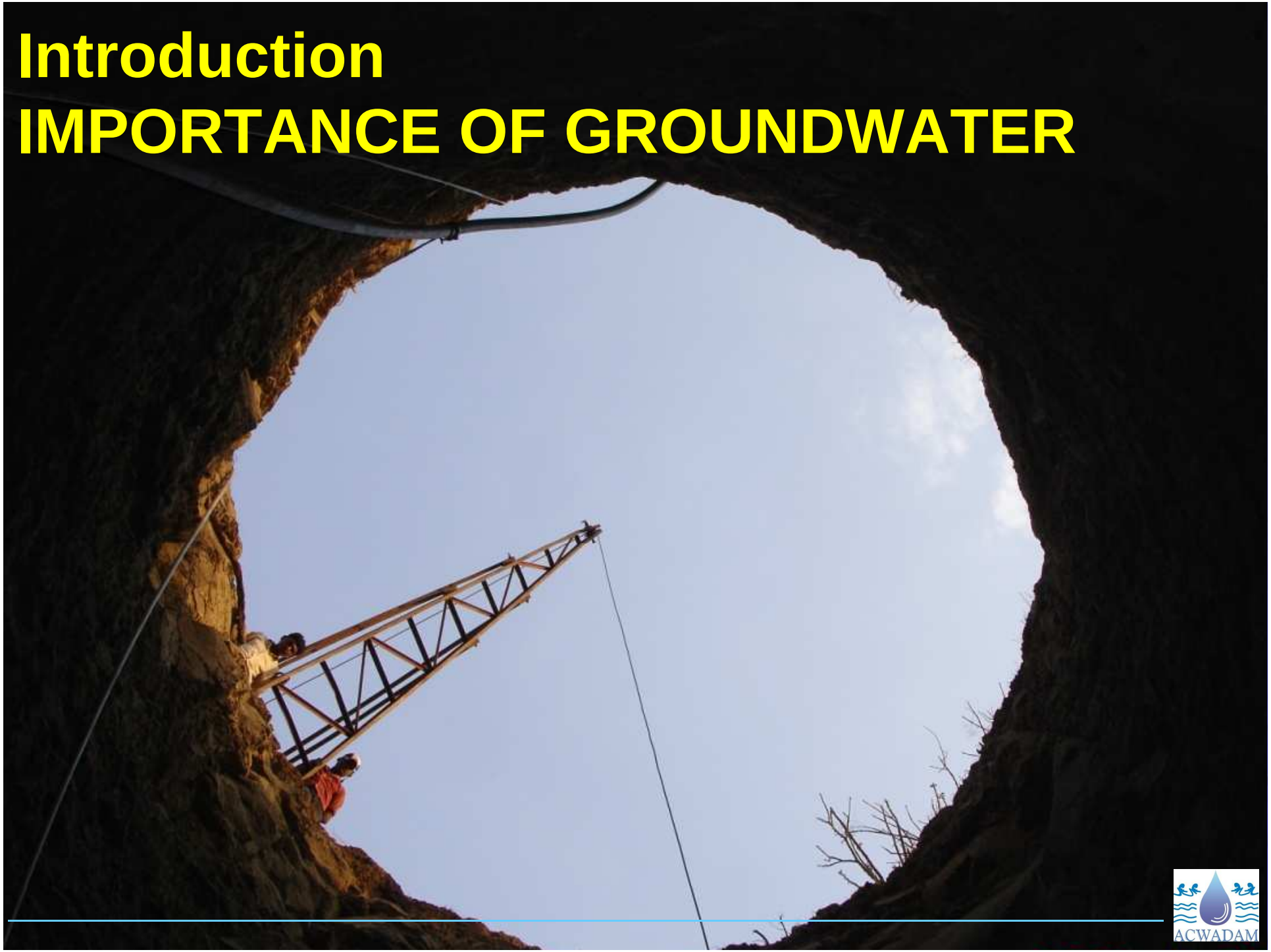
Introduction
IMPORTANCE OF GROUNDWATER



Global Groundwater Situation

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Sources for presentation

- ACWADAM's database
- CGWB, *various publications*
- FAO-database
- Various United Nations publications.
- UN World Water Development Report 2, 2006
- Comprehensive Assessment of Water Management in Agriculture (Earthscan 2007)
- Falling Water Tables, Falling Harvests by Lester R. Brown in http://www.earth-policy.org/Books/Seg/PB3ch04_ss2.htm
- *Personal communication* with various researchers from all over the world.

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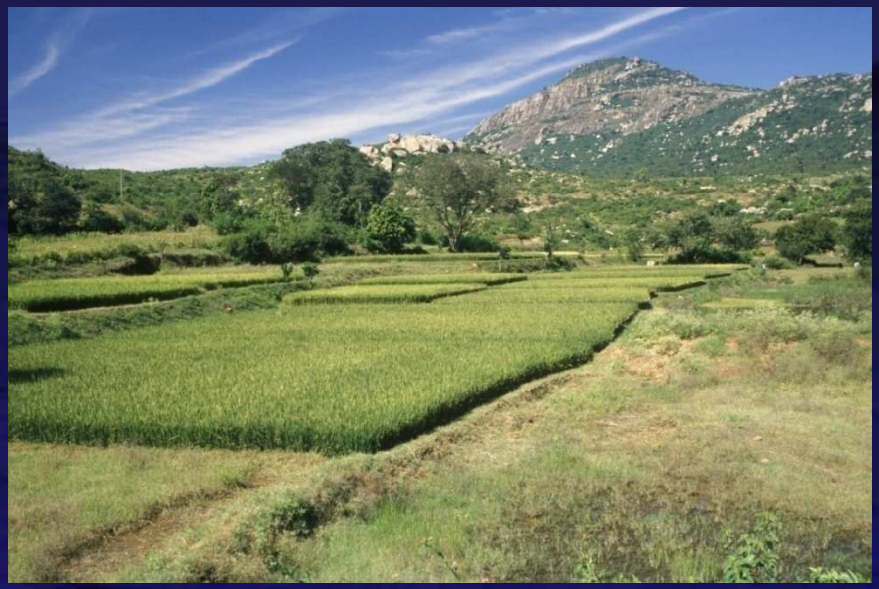
Some glaring global facts

- Countries that contain more than half of the world's people are also dominantly groundwater dependent.



- These countries include the three big *grain producers*- China, India & USA.

- Most of these countries are *overpumping* their groundwater to satisfy their ever-growing water demand.

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Consequences of groundwater overuse – global examples

- CHINA: When the North China Aquifer is depleted, the grain harvest will drop by 40 million tons- *enough to feed 120 million Chinese*.
- INDIA: Some 175 million Indians are fed with grain produced with water from irrigation wells that will soon go dry.
- USA: Wells have gone dry on thousands of farms in the Southern Great Plains, forcing farmers to return to lower-yielding dryland farming.
- SAUDI ARABIA: Saudi government announced (2008) plans to phase out wheat production entirely by 2016.

Uses of groundwater

- Drinking and domestic purposes
- Agriculture
- Livestock
- Industry
- Maintaining the ecological balance

