Urban Groundwater
Sustainability, Recharge and Quality Challenges (in context of Delhi)

Webinar
Centre for Science and Environment
06-09-2022

Shashank Shekhar
Department of Geology
University of Delhi
Delhi-110007.

Challenges & aspects involved in managing the urban groundwater system

- Aquifer mapping, GW potential, delineation of aquifer heterogeneity and identification of potential aquifers for development of the groundwater resources.
- Mapping of the horizontal & vertical variations in groundwater quality.
- Identification of the anthropogenic and geogenic forcing in context of the water pollution.
- Vulnerability of the groundwater system to pollution under different stress conditions.
- Source sustainability.
- Augmentation of the groundwater reserve through recharge.

Urban groundwater Management involves

- Effective policy framework backed by rigorous scientific research
- Effective governance measures
- Sensitization of masses
- Peoples participation

Some conventional approach

- Demand side management and water conservation
- Supply side management
- Water resource augmentation

Demand side management & Water Conservation

- **Enhancing water use efficiency**

  Domestic sector: No showers, Shaving with a mug of water etc.

  Industrial sector: Value addition in cooling processes, condensate recovery etc.

  Agricultural sector: More crop per drop

- **Water efficient gadgets.**

  Bio-urinals, sophisticated cisterns, water efficient washing machines etc.

- **Water pricing, differential slab.**

  High end users to pay commercial rates

  All multistoried housing societies should have water meters in individual flats rather than water tariff being included in flat maintenance charges and high end users should pay more

Supply side management

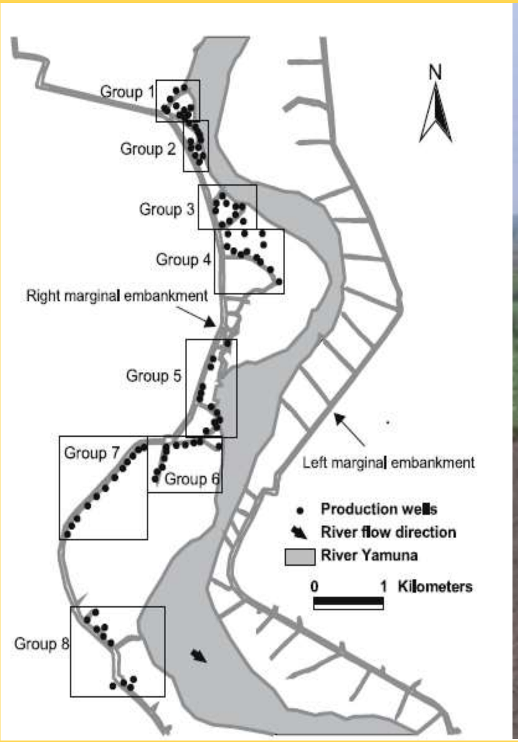
- Leakage and pilferage control
- Dual water supply, already adopted in many parts of Delhi and NCR. Still we need to implement ZLD colonies.
- All Industrial units to be ZLD and supplied with trated water for cooling, washing, mopping etc.
- Assured and timely water supply to avoid tap being left open phenomenon
- Supplying groundwater stressed area with surface water sources for domestic uses and diversion of surface water supply from groundwater rich areas (for example see Shekhar et al.2015).

Water resources augmentation measures

- Augmentation in River flow by ensuring e flow (Soni et al.2014).
- Conservation and rehabilitation of natural water bodies.
- Natural wetland conservation.
- Artificial water bodies and wetlands.
- Flood water harvesting.
- Treated sewage water.
- Rainwater harvesting and artificial recharge to groundwater system.
- Enhancement in flood Induced recharge to groundwater system in active flood plain of perennial rivers. Eg. Palla well field of Delhi - Peak flood water harvesting.

Groundwater supply from Palla well field of Delhi by harvesting flood water

(A success story of GW exploration based management plan by CGWB and its field implementation by a chain of CGWB scientists)



- Around battery of 100 T.W & 5 Ranney wells supplies GW to Delhi for drinking & domestic uses.

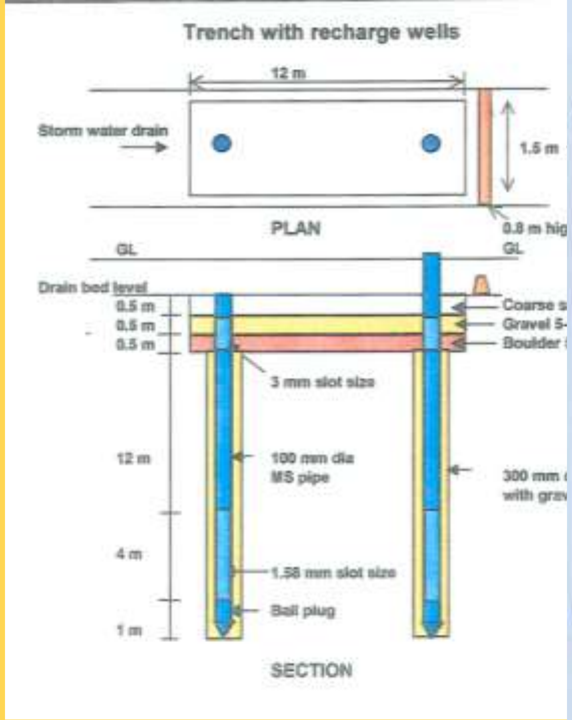
- By GW Hydraulic consideration, 100 T.W can yield around 40-45 MGD & 5 R.W about 9-10 MGD, still mutually agreed yield is ~30 MGD from both(after Shekhar & Rao 2010). (A recent study suggest sustainable yield as 60 MGD from the area by increasing the number of T.W?)

