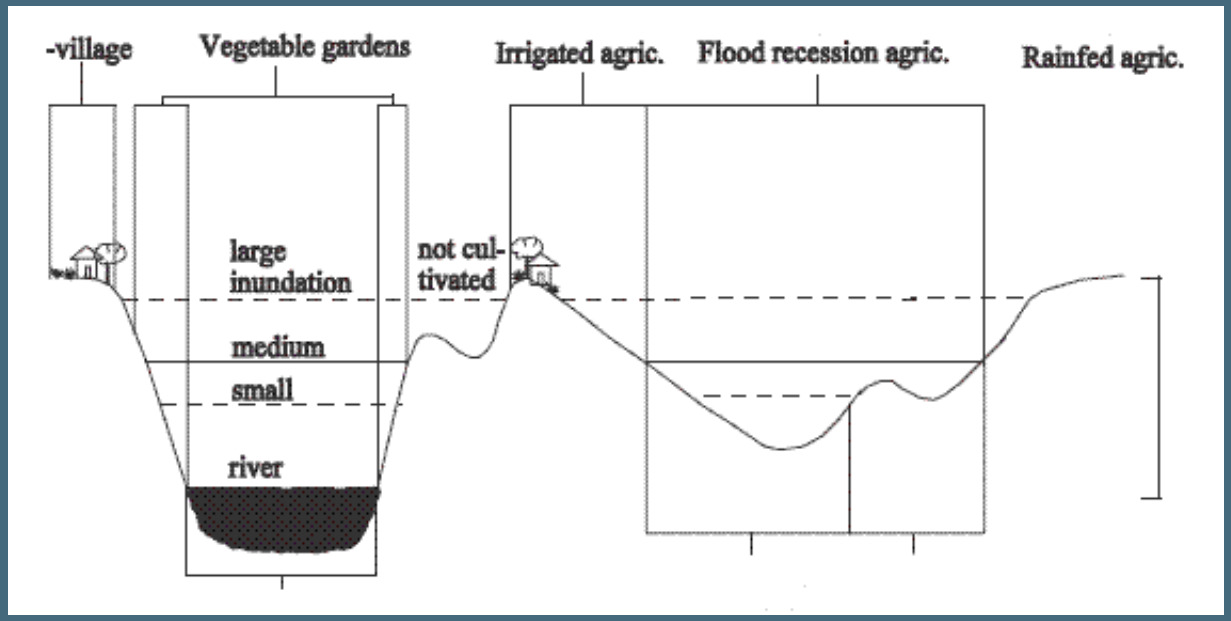
Bento et al. 2007

# African buffalo

- Vital ecological role as bulk grazer
- Dry season body condition linked to declining soil moisture content
- Loss of carrying capacity related to wetland drying and increased fire
- Ecotourism and safari hunting revenue valued at $millions/yr

# Linking Zambezi waters to human livelihoods

- >800 hours of participatory rural appraisal along entire lower Zambezi
- Research on flow-related changes in prawn industry, subsistence and commercial agriculture and fisheries, grazing, and hunting (carrying capacity for trophy species)
- Economic valuation of flow-related ecosystem services
- Changes in access to domestic water supply, sanitation, cultural use of water
- Community aspirations for river-wetland management




# Flood-dependent agriculture

- Mistimed floods damage riverbank cropping; increase drought vulnerability
- Reduced area for flood recession crops linked to >30% productivity decline
- Salinity intrusion most significant threat to sugar production
- Economic valuation of annual floods for agriculture suggests $millions/yr

