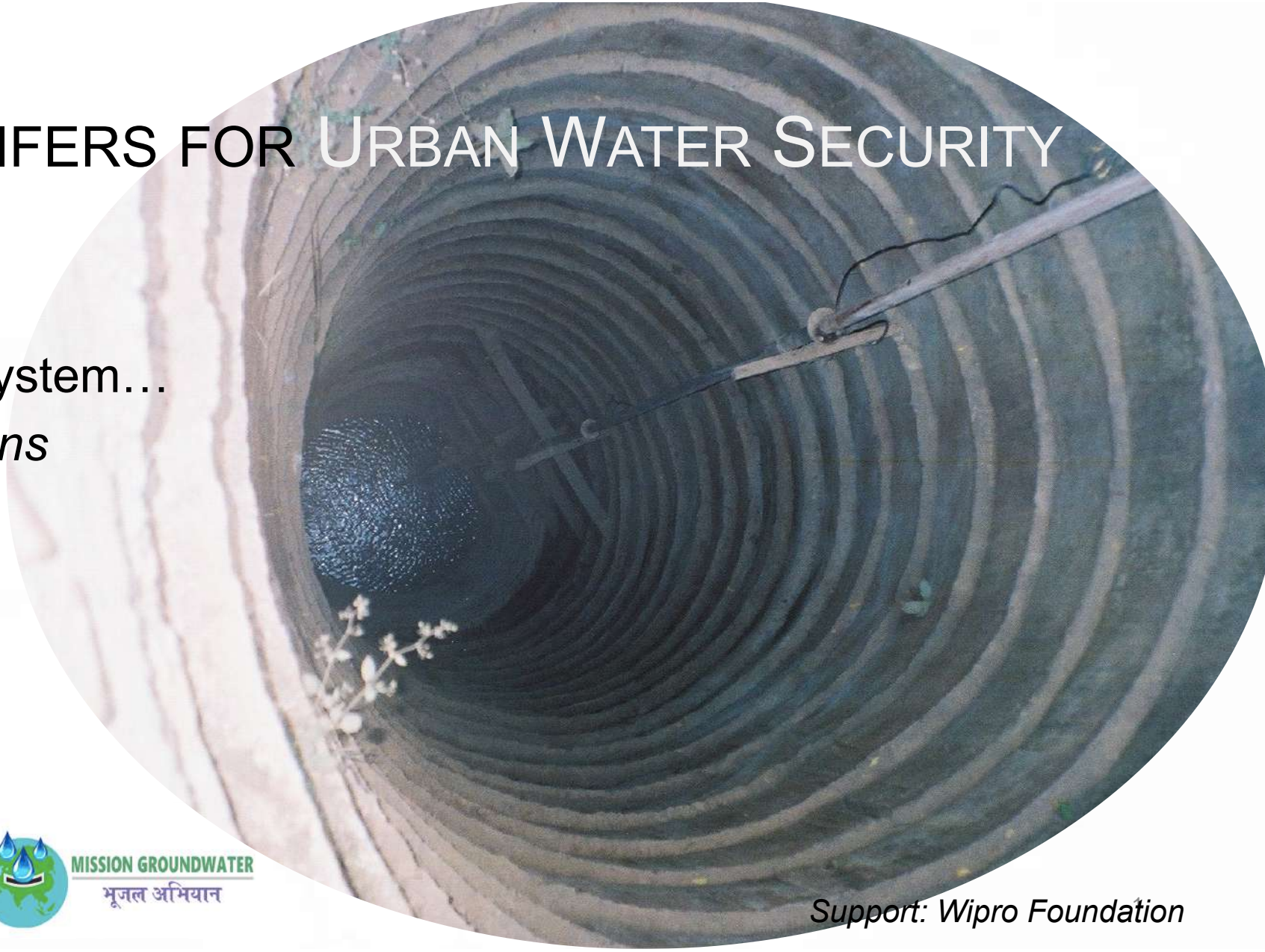
URBAN AQUIFERS FOR URBAN WATER SECURITY



Pune's Aquifer System…

some early lessons

ACWADAM

CEE
Centre for Environment Education

MISSION GROUNDWATER
भूजल अभियान

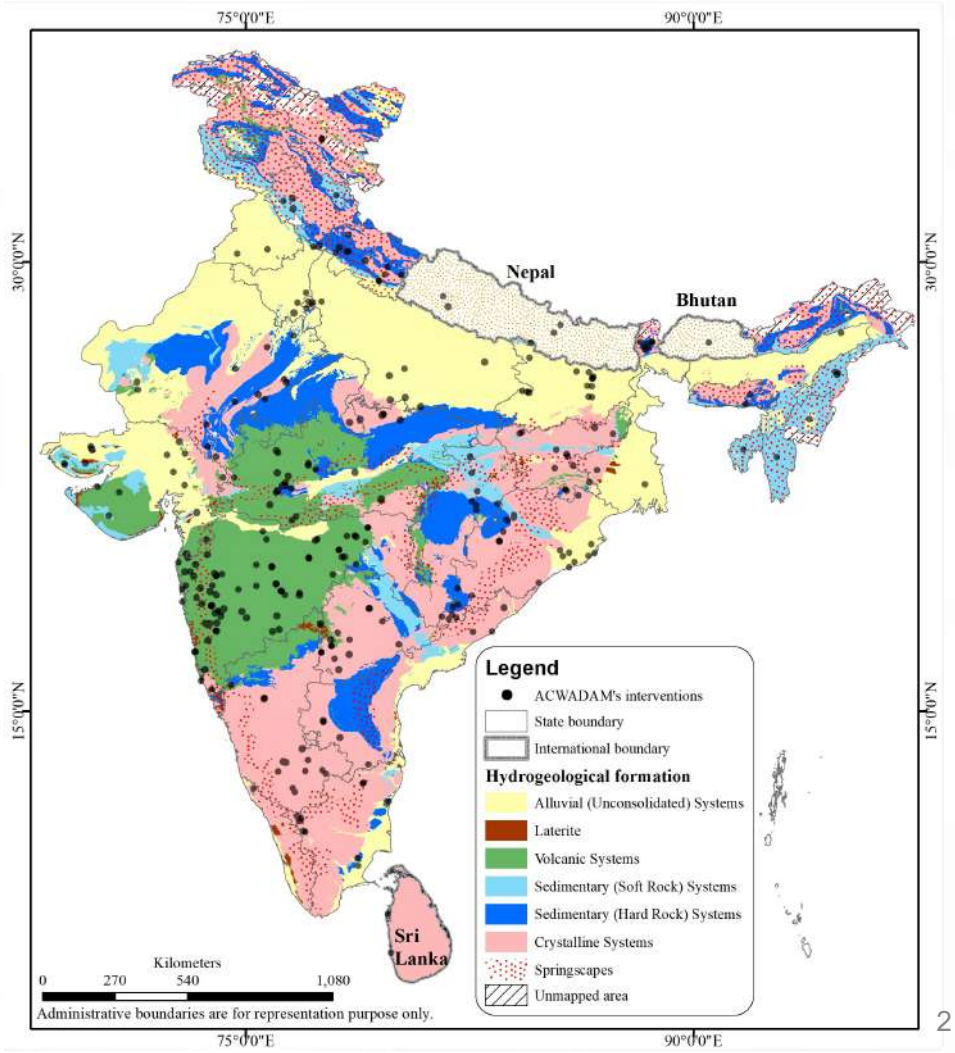
Support: Wipro Foundation

ACWADAM's work: ..in the most hydrogeologically diverse setting in the world – based on partnership and collaboration

We are a think-tank and action-research based organisation working on the science of groundwater and its applications to societal development. We work on the practice and policy of aquifer-based, participatory groundwater management…

- Aquifer-based groundwater management
- Training
- Action research and decision support
- Policy and programmes

Bringing aquifers closer to communities…



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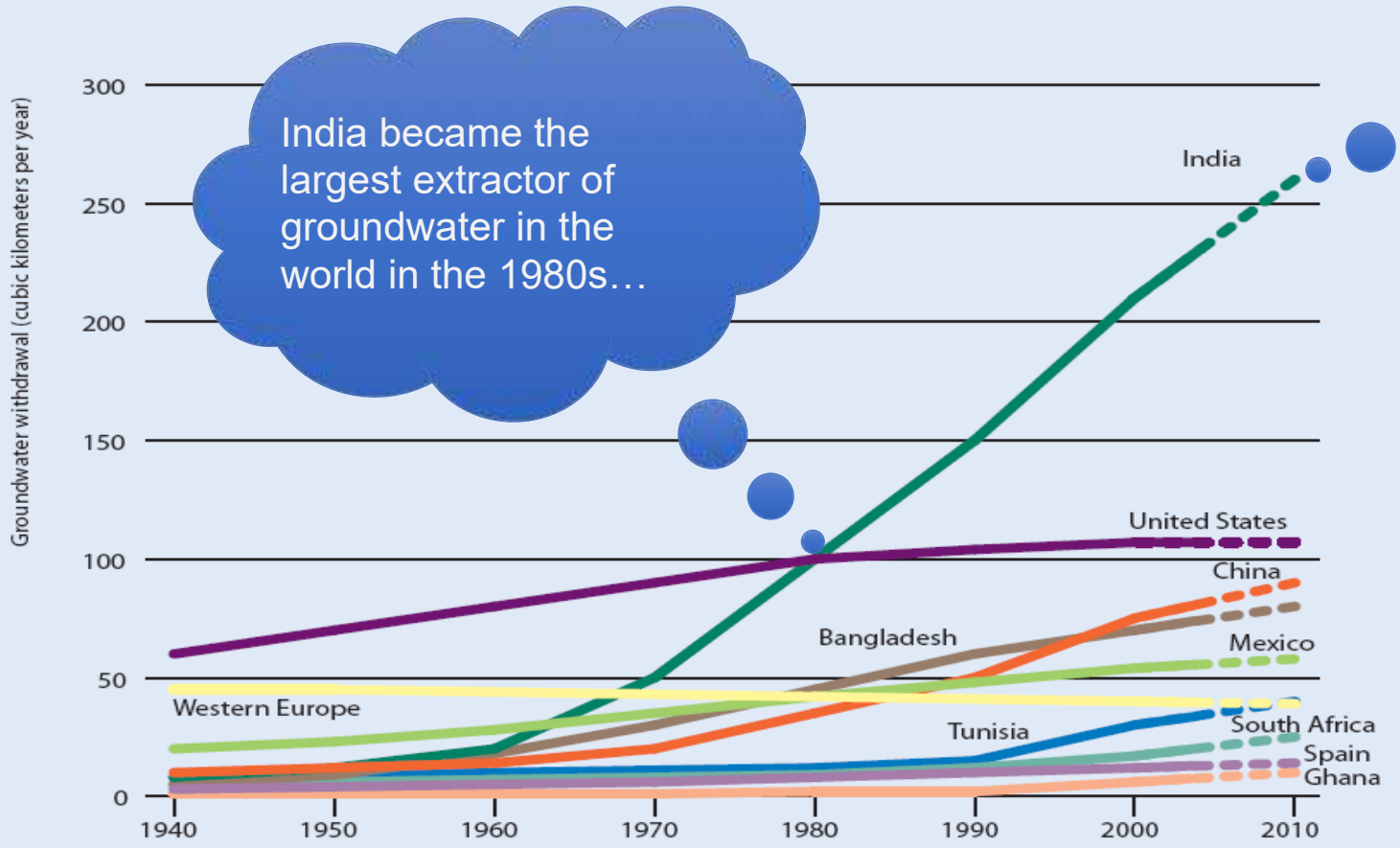
Groundwater use in agriculture: global trends

Development in groundwater withdrawal in selected countries



India became the largest extractor of groundwater in the world in the 1980s…

India's groundwater abstraction has now reached 25% of the global annual total

Source: Shah 2005.

Credit: Comprehensive Assessment of Water Management in Agriculture
Publisher: Earthscan www.earthscan.co.uk

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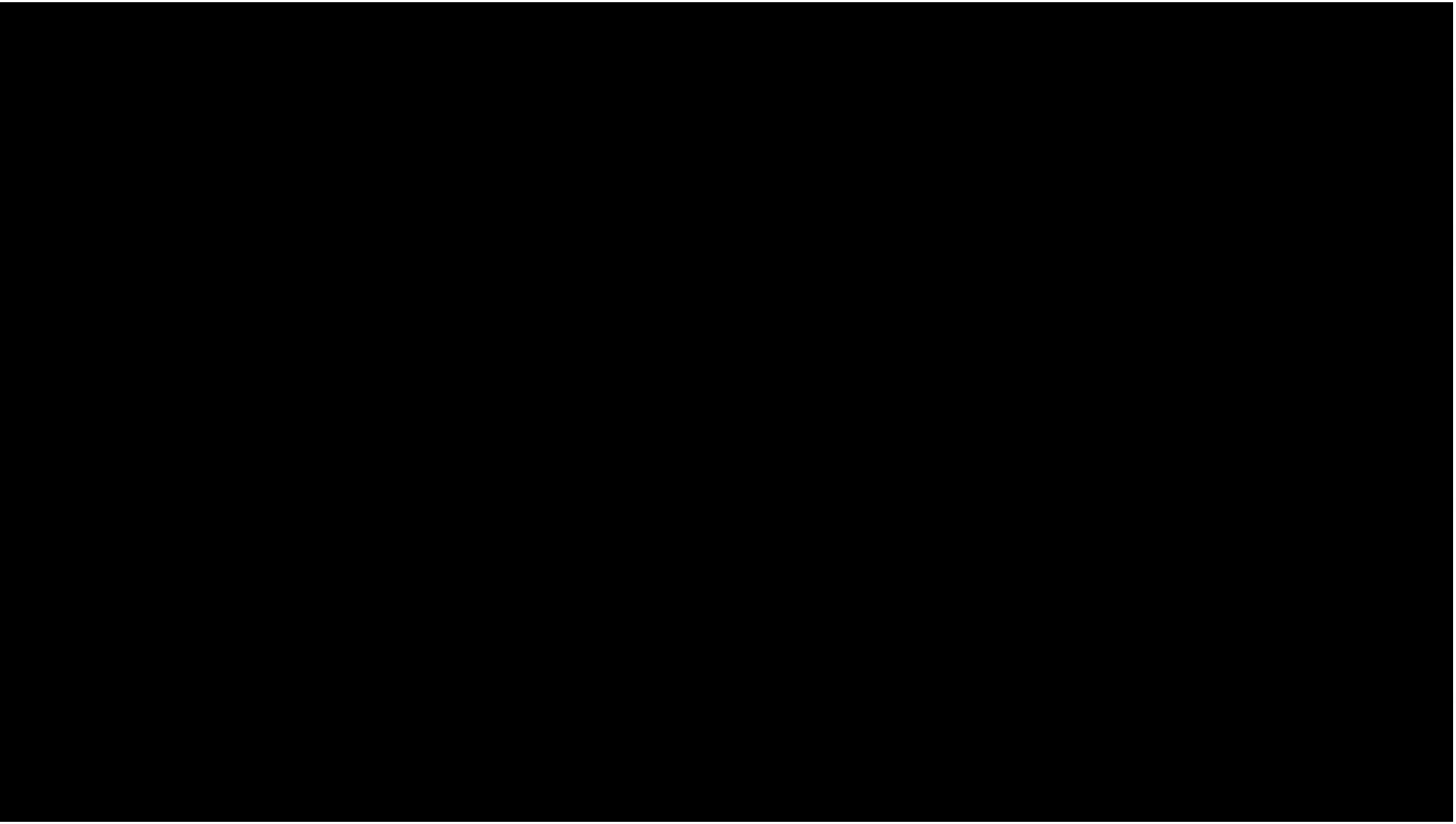
India’s unique groundwater story