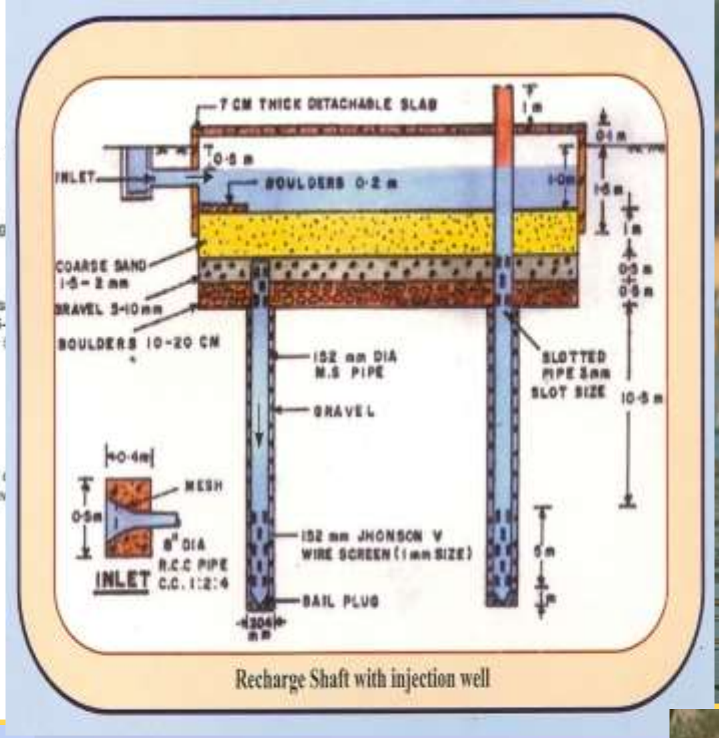
The Economics of Palla well field

- Annual water yield from Palla well field is about Rs. 750 crores/annum at commercial tariff of DJB

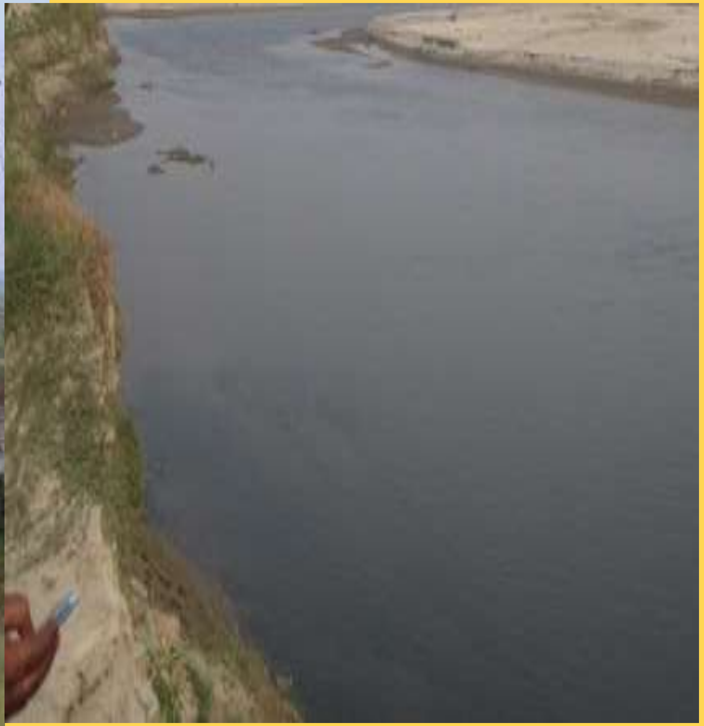
- From 2002 to 2022 for 20 years the well field has yielded water worth Rs.15,000 corers

- This is at a minimal capital investment






http://images.nationalgeographic.com/wpf/media-live/photos/000/132/cache/rivers04-ganges-india_13245_600x450.jpg



Water body rejuvenation
(example from Dwarka sub city of Delhi)

Kumar et al (Anon)

- An estimate says that revival of natural water bodies in Dwarka subcity would be able to harvest water enough to meet the drinking water deficit of the city

Managed Aquifer Recharge (MAR) & Soil Aquifer Treatment (SAT)

- The deliberate recharge of depleted aquifer storage and later recovery, known as managed aquifer recharge (MAR), is an important tool for water management and sustainability.

