Integrated Management of Land Use, Land Cover, and Hydrology: Preparing for Climate Change



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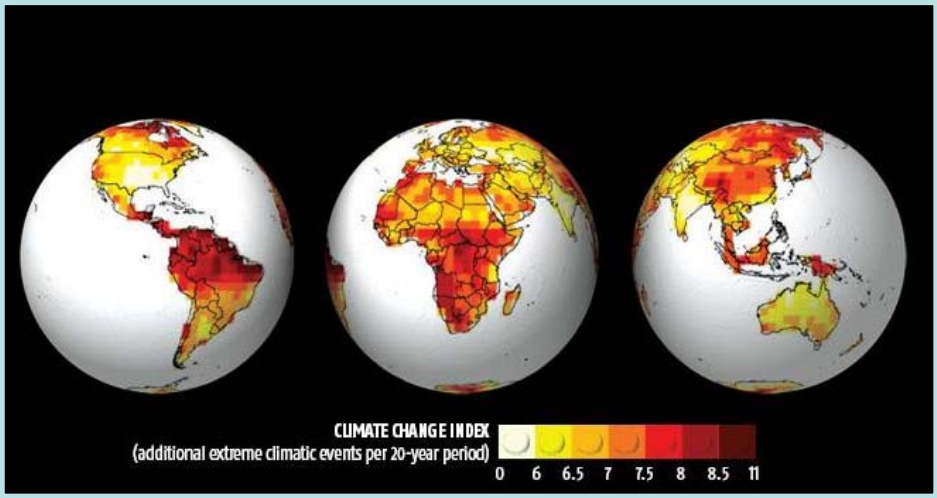
The World Bank, Washington, DC.

Climate Change

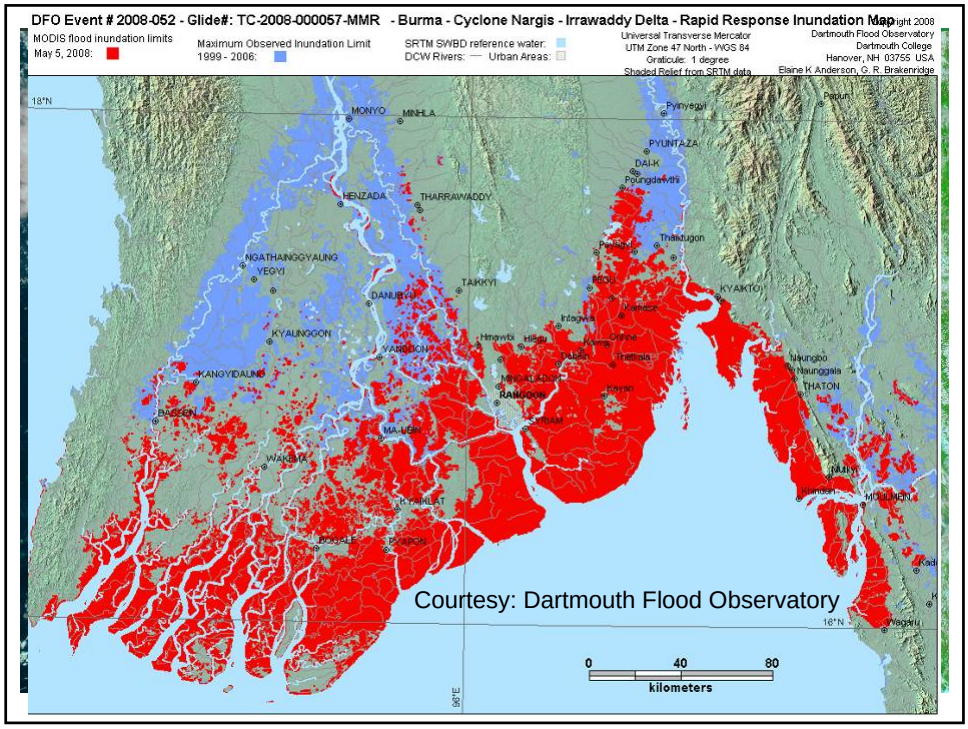
- Climate change presents an urgent challenge to the well-being of all countries...
- ….and particularly to the poorest countries and the poorest people (especially women and children) in vulnerable regions.
- Addressing climate change is central to the development and poverty reduction agenda.
- Tackling climate change is feasible…
- …but who bears how much of the costs remains the key issue [UNFCCC estimates $100b for mitigation + ~$40b for adaptation in addition to ODA]

