Adapting to Water Scarcity

University of Newcastle July 2011

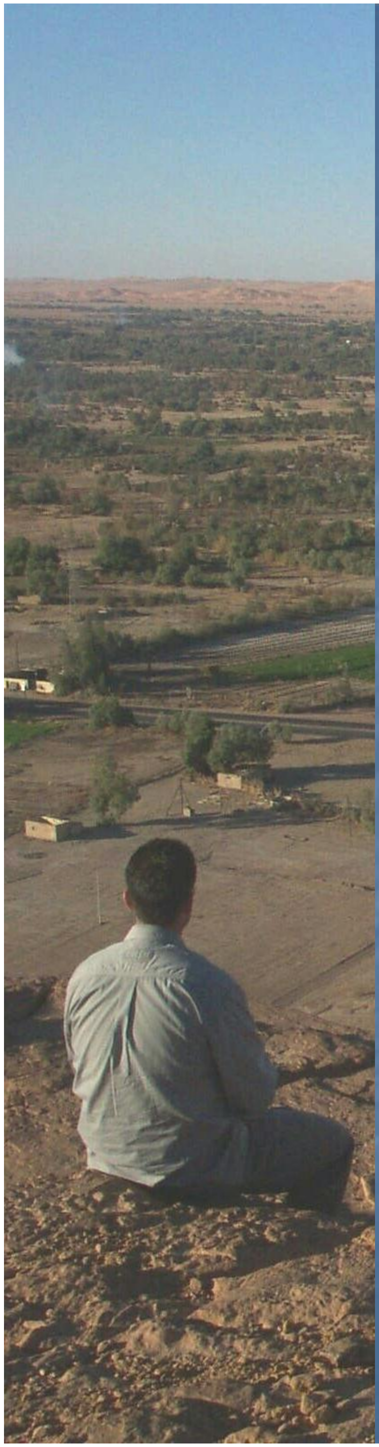
Prof W Mike Edmunds

Oxford University

School of Geography and the Environment

Oxford Water Futures Programme

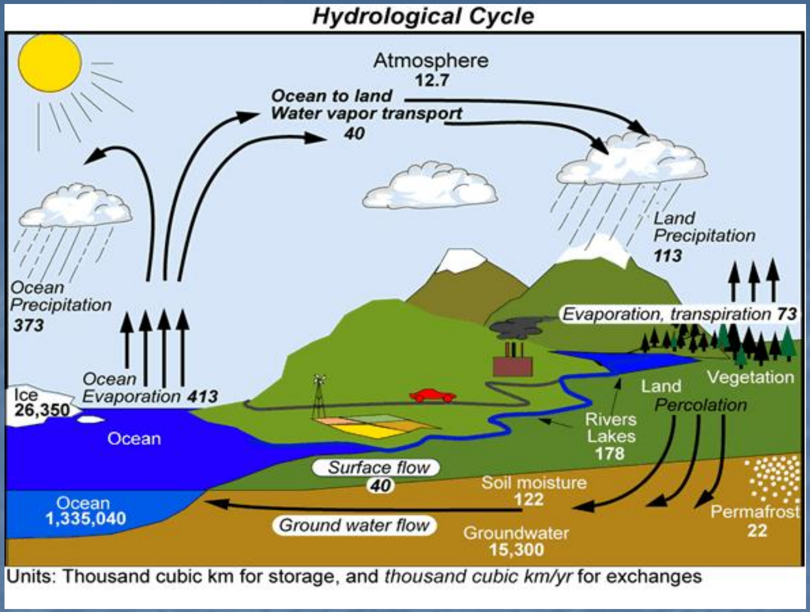
UNIVERSITY OF OXFORD



Outline

- Water scarcity – are we running out of water?
- Water occurrence - groundwater focus
- Water quality and pollution – degradation of resources
- Case studies
  - Nigeria (Lake Chad)
  - India (Rajasthan)
  - China (North west)
- Adaptation and good news stories

UNIVERSITY OF OXFORD



Primary water reserves are becoming exhausted

- *Ice caps and glaciers* and *groundwater* are the only stores of fresh water
- The glaciers of the Tibetan plateau, sources of great Asian rivers, are being reduced by some 50 per cent every decade. Glacial melt waters have a direct impact on the livelihoods of some 3Bn people in Himalayan region

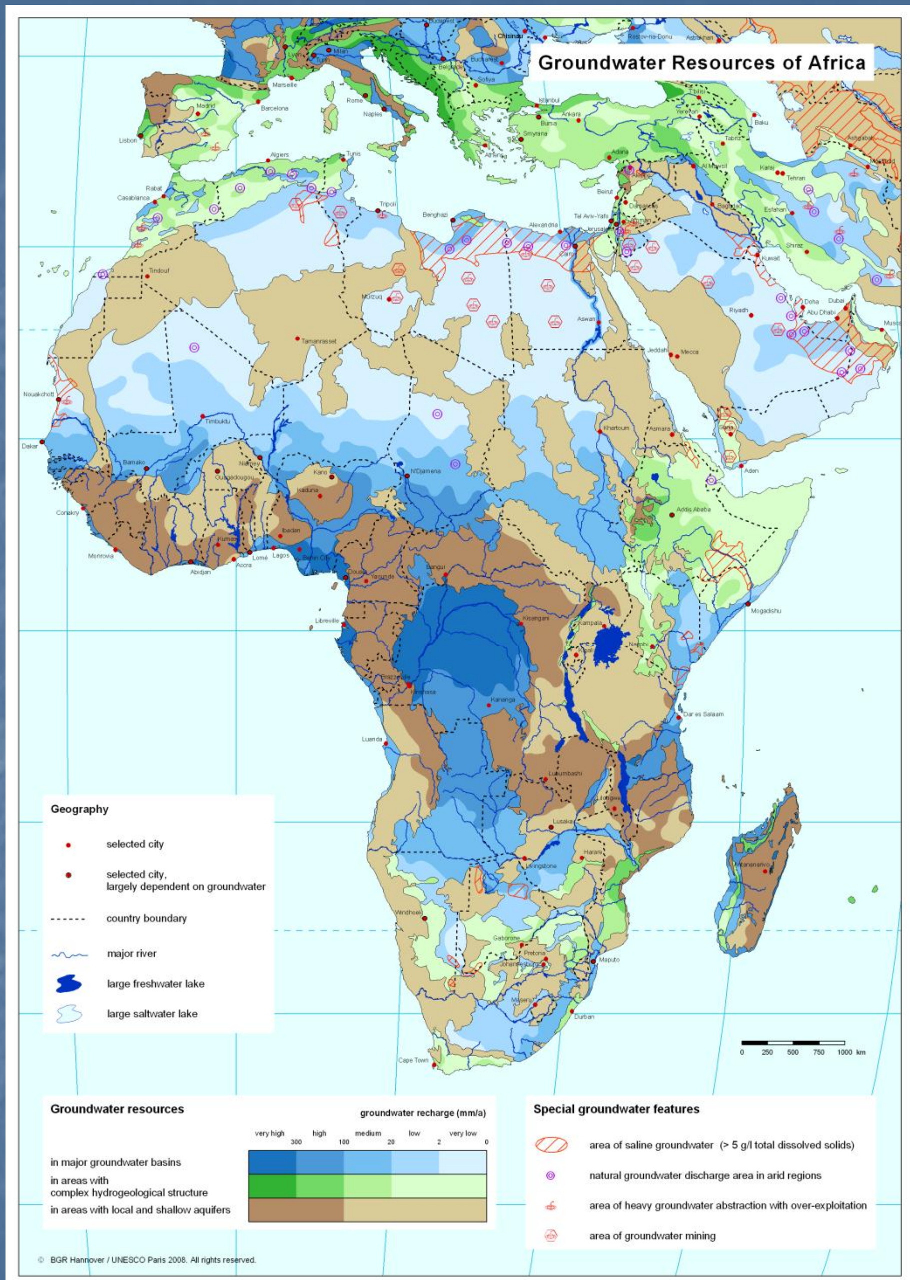
- *Surface waters* have short residence times, major resource in high rainfall areas but "fully allocated"