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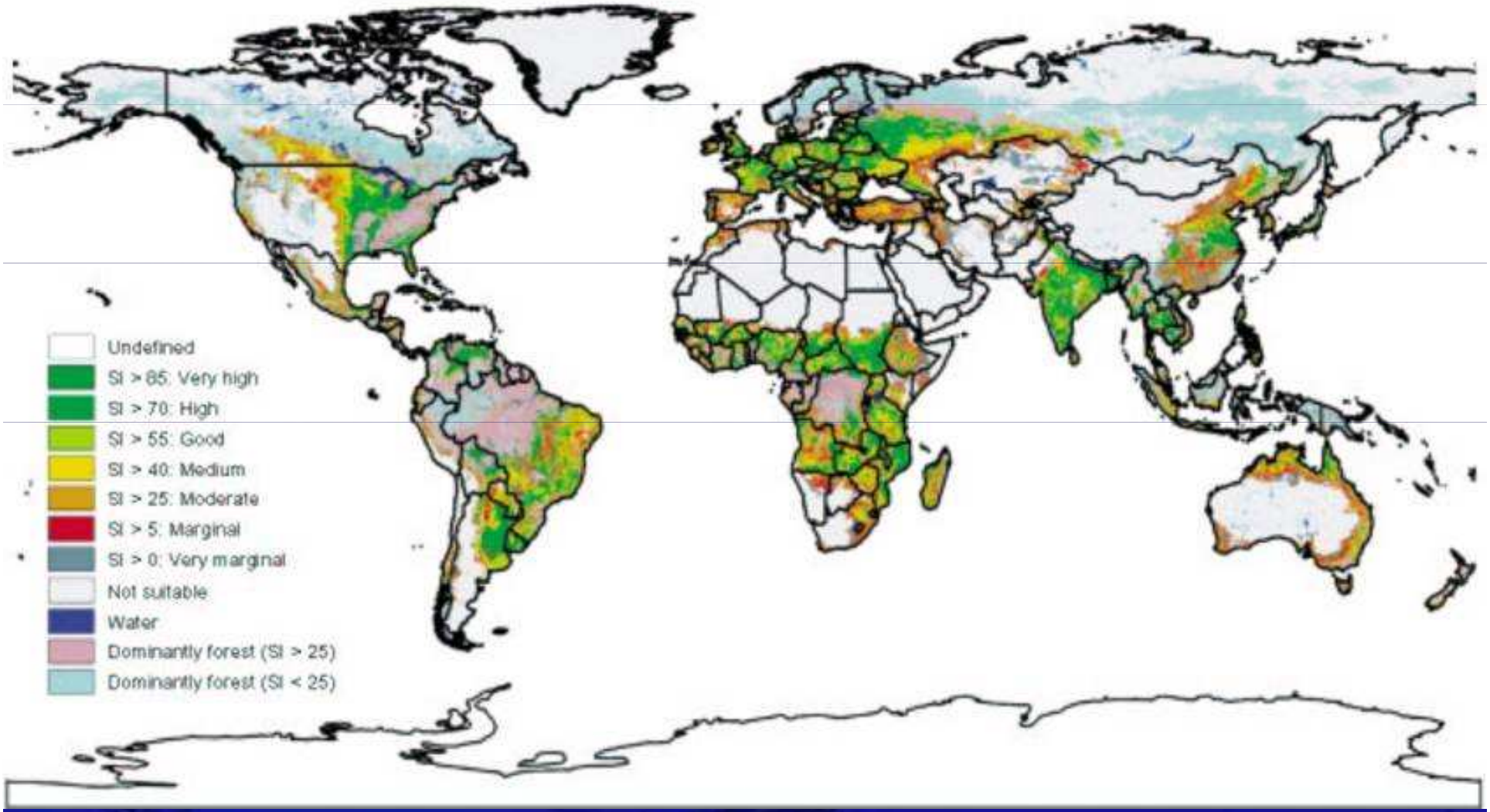
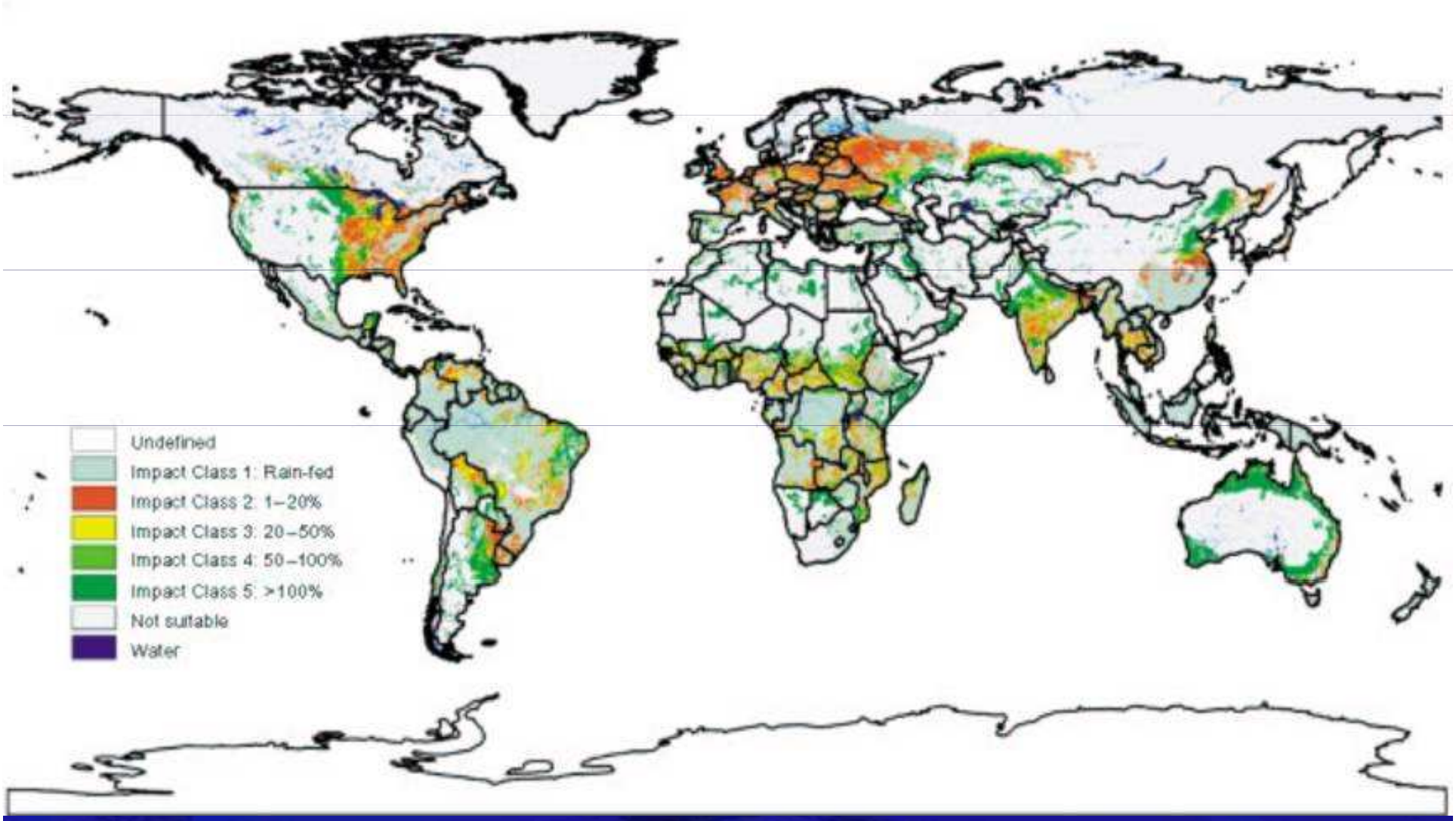
Rainfed agriculture