- SAT is a method that recharges appropriately treated wastewater through intermittent percolation in infiltration basins.

- Upcoming ideas of agricultural SAT, or Ag-SAT, as a combination of SAT and Ag-MAR.

Soil requirements

- Infiltration basins for SAT systems should be located in soils that are permeable enough to give optimal infiltration rates.
- This requirement is important where sewage flows are relatively large, where excessive basin areas should be avoided (due to land cost) and where evaporation losses from the basins should be minimized.
- The soils, however, should also be fine enough to provide good filtration and quality improvement of the effluent as it passes through.
- Thus, the best surface soils for SAT systems are in the fine sand, loamy sand, and sandy loam range. Materials deeper in the vadose zone should be granular and preferably coarser than the surface soils.
- Soil profiles consisting of coarse-textured material on top and finer-textured material deeper down should be avoided because of the danger that fine suspended material in the sewage will move through the coarse upper material and accumulate on the deeper, finer material.
- This could cause clogging of the soil profile at some depth, where removal of the clogging material would be very difficult.
- Vadose zones should not contain clay layers or other soils that could restrict the downward movement of water and form perched groundwater mounds.
- Aquifers should be sufficiently deep and transmissive to prevent excessive rises of the groundwater table (mounding) due to infiltration.
- Groundwater tables should be at least 1-2 m & preferably 10 m below the bottom of the infiltration basins during flooding.
- Above all, soil and aquifer materials should be granular.
- Fractured-rock aquifers should be protected by a soil mantle of adequate texture and thickness (at least a few metres).
- Shallow soils underlain by fractured rock are not suitable for SAT systems.

Limitations and risks that need to be addressed when implementing SAT

- **The need for a vadose zone at least 2 m in depth (EPA, 2004), ideally from 10 to 30 m .**

- **The need for specific hydrogeological conditions: high soil permeability for optimal effluent percolation (Silty sand, fine sand, loamy sand, and sandy loam).**

- **Leaching of matter form the sediments under reducing conditions, resulting in elevated impurity concentrations in recovered water (e.g., manganese, iron, fluoride etc).**

- **Excessive land area is required for infiltration basins, which may not be available especially in urban areas.**

- **These limitations and risks are related, either directly or indirectly, to a lack of air penetration in the SAT basin, resulting in anaerobic conditions in the soil.**

Limitations and risks that need to be addressed when implementing SAT

- SAT may be only a limited barrier for certain contaminants. There is potential of contamination of aquifers, in case of improper design and inadequate pre-treatment.

- Clogging of the infiltration basin, chemical precipitations etc are some of the limitations

Advantages of SAT & MAR

- **Reduction of evaporation rate & insect breeding.**
- **Natural buffer of seasonal variations in availability and demand, temperature etc.**
- **Underground storage/natural buffer, which has advantages in terms of public perception.**
- **Mitigation of saltwater or contaminant intrusion.**

Disadvantages of SAT & MAR

- **Risk of nutrient discharge into GW aquifer, if not sufficiently pre-treated.**
- **Space demand for infiltration basins limits urban applicability.**
- **Vulnerability to clogging.**
- **Dependency on pre-treatment steps.**

Most important pre & post conditions for SAT

- **Regular monitoring with respect to:**

  1. **Source water characterization.**

  2. **Infiltrated water characterization.**

  3. **Impact assessment and demarcation of the area of influence.**

Online continuous reporting of BOD, COD & DO of the water in the basin

- BOD (Biochemical Oxygen Demand): is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period (Source: https://en.wikipedia.org, accessed 15-07-18).

- **Chemical oxygen demand** (**COD**) : is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It assesses oxygen demand during decompositions of the organic matter and also oxidation processes like oxidation of ammonia and nitrites (Source: https://en.wikipedia.org, accessed 15-07-18).

- **Dissolved Oxygen (DO):** It is measure of the amount of gaseous **oxygen**(O2) **dissolved** in the water. This **Oxygen** either enters the water by directly from atmosphere or as a photosynthesis product of plants. Adequate DO ensures aquatic life.

(Source: http://www.mymobilebay.com/stationdata/whatisDO.htm, accessed 17-07-18).

Monitoring for Eutrophication

(Source: https://en.wikipedia.org, accessed 15-07-18)

- It refers to the condition of a water body when it becomes overly enriched with minerals and nutrients, which leads to excessive growth of plants and algae.

- It may result in oxygen depletion of the water body.

- "Eutrophication is triggered by the discharge of nitrate or phosphate-containing detergents, fertilizers, or sewage into an aquatic system".