UNIVERSITY OF OXFORD

Groundwater resources under threat

- Is groundwater renewable - if so how much and over what timescales
- Water tables in many countries are falling with severe consequences for public supplies and ecosystems.
- Scarcity has rapidly become a problem mainly in past 50 years through introduction of the submersible pump in mid-20th century - and with subsidies for electricity.
- Depletion of reserves exacerbated by quality deterioration
- Groundwater is still poorly understood: "out of sight and out of mind"; compared with surface waters timescales of change are slow

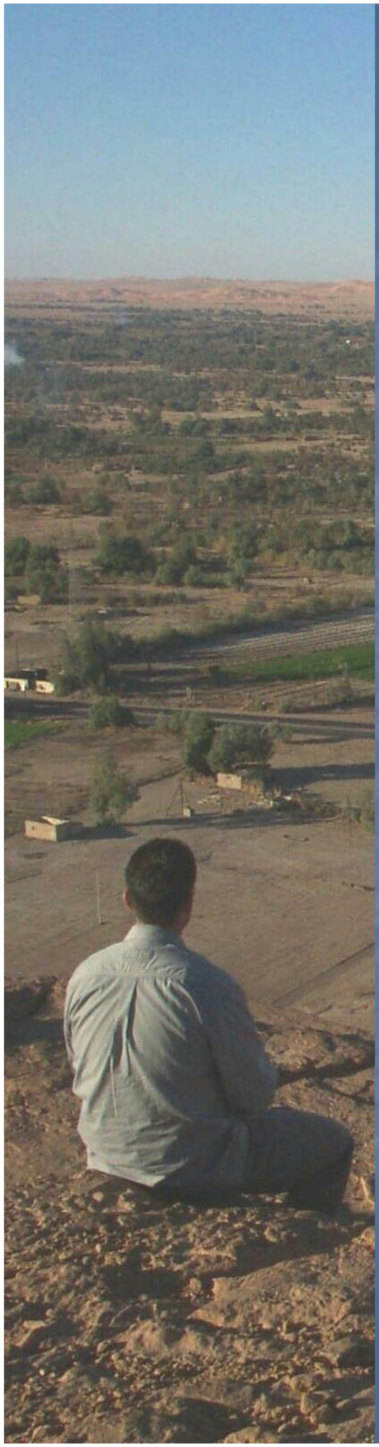
UNIVERSITY OF OXFORD



Where are there reliable *renewable* sources of water?

- Africa hydrogeological map
- Sedimentary basins
- Contrasting residence times according to geology
- Renewability on a human timescale

UNIVERSITY OF OXFORD

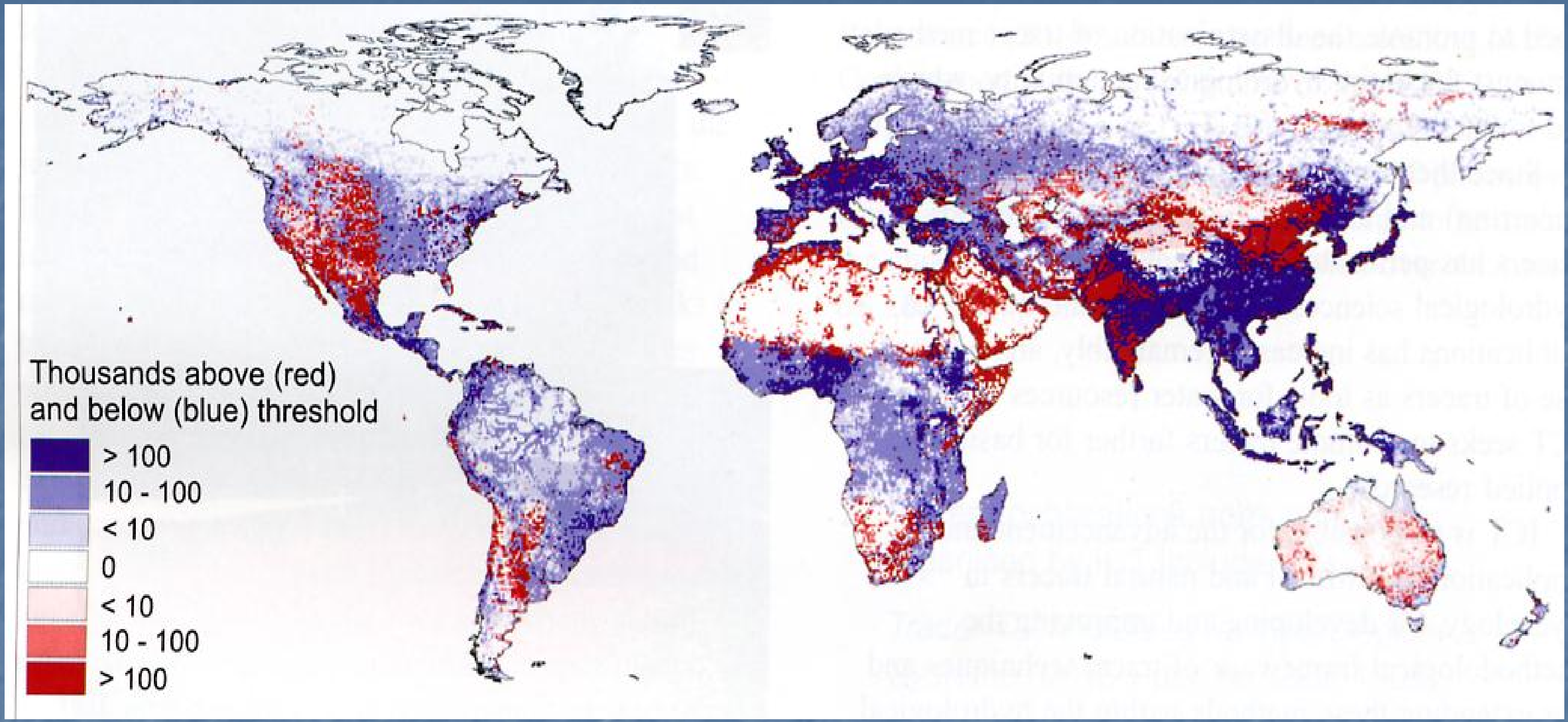


Water scarcity is not an isolated issue

- Water scarcity is closely linked to climate change, energy needs, population increases as well as water availability for domestic uses, food and industry……
- Importantly it is a political issue!

UNIVERSITY OF OXFORD

Global water stress



- Emphasizes where human water use exceeds annual renewal
- Coincides with those regions dependent on irrigated agriculture
- An under-estimate of the problem: impacts of seasonal shortages omitted.
- Consequences of overuse include diminished river flow, depletion of groundwater reserves, reduction of environmental flows and potential for conflict.