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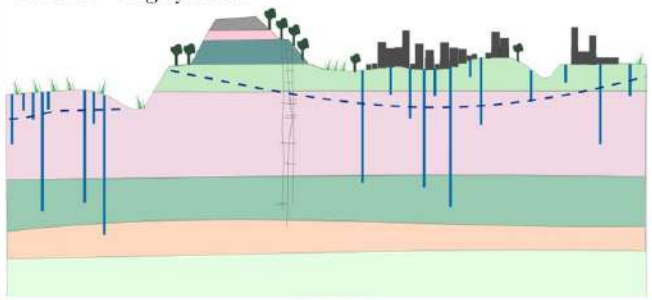
Urban water crisis…

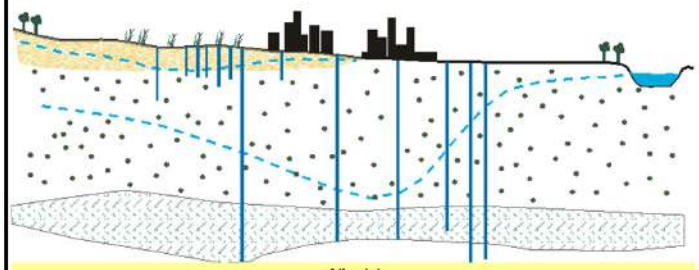
India's towns and cities are underlain by a diverse set of aquifer systems

Volcanic – largely basalt



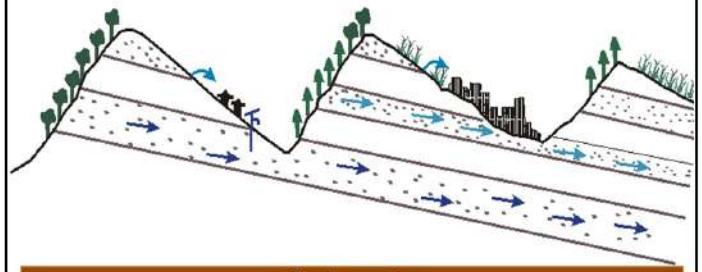
Volcanics		
A	Urban Agglomerations	2
B	Million plus cities	6
C	Lakh plus cities	24
	Total cities(A+B+C)	32
	Total cities %	10.5%
	Smaller towns corresponding to taluka headquarters	391
	Talukas %	7%

Extensive alluvium



Alluvial		
A	Urban Agglomerations	5
B	Million plus cities	19
C	Lakh plus cities	118
	Total cities(A+B+C)	142
	Total cities %	46%
	Smaller towns corresponding to taluka headquarters	1847
	Talukas %	32%

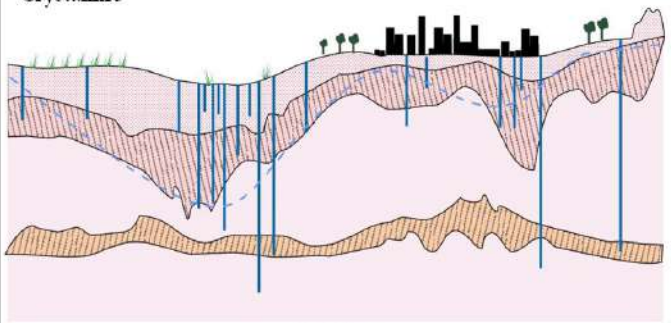
Himalayan mountain region



Himalayan region		
A	Urban Agglomerations	
B	Million plus cities	
C	Lakh plus cities	
	Total cities(A+	
	Total cities	
	Smaller towns correspondi	
	Ta	

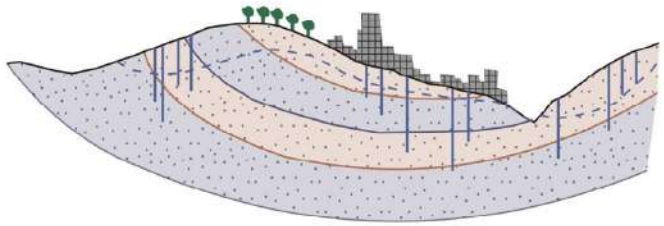
HALF OF THE URBAN WATER SUPPLIES IN INDIA AT MET FROM GROUNDWATER

Crystalline



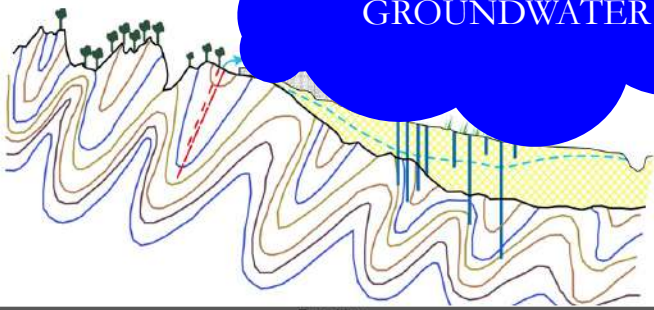
Crystallines		
A	Urban Agglomerations	4
B	Million plus cities	21
C	Lakh plus cities	89
	Total cities(A+B+C)	114
	Total cities %	35.5%
	Smaller towns corresponding to taluka headquarters	1773
	Talukas %	31%

Consolidated sedimentary



Sedimentary Systems		
A	Urban Agglomerations	0
B	Million plus cities	1
C	Lakh plus cities	12
	Total cities(A+B+C)	13
	Total cities %	4.0%
	Smaller towns corresponding to taluka headquarters	172
	Talukas %	3.0%

Transition



Transition		
A	Urban Agglomerations	
B	Million plus cities	
C	Lakh plus cities	
	Total cities(A+B+C)	0
	Total cities %	
	Smaller towns corresponding to taluka headquarters	1142
	Talukas %	20%

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Pune – urban versus rural population densities

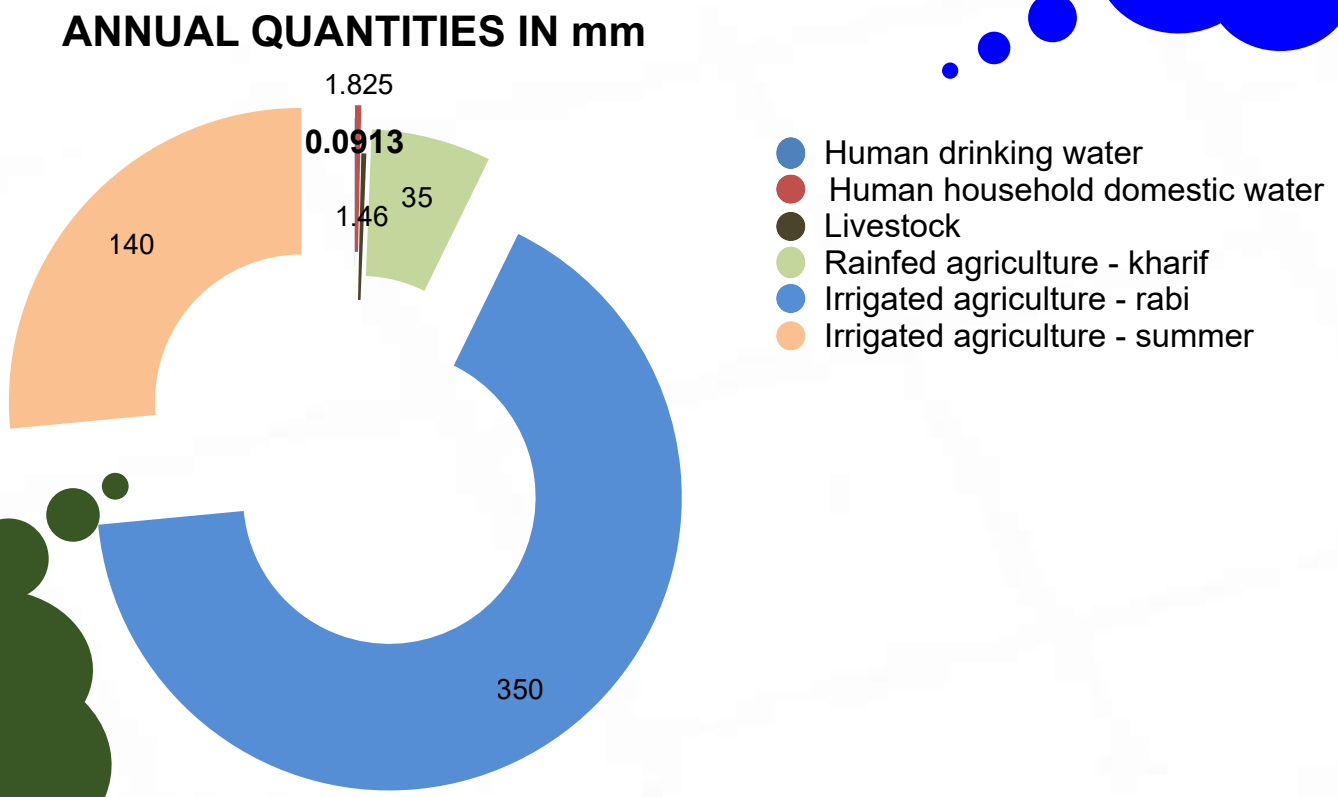
Figures are approximate

	RURAL	URBAN
AVERAGE POPULATION	1000	4000000
AVERAGE AREA OF VILLAGE / CITY (in hectares)	1000	25000
DENSITY OF POPULATION (persons per hectare)	1	160 (Pune) 170 (Bengaluru)
ANNUAL DOMESTIC WATER DEMAND (m^3)	@55 lpcd 20075	@150 lpcd 219 million
ANNUAL DOMESTIC WATER DEMAND PER HECTARE (CALCULATED IN mm/ha)	**2 mm**	**876 mm**

Demand – availability - supply

Demand based WB of a typical Indian village – in mm

1000 ha; 500 ha agriculture;
100 households; 500 people…
ANNUAL DEMAND = 528 mm



Domestic demand including drinking water is less than 2 mm / year

A typical shallow basalt aquifer system holds an equivalent groundwater storage of an equivalent 20 to 150 mm of groundwater

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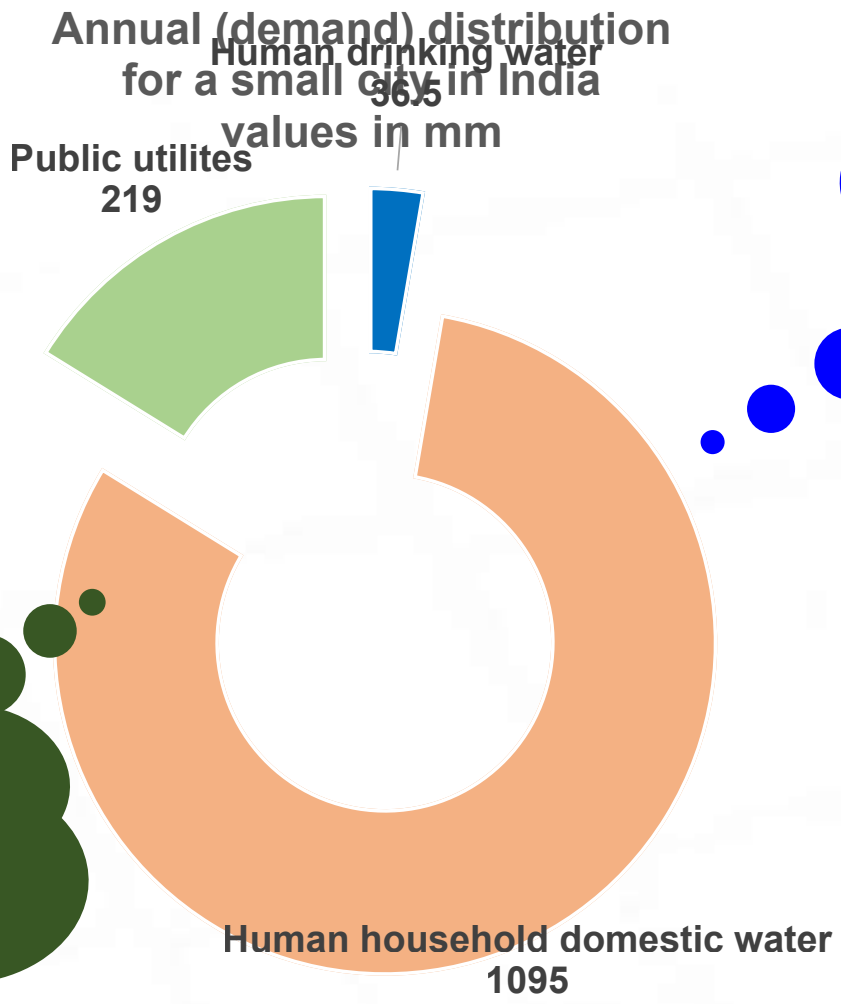
Demand – availability - supply

Area = 200 km2
Population = 2 million
DEMAND = 5 lpcd (drinking); 150 lpcd (domestic); 3000 lpd/ unit of 60 to 70 hectares (public utilities)



Domestic demand including drinking water is as much as 1132 mm / year

A typical shallow basalt aquifer system holds an equivalent groundwater storage of an equivalent 20 to 150 mm of groundwater