Brito 2006

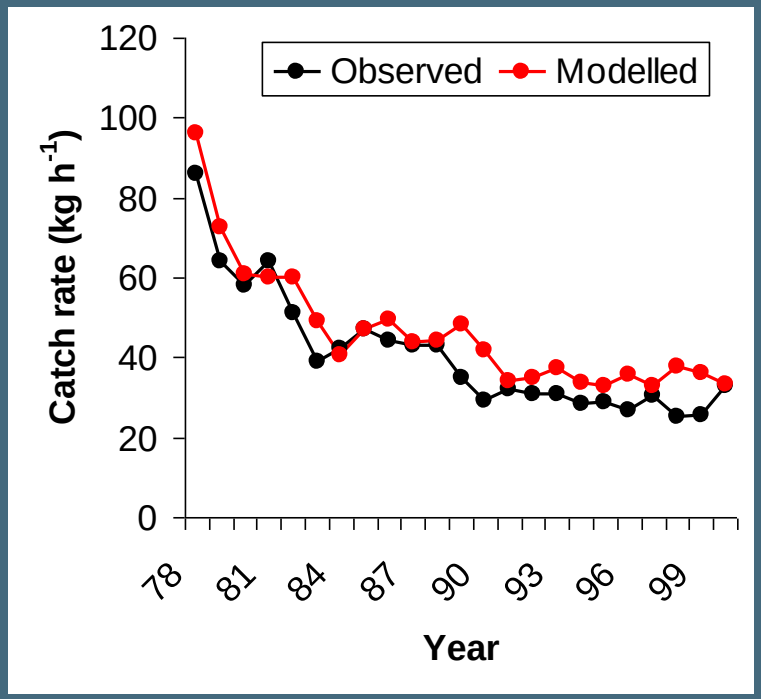
## Freshwater fisheries

- Reduction in freshwater fisheries directly related to reduced flooded area and duration and mistimed flooding regime
- 30,000-50,000 tonnes per annum under restored flooding regime
- Highly responsive to large flooding events (2001, 2008)

Tweddle 2006

# Wild-caught prawn fisheries

- Life-cycle depends on wet season flood pulse and dry season low flows
- Strong correlation between Zambezi annual runoff pattern and fishery catch rate
- Lost economic value $10-30 million/yr could be recovered




Gammeslrod 1992; Hoguane 2002

## Floodplain grazing lands

- Reduced extent and quality of end-of-dry season grazing lands for cattle
- Restored floods flush disease-bearing ticks off of floodplain
- Lost economic value $millions could be recovered

da Silva 2006

## Water supply

- >5 m water table decline on delta floodplain due to diminished recharge
- Increasing dependence on Zambezi River to meet domestic water requirements—crocodiles, waterborne disease
- Est. annual value $9 million during normal/flood; $14 million during drought years.

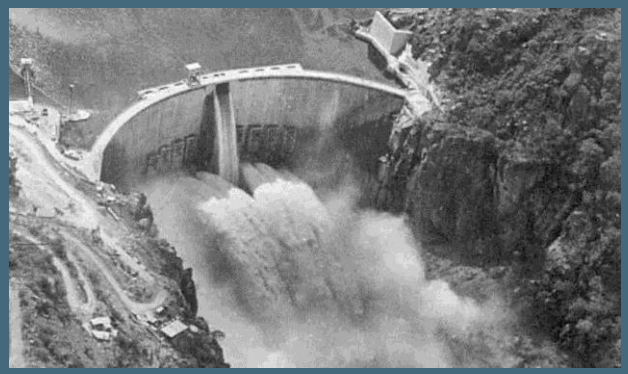
Guveya & Sukume (2008)



# Settlement and displacement

Further changes in settlement patterns (adaptation to loss of regular annual floods) result in higher social and economic costs during very large (uncontrollable) floods