Vorosmarty et al. Science 289, 284-288

Salinity impacts and loss of resources

Dryland salinity Australia

Saline groundwater Tunisia

Kufra oasis, Libya:

Coastal intrusion and salinity

UNIVERSITY OF OXFORD

Timescales of renewal –scientific tools to measure residence times

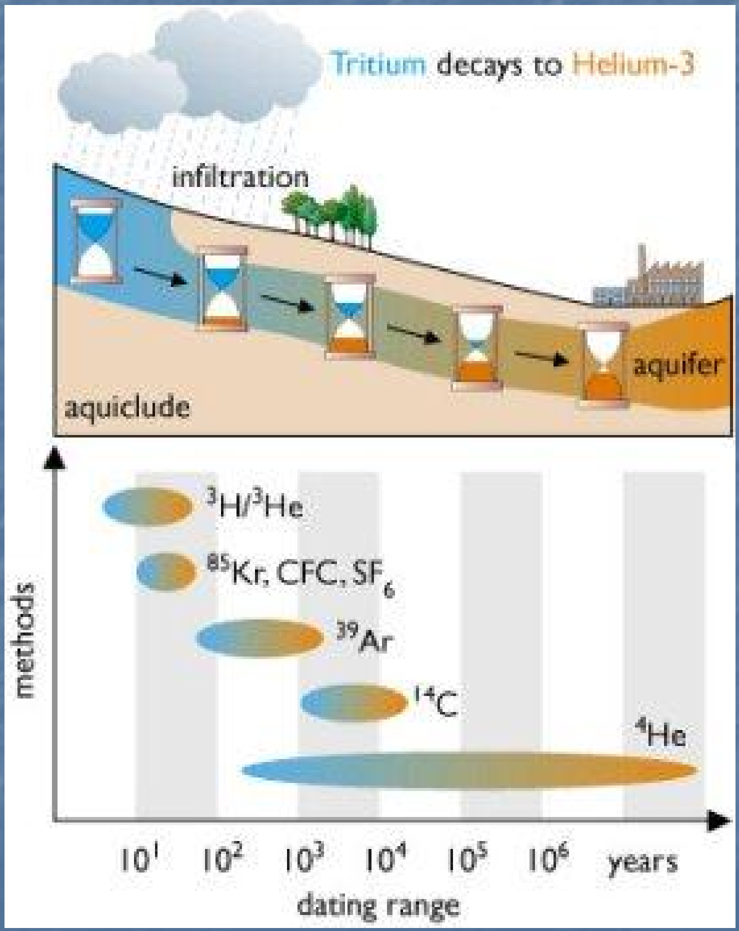
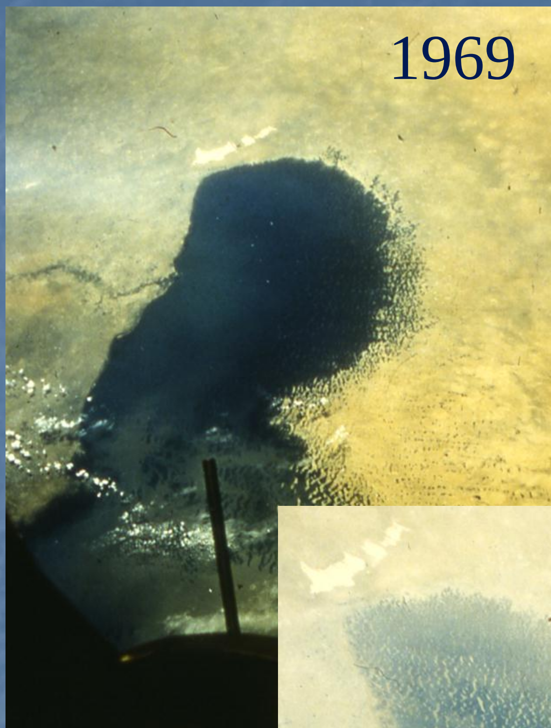


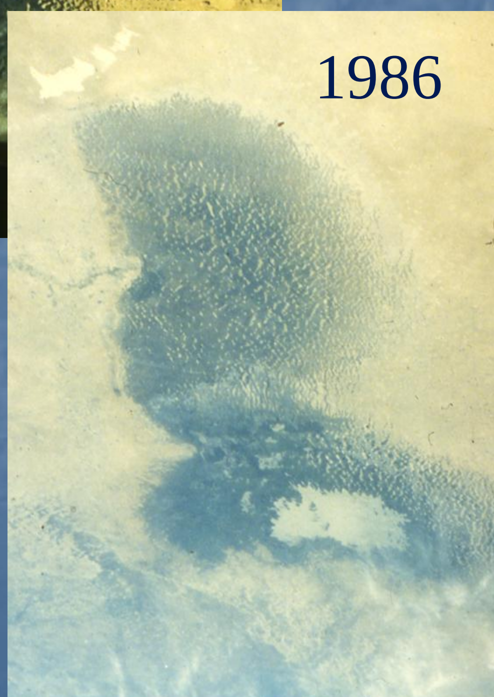
Diagram by
Roland Purtschert, Univ Bern

- Use of geochemical "clocks" – isotopes and dissolved gases
- Tritium and radiocarbon are important radiometric dating tools
- Recognition of modern water is possible from anthropogenic contaminants (eg CFCs with known history) and chemical impacts (Cl, NO_3, pesticides)
- Renewable and non-renewable water – timescales – we are mining groundwater