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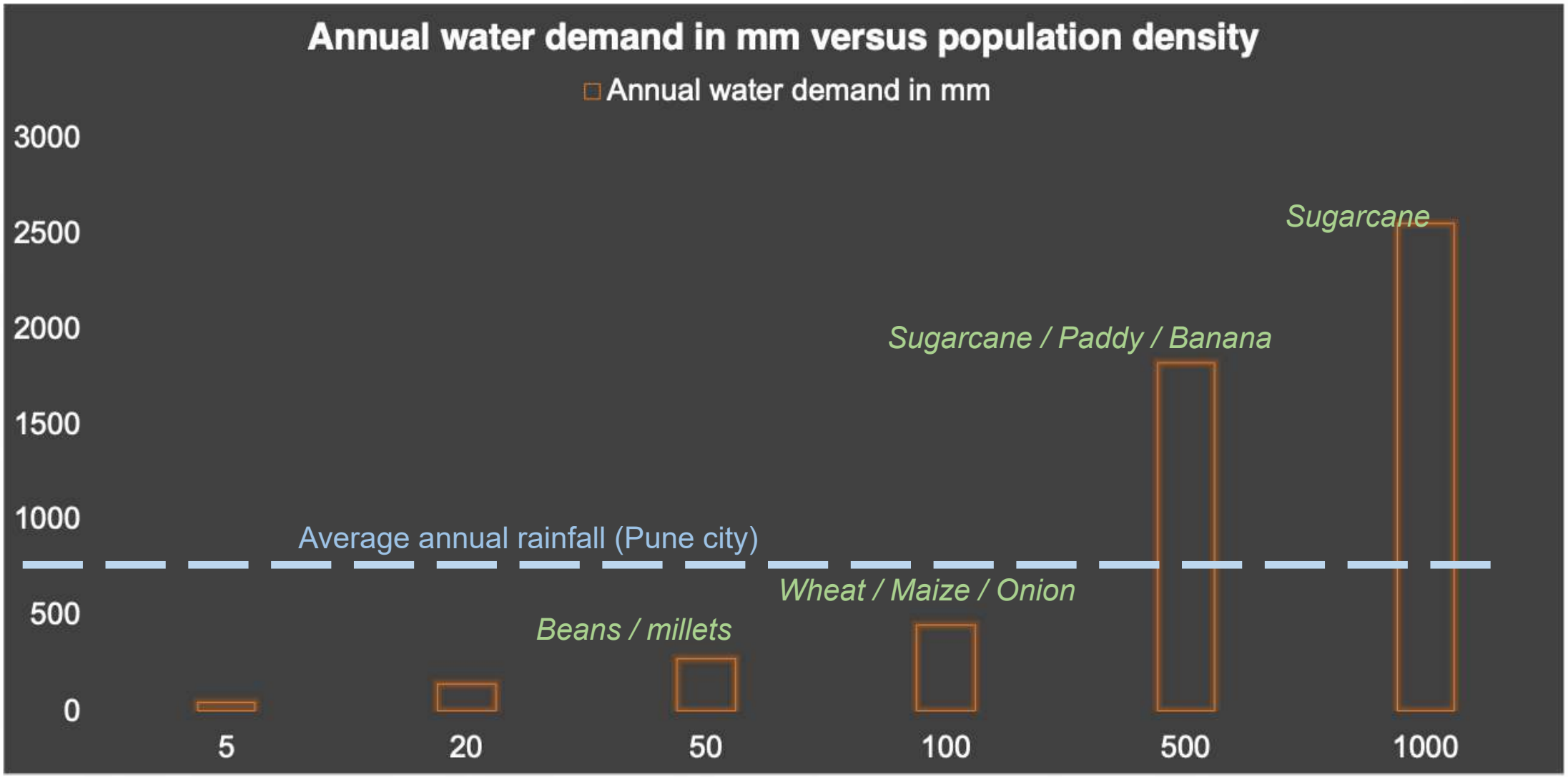
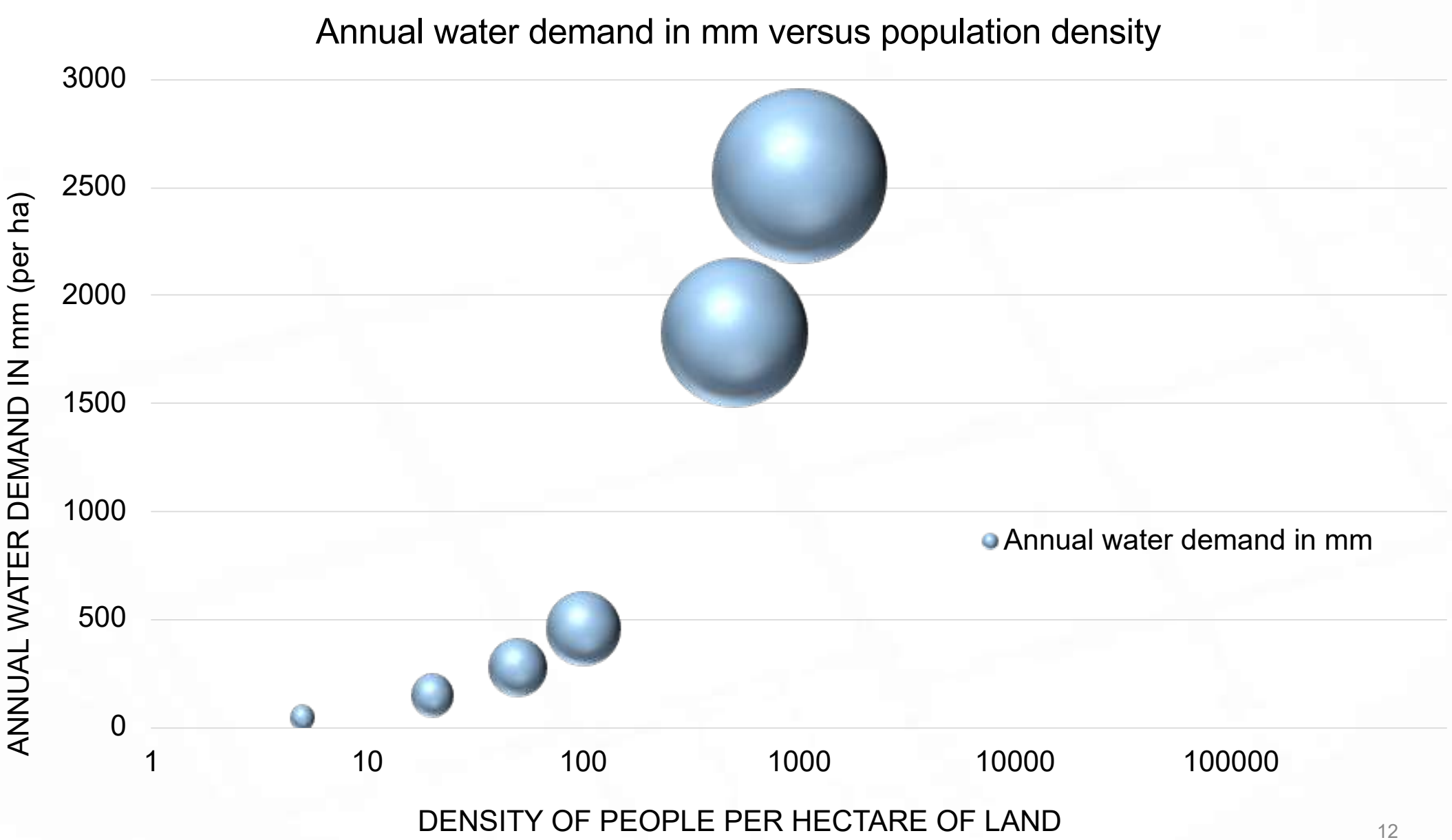
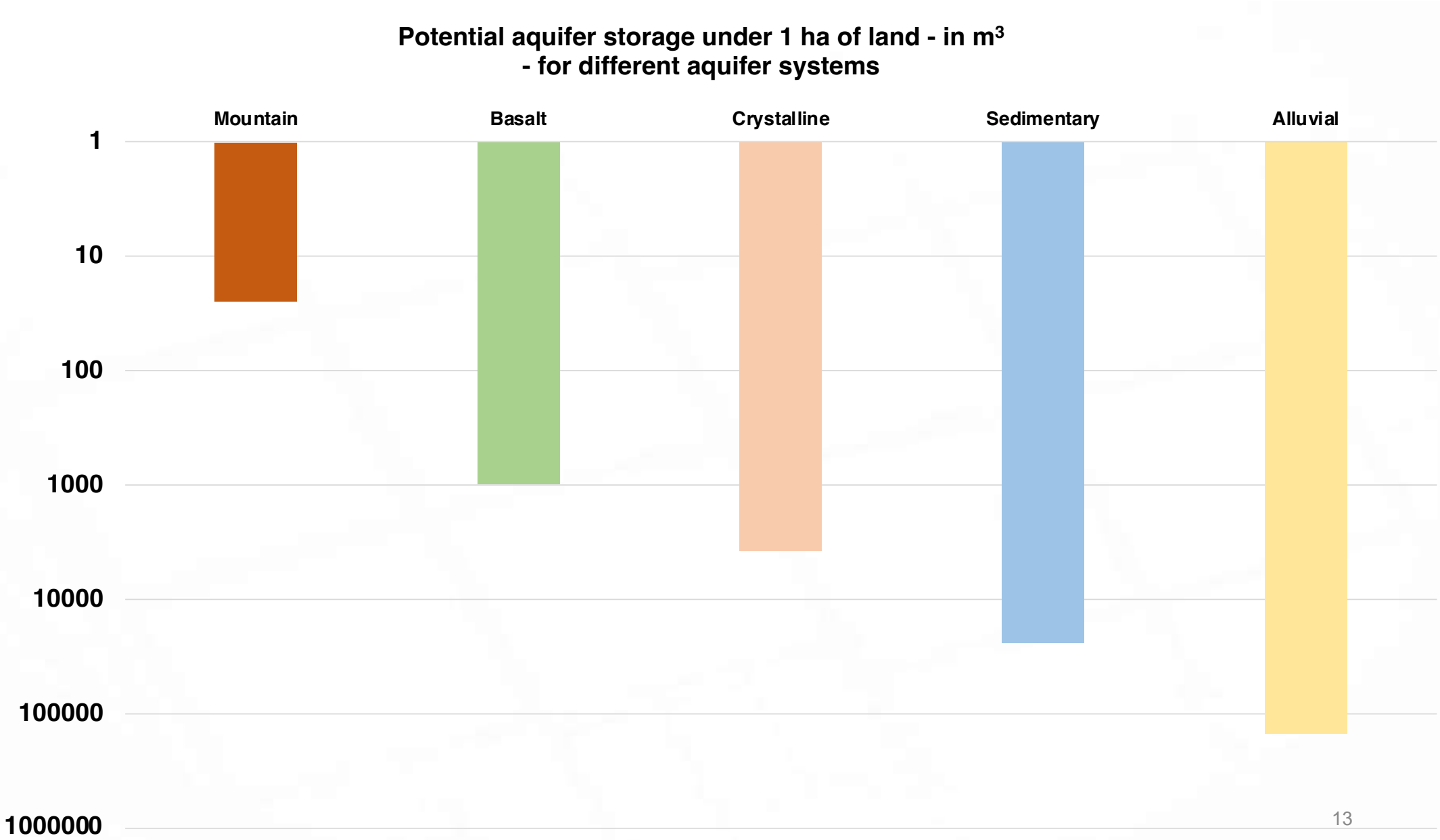
…using density of people per unit of land

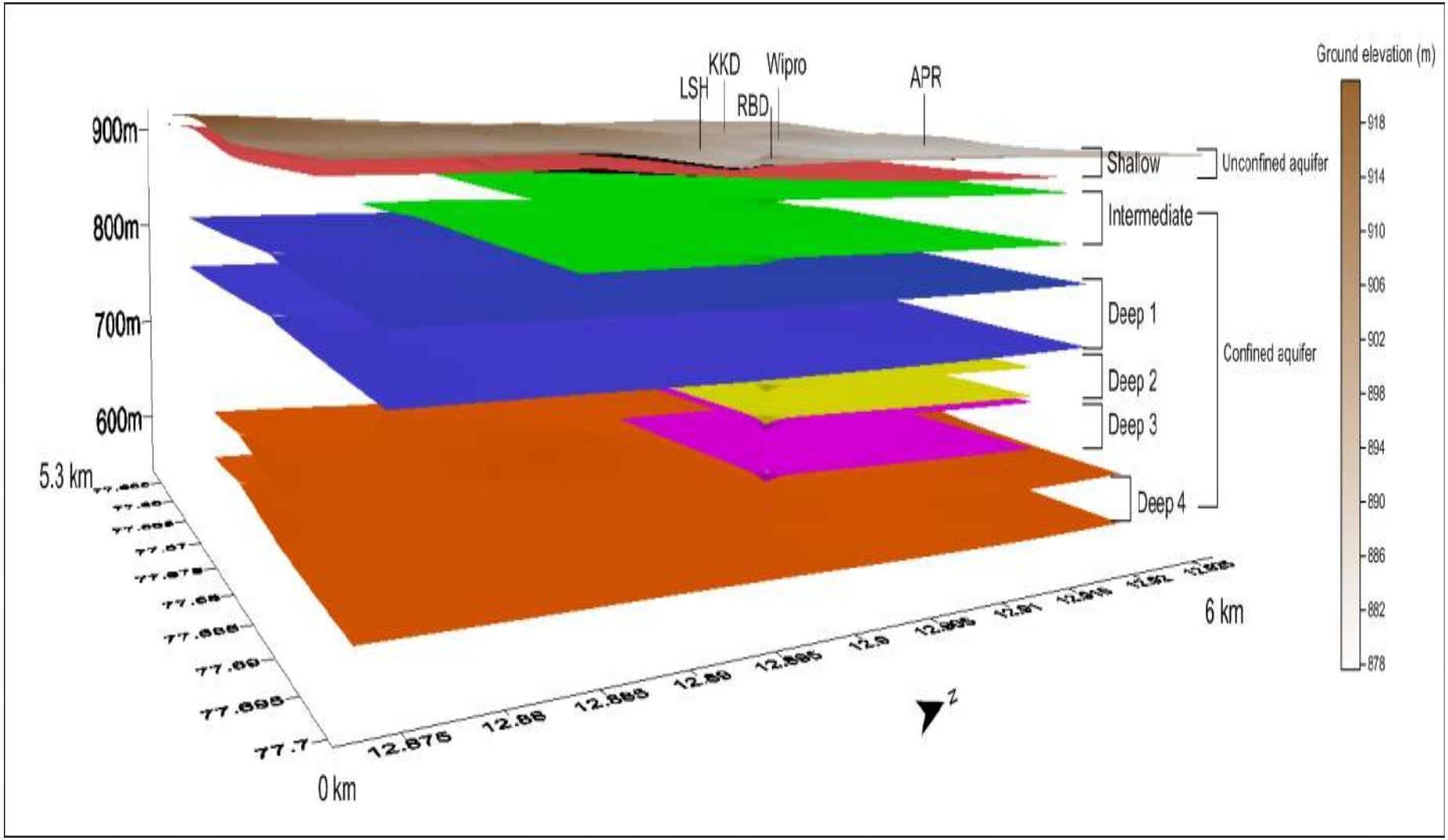
1 Hectare

Modeled densities and annual water demand




Annual water demand in mm versus population density
ANNUAL WATER DEMAND IN mm (per ha)
3000
2500
2000
1500
1000
500
0
1
10
100
1000
10000
100000
DENSITY OF PEOPLE PER HECTARE OF LAND
Annual water demand in mm