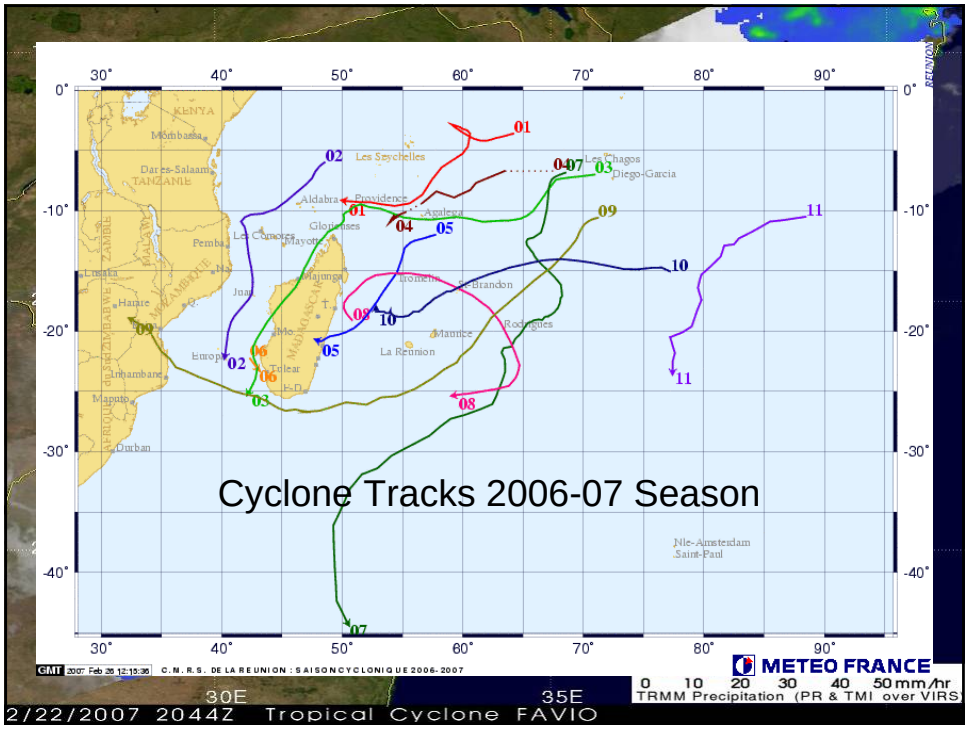
Projected Change in Frequency of Extreme Events in next 20 years



Baettig, M. B., M. Wild, and D. M. Imboden (2007), A climate change index: Where climate change may be most prominent in the 21st century

Myanmar: May, 2008


DFO Event # 2008-052 - Glide#: TC-2008-000057-MMR - Burma - Cyclone Nargis - Irrawaddy Delta - Rapid Response Inundation Map
MODIS flood inundation limits
May 5, 2008:
Maximum Observed Inundation Limit
1999 - 2006:
SRTM SWBD reference water:
DCW Rivers:
Urban Areas:
Universal Transverse Mercator
UTM Zone 47 North - WGS 84
Graticule: 1 degree
Shaded Relief from SRTM data
Copyright 2008
Dartmouth Flood Observatory
Dartmouth College
Hanover, NH 03755 USA
Elaine K Anderson, G. R. Brakenridge
MONYO
MINHLA
PYUNTAZA
DAI-K
HENZADA
THARRAWADDY
NGATHAINGGYAUNG
YEGYI
TAKKYI
DANUBYU
KYALINGGON
KANGYIDAUNG
BASSEIN
WAKEMA
KYAIKLAT
BOGALE
PYAPON
RANGOON
KYAIKTO
THATON
MOULMEIN
Courtesy: Dartmouth Flood Observatory
0
40
80
kilometers