UNIVERSITY OF OXFORD

NIGERIA: The disappearance of Lake Chad

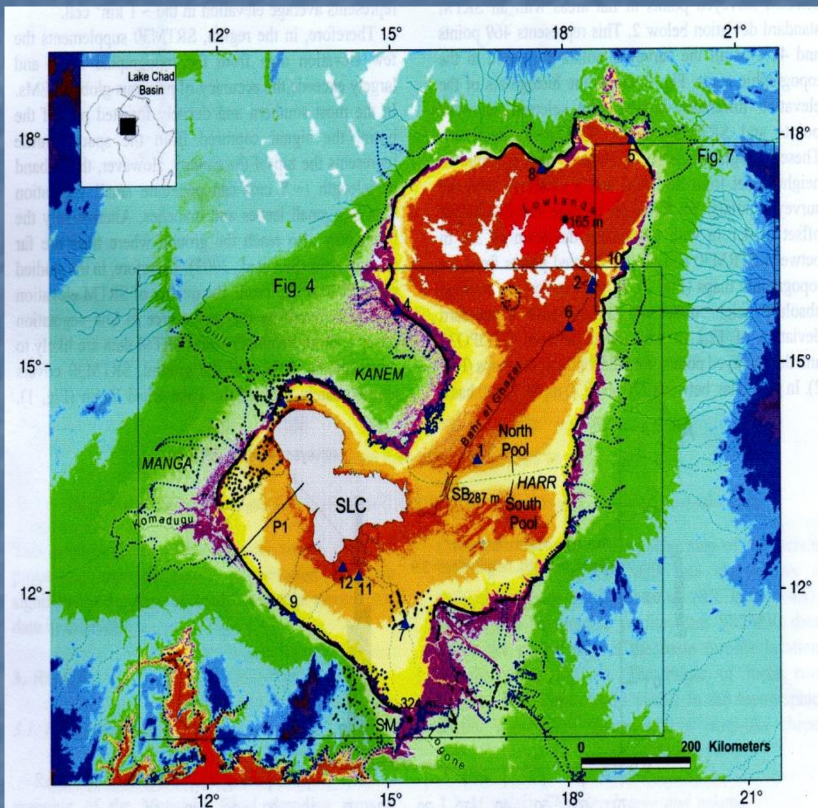




1969:The arrival of the fisheries research vessel

UNIVERSITY OF OXFORD

Lake Chad Basin

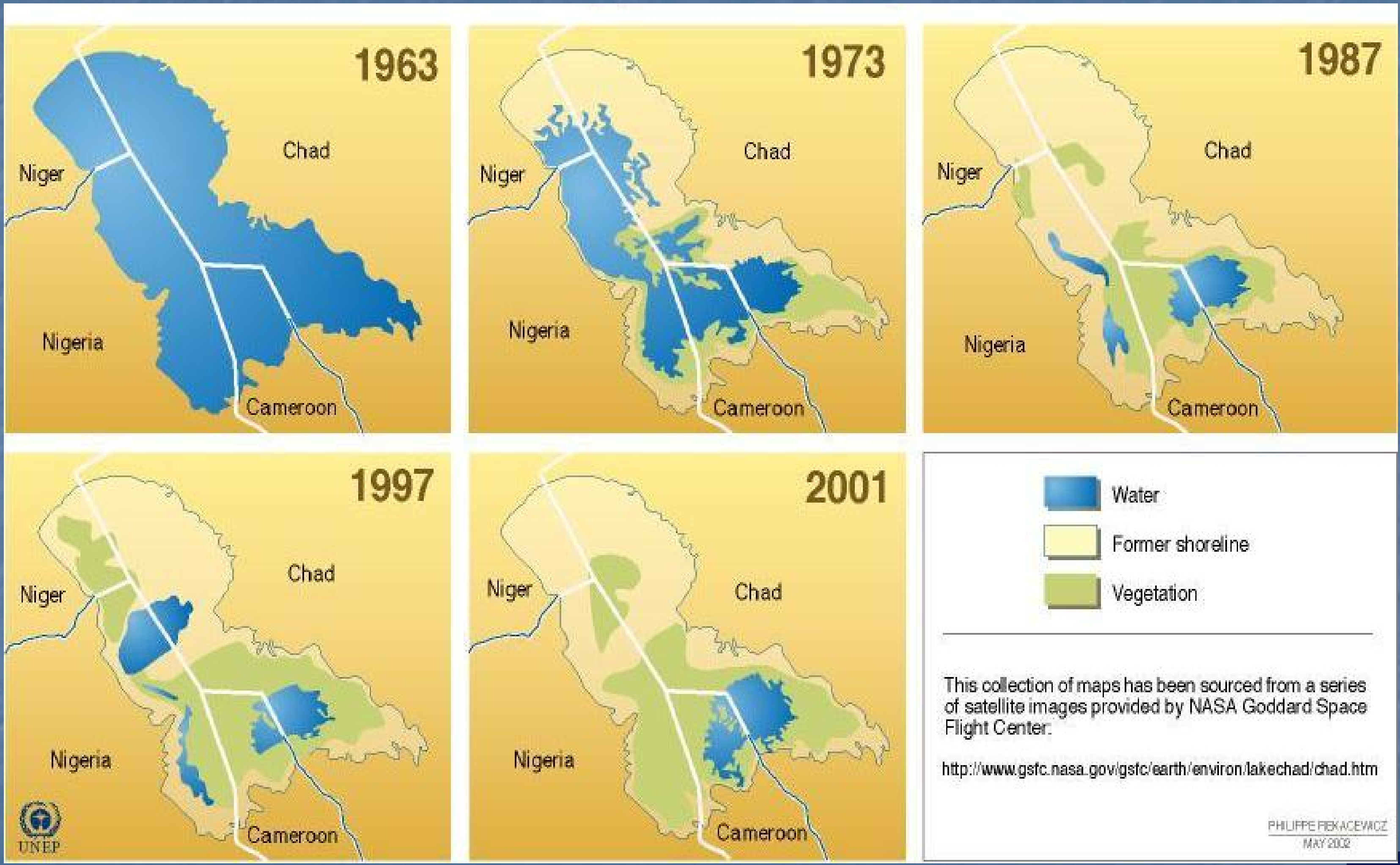


Holocene Lake MegaChad:
palaeoshorelines from space
7000 years BP

M Schuster et al.
Quat Sci Rev. 24 2005, 1821 -1827

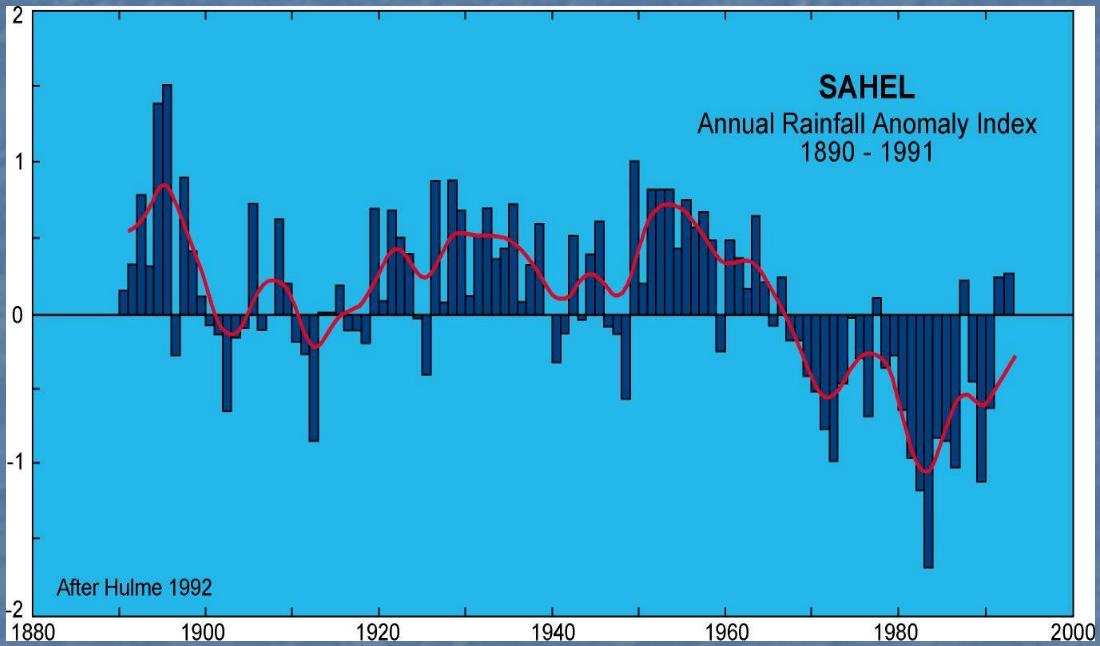
UNIVERSITY OF OXFORD

A chronology of change
Natural and anthropogenic factors affecting Lake Chad



UNIVERSITY OF OXFORD

Climate change or human impacts?