Potential aquifer storage under 1 ha of land - in m3
- for different aquifer systems
Mountain
Basalt
Crystalline
Sedimentary
Alluvial
1
10
100
1000
10000
100000
1000000



SARJAPURA AQUIFER LAYOUT-3D

(after Bengaluru Participatory Aquifer Management Project – Biome-ACWADAM, support by Wipro)

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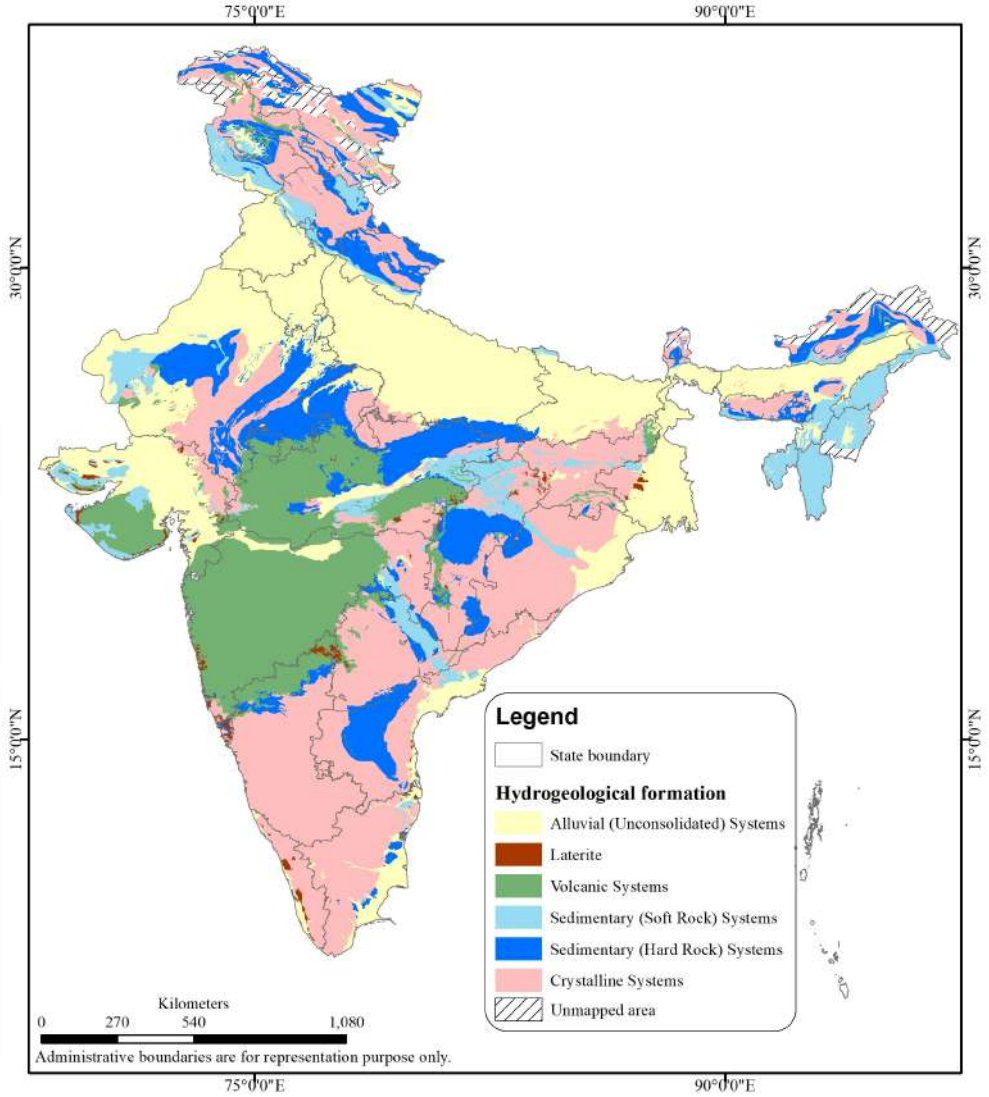
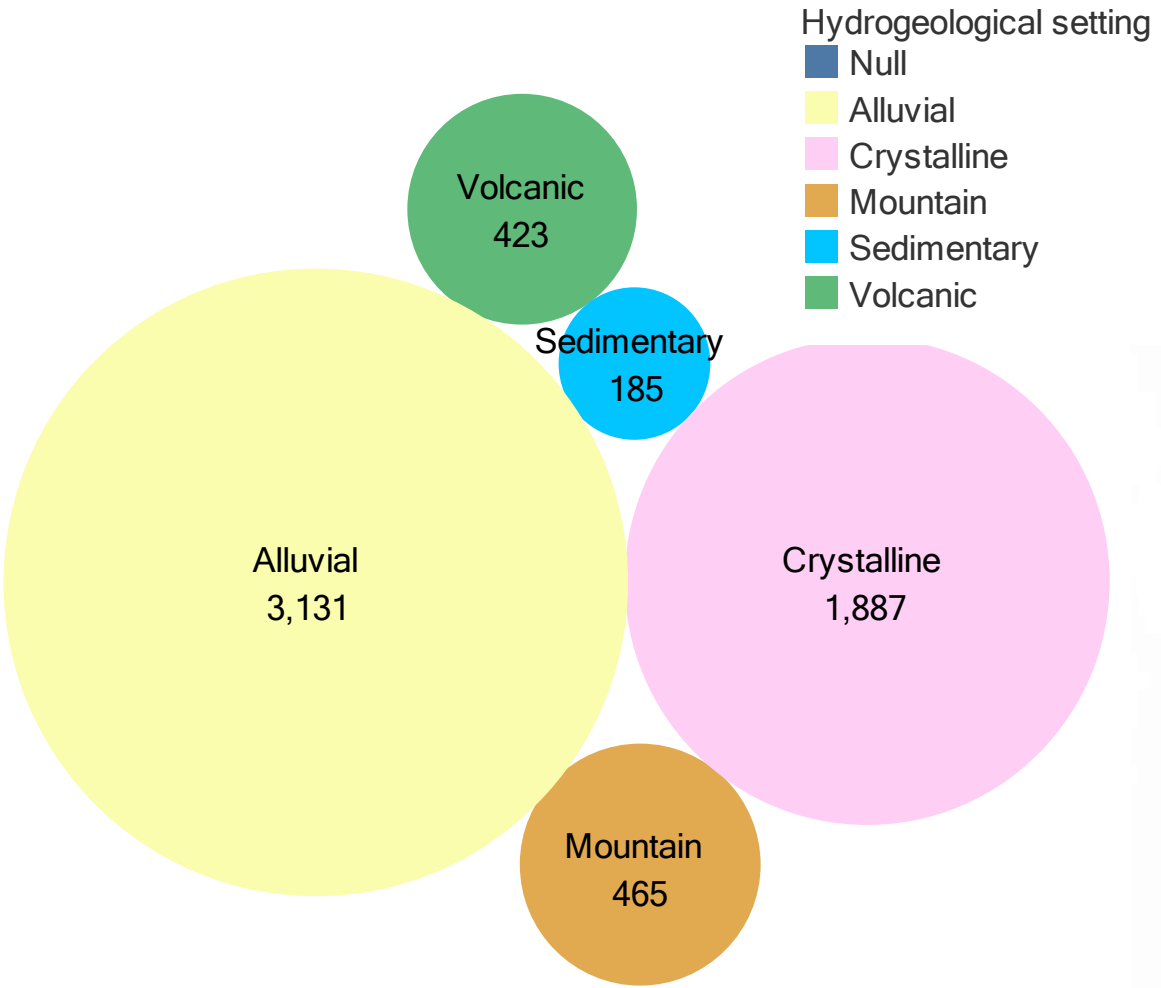
India's hydrogeological diversity



After: COMMAN 2005; GSI (various years), ACWADAM (various publ.), CGWB (2012)

Typology based distribution of urban habitations



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Sequence of basalt lavas shows alternate units with vertical and horizontal jointing patterns, traversed by regional fracture zones or dykes

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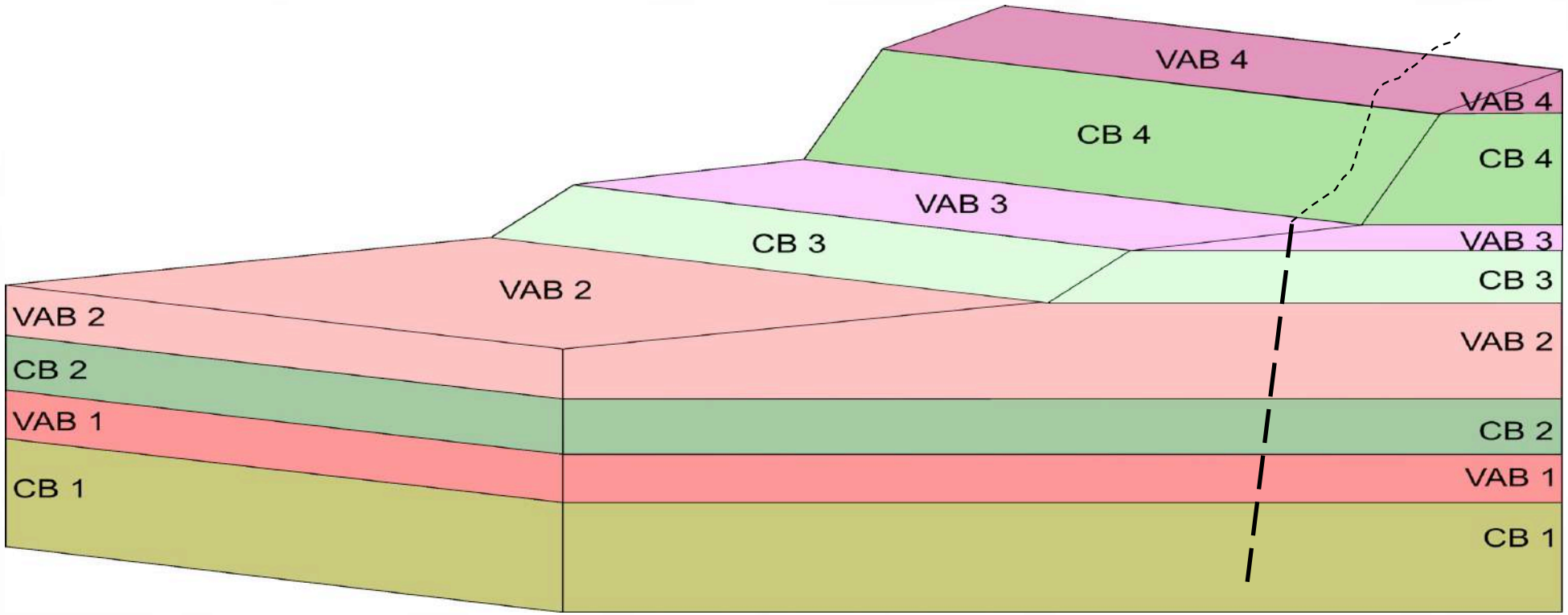
These layers are exposed above the ground and are largely horizontal below – geological mapping



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Compound basalt

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Columnar jointed basalt

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Vesicular-amygdaloidal basalt

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Fracture zones

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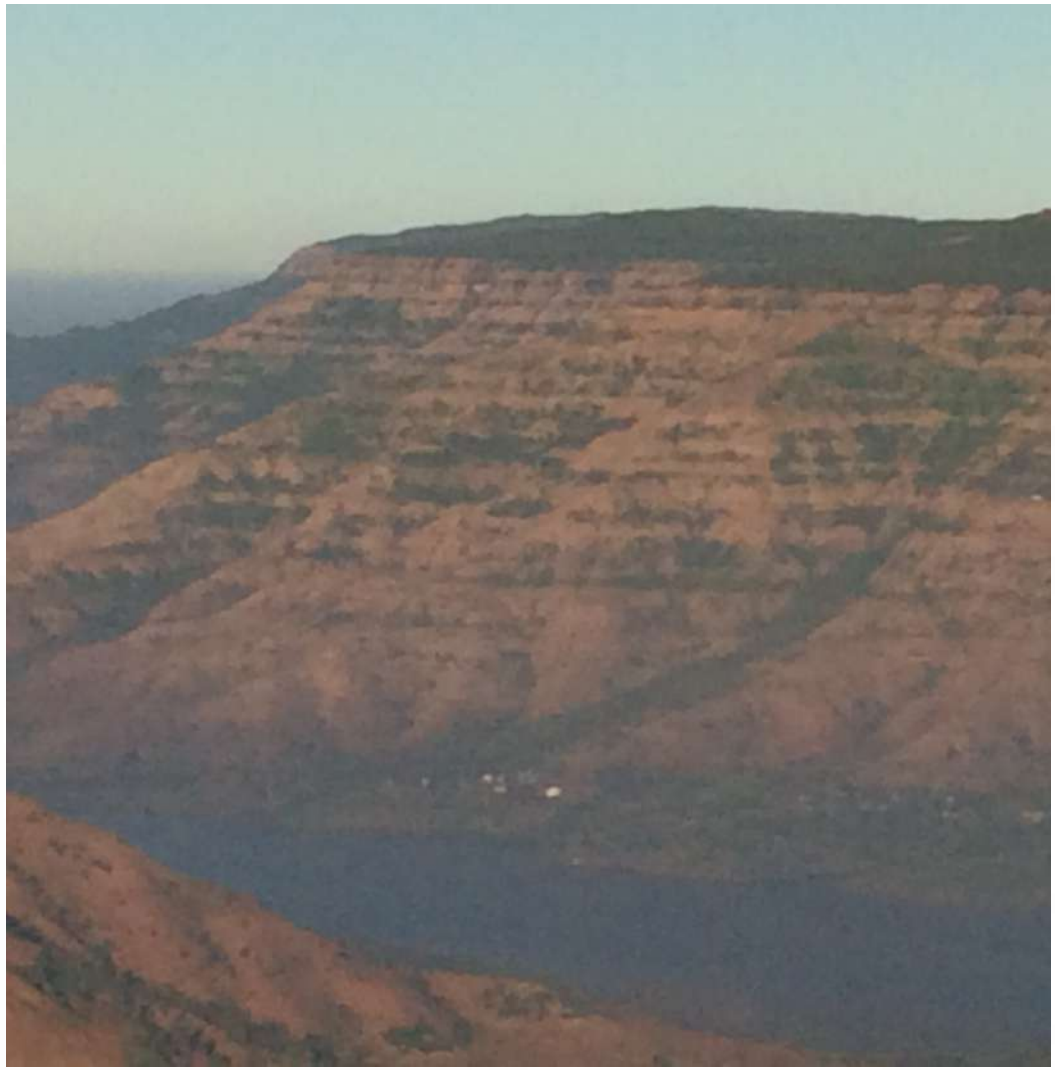
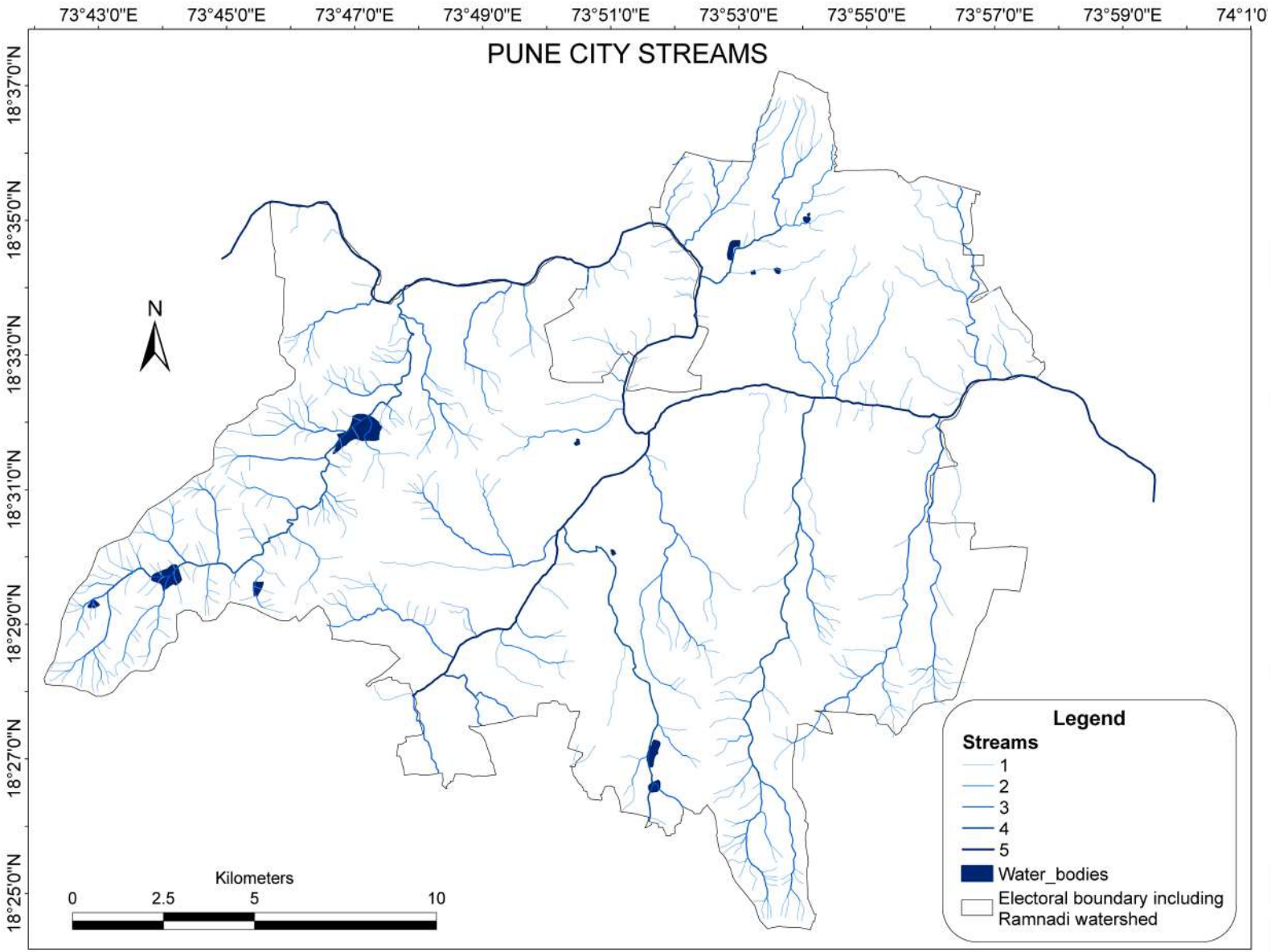