Cyclone Tracks 2006-07 Season
KENYA
Mombasa
Dar-es-Salaam
TANZANIE
Les Seychelles
Aldabra
Providence
Agalega
Glorieuses
Les Comores
Mayotte
Pemba
Lusaka
Juan
Majunga
Tromelin
Brandon
Rodrigues
Maurice
La Reunion
Europa
Tulear
Inhambane
Maputo
Durban
Nle-Amsterdam
Saint-Paul
Les Chagos
Diego-Garcia
METEO FRANCE
TRMM Precipitation (PR & TMI over VIRS)
2/22/2007 2044Z Tropical Cyclone FAVIO

Adaptation to Climate Variability & Change

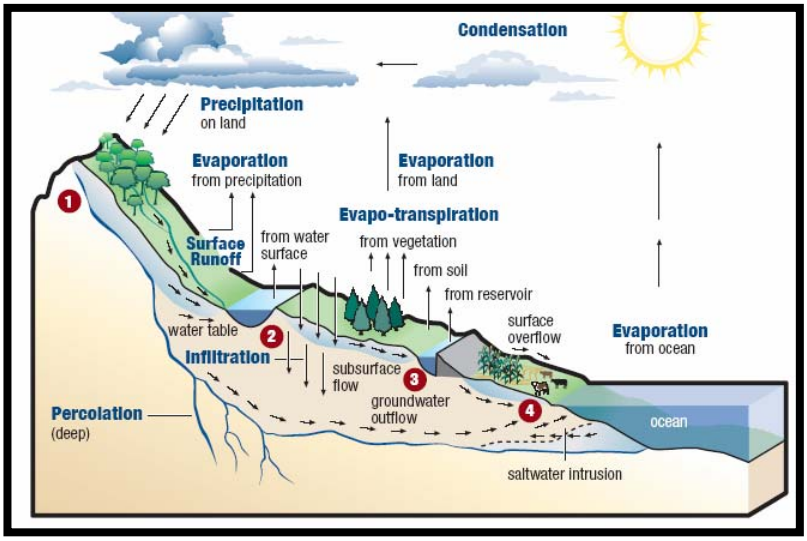
Zambezi Floods, Jan-Feb, 2007

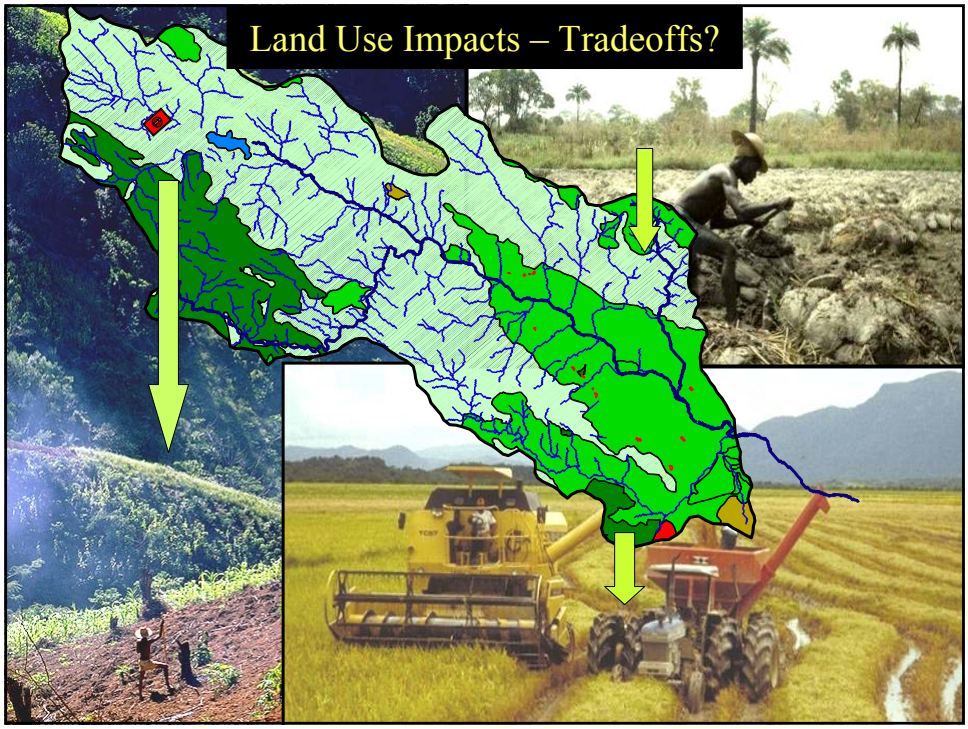
Mozambique: Impact of 2000 floods on the economy