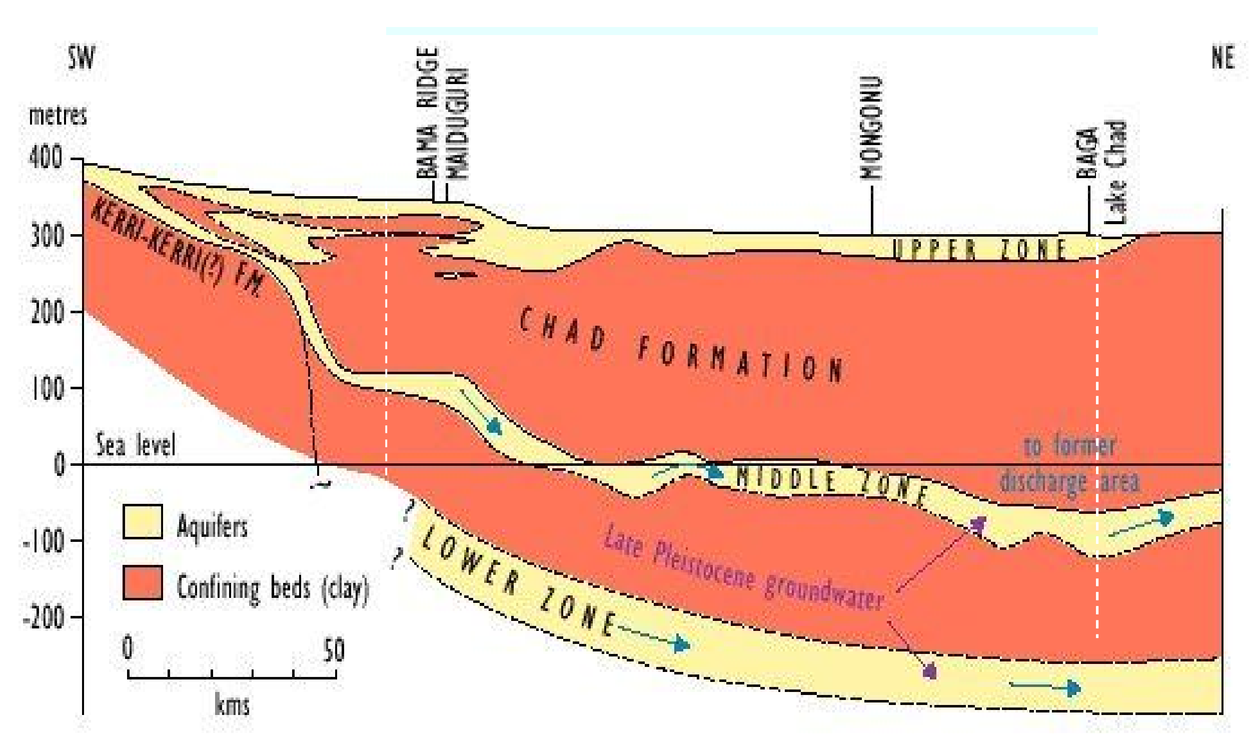


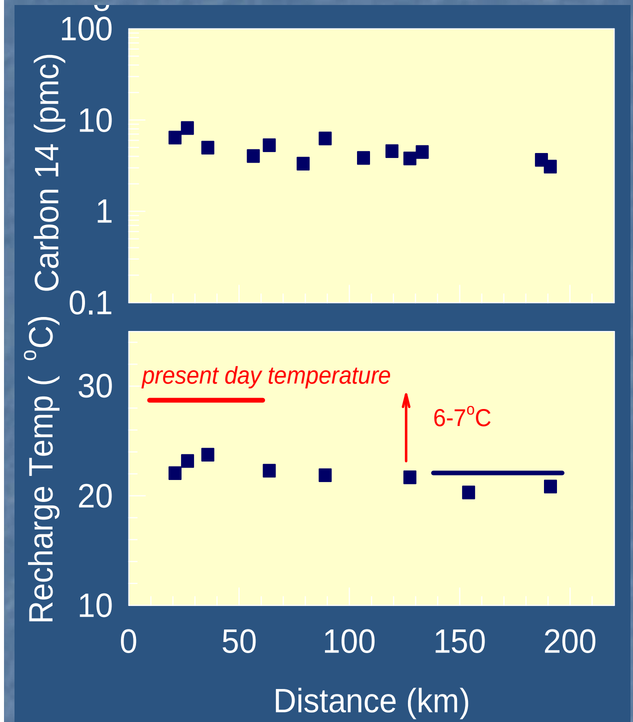
- Climate change or human impacts?
- 1966-75 irrigation accounts for 5% decrease
- 1983-1994 irrigation accounts for 50% of decrease
- Land use change
- Future trends?

UNIVERSITY OF OXFORD

What is happening *beneath* Lake Chad?

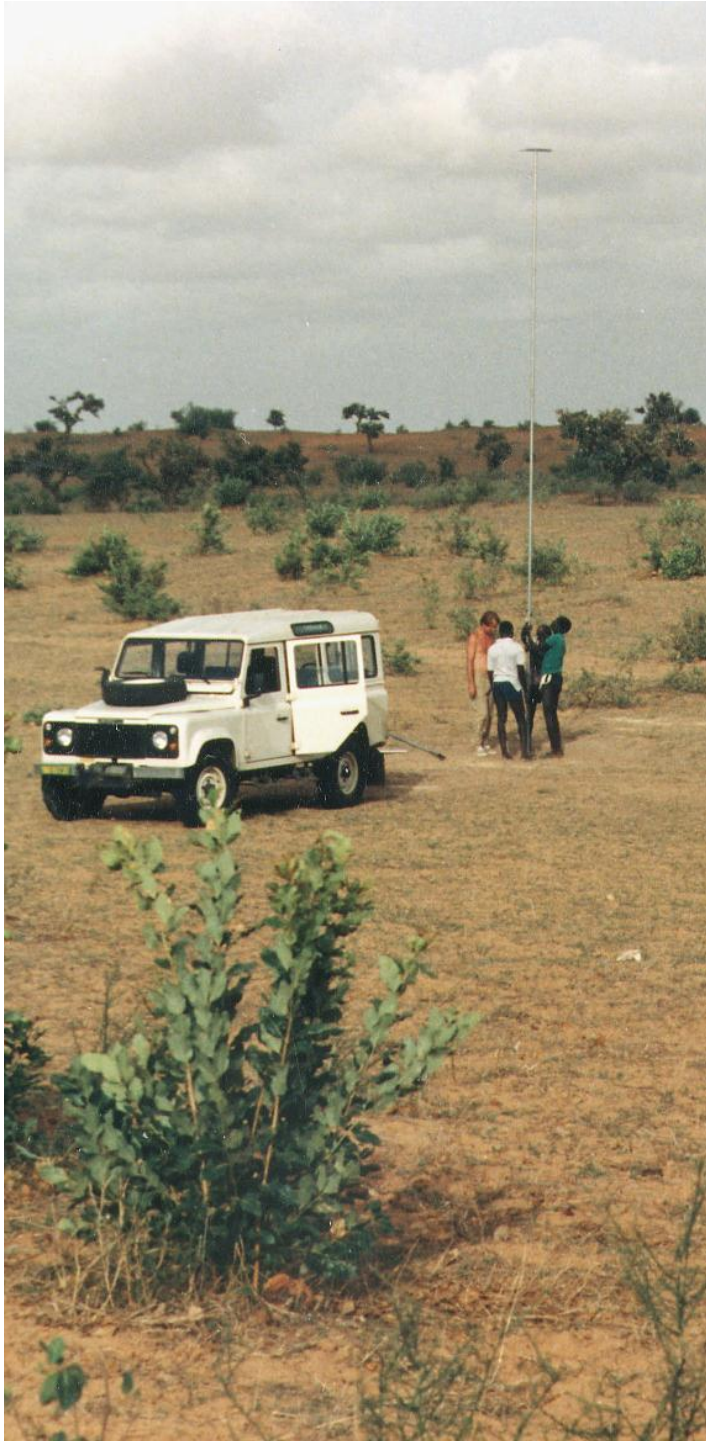
Boreholes drilled in 1960s to intercept artesian water



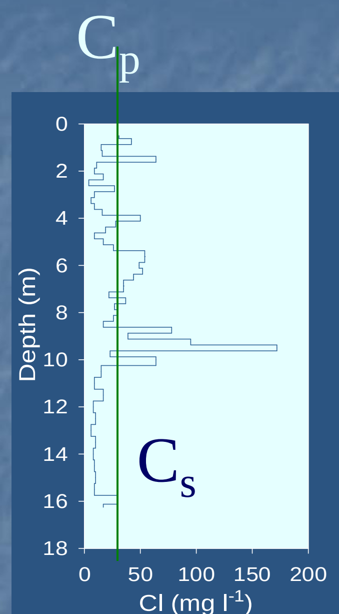


Recharge under wetter climate ï more than 20,000yrs ago:

Cooler conditions ï 6-7º lower than today (Noble Gas Recharge Temperature measurements)



How much renewable water?