Gundatwadi
Bhursewadi
Kadha
e Earth
lt lavas - horizontal disposition across the landscap
escription for your map.
800 m


PUNE CITY STREAMS
73°43'0"E
73°45'0"E
73°47'0"E
73°49'0"E
73°51'0"E
73°53'0"E
73°55'0"E
73°57'0"E
73°59'0"E
74°1'0
18°37'0"N
18°35'0"N
18°33'0"N
18°31'0"N
18°29'0"N
18°27'0"N
18°25'0"N
N
Kilometers
0
2.5
5
10
Legend
Streams
1
2
3
4
5
Water_bodies
Electoral boundary including Ramnadi watershed

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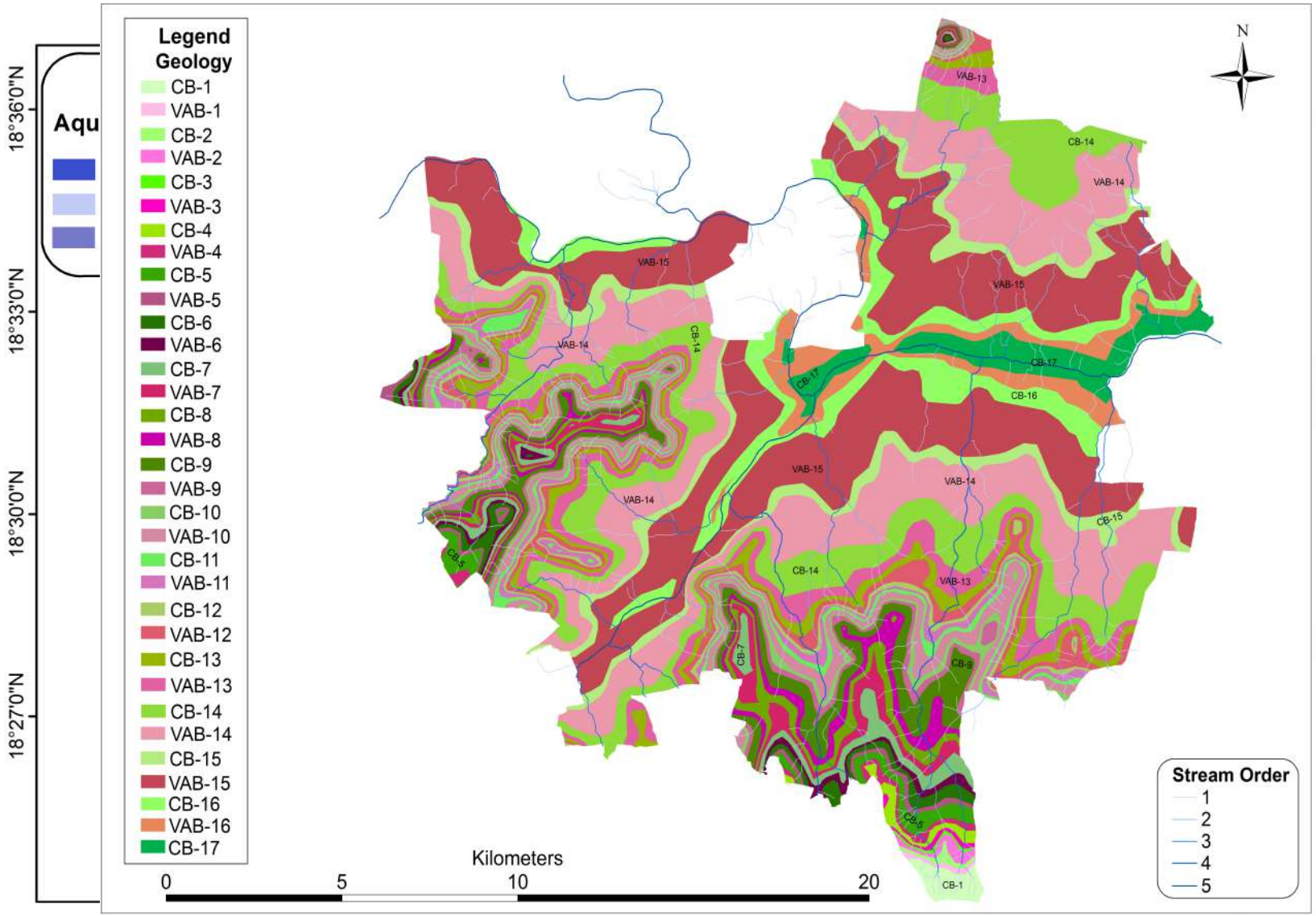
Geology, watersheds and expansion of Pune urban in the last 100 years…



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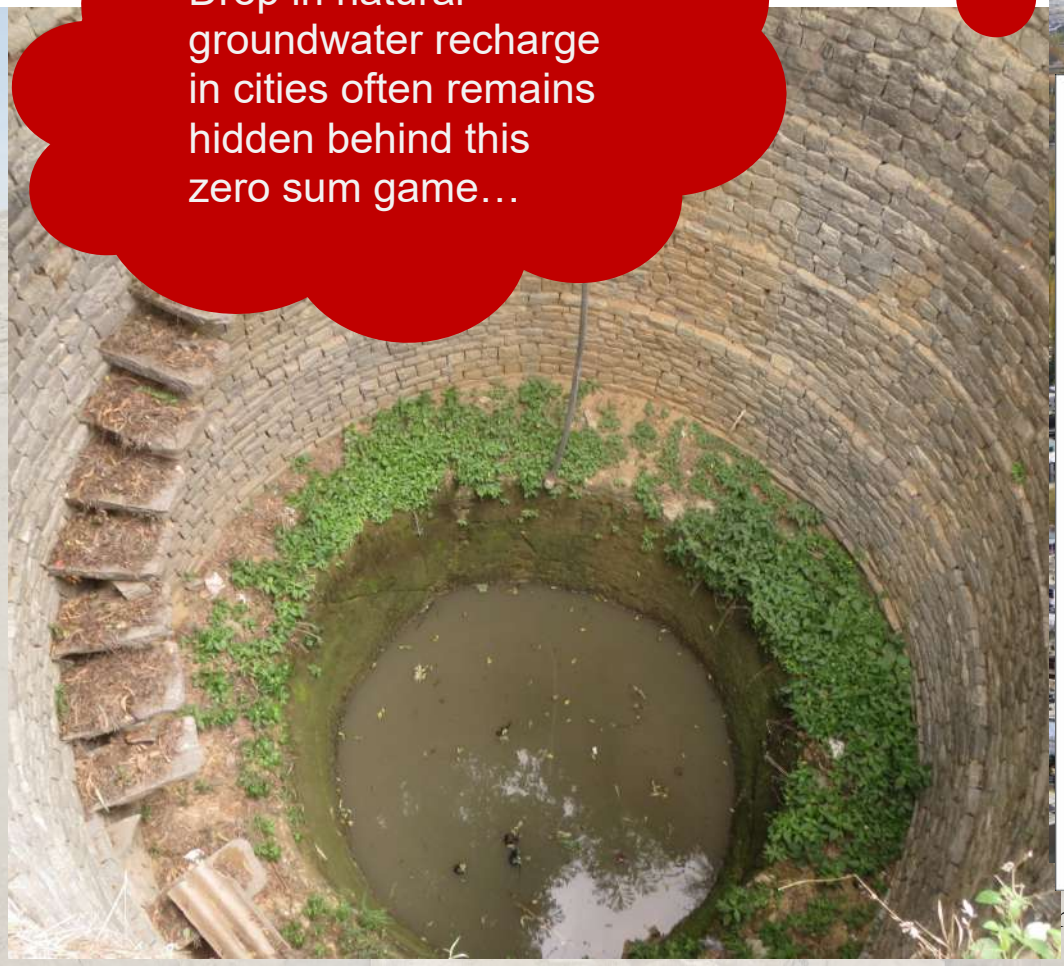
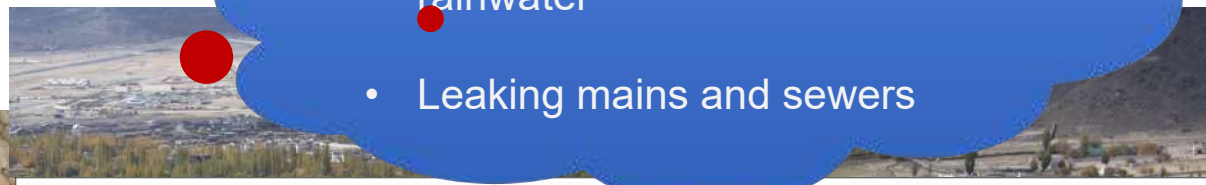
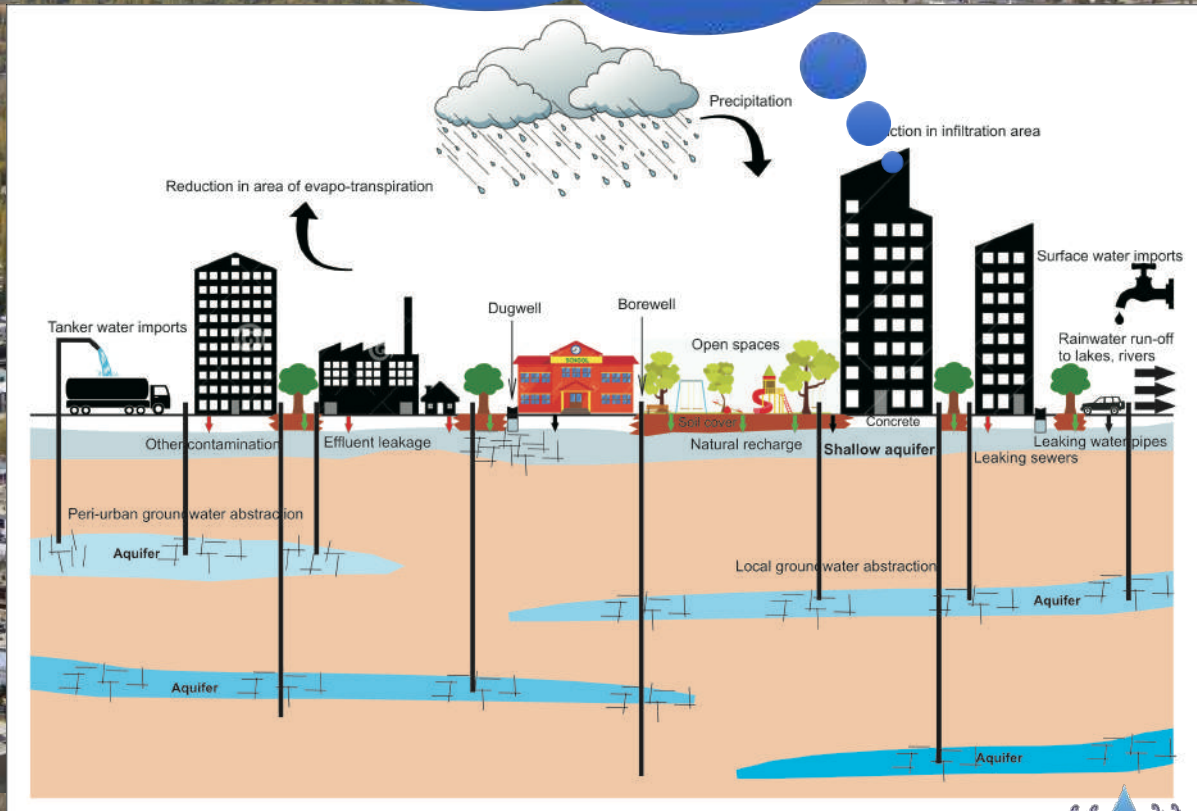
The need for rainwater harvesting lin