Endemic and Endangered species


People

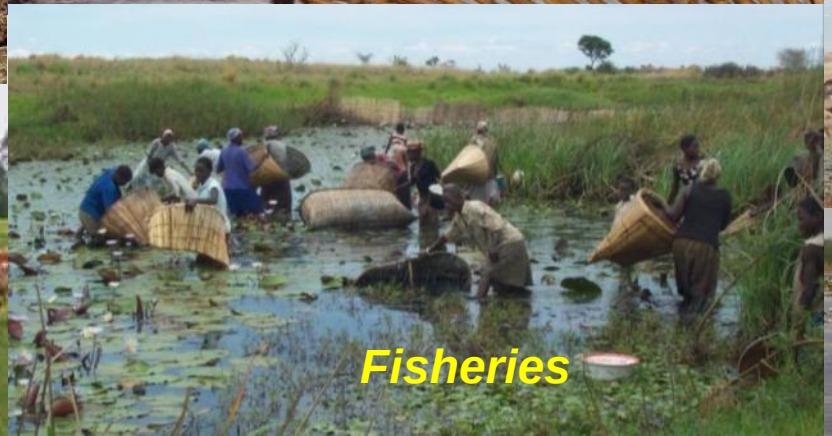

Tourism


Fertile soils

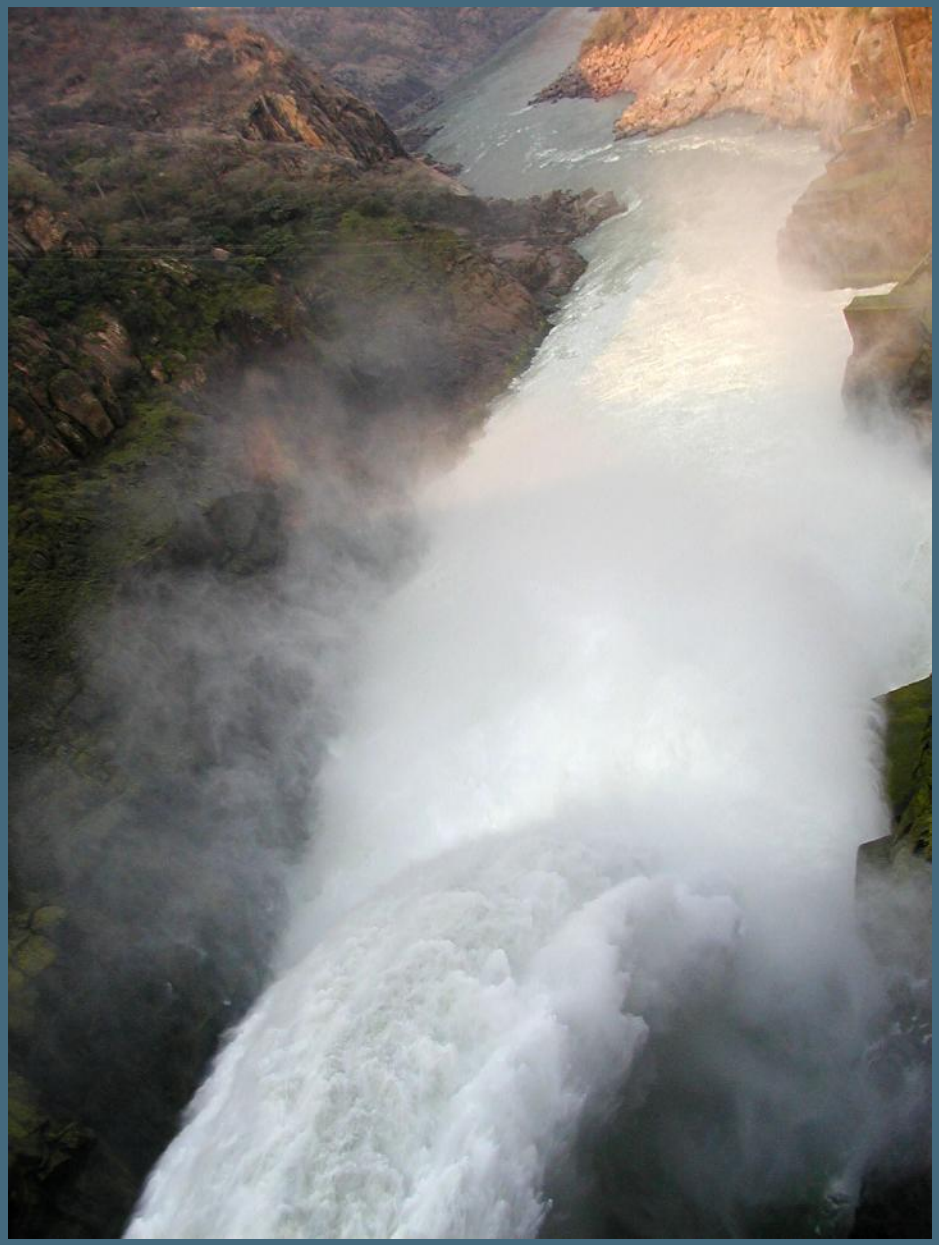

Culture


Materials


Grazing lands


Fisheries


Flora and fauna