Eutrophication in the Vaigai River of Madurai

(https://www.thehindu.com/sci-tech/energy-and-environment/worlds-freshwater-bodies-choked-with-phosphorus/article22716024.ece)

ALTERNATIVE SOURCES OF WATER SUPPLY FOR URBAN AREAS

- **Exploration and development of Brackish Water Aquifers**
- **Desalination of Saline Groundwater**
- **Treated domestic and Industrial waste water to the desirable level**
- **Recycle and reuse of water**

Source: (Shekhar et al.2009)

River water based supply: issues & challenges

- **River water based supply preferred over GW based supply by institutions:**

  Benefit of large volume at one place

  Economical vis-à-vis pipeline cost

  Ease of handling at centralized infrastructure

- **Issues with River water based supply**

  Huge infrastructure cost in sourcing raw water

  Mandatory water treatment & Recurring cost

  Raw water quality vulnerable & variable

  Monsoon dependent

GW supply issues & challenges

➢ Where GW supply has advantage

I. Hardly any treatment is required

II. It gives insitu local soultion

III. Source can be planned near to demand site

IV. Disaster mitigation resource

V. Not easily vulnerable to contamination

➢ Issues with GW based supply

I. Small volume per unit TW, so well field?

II. A few tubewells not economical vis-à-vis pipeline cost

III. Limitations of the GW sources

Where the conventional management practices lacked?

- It was focused mostly on managing only water resources and too much sector specific.
- It was centered around tops down approach.
- Highly technical lacking concrete sociological and ecological integration.
- Forgot to see the inter linkages of the water resources with other aspects (land, equity, environment etc.).
- Thus the need for Integrated water resources management was proposed as a superior alternative development paradigm

INTEGRATED WATER RESOURCES MANAGEMENT

(United Nations Declaration)

- It requires application of an integrated approach to develop, manage and use water resources.

- It proposes water resources management in environmental, ecological, socio economic and political perspective.

- The question is than integration of what with the water resources management practices and what are the broad objectives.

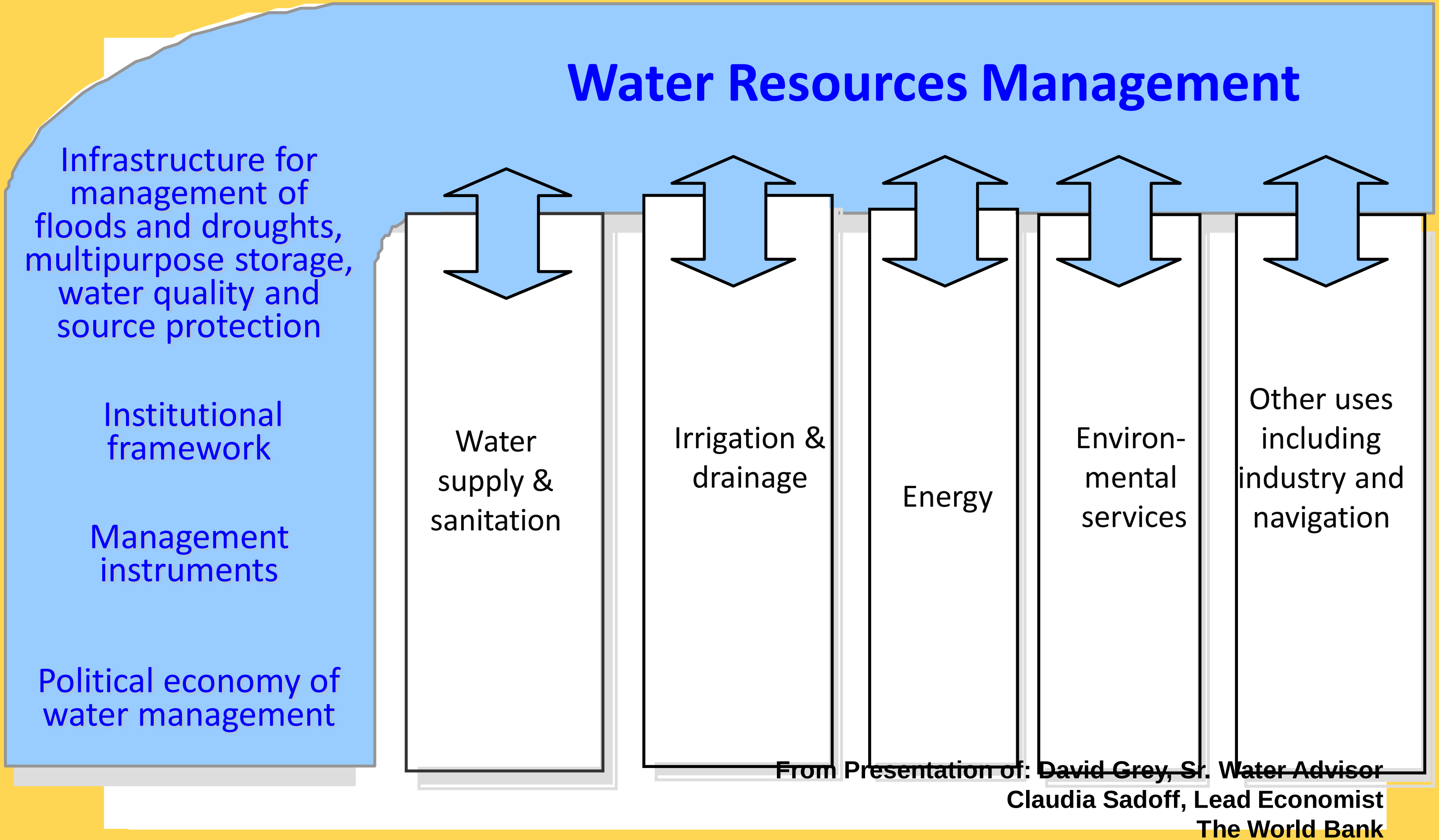
Broad Objectives of the Integrated Water Resources Management

- Economically viable and efficient utilization of the water resources.
- Equitable distribution of the water resources.
- Environmentally sustainable exploitation of the water resources.