$R_d = P.C_p/C_s$

P - 400 mm

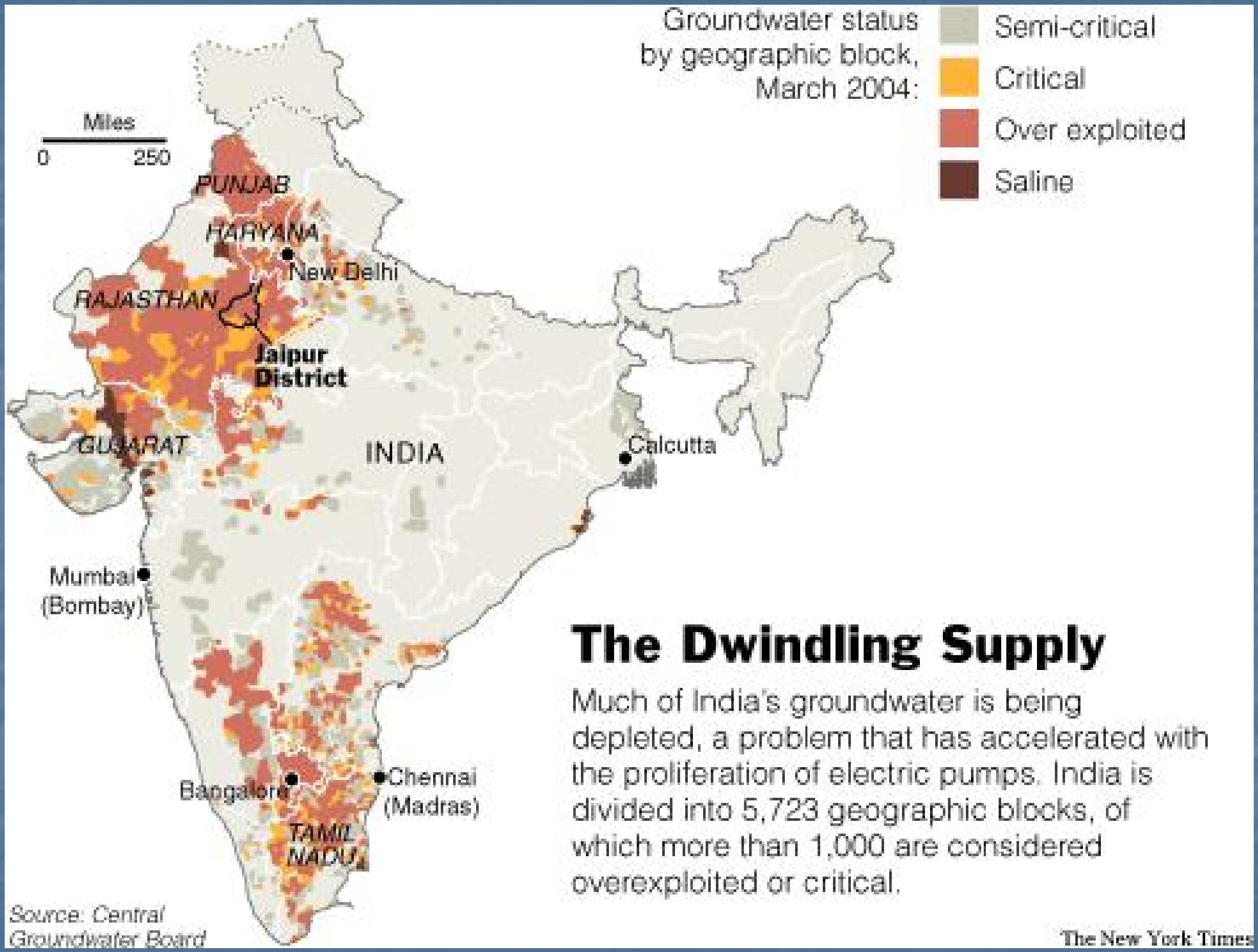
C_p - 2.0 mg/l

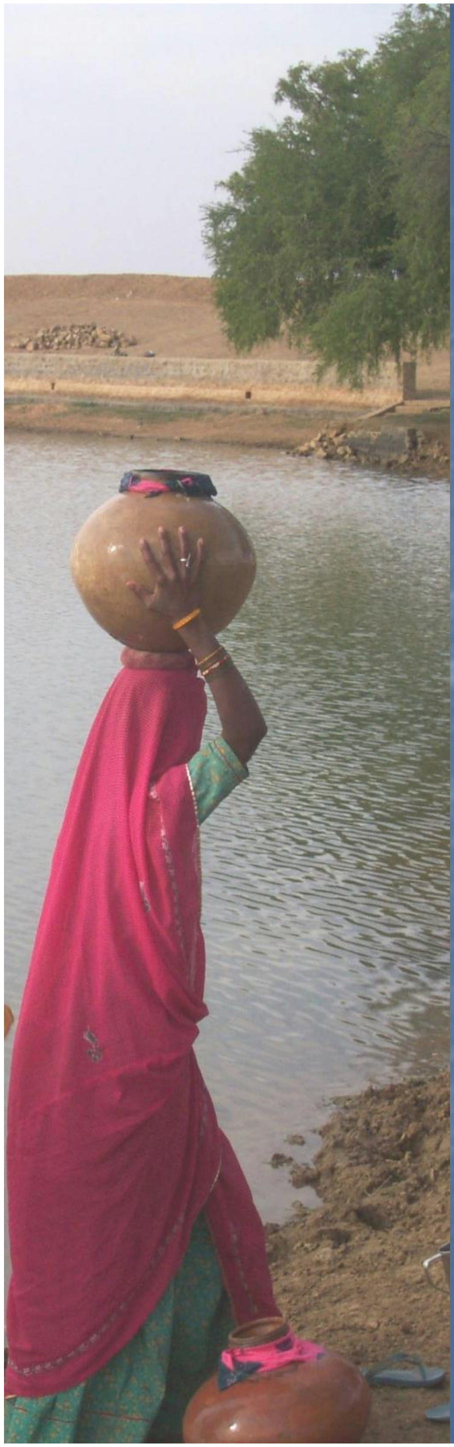
C_s - 29.5 mg/l

R_d - 25 mm yr

UNIVERSITY OF OXFORD

India

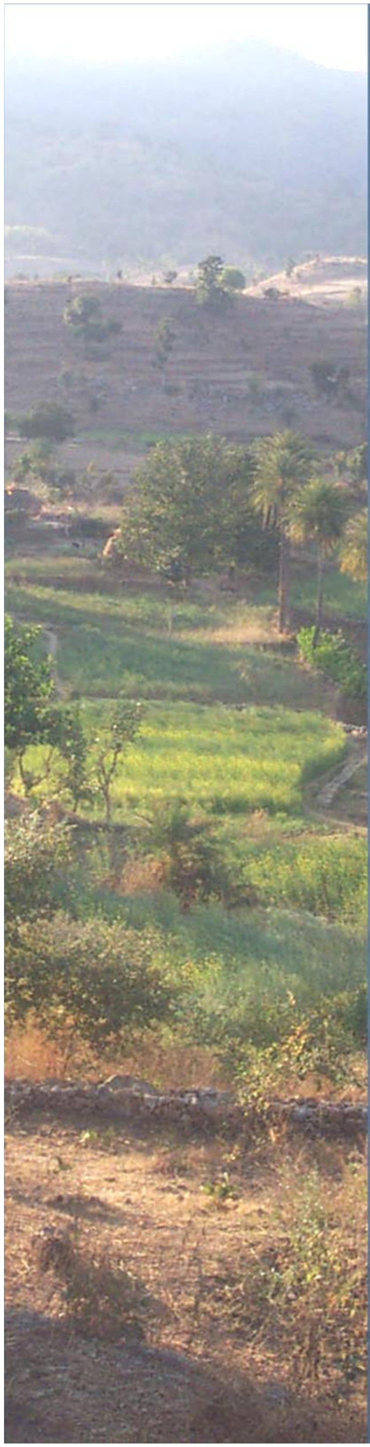

Groundwater status by geographic block, March 2004:
Semi-critical
Critical
Over exploited
Saline
Miles
0
250
PUNJAB
HARYANA
New Delhi
RAJASTHAN
Jaipur District
GUJARAT
INDIA
Calcutta
Mumbai (Bombay)
Bangalore
Chennai (Madras)
TAMIL NADU
The Dwindling Supply
Much of India's groundwater is being depleted, a problem that has accelerated with the proliferation of electric pumps. India is divided into 5,723 geographic blocks, of which more than 1,000 are considered overexploited or critical.
Source: Central Groundwater Board
The New York Times



India – (Ground)water Problems

- Green revolution, a massive increase in irrigation. Groundwater mining: introduction of the electric pump
- A million more pumps have been introduced every year
- Heavily subsidised electricity used to pump water to the surface
- A land of 750 000 villages
- Some 21M Indian farmers now dependent on and irrigate their land with groundwater – abstracting 250 km^3 – as opposed to renewal of >150 km^3
- Growing the wrong crops – rice, sugar cane, alfalfa and cotton
- Half the traditional hand dug wells and millions of tube wells have dried up – only half the land irrigated as of a decade ago
- Regulation is virtually non existent – nobody knows where the boreholes are, where the pumps are or who owns them.