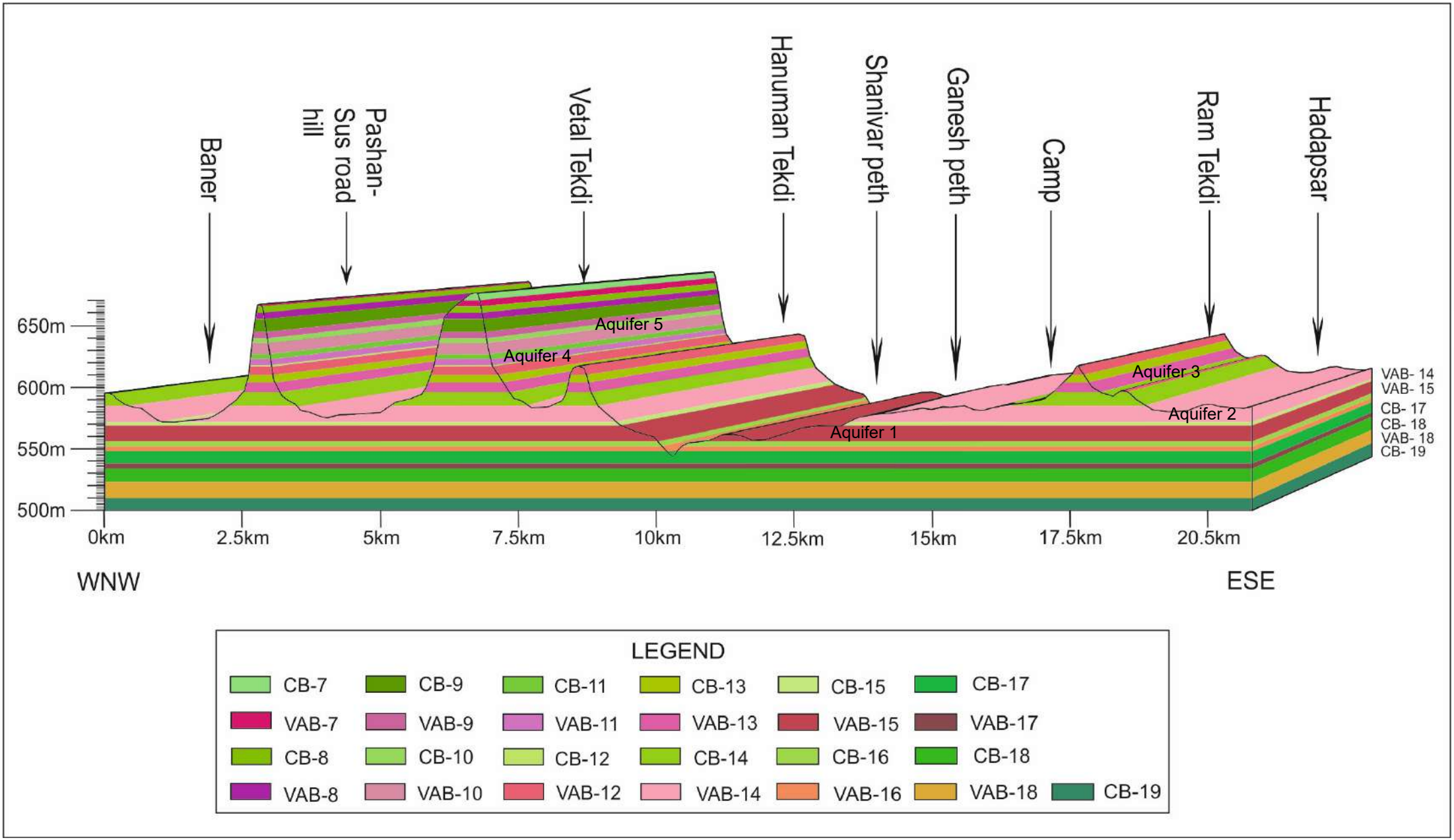
- Drop in natural groundwater recharge in cities often remains hidden behind this zero sum game…

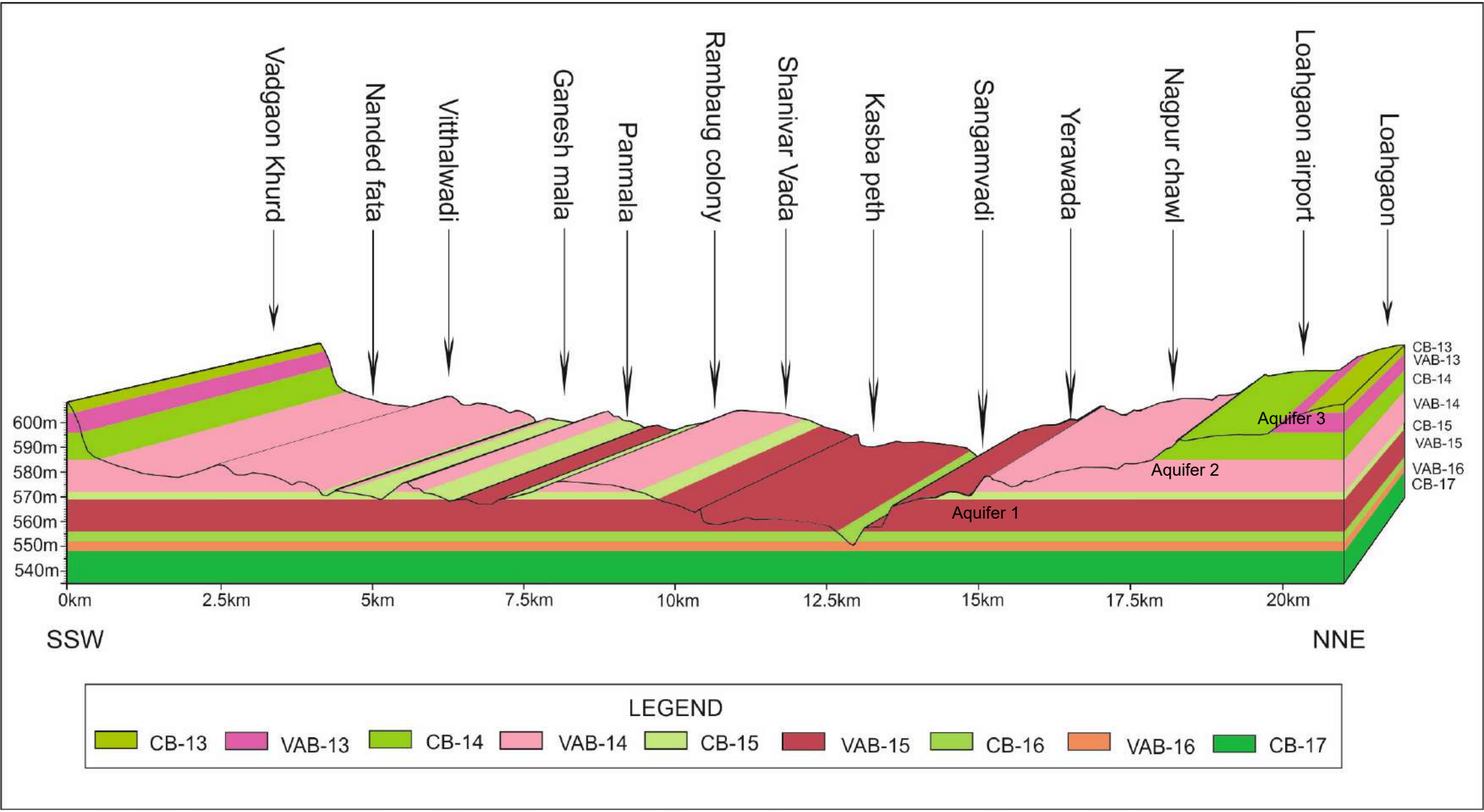


- Reduction in surfaces that induce infiltration of rainwater
- Leaking mains and sewers

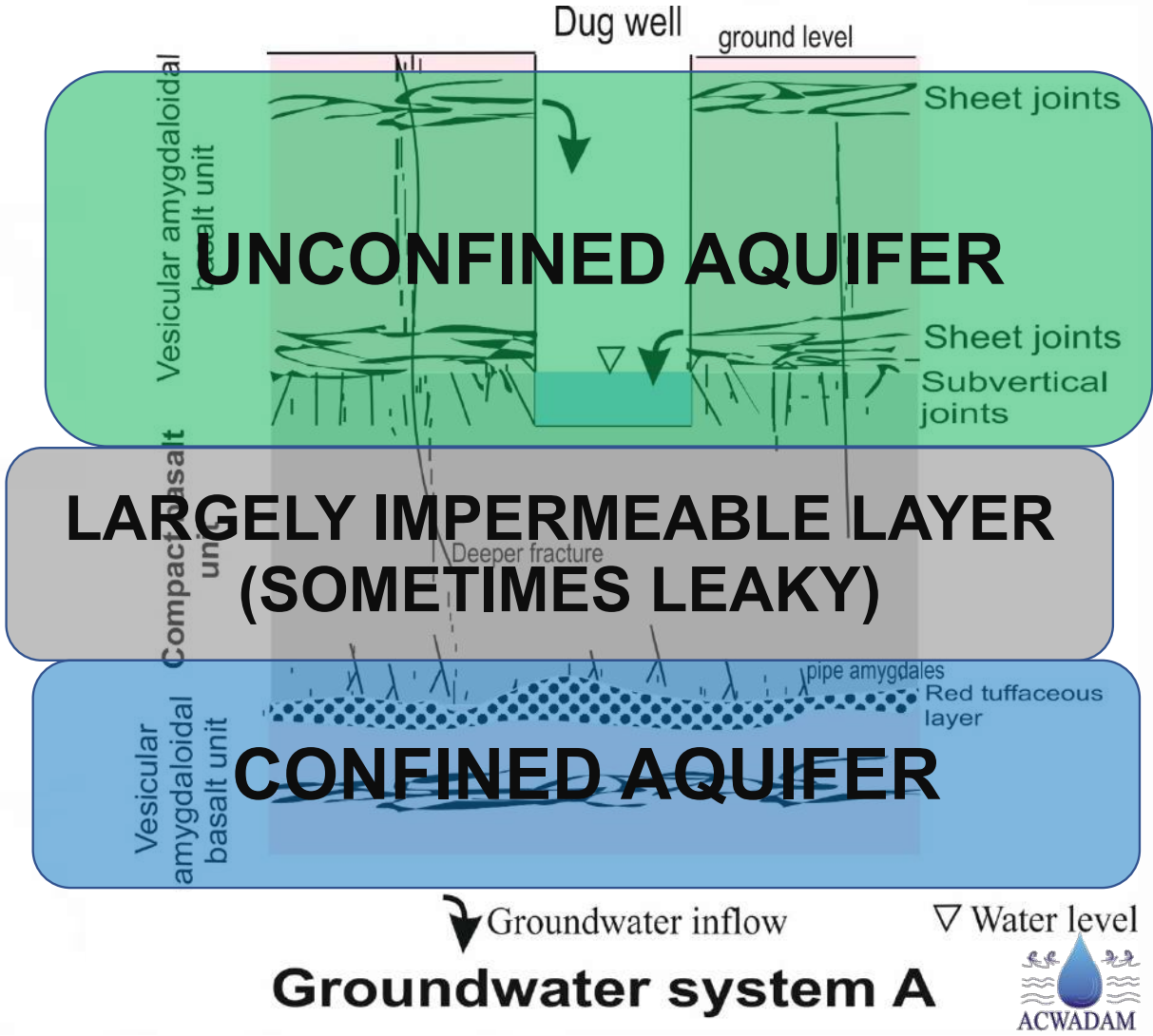


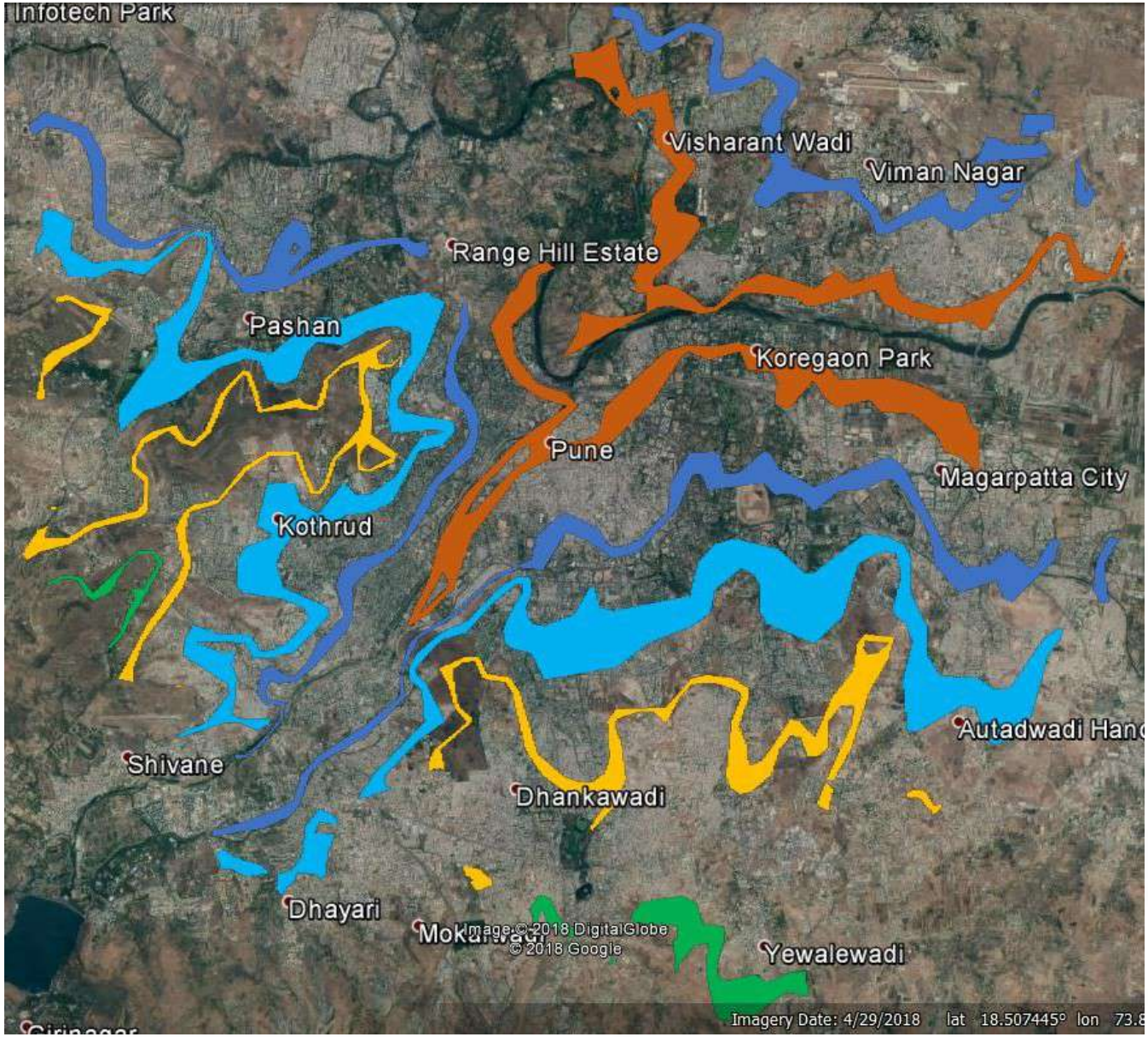



Baner
Pashan-
Sus road
hill
Vetal Tekdi
Hanuman Tekdi
Shanivar peth
Ganesh peth
Camp
Ram Tekdi
Hadapsar
650m
600m
550m
500m
Aquifer 5
Aquifer 4
Aquifer 3
Aquifer 2
Aquifer 1
VAB- 14
VAB- 15
CB- 17
CB- 18
VAB- 18
CB- 19
0km
2.5km
5km
7.5km
10km
12.5km
15km
17.5km
20.5km
WNW
ESE
LEGEND
CB-7
CB-9
CB-11
CB-13
CB-15
CB-17
VAB-7
VAB-9
VAB-11
VAB-13
VAB-15
VAB-17
CB-8
CB-10
CB-12
CB-14
CB-16
CB-18
VAB-8
VAB-10
VAB-12
VAB-14
VAB-16
VAB-18
CB-19