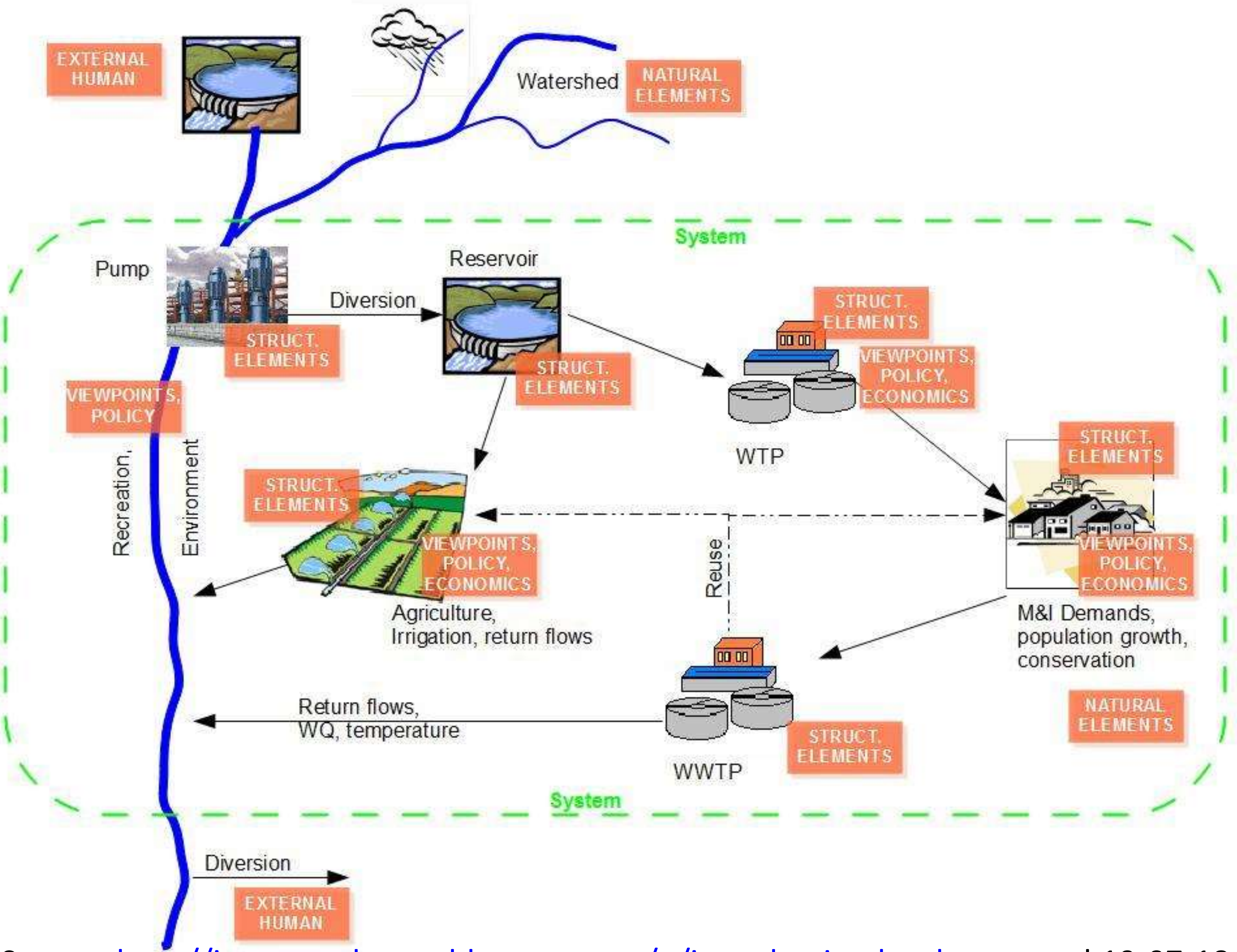
Integration of what? & the additional perspective In integrated water resources management

- Land Resources and crop farm management.
- Environment management.
- Water economics.
- Water rights.
- Water governance.
- Waste water cycle.
- Source sustainability.
- Conjunctive use of surface and groundwater in the best possible way.
- Paradigm shift from tops down to bottoms up approach.
- Planning at basin level
- Industrial water management and so on to make it a holistic list.
- To sum up integration of everything and anything which has some or other, direct or indirect linkage with the water resources sector.