Socio-economic value of water for downstream users and wetlands exceeds value of water for strict hydropower

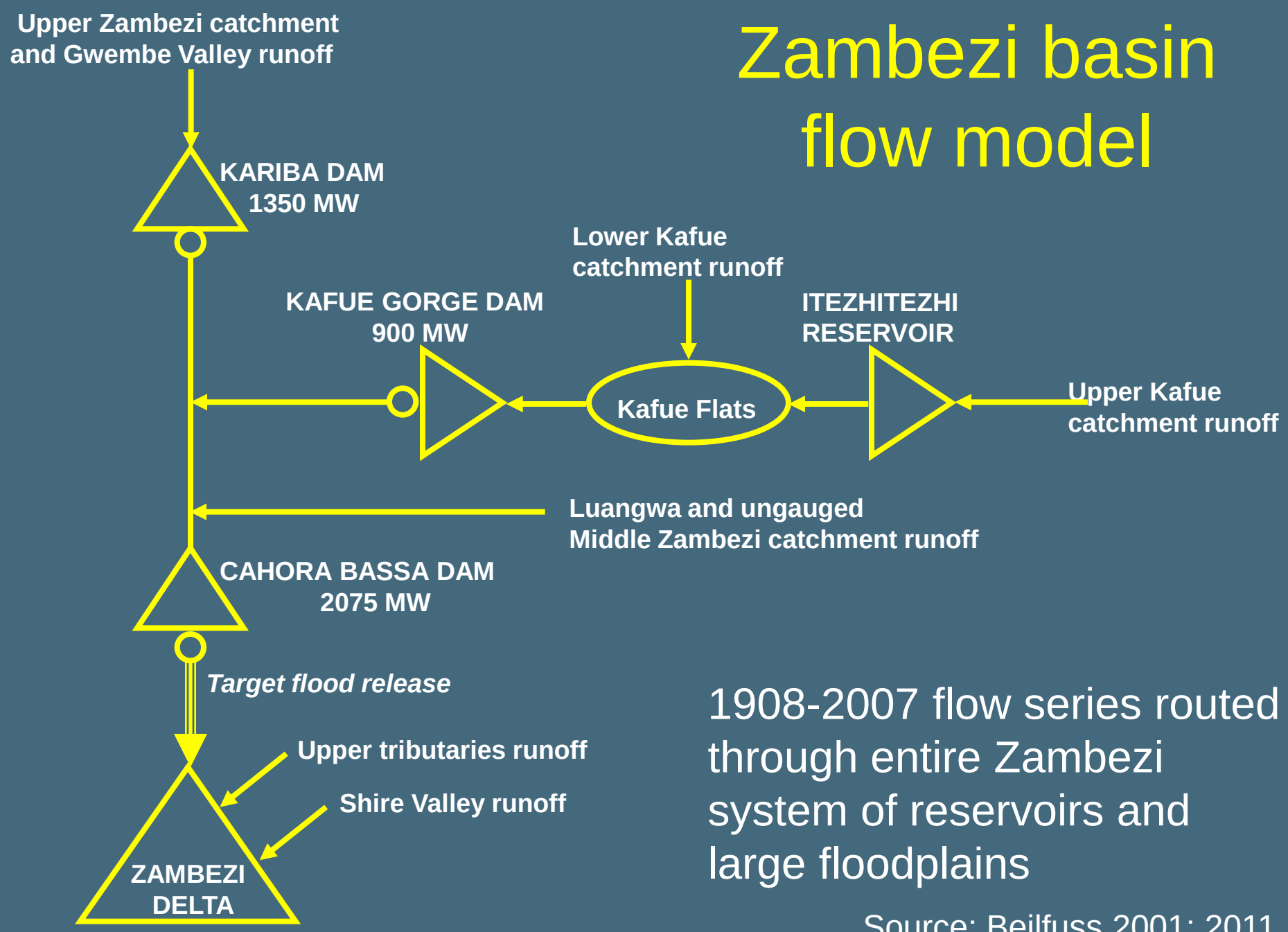
# Modeling water availability for environmental flows to wetlands