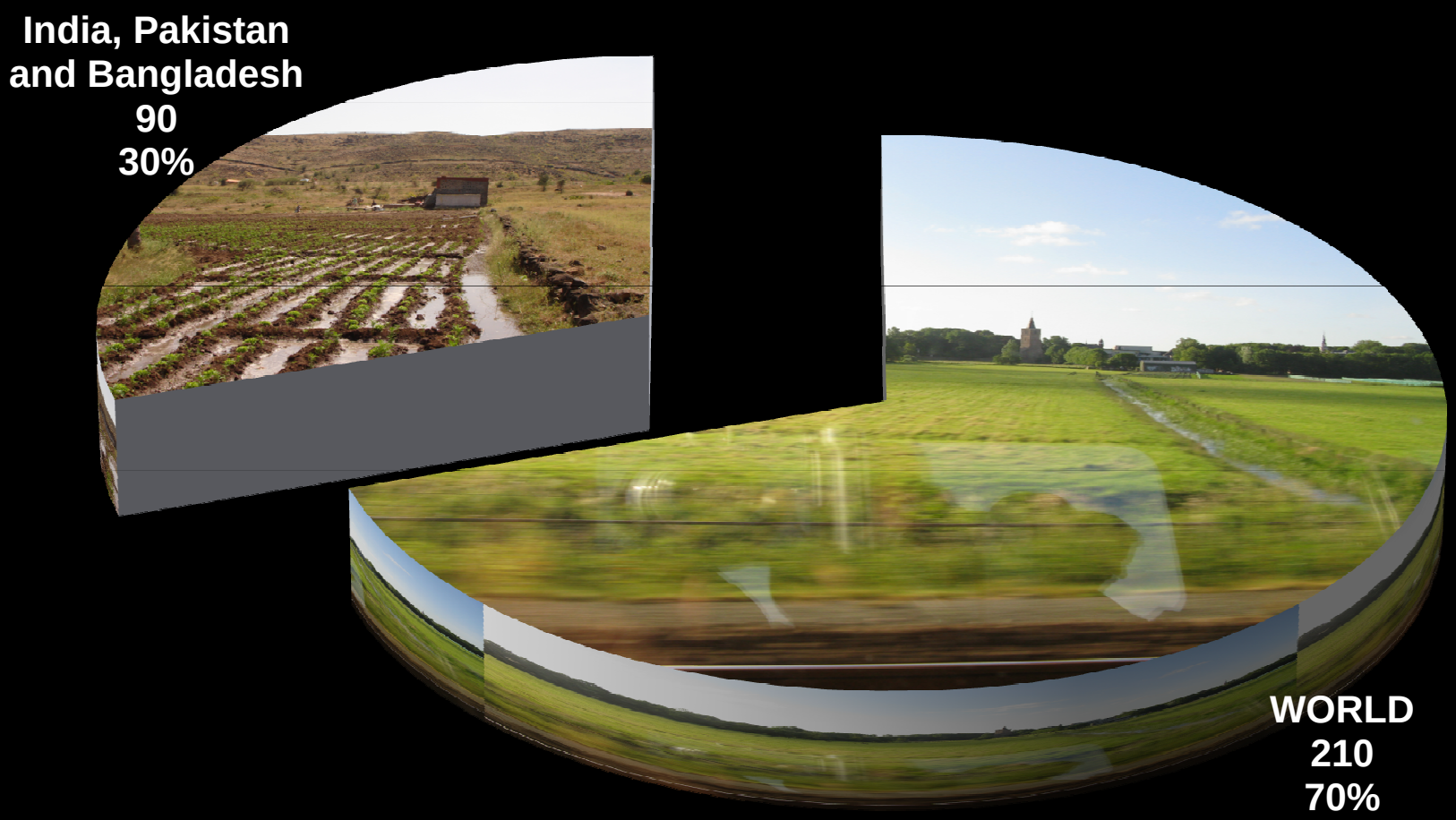
World Rainfed Crop Map: FAO

Irrigated agriculture



World Irrigated Crop Map: FAO

Area under irrigation - 2002



Figures in million hectares and percentages

T. Shah, 2009

Groundwater irrigation: India's unique story

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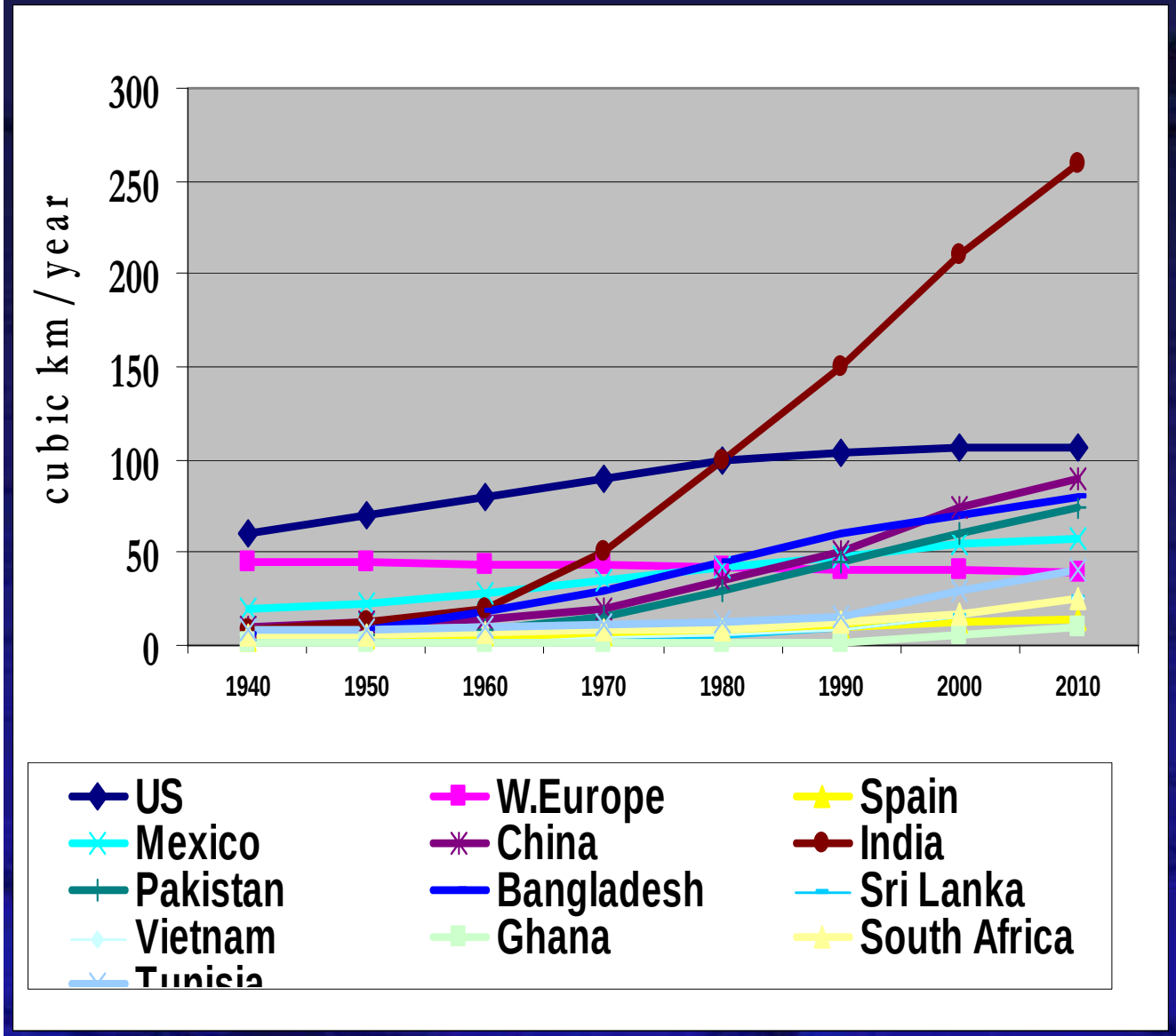
India is the world's largest user of groundwater for agriculture…

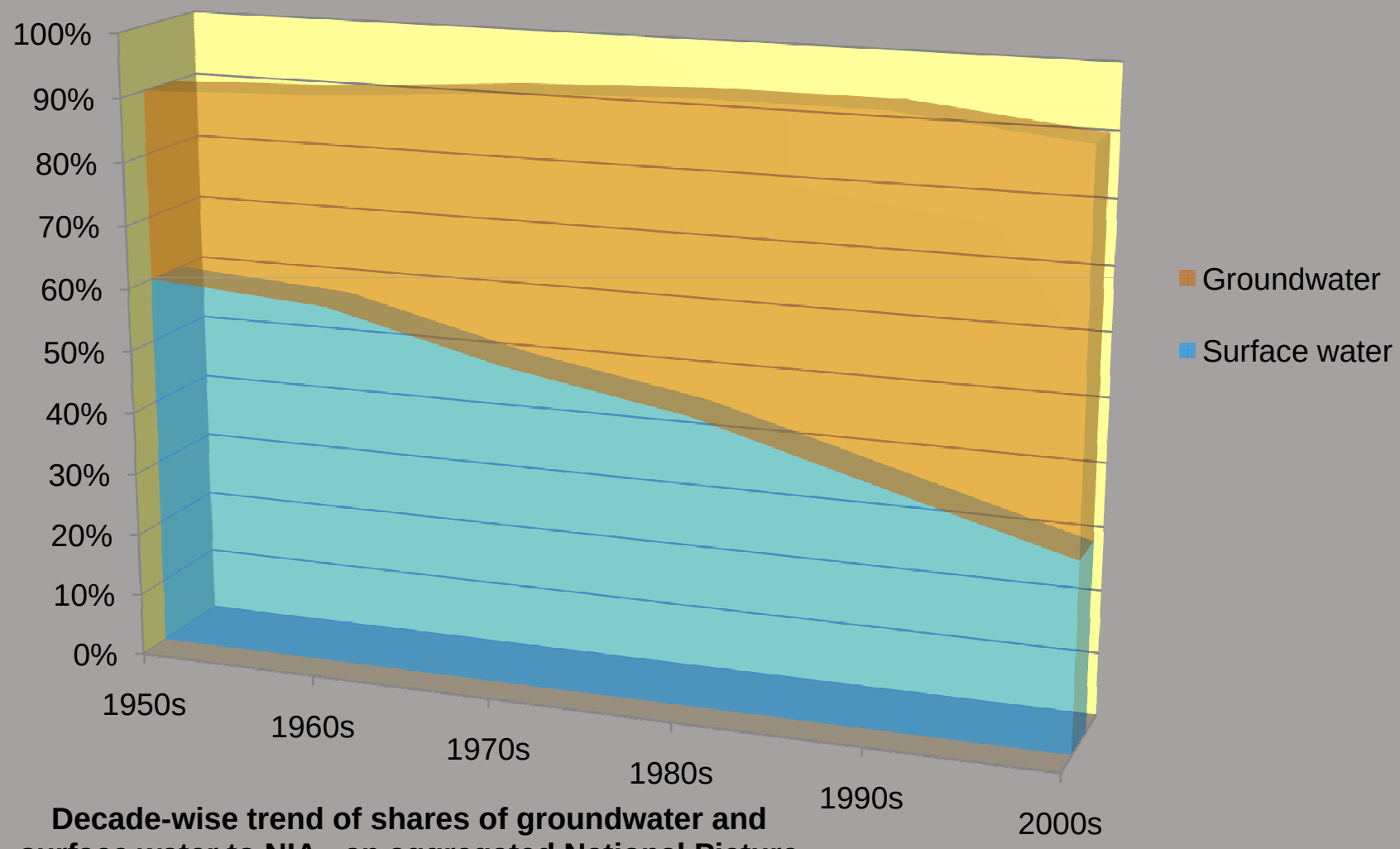


India has over 20 million irrigation wells. We add 0.8 million/year.

Every fourth cultivator owns an irrigation well; non-owners depend on groundwater markets.