	Actual		Projection				
			Before the Floods		After the Floods		
	1998	1999	2000	2001	2000	2001	
Real GDP (ann. Growth rate)	12.0	9.0	7.0	7.2	5.4	7.9	-23%
Inflation (ann. average, %)	0.6	2.0	6.6	5.0	9.5	5.0	+44%
External current account:							
Before grants	-20.5	-31.7	-23.0	-15.7	-31.5	-18.4	
After grants	-12.4	-21.5	-16.3	-9.1	-19.7	-11.0	
Fiscal Balance:							
Before grants	-10.7	-12.1	-12.1	-10.7	-16.0	-11.5	
After grants	-2.4	-1.2	-5.2	-4.4	-7.0	-5.1	
Memorandum: GDP (Mt billion)	46,134	52,913	60,177	67,790	61,471	69,673	

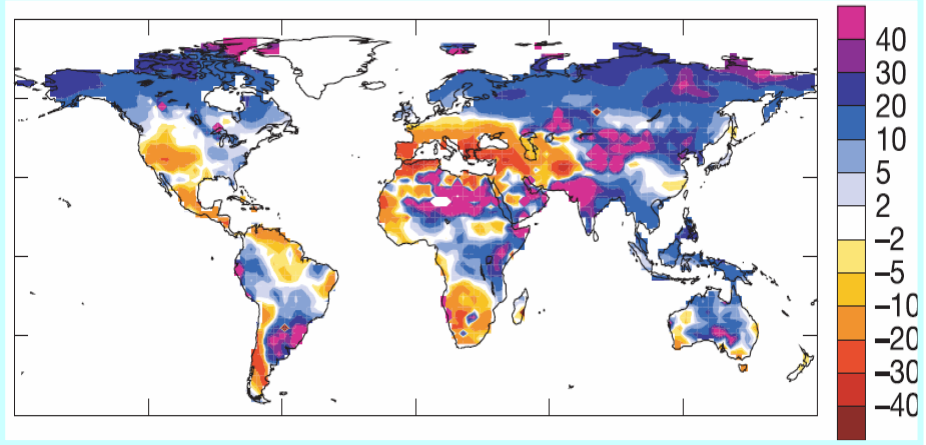
Source: Staff estimates, IMF and Government of Mozambique

Production Landscapes
Watershed to Basin Scales





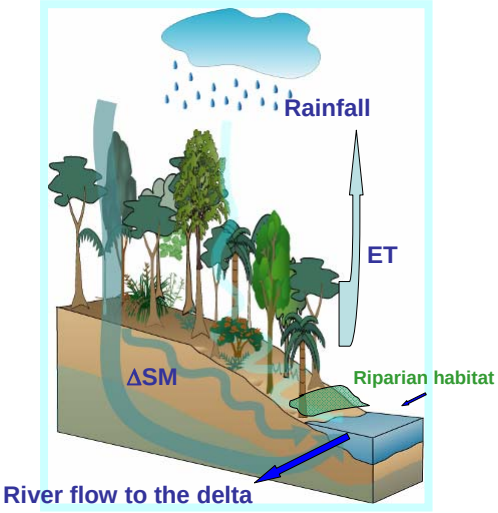
% change in runoff by 2050



- Many of the major “food-bowls” of the world are projected to become significantly drier
- Globally there will be more precipitation
- Higher temperatures will tend to reduce run off
- A few important areas drier (Mediterranean, southern South America, northern Brazil, west and south Africa)