Water Resources – Many Uses, Many Users …



From Presentation of: David Grey, Sr. Water Advisor
Claudia Sadoff, Lead Economist
The World Bank



Source: http://integratedwater.blogspot.com/p/introduction.html, accessed 19-07-18

Water quality challenges

The drastic and apparently visible anthropogenic alteration to water quality is mostly an urban phenomenon

A brief glimpse in to it

Water quality in urban perspective

- Water quality for domestic uses.
- Water quality for industrial uses.
- Water quality for horticultural uses.

Sources of groundwater contamination and pollution in urban areas

- Seepage from septic tanks, sewer lines, sewer collection points.
- Leakage from landfill sites.
- Chance leakage from STPs, ETPs.
- Infiltration of contaminated/ polluted surface runoff from industrial establishments, landfill sites etc.
- Leaks from storage tanks (especially hydrocarbons?), pipes.
- Untreated or partially treated effluents? Malpractices?
- Issue of excess nutrients in water bodies

Emerging pollutants

(Not generally monitored)

- Pharmaceuticals
- Personal and beauty care products
- Pesticides & Insecticides
- Industrial and household chemicals
- Industrial additives and solvents
- Micro plastics

Many of these pollutants are known to have adverse effect on hormonal secretions, body resistance and overall ecology .

The central agencies need to initiate thematic study on these issues

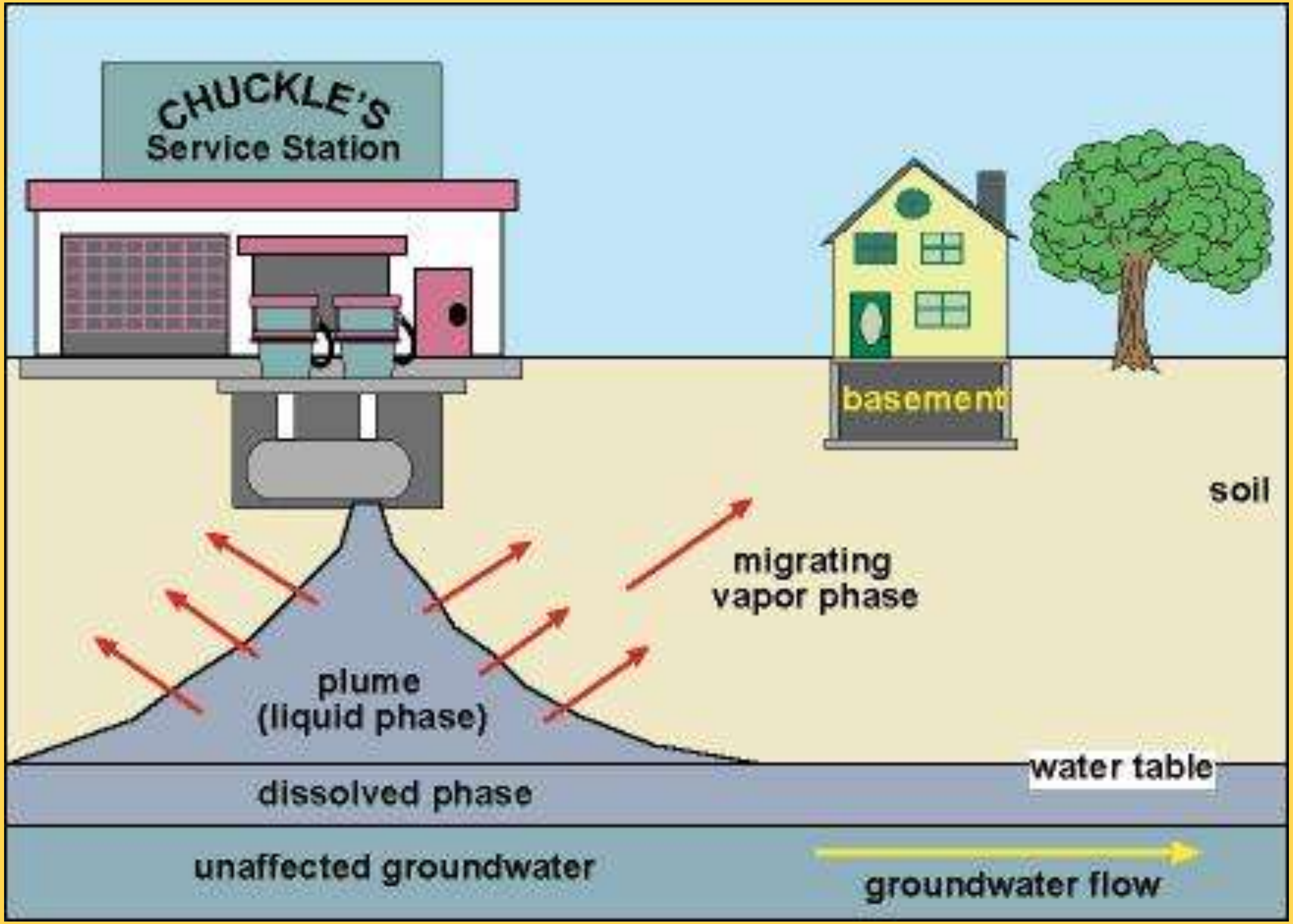
With input from: https://en.unesco.org/waterquality-iiwq/wq-challenge; accessed 19-03-2019

Landfill leachates

(Source: http://leachate.blogspot.com/p/what-is-leachate-landfill-leachaet.html, accessed 15-07-2018)

Leakage from underground tanks

(Source: https://www.coastalreview.org/2016/07/15371/, accessed 15-07-2018)



Way forward (Urban areas)

- Regular assessment of urban water quality.
- Intensification of water quality assessment in critical areas.