T. Shah, 2009

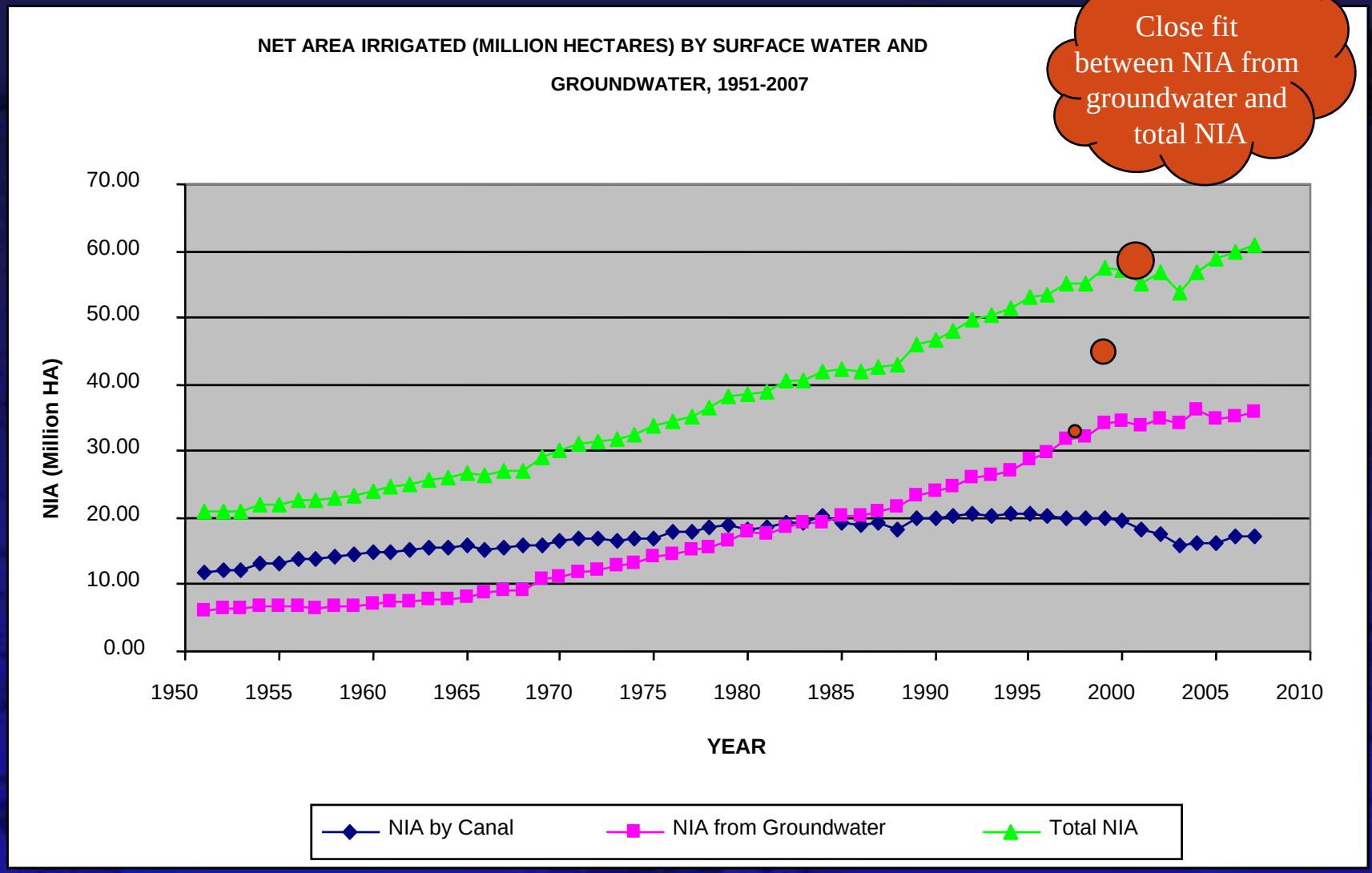
NIA, surface water & groundwater



Decade-wise trend of shares of groundwater and surface water to NIA - an aggregated National Picture

Source: Indian Agricultural Statistics, 2008

Groundwater contribution to 'irrigation'



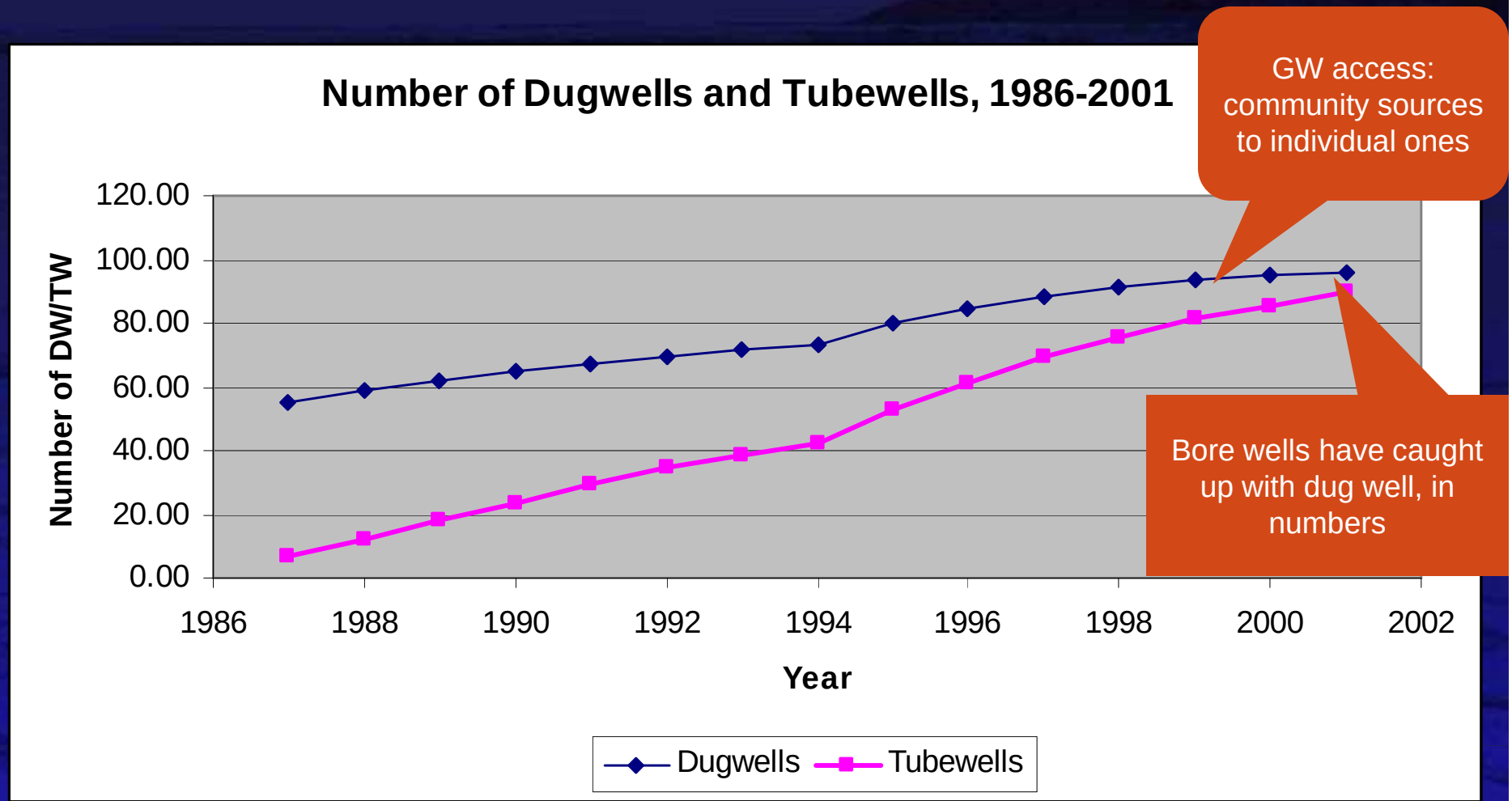
Indian Agricultural Statistics, various years

Status of groundwater use: 1995 *vs* 2004

Level of Groundwater Development	% of Total Districts		% of Total Area		% of Total Population	
	1995	**2004**	**1995**	**2004**	**1995**	**2004**
0-50% (“Safe”)	82	55	89	52	80	45
50-70% (“Safe”)	10	15	7	16	13	20
70-90% (“Semi-Critical”)	**4**	**13**	**2**	**14**	**3**	**17**
90-100% (“Critical”)	**1**	**4**	**1**	**5**	**1**	**3**
>100% (“Overexploited”)	**4**	**14**	**2**	**14**	**3**	**15**
TOTAL	*100*	*100*	*100*	*100*	*100*	*100*

CGWB, 2006

Trends: dug wells *vs* tube wells



Minor Irrigation Census, 2001

India's groundwater economy

Parameters	*Unit*	*Quantity*
Total Groundwater Structures	Million	17.5
Average Output of Groundwater Structures	m^3/hr	30
Average Hours of Operation per Well per Year	Hours	360
Estimated Groundwater Use	km^3	210
Imputed Value of Groundwater Used per year	Rs. (crores)	42000

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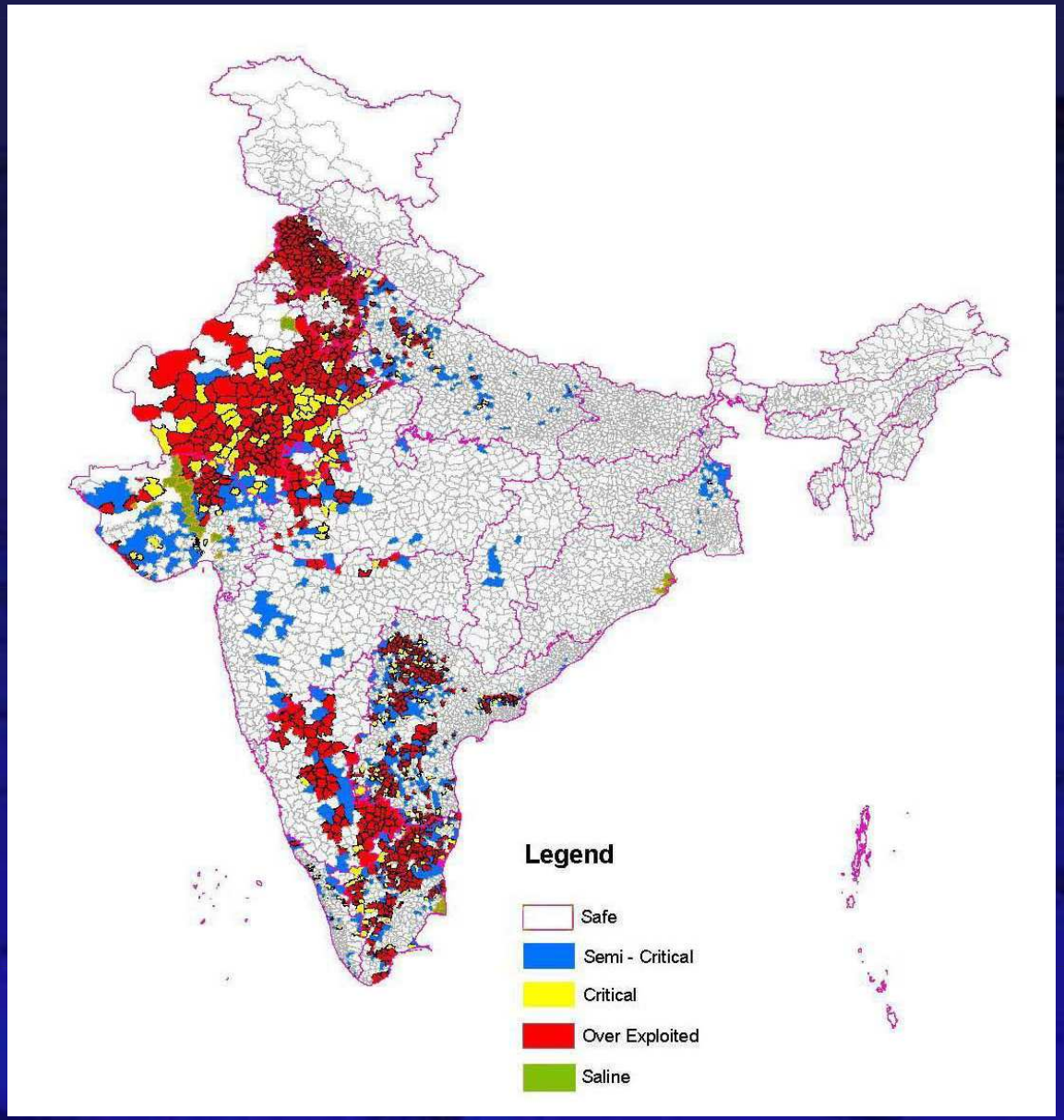
T. Shah, 2009