UNIVERSITY OF OXFORD



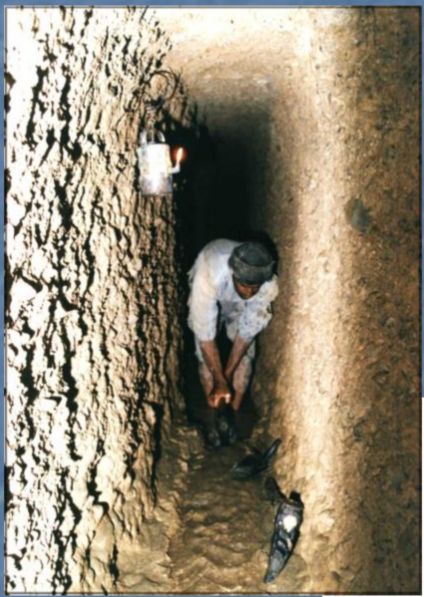
India – Water Solutions

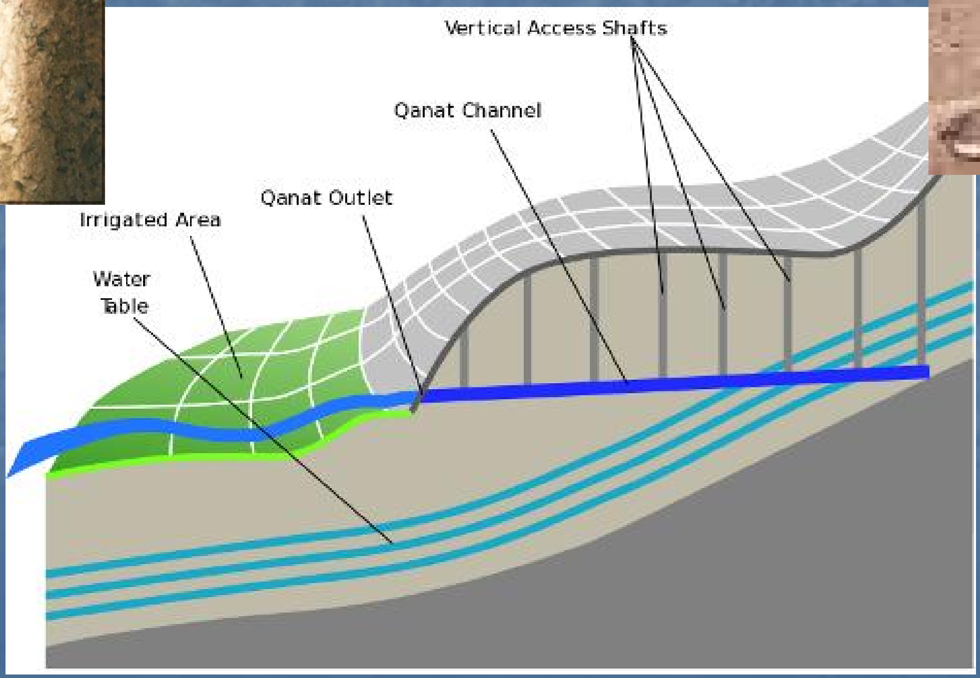
- Top down schemes? More engineering supply - led solutions? Large dams and water transfers? A national grid?
- A need to create sustainable rural development
- "Dying wisdom" – a new look at traditional solutions. Raising awareness of water scarcity. Potential for rainwater harvesting. Aquifer recharge. Applicable not only to rural areas – also to cities
- Demand management, community involvement and action. Holistic schemes – water security as a basis - to raise livelihoods of women, children – prevent migration…

UNIVERSITY OF OXFORD

Traditional and sustainable ways of water management

The Qanat systems of Persia and Middle East and Asia

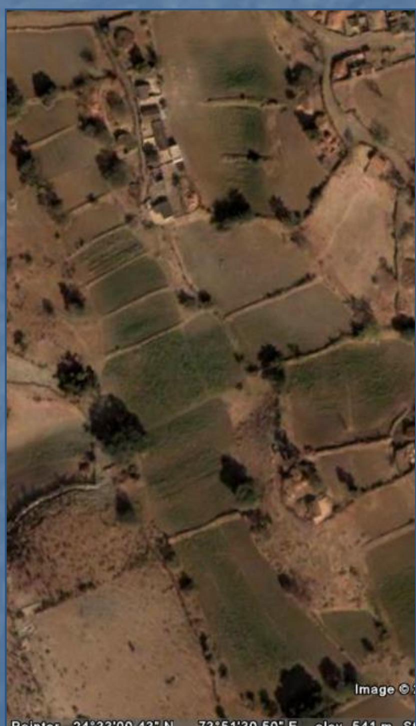




UNIVERSITY OF
OXFORD

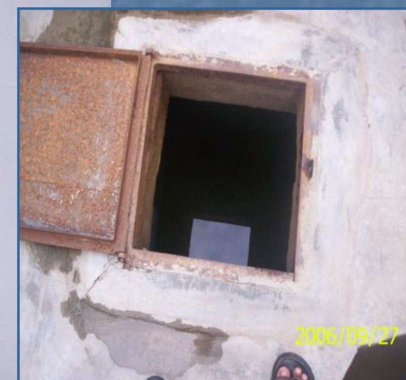
Small scale rainwater harvesting solutions Rajasthan

Adapting traditional approaches for holistic development in rural areas



Khadin (Field bunds)