Vadgaon Khurd
Nanded fata
Vitthalwadi
Ganesh mala
Panmala
Rambaug colony
Shanivar Vada
Kasba peth
Sangamvadi
Yerawada
Nagpur chawl
Loahgaon airport
Loahgaon
600m
590m
580m
570m
560m
550m
540m
0km
2.5km
5km
7.5km
10km
12.5km
15km
17.5km
20km
SSW
NNE
CB-13
VAB-13
CB-14
VAB-14
CB-15
VAB-15
VAB-16
CB-17
Aquifer 3
Aquifer 2
Aquifer 1
LEGEND
CB-13
VAB-13
CB-14
VAB-14
CB-15
VAB-15
CB-16
VAB-16
CB-17

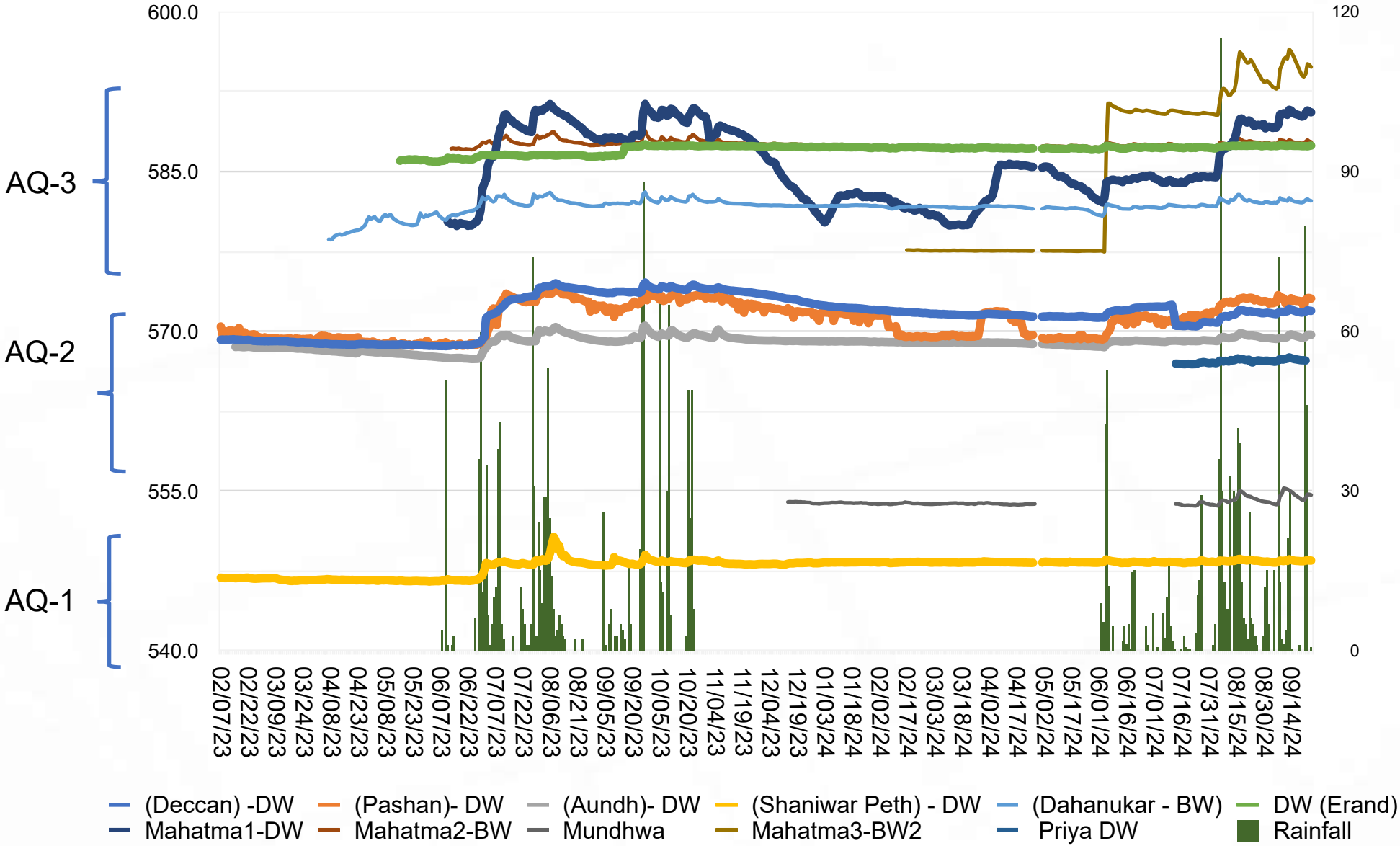
Geology to hydrogeology: conceptualizing aquifer system A





Broad recharge-conducive areas of Pune

- Aquifer - 1
- Aquifer - 2
- Aquifer - 3
- Aquifer - 4
- Aquifer - 5


AQ-3
AQ-2
AQ-1
600.0
585.0
570.0
555.0
540.0
120
90
60
30
0
02/07/23
02/22/23
03/09/23
03/24/23
04/08/23
04/23/23
05/08/23
05/23/23
06/07/23
06/22/23
07/07/23
07/22/23
08/06/23
08/21/23
09/05/23
09/20/23
10/05/23
10/20/23
11/04/23
11/19/23
12/04/23
12/19/23
01/03/24
01/18/24
02/02/24
02/17/24
03/03/24
03/18/24
04/02/24
04/17/24
05/02/24
05/17/24
06/01/24
06/16/24
07/01/24
07/16/24
07/31/24
08/15/24
08/30/24
09/14/24
(Deccan) -DW
(Pashan)- DW
(Aundh)- DW
(Shaniwar Peth) - DW
(Dahanukar - BW)
DW (Erand)
Mahatma1-DW
Mahatma2-BW
Mundhwa
Mahatma3-BW2
Priya DW
Rainfall

Groundwater Recharge

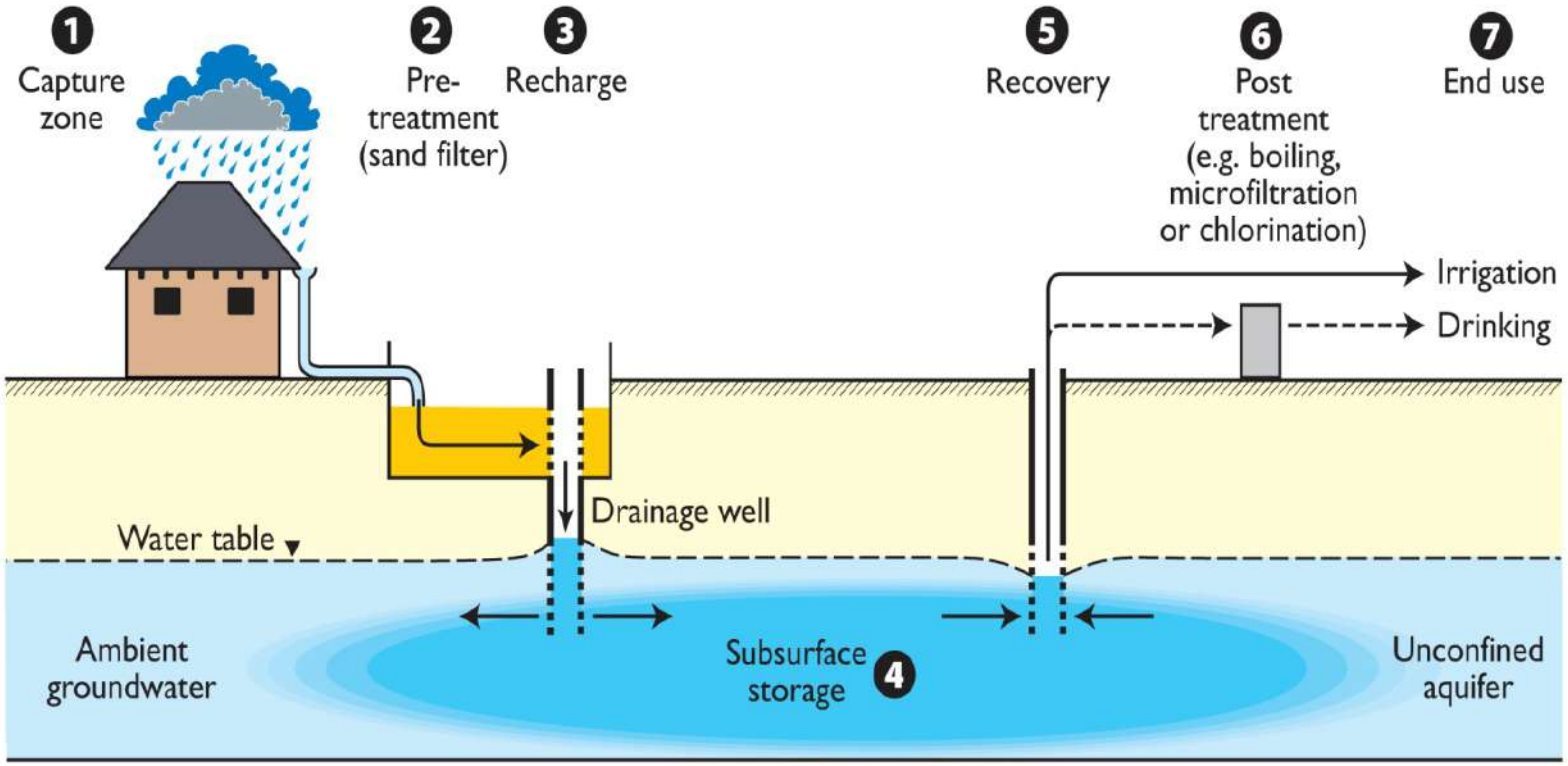
Managed Aquifer Recharge (MAR)

- MAR is the intentional or designed recharge of water to aquifers for:
  - Subsequent recovery for meeting anthropogenic needs
  - Environmental benefit

- Hence, the managed process strives for adequate protection of human health and the environment

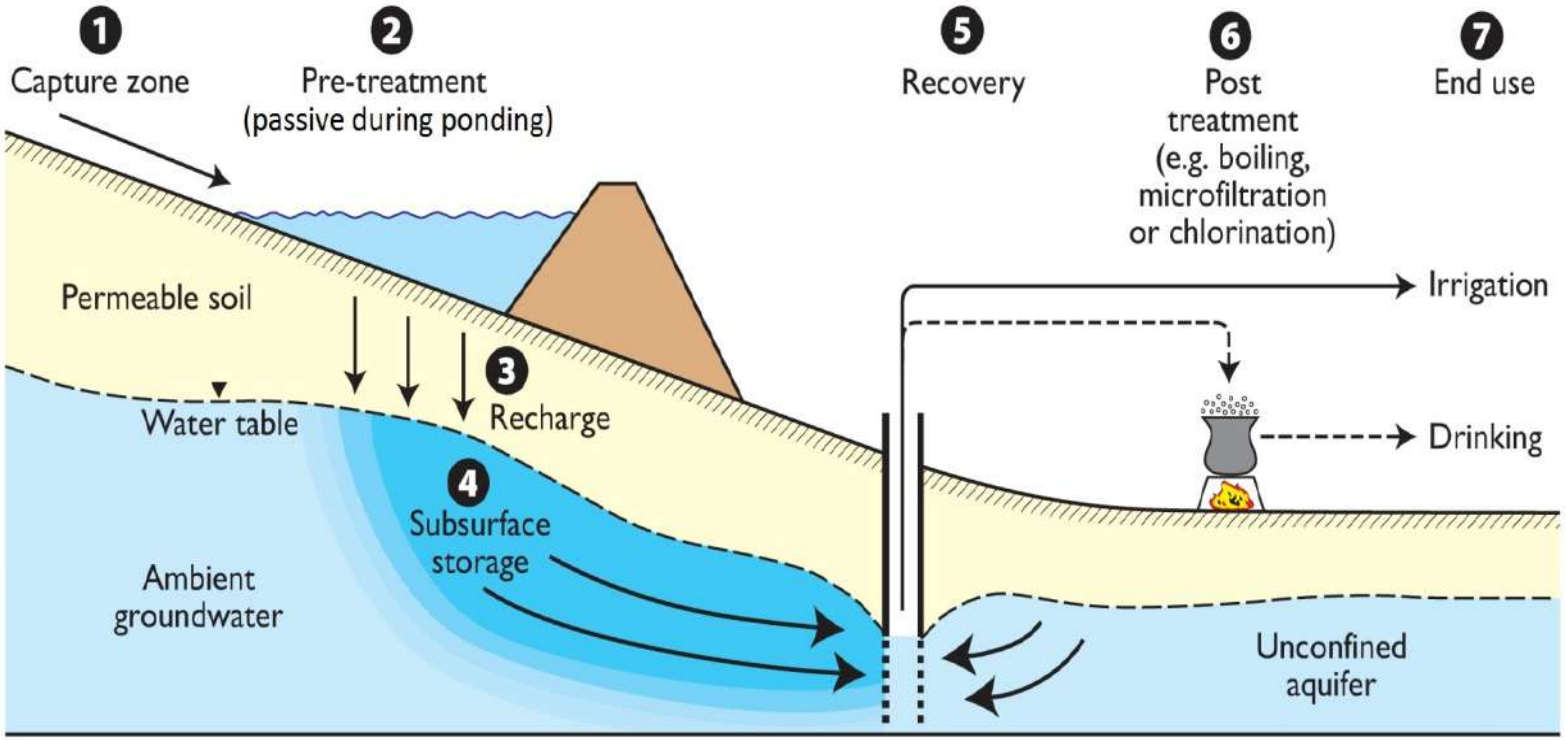
- Aquifers may be recharged by diversion of water into wells or infiltration of water through the floor of basins, galleries or rivers