Talukas/Blocks: stage of GW development



CGWB, 2006

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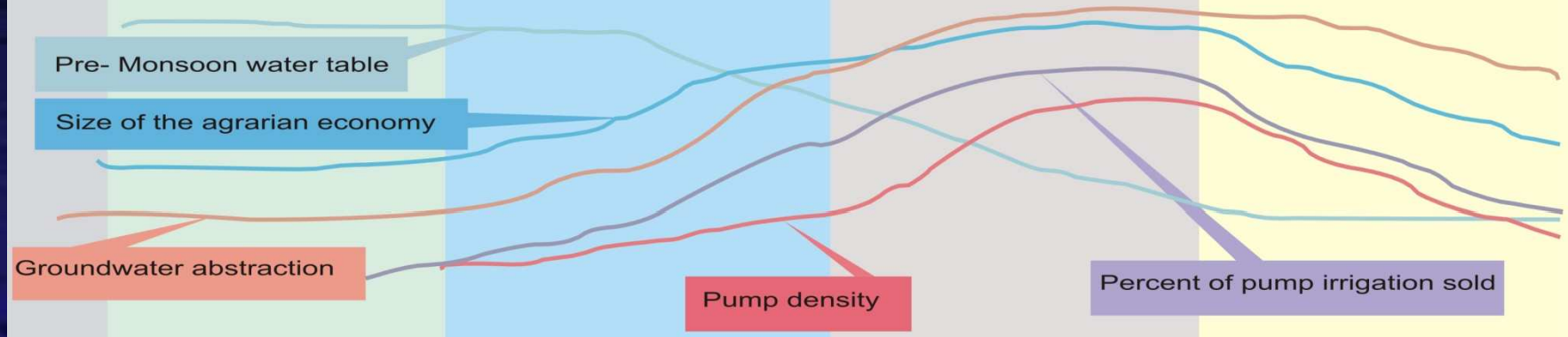
CGWB, 2006

SA groundwater typology: rise and fall of groundwater socio-ecologies (*T. Shah, 2009*)

Stage	Stage 1	Stage 2	Stage 3	Stage 4
Stage	The rise of green revolution and tubewell technologies	Groundwater based Agrarian Boom	Early symptoms groundwater overdraft/ degradation	Decline of the groundwater socio-ecology with immiserizing impacts
Examples	North Bengal and North Bihar, Nepal Terai, Orissa	Eastern Uttar Pradesh, Western Godavari, Central and south Gujarat	Haryana, Punjab, Western Uttar Pradesh, Centra Tamilnadu	North Gujarat, Coastal Tamilnadu, Coastal Saurashtra, Southern Rajasthan
Characteristics	Subsistence agriculture; protective irrigation traditional crops; concentrated rural poverty; traditional watering devices using human and animal power	Skewed ownership of tubewells; access to pumping irrigation prized; rise of primitive pumping irrigation 'exchange' institutions. Decline of traditional technologies; rapid growth in agrarian income and employment	Crop diversification; permanent decline in water tables. The groundwater based 'bubble economy' continues booming; tensions between economy and ecology surface as pumping costs soar and water markets become oppressive; private and social costs of groundwater use part ways	The "bubble" bursts; agricultural growth declines; pauperization of the poor is accompanied by depopulation of entire clusters; water quality problems assume serious proportions; the "smart" begin moving out long before the crisis deepens; the poor get hit the hardest.
Interventions	Targeted subsidy on pump capital; public tubewell programmes; electricity subsidies and flat tariff	Subsidies continue. Institutional credit for wells and pumps. Donors augment resources for pump capital; NGOs promote small farmer irrigation as a livelihood programme	Subsidies, credit, donor and NGO-support continue apace; licensing, siting norms and zoning system are created but are weakly enforced. Groundwater irrigators emerge as a huge, powerful vote bank that political leaders cannot ignore.	Subsidies, credit and donor support reluctantly go; NGOs, donors assume conservationist posture zoning restrictions begin to get enforced with frequent pre-election relaxations; water imports begin for domestic needs; variety of public and NGO sponsored ameliorative action starts



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Lessons from the past?

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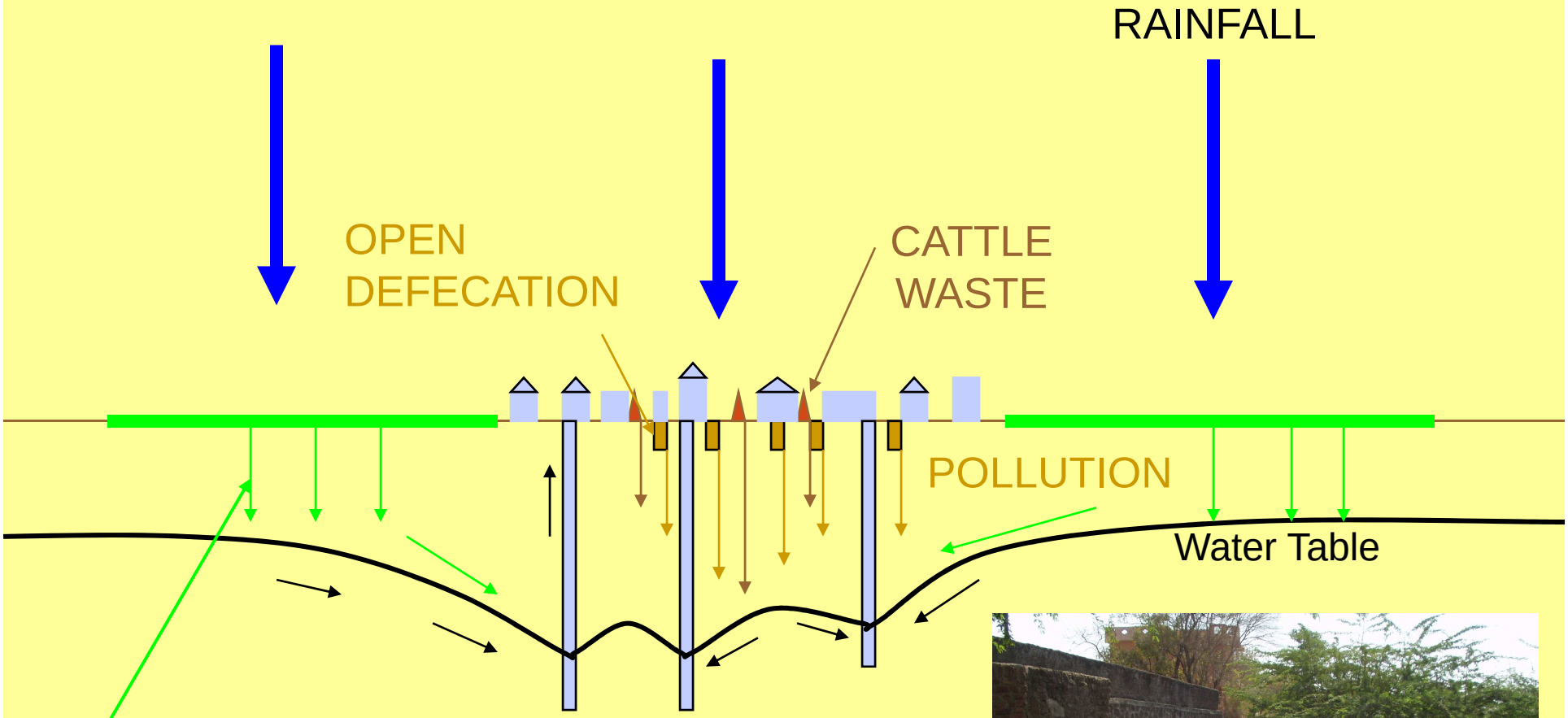
Groundwater vulnerability

Description	Number of Districts	% to Total Districts	States where these Districts are Located
Districts with High Level of Groundwater Development (GD>70%) ("Unsafe" districts)	173	30%	Punjab, Haryana, Rajasthan, UP, Gujarat, Tamil Nadu
Districts with at least one of the 3 most serious quality problems (Arsenic or Fluoride or Salinity)	169	29%	Assam, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, West Bengal
TOTAL	**342**	**59%**	

Kulkarni, Shankar & Krishnan, 2009

…the importance of geology

Potential Groundwater Pollution



Hydrogeology is most important in watershed management projects

- Harvesting
- Conservation
- Recharge

Is this a percolation tank or an irrigation dam?

Where to do what???