1. Likelihood that different e-flow scenarios can be achieved, constrained by water availability and hydropower contracts

2. Assess the affect of each e-flow scenario on firm power generation and total annual energy production

3. Sensitivity of 100-year flow series to increased water abstractions and reduced runoff scenarios (climate change)

# Zambezi basin flow model




1908-2007 flow series routed through entire Zambezi system of reservoirs and large floodplains

Source: Beilfuss 2001; 2011

# Is there water available for environmental flows given constraints for hydropower production?

- YES—Modeling indicates a range of eflow scenarios are possible depending on targeted wetland water condition
- Some beneficial scenarios realized through reallocation of waters with no reduction in hydropower generation
- With modest reductions in hydropower, many target flow patterns could be realized downstream
- E-flows could help ameliorate climate change flow reductions if power production commitments realigned

# Modeling trade-offs among water users

What are the trade-offs in water requirements (magnitude, duration, timing) among the different users?

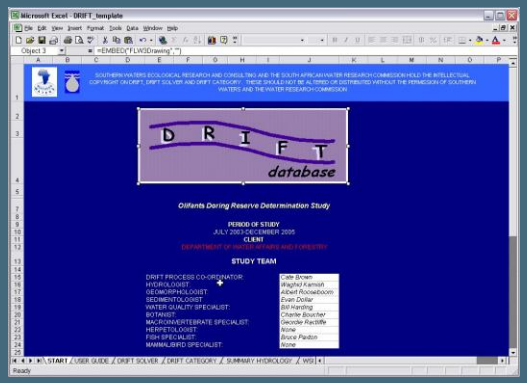
What are the "minimum" flood  requirements?

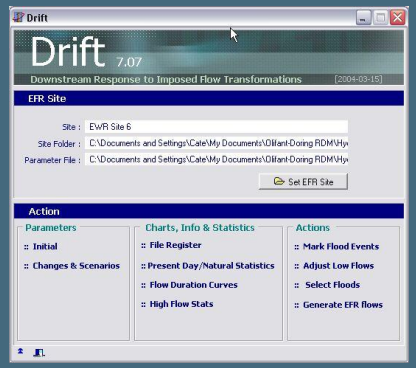
Are the "minimum" flood requirements realistic with respect to the hydropower generation?