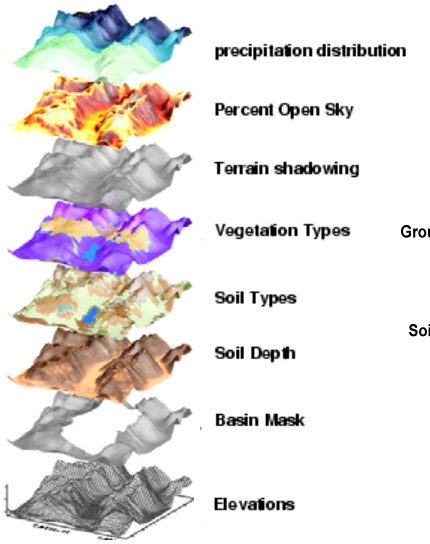
Climate – Landsurface – Water Cycle (1)

Q (river flow) = P (rainfall) - ET (evapotranspiration) + ΔSM (soil moisture)

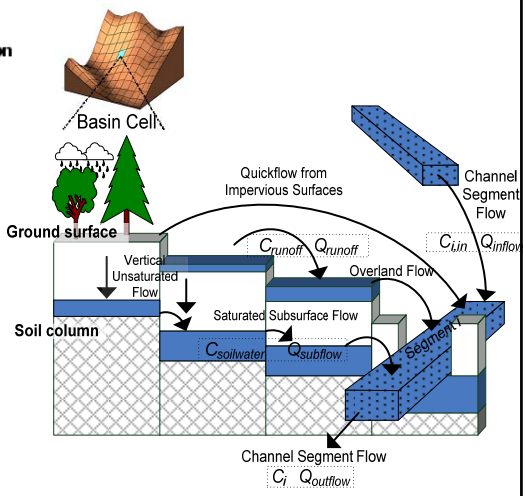


Climate – Landsurface – Water Cycle (2)

Climate and landscape structure



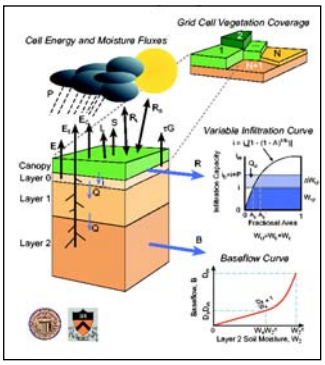
Water and "stuff" movement



Bring it to life: geospatially-explicit, process-based Landscape-Hydrology Models

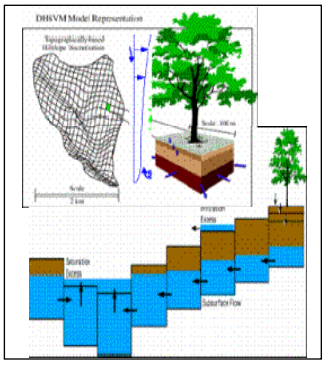
Large Scale

e.g. VIC (Variable Infiltration Capacity) Meso/Macroscale Landscape/Hydrologic Model. (moderate to large-scale resolution)



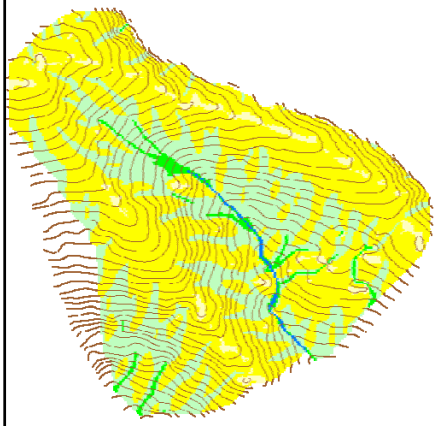
Small-Scale

e.g., DHSVM (Distributed Hydrology Soil Vegetation Model) Micro/Mesoscale Landscape/Hydrologic Model (high to moderate resolution)