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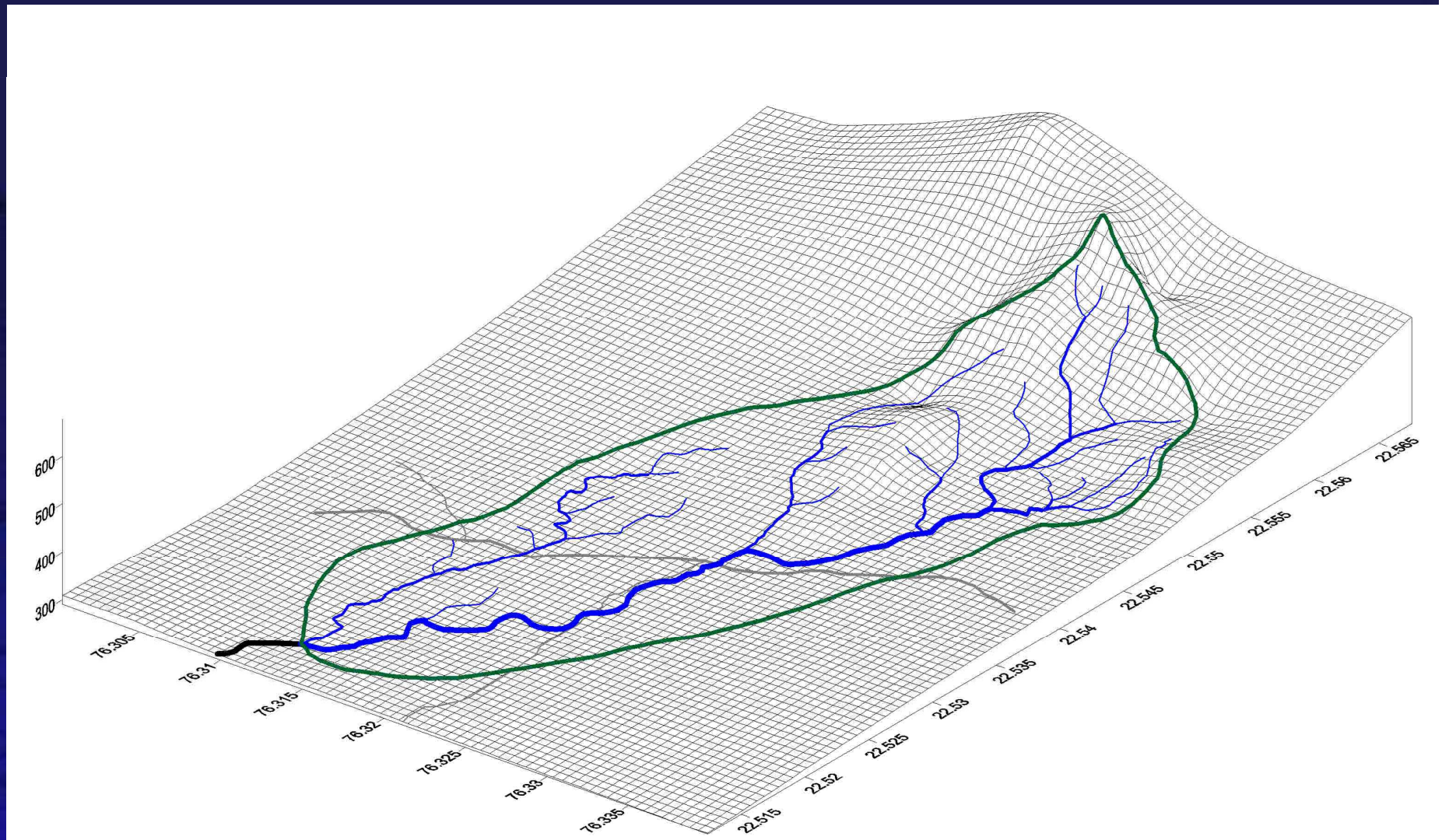

…a watershed…

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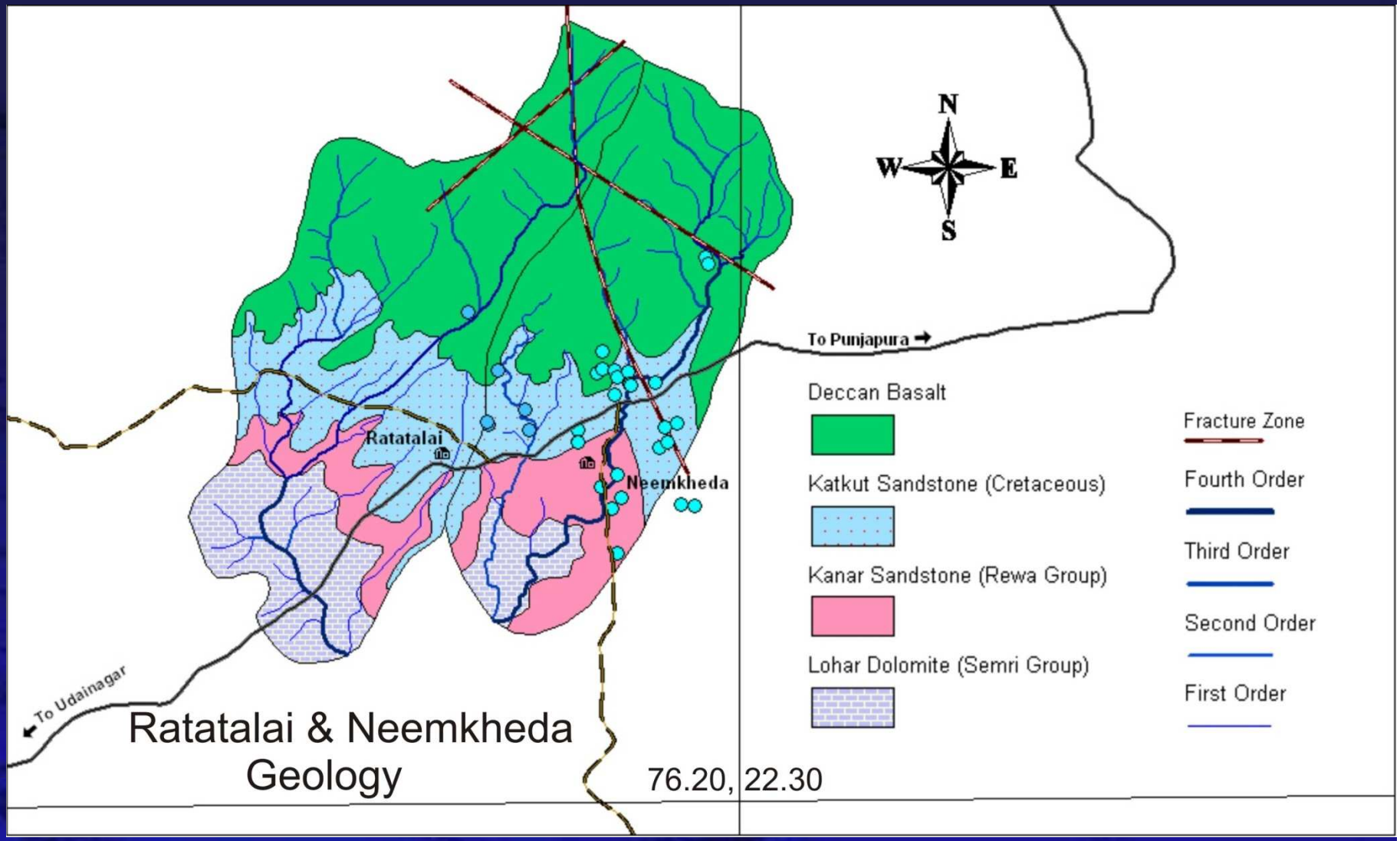
…geology…