DOMESTIC SEWERAGE

- Bottoms up approach in sewer treatment.
- Decentralization of sewer treatment together with intensification of bulk treatment.

    ZLD colonies and Housing societies.
    STP for each feeder drain and major main drains .

- Lining of drains.
- Zero tolerance to non functional STPs.
- Optimal utilization of STPs.

RECYCLE AND REUSE OF TREATED WASTE WATER

- Proper timely cleaning and water proofing of septic tanks.

Way forward (Urban areas)

INDUTRIAL EFFLUENTS

- ZLD for hazardous industry.
- ZLD endeavor for all industrial units.
- Daily monitoring of CETPs and zero tolerance to their malfunctioning.
- Provision for alternate facility in case of major breakdown in CETP.
- Strict monitoring and punitive measures for non compliance.
- Incentives to green units.
- Facilitation of Project based micro level pollution studies in industrial areas and near petroleum product storage subsurface tanks by academic institutions without any collaboration with industries.

Landfill sites

- Proper site selection, pollution prospects should be an important criteria.

- Scientific design.

- Regular monitoring.

- No over use.

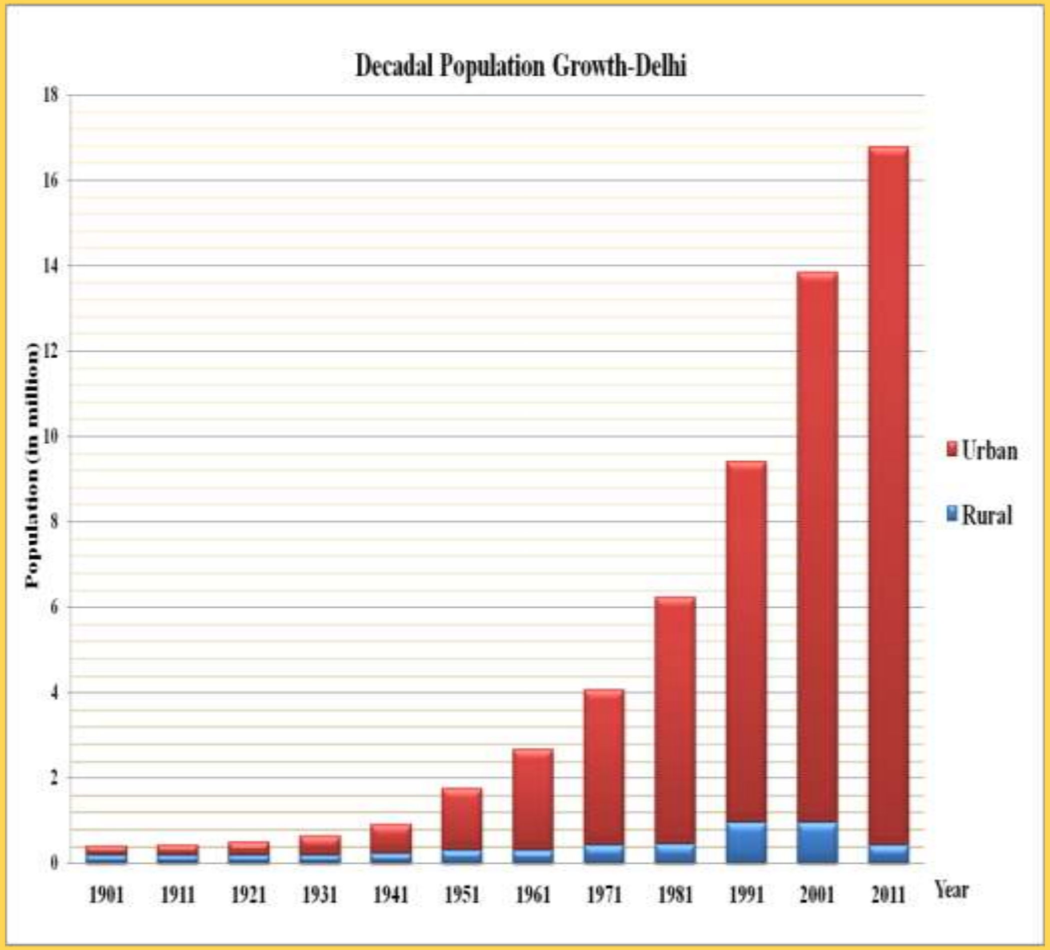
Water Resources of Delhi

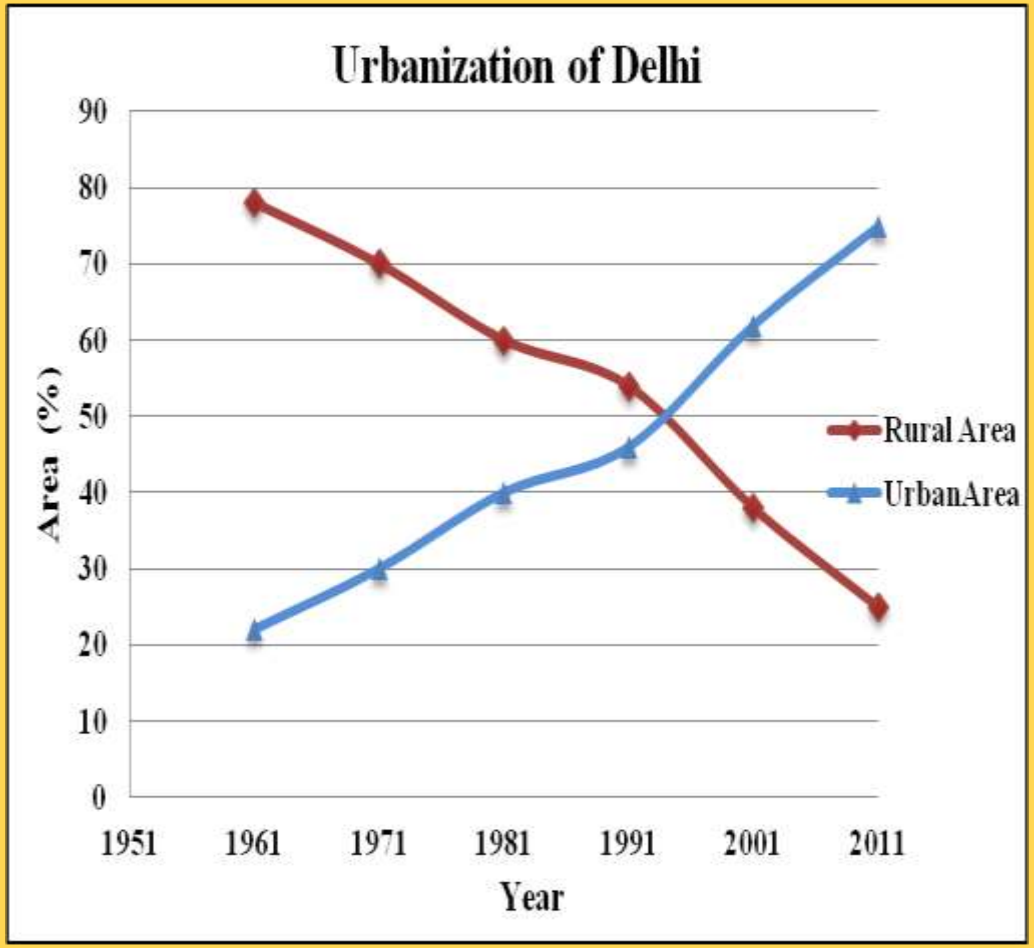
Water resources of Delhi

(As per water policy of Delhi)

- Surface water [Sources: chiefly Yamuna sub-basin, Ganga and Indus Basins]
- Potential surface water sources from proposed dams in the high Himalayas ?
- Ground water aquifers especially in alluvial formations