Roof water harvesting



UNIVERSITY OF
OXFORD

Sanitation

a greater social and development problem than safe water provision

UNIVERSITY OF OXFORD

Safe water as the basis of holistic development

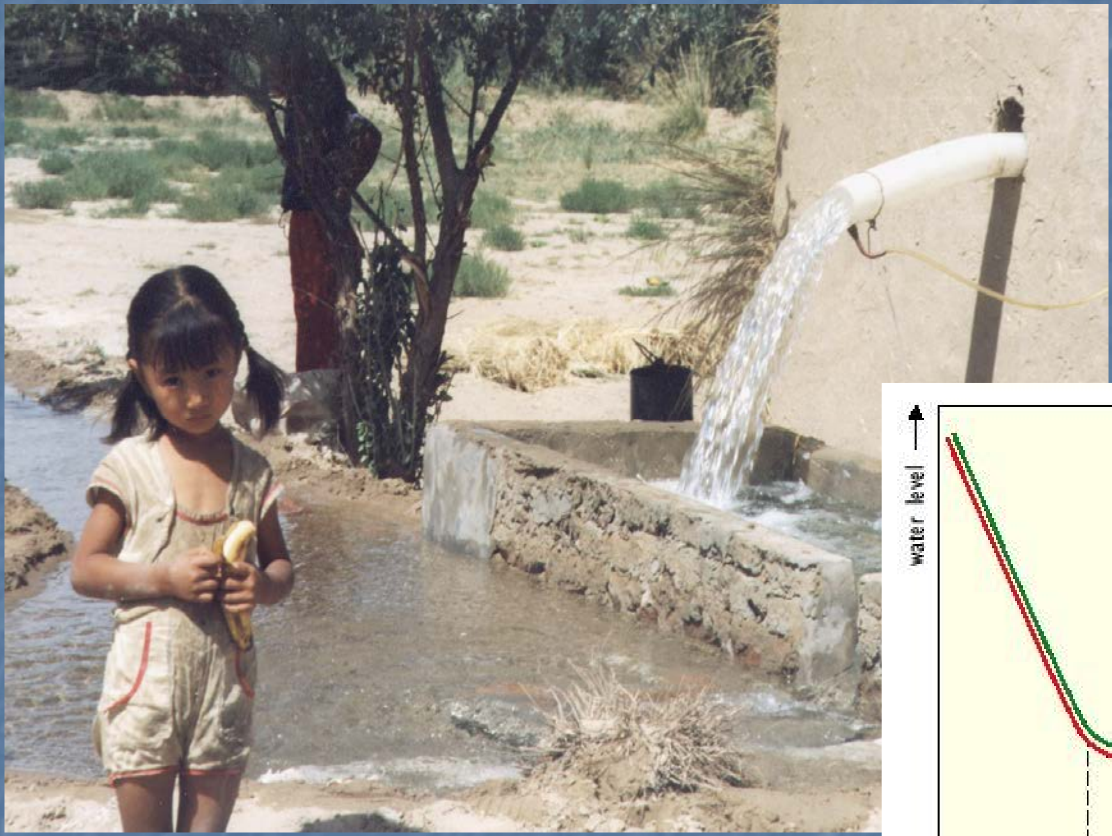
UNIVERSITY OF OXFORD

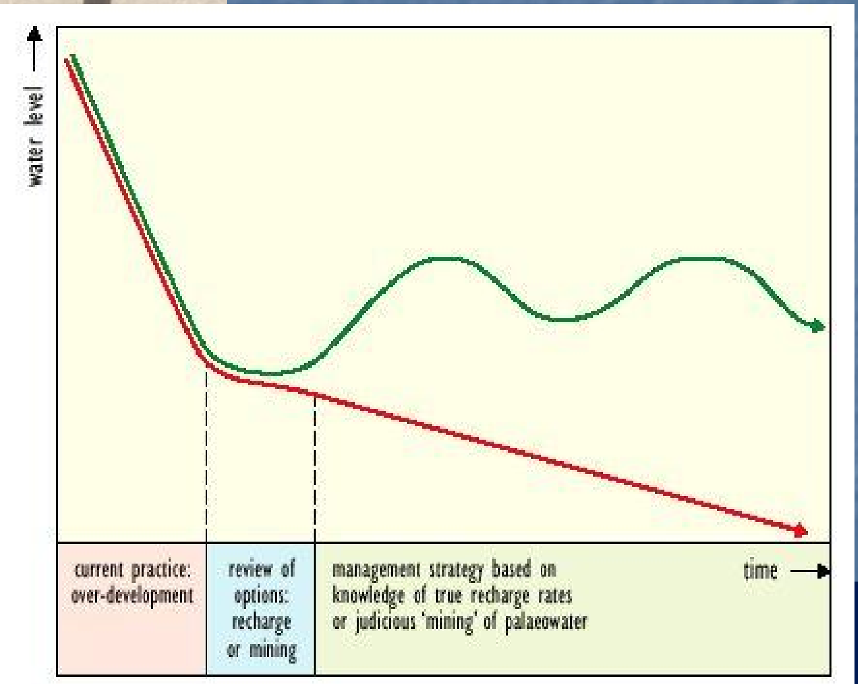
Water Harvesting with community participation as the basis of sustainable and holistic rural development

UNIVERSITY OF OXFORD

Adaptation and the future

Renewable and non-renewable water resources – lessons from China



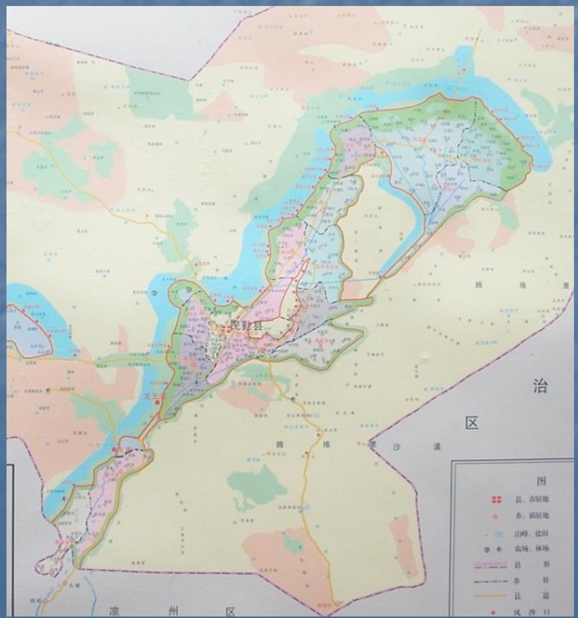


UNIVERSITY OF OXFORD

Minqin Basin - Gobi Desert
Salinisation and relocation

Shut down wells
Reduce farming
Move out of village
Closed for grazing

Signs of recovery 2009



UNIVERSITY OF OXFORD

New and improved approaches to water security in rural semi-arid regions

- Reapply traditional knowledge
- Water harvesting
- Conservation
- Green water use: rain fed agriculture
- Small scale and/or efficient agriculture water use
- Demand rather than supply led solutions
- Managed aquifer recharge

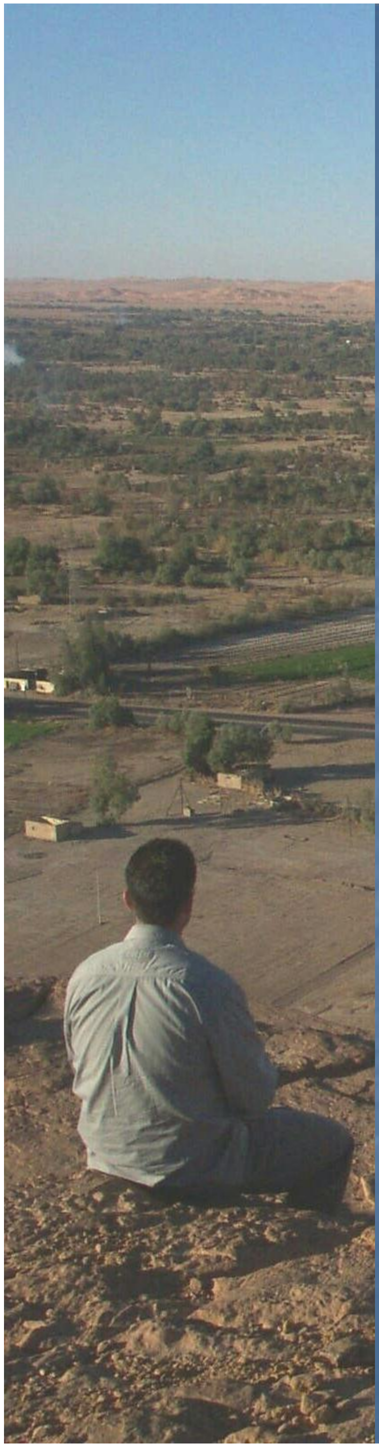
UNIVERSITY OF OXFORD

Holistic development based on water security

efficient and productive uses of domestic water

- Paradigm shift – construct water systems where resources, system capacity and user demand can deliver water beyond basic needs to allow for small-scale productive uses (livestock, gardens, business) for food, health and dignity
- Integration of technical, social and economic aspects of this approach on a water first basis

UNIVERSITY OF OXFORD



Conclusions

- Water scarcity – are we running out of water?
- The importance of groundwater and storage
- Renewable waters and soil water key to sustainable development
- Water, food and ecosystem
- Sustainable rural development – models are being shown to work

UNIVERSITY OF OXFORD