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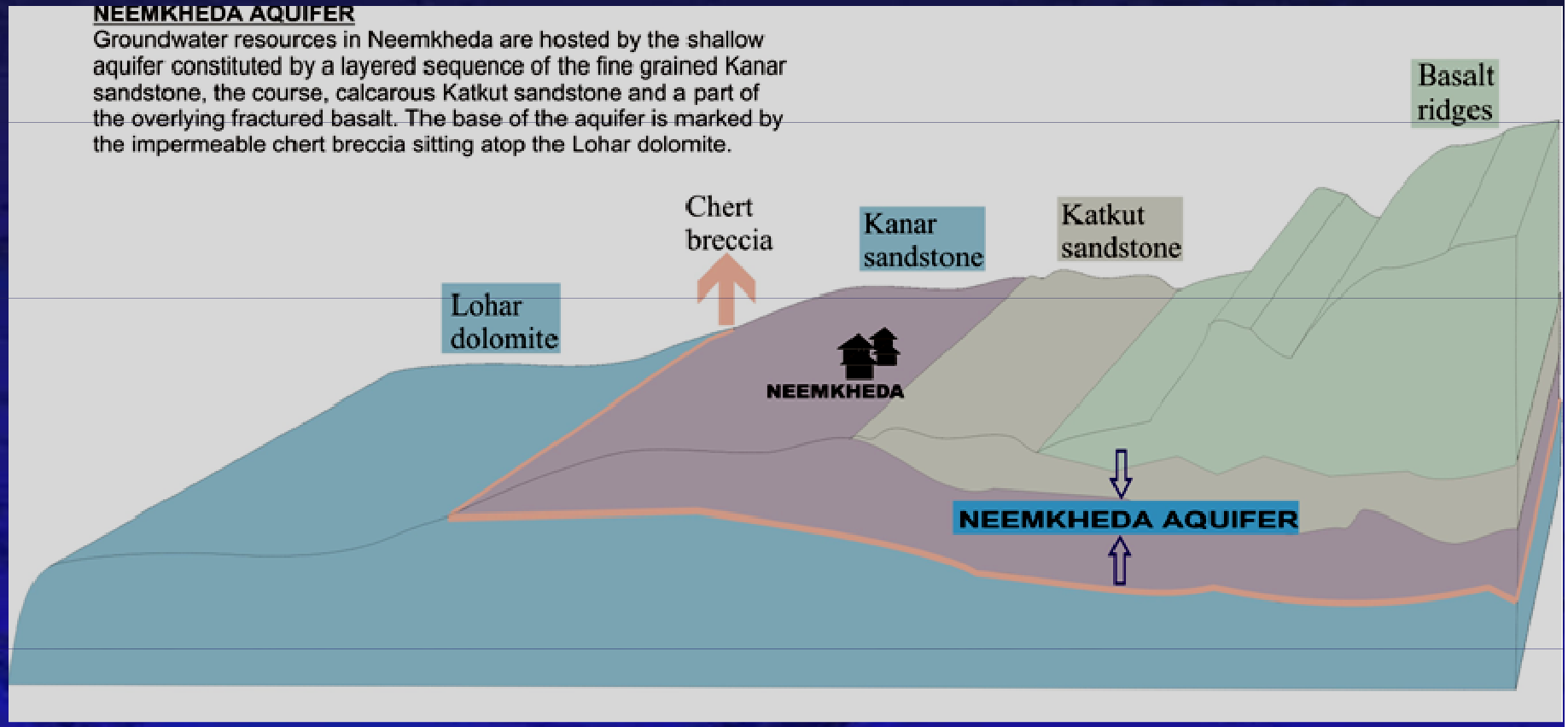
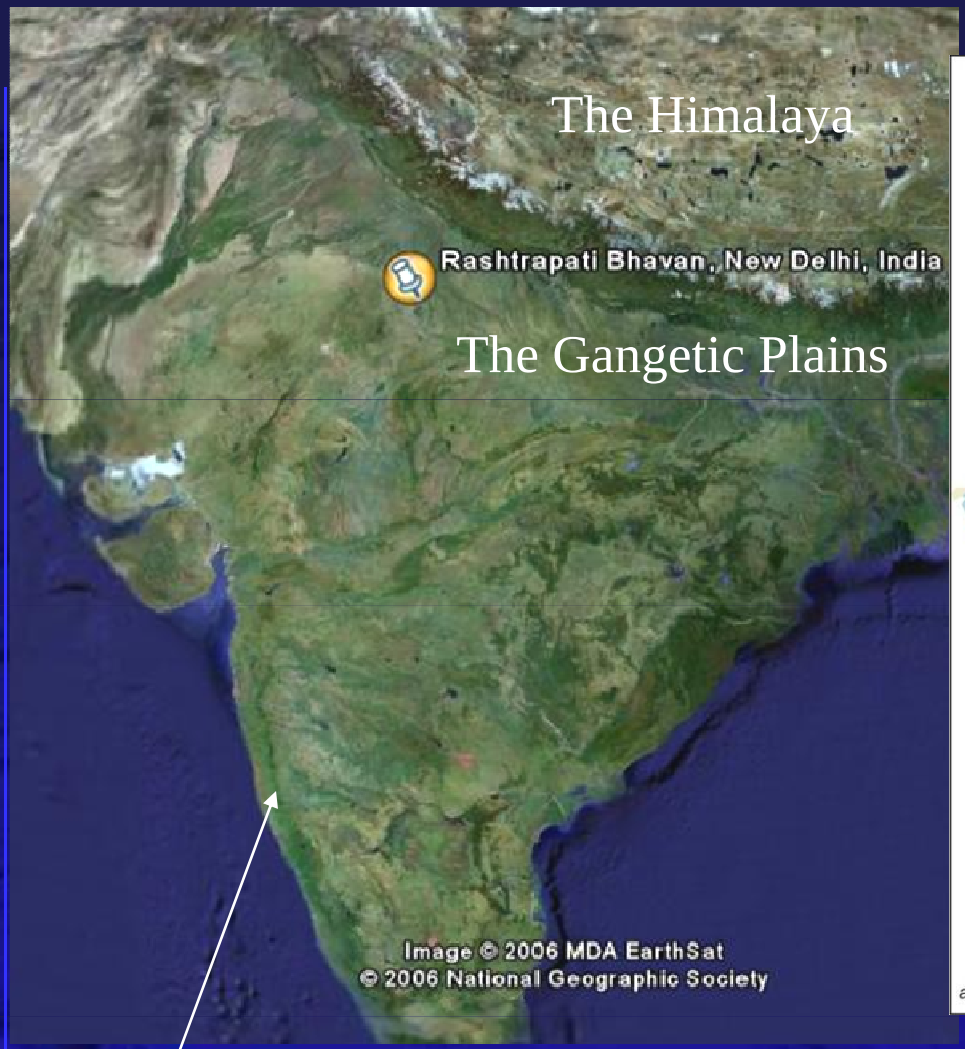
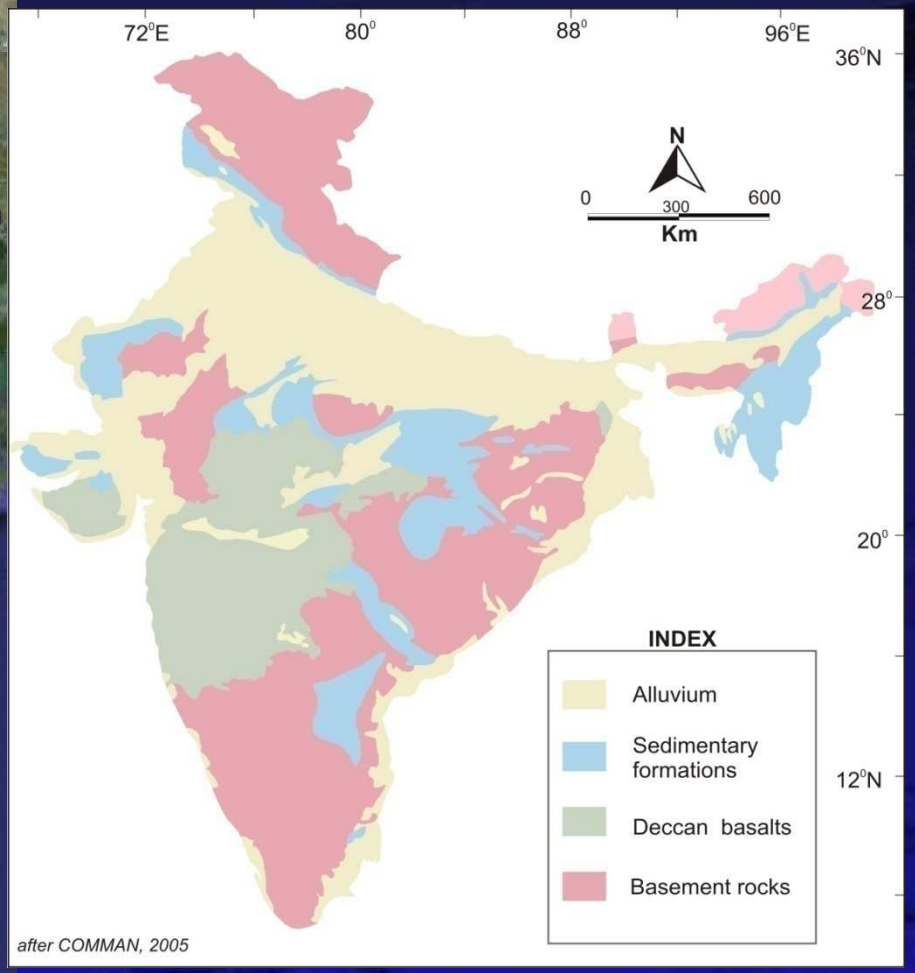
…aquifer(s)…


NEEMKHEDA AQUIFER
Groundwater resources in Neemkheda are hosted by the shallow aquifer constituted by a layered sequence of the fine grained Kanar sandstone, the course, calcarous Katkut sandstone and a part of the overlying fractured basalt. The base of the aquifer is marked by the impermeable chert breccia sitting atop the Lohar dolomite.
Basalt ridges
Chert breccia
Kanar sandstone
Katkut sandstone
Lohar dolomite
NEEMKHEDA
NEEMKHEDA AQUIFER

Understanding groundwater…

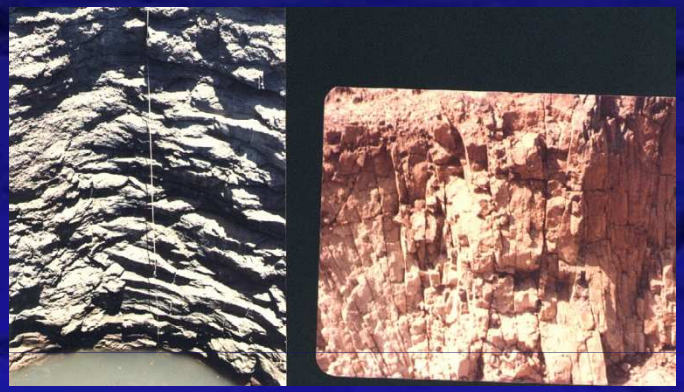
Hydrogeological diversity in India





The Western Ghats

GEOLOGY plays a very important role in the formation of aquifers, and consequently, on the accumulation and movement of groundwater..