System/Terrain Analysis method

Example map of contributing area



Wetness index:

$$\omega = \ln\left[A_s/\tan\beta\right]$$

Sediment transport index:

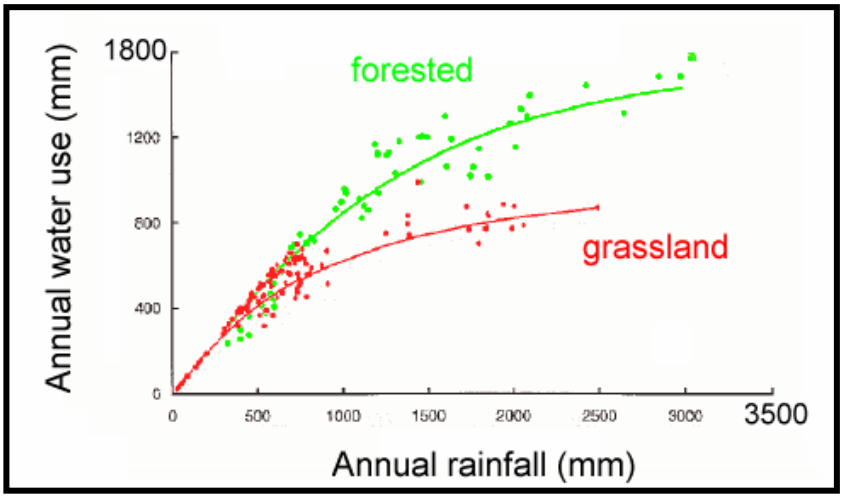
$$\tau = \left(\frac{A_s}{22}\right)^{0.6}\left(\frac{\sin\beta}{0.09}\right)^{1.3}$$

A_s = contributing area

β = slope

Moore et al. 1991, 1992

Water Use – Plantation Forests v Grasslands

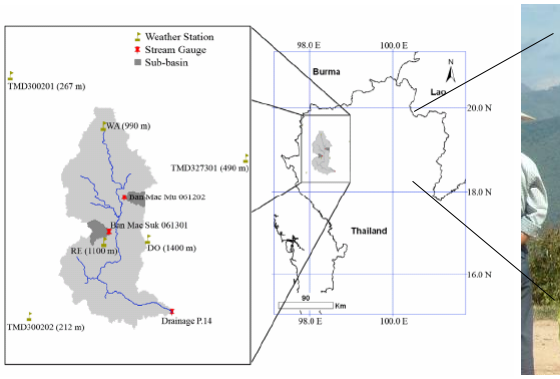


(Source: Zhang et al., 2001)

User-Friendly Decision Support Systems

Effects of landuse change on the hydrologic regime of The Mae Chaem river basin, NW Thailand

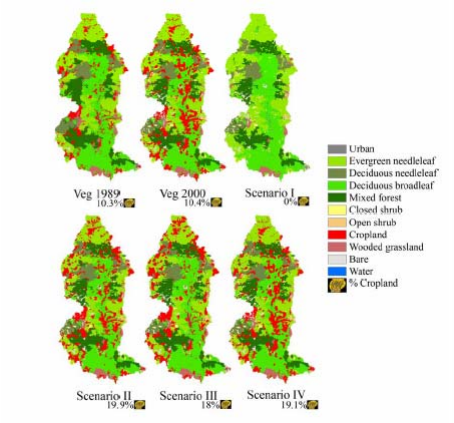
Thanapakpawin et al (in press) J. of Hydrology*