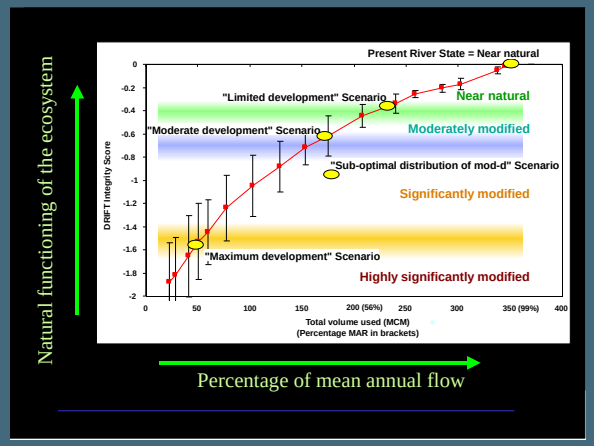
# DRIFT

## Downstream Response to Imposed Flow Transformations

A holistic, scenario-based environmental flows methodology applied to a range of river basins worldwide






King et al. 2004

# Different water users/concern in the delta

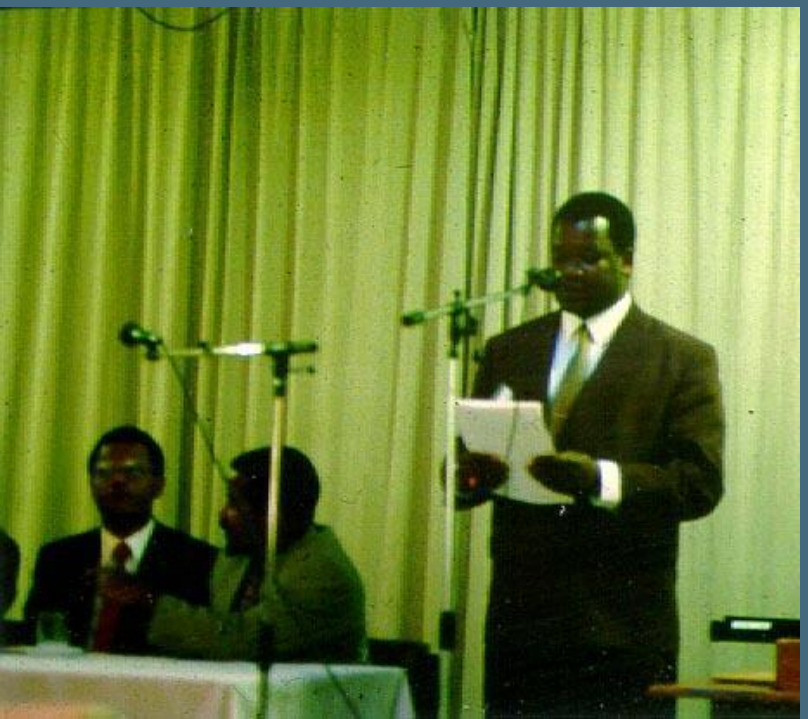
- Small scale agriculture (subsistence and cash crop)
- Irrigated commercial agriculture
- Estuarine ecology and coastal fisheries (esp. prawns)
- Freshwater fisheries
- Livestock
- Large mammals
- Waterbirds  (as a proxy for wetland biodiversity)
- Wetland vegetation and invasive species
- Natural resource utilisation (socio-economic and cultural)
- Water quality
- Domestic water supply
- In-river navigation
- Public health
- Settlement patterns

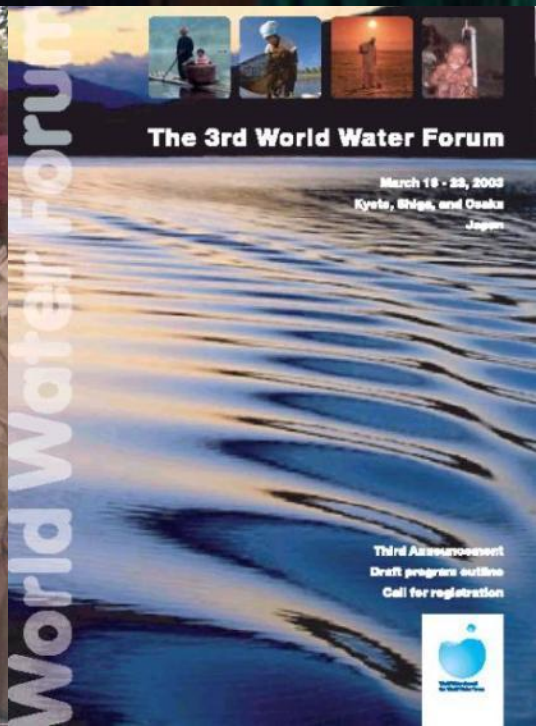
# Are there significant trade-offs among wetland water requirements?