Geological conditions tend to vary, both laterally and vertically…

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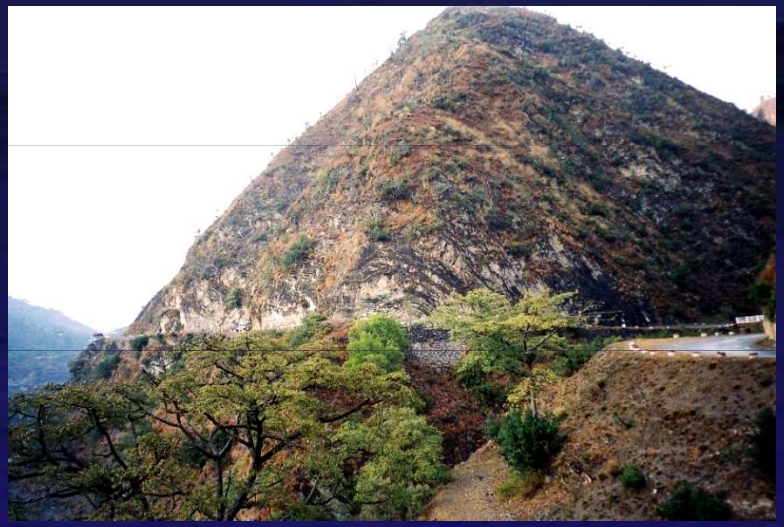
Therefore, the need to *understand* groundwater…

Hydrological processes…

Watershed geology: a clearer perception of groundwater in the watershed

- Geology: rock types, their interrelationship and structures in the rocks.
- First step in understanding groundwater resources in the watershed.
- A useful tool for planning watershed development structures.
- Hydrogeology: going from geology to understanding groundwater



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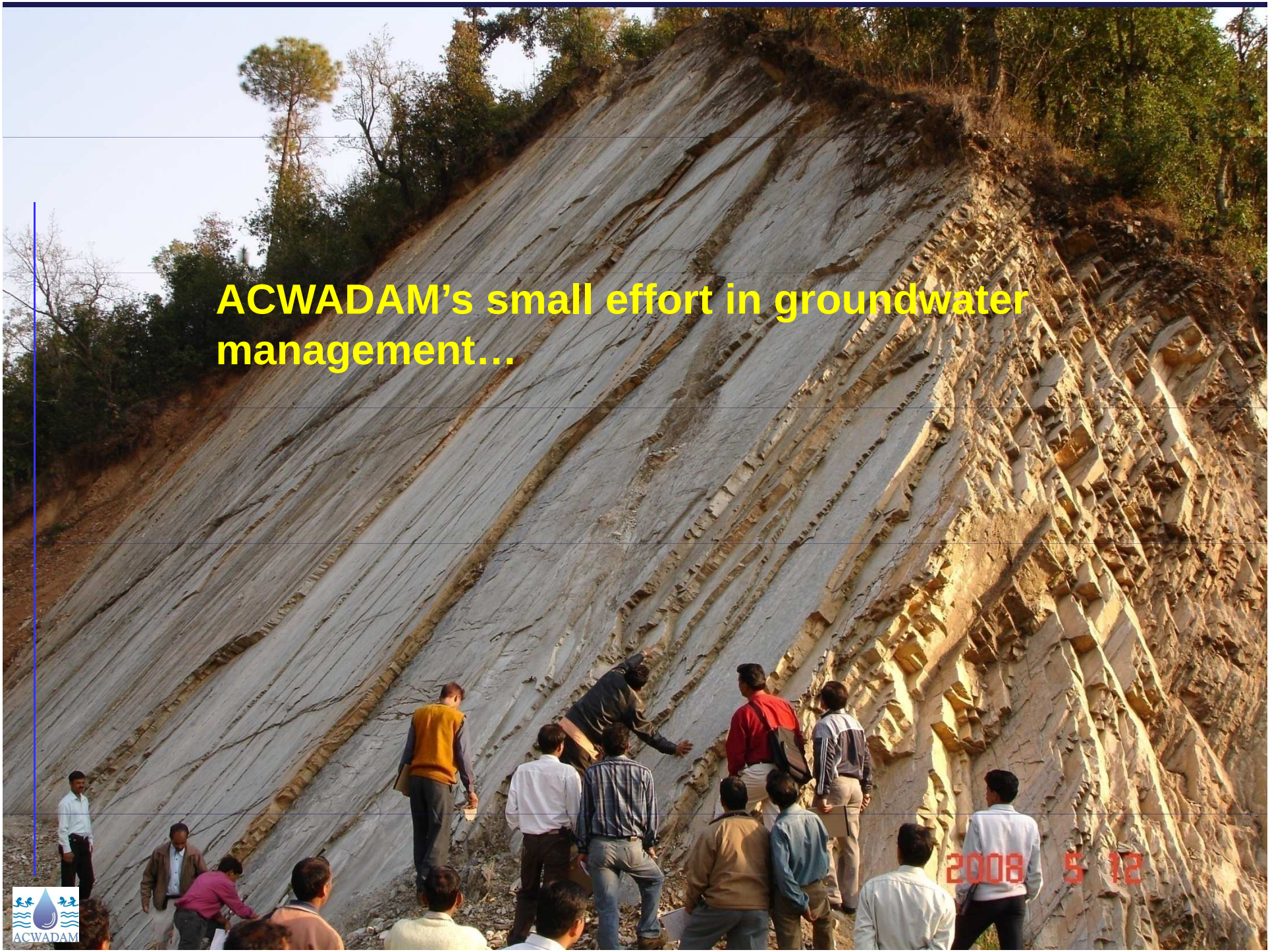

ACWADAM's small effort in groundwater management…
2008 5 12

ACWADAM's goal

To help achieve scientifically based, sustainable management of water resources, especially groundwater, in different settings –

- *Geographically diverse locations.*
- *Rural & urban*
- *Domestic, agricultural & industrial*

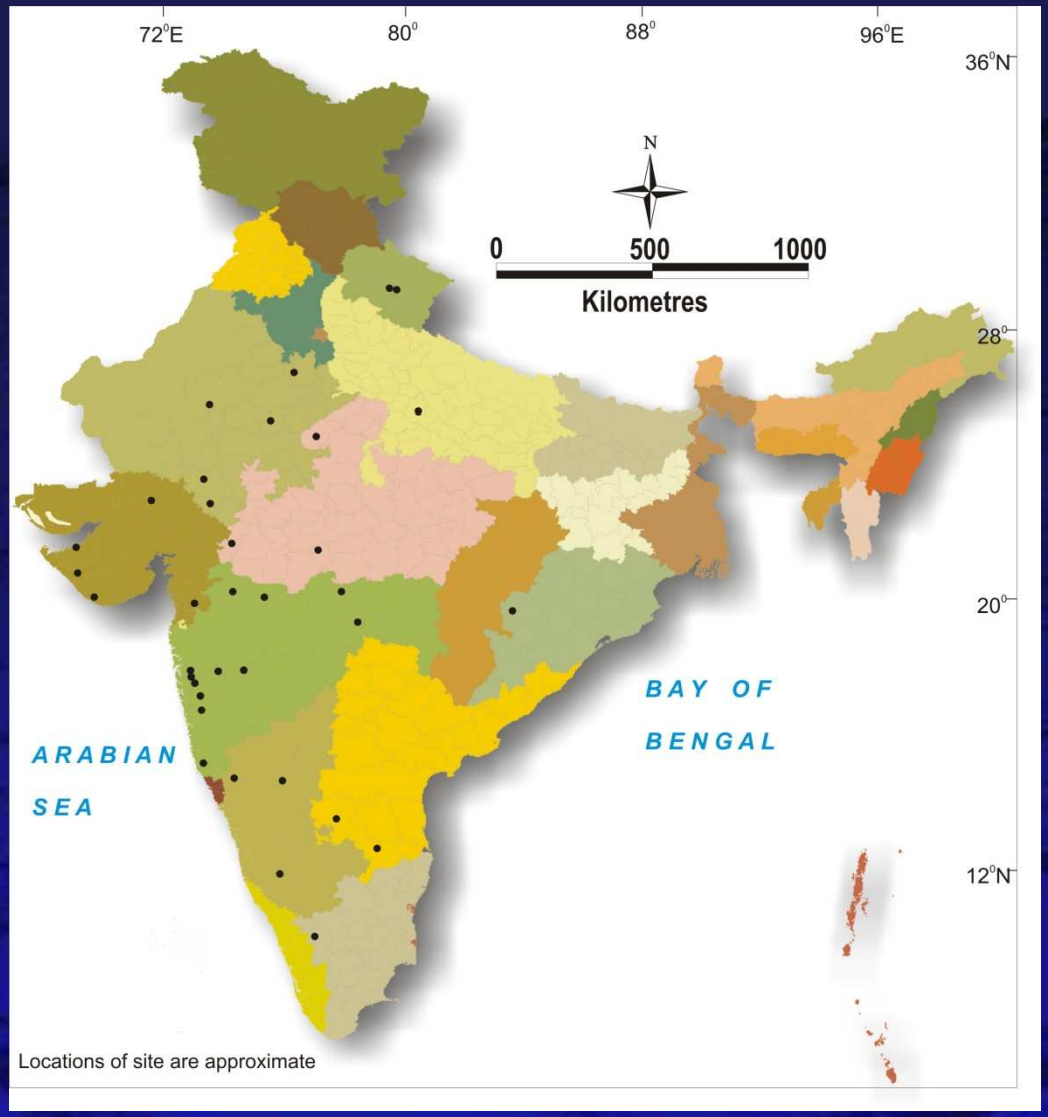
Our approach

- Action research
- Education and training
- Customisation

Partnerships and collaborations based on mutual strengths

e.g. ACWADAM's scientific capabilities often combined with social skills or engineering capacities of partner organisations..

Locations of our interventions



- Began with sites in Maharashtra
- Currently, working with different partners in other parts of India
- Spreading our work to newer areas

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Our small effort at fighting groundwater problems

- Research: To new levels, with possible experimentation of groundwater management models.
- Training: Widening and deepening of “training” inputs.
- Dissemination of research and education in groundwater to wider audiences.

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