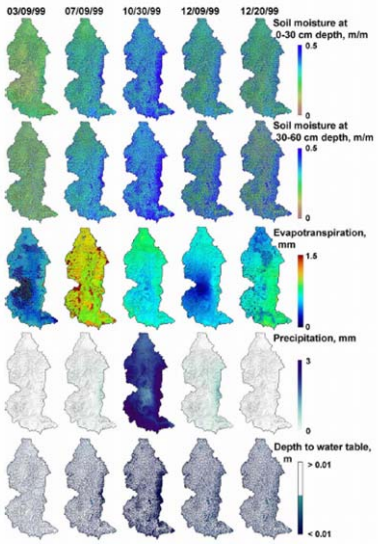
4000 km^2/Sparse Data

**NSF, BNPP Functional Value of Biodiversity*

Landcover Scenarios

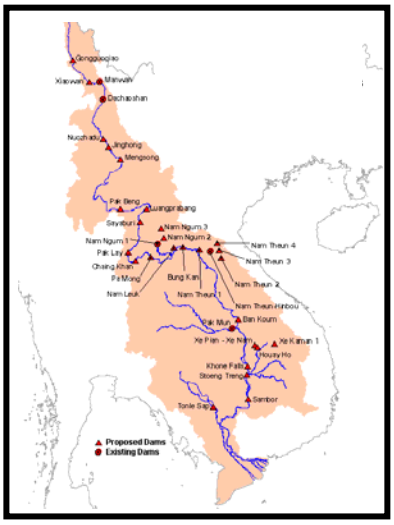


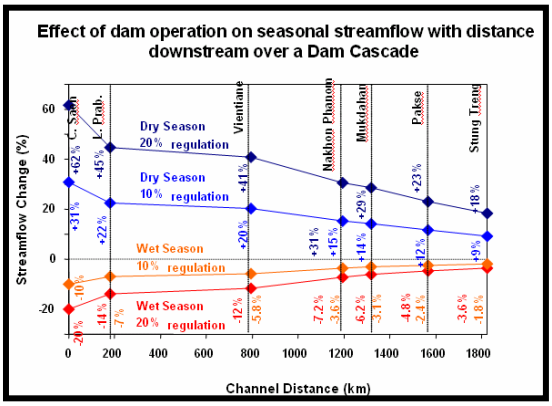
Underlying Dynamic Changes



Landcover scenarios		Average hydrologic components (1995 – 2000)			
		Annual yield, mm (m^3/s)	High flow, m^3/s^a	Low flow, m^3/s	Annual evapotranspiration, mm
Veg 2000	I	215 (26.2)	54.7	7.6	762
	NI	249 (30.5)	58.6	12.0	727
Scenario I	NI	223 (27.2)	53.3	11.1	752
Scenario II	I	202 (24.7)	53.6	5.8	781
	NI	261 (31.8)	61.2	12.5	715
Scenario III	I	220 (25.6)	56.8	7.0	759
	NI	269 (32.8)	63.1	12.7	707
Scenario IV	I	193 (23.6)	51.6	5.6	786
	NI	251 (30.7)	59.1	12.2	724

EFFECT OF DAMS ON FLOW SUB-MODEL





Pro-Poor Instruments

- Integrated Land & Water Management (Soil carbon, avoided deforestation, Rehabilitation of degraded lands)
- Capacity strenghtening (regional, national, local)
- Methodologies and transaction costs
  - New science and new technologies
  - Improved temporal and spatial resolution
  - Better handle on assessing tradeoffs
  - Empowering communities with knowledge and access to technologies (early warning, decision support, relocation, infrastructure…)

Analyses & Actions

- Optimal spatial scales for conducting analysis of spatially variable economic and bio-physical processes.
- Clean Energy Investment Framework (CEIF)
- Economics of Adaptation
- Strategic Framework on Climate Change (SFCC)

Towards a Strategic Framework on Climate Change (SFCC)

Climate change "is a development, economic, and investment challenge. It offers an opportunity for economic and social transformation that can lead to an inclusive and sustainable globalization. That is why addressing climate change is a critical pillar of the development agenda."

Robert Zoellick - United Nations Climate Change Conference in Bali, Indonesia, December 2007

www.worldbank.org/climateconsult


Thank you!
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The Zambezi River in Mozambique