MAR system components: eg rainwater harvesting



Reference: MAR, CSIRO, Australia

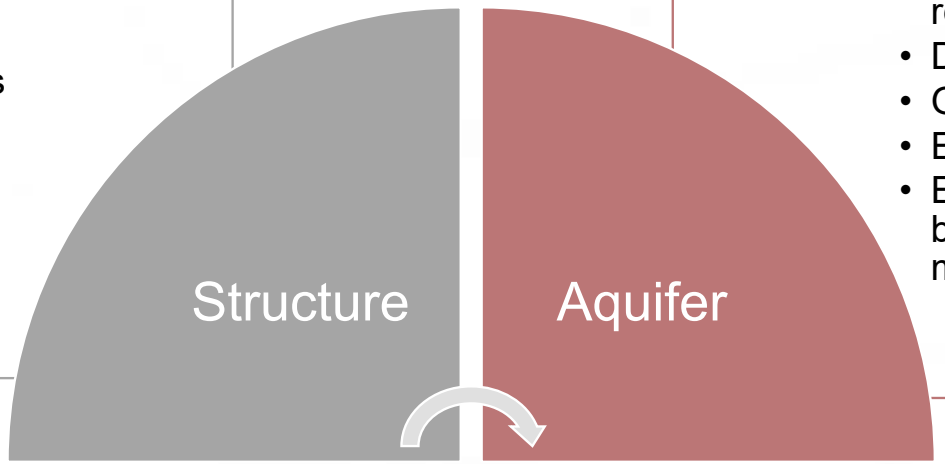
MAR system components: eg check dam recharge



Reference: MAR, CSIRO, Australia

Recharge at different scales…

- Strategic location of structures
- Efficiency of recharge structures – quantities & quality of water
- Operation and maintenance of structures - sustainability



- Actual and potential recharge
- Degree of usage
- Groundwater quality
- Equity in recharge
- Efficiency of aquifer based groundwater management

Where?
How much?
How?

Scales: one well, one bore hole, a housing society, a cluster of societies, a ward or even an urban watershed!

The importance of aquifers as a reference to groundwater recharge!

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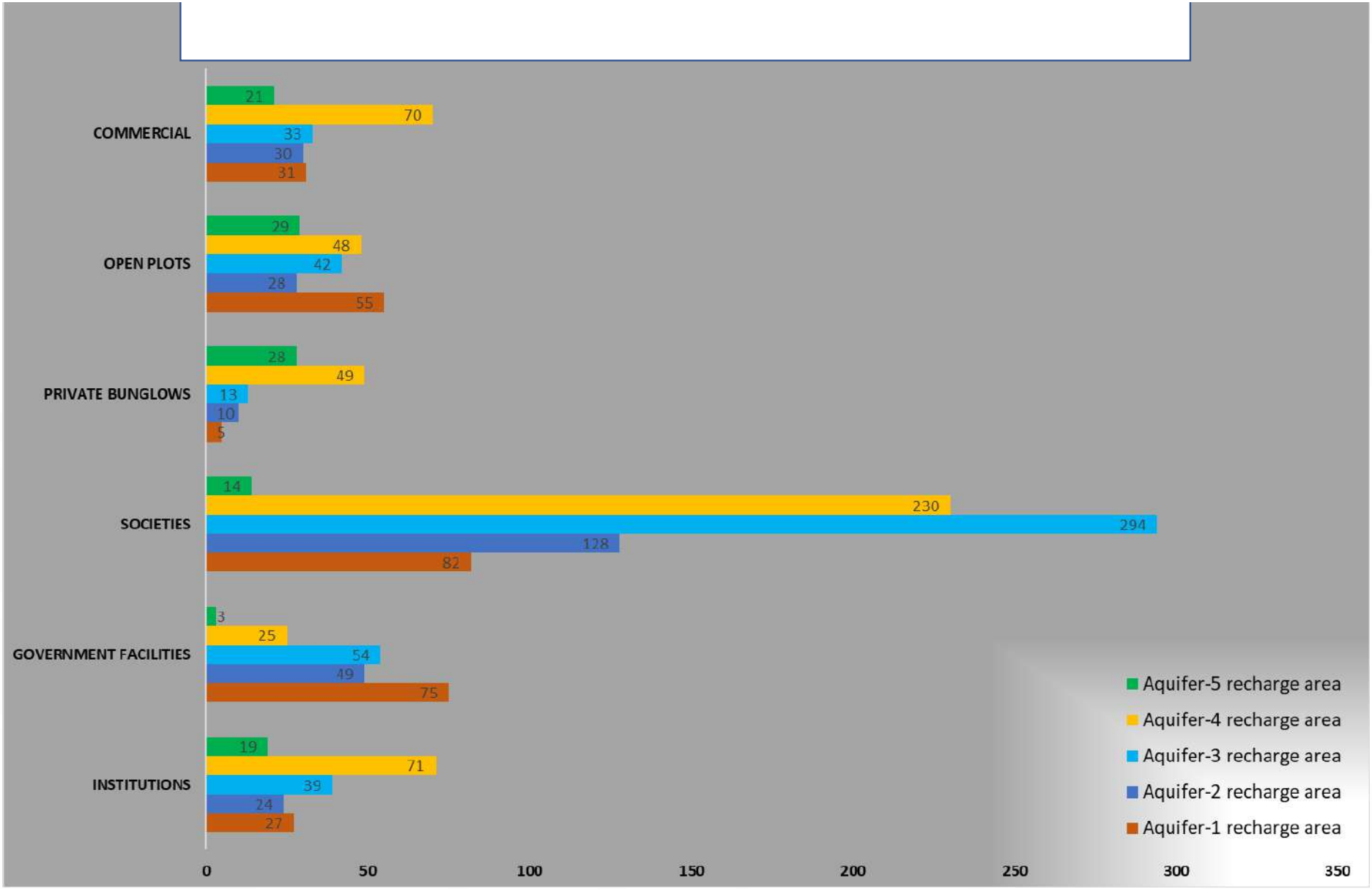
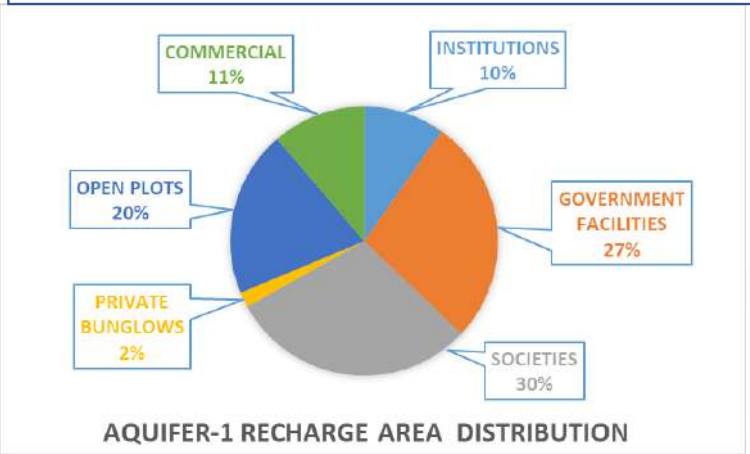
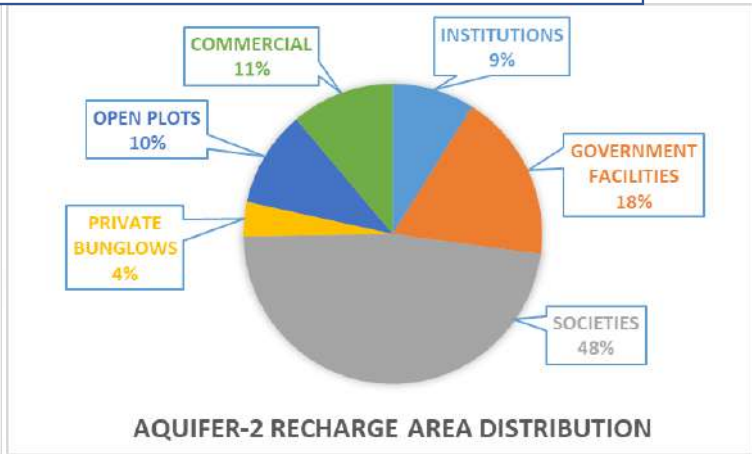

COMMERCIAL
21
70
33
30
31
OPEN PLOTS
29
48
42
28
55
PRIVATE BUNGLOWS
28
49
13
10
5
SOCIETIES
14
230
294
128
82
GOVERNMENT FACILITIES
3
25
54
49
75
INSTITUTIONS
19
71
39
24
27
0
50
100
150
200
250
300
350
Aquifer-5 recharge area
Aquifer-4 recharge area
Aquifer-3 recharge area
Aquifer-2 recharge area
Aquifer-1 recharge area

ACWADAM



AQUIFER-1 RECHARGE AREA DISTRIBUTION



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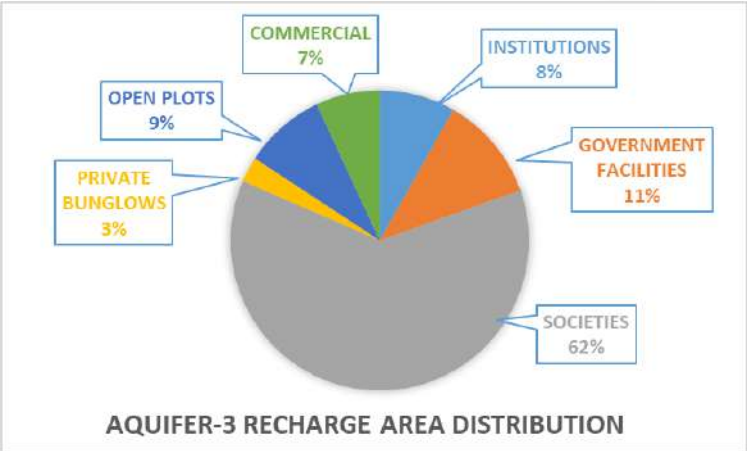
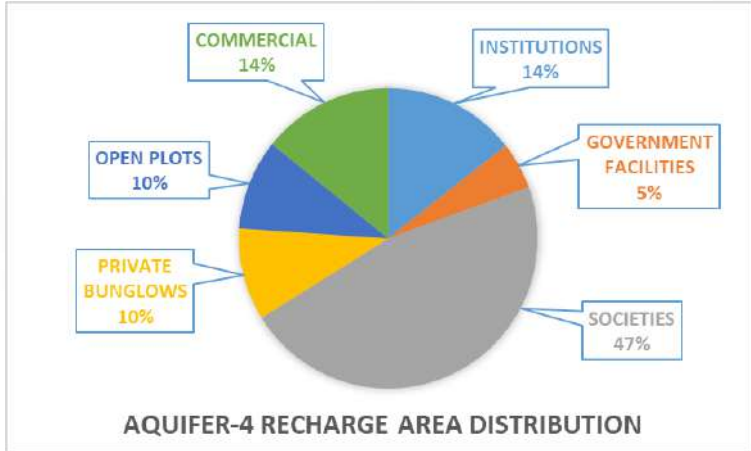
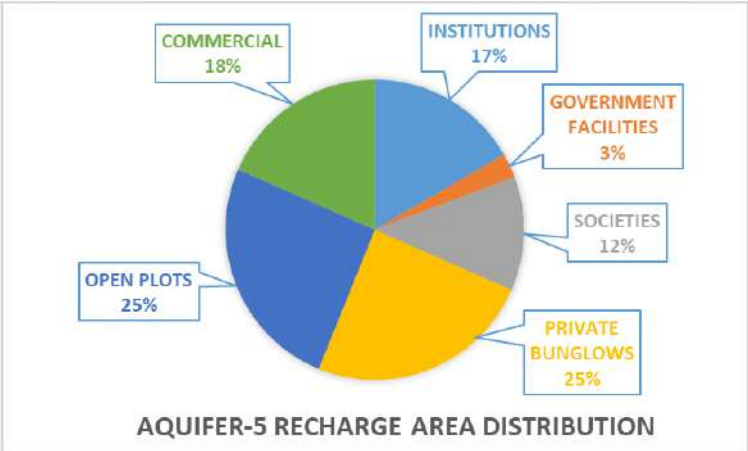


AQUIFER-3 RECHARGE AREA DISTRIBUTION



AQUIFER-4 RECHARGE AREA DISTRIBUTION



AQUIFER-5 RECHARGE AREA DISTRIBUTION

ACWADAM

Principle	Objecti
Groundwater as a common pool resource	Going from "extractabili ity-based" pedagogy of g
Aquifer based understanding through participatory data gathering	Understanding and water security in r
Groundwater across different uses and users	Develop protocols to use, how much t equity
Integrating habitations, watersheds and aquifers	Developing a clea respective institutions
Longer-term engagement	Ensuring the sustainability nanagement – sustaining aquifers through good prac
Catalysing community action without being prescriptive	Ensuring collaboration and partnerships - ownership of practices and protocols by communities along with shared responsibility
Integration of formal science and peoples' knowledge	Behaviour change and conversion of knowledge to action

MAR alone will not solve the problem. Managing aquifers and community behaviour together defines PGWM…

1. Recharge
2. Managing demand – reducing usage, changing patterns of usage and the concept of 3Rs – reduce, recycle and recharge
3. Improve efficiencies of supply and usage

ACWADAM

How can citizens ‘participate’?

1. Sensitisation and awareness generation
2. Measurement and monitoring
3. Knowledge and information through demystified science: generation, sharing and application
4. Decision support systems – in the real world – NOT JUST VIRTUAL

5. Actions at community scales

Urban Groundwater Management

- Phase 1: MAPPING
  - Mapping and Registration of Key Groundwater Sourc
  - Participatory Aquifer Mapping, including a recharge pi
  - Stakeholder database
- Phase 2: MANAGEMENT
  - Strategic recharge activities – concept of public recharge must have precedence over individual (privatised) recharge
  - Participatory Groundwater Management - efficiency, equity and sustainability
- Phase 3: GOVERNANCE
  - Regulatory framework
    - Securing Groundwater from impacts of Sanitation and Waste Disposal
    - Protection of Recharge Zones
  - Institutions that are organised around Urban Governance structures – mohallas, wards etc.

Local resources

Community participation

Governance – public trust doctrine

ACWADAM