- NO—range of water users show consistent need for improved flows, especially annual floods
- Strong consensus among experts/representatives
- One scenario indicates improvements with no hydropower reduction
- Several scenarios indicate a range of benefits with modest hydropower reductions



Beilfuss and Brown 2006, 2010




World Water Forum
The 3rd World Water Forum
March 16 - 23, 2003
Kyoto, Shiga, and Osaka
Japan
Third Announcement
Draft program outline
Call for registration

# Joint Zambezi River Basin Environmental Flows Program

Strategic partners:

- ZRA, ARA-Zambeze, ZINWA (water management)
- HCB, ZESCO,ZPC, HMN (hydropower generation)
- Government (Water, Environmental, Meteorological, Disaster Management, Fisheries & Agriculture Institutions)
- Zambezi Commission (ZAMCOM) Secretariat

Coalition partners:

- World Wide Fund for Nature
- International Crane Foundation
- UNESCO-IHE
- Universities of Mozambique, Zambia, Zimbabwe

# Shared challenges/issues identified by Zambezi basin operators for collaboration with environmental flows partnership

**1. Environmental Flows**

- Data gathering and information sharing
- Flow scenario development
- Monitoring and adaptive management
- Capacity building and personnel exchange
- Water quality as well as quantity

**2. Conjunctive Dam Management**

- Governance
- Technical operations
- Benefit sharing

# Shared challenges/issues identified by Zambezi basin operators for collaboration with environmental flows partnership

**3. Managing extreme floods and droughts**

- Forecasting
- Infrastructure
- Climate change
- Emergency preparedness

# Partnership Vision

- The operating rules of hydropower dams incorporate environmental flow targets
- Essential freshwater resource areas are secured
- Tributaries/river-floodplains stretches with high ecological importance are kept dam-free

# Learning from Experimental Releases

# Alternative Development Futures


A National Disaster


A New Ramsar Site

# Reflections

- Still a window of opportunity to secure large-scale wetland functions and biodiversity
- Think big and simplify complexity as needed to move forward
- Mutual trust is fundamental to overcome risk and uncertainty among water authorities/operators, communities, agencies, faculty
- All aspects of capacity development—from research to implementation—essential to sense of ownership
- Disseminate research & monitoring results frequently to stakeholders through forums and all available media

# Reflections

- Reframe case as regional challenge of equity in shared water and wetland resources rather than people v. wetlands
- Many wetland resource users (grazing, fisheries, agriculture) are key allies in getting water right
- Invasive species (not people!) as a national security threat
- To succeed, this process requires commitment of time and resources over the long-term

# Thank You

International Crane Foundation
World Wide Fund for Nature
University of Eduardo Mondlane
University of Zambia
Zambia Wildlife Authority
Africa Dams Project
Zambezi Valley Planning Authority
Zambezi River Authority
Zambia Electrical Supply Company
Cahora Bassa Hydroelectric Ltd
Southern Waters Ecological Consulting
Endangered Wildlife Trust
Zambeze Delta Safaris
Department of Water Affairs-Mozambique
University of Minnesota MacArthur Peace Studies Program
Ramsar Bureau
Liz Claiborne and Art Ortenberg Foundation
Disney Wildlife Conservation Fund
Foundation for Wildlife Conservation
John D. and Catherine T. MacArthur Foundation
Ford Foundation
Luc Hoffman--Mava Foundation
Netherlands Embassy