- Treated wastewater [increases commensurately with supplies]
- Rainwater
- Let us add : Lake/Pond water

Population growth and Urbanization of Delhi
(*The most important variable in water security*)





Source: Sarkar Aditya, Ali Shakir, Kumar Suman , Shekhar Shashank, Rao SVN. 2016. Groundwater Environment in Delhi, India in book Groundwater Environment in Asian Cities: Concepts, Methods and Case Studies, Ed. S Shrestha; V Pandey; B R Shivakoti; S Thatikonda, Elsevier Inc. 77-108.

Current water demand & supply scenario

- Delhi Jal Board has projected the water demand for year 2017 as 1140 MGD, for 2022 it may be 30 to 40 MGD more, say 1170 MGD
- Total present production by DJB is ~ 1000 MGD
- Considering line loss @ 20% (CGWB 2021)
- The water reaching stakeholders ~ 800 MGD
- So a deficit of ~ 370 MGD

[CGWB (2021). Dynamic Ground Water Resources OF NCT, Delhi, as on March 2020, Report, Central Ground Water Board, New Delhi]

What will be the final call on water demand & supply scenario of Delhi?

- Delhi's population may be assumed to stabilize at a maximum of 27 million by 2031 (Water policy of Delhi, 2016)
- The projected water demand for 27 million population would be around: 1332 MGD.
- Total present production by DJB is ~ 1000 MGD
- Considering line loss @ 20% (CGWB 2021)
- The water reaching stakeholders ~ 800 MGD
- So a in about a decade the deficit would be ~ 532 MGD
- We require planning to augment the water availability by ~532 MGD in a decade?

TOUGH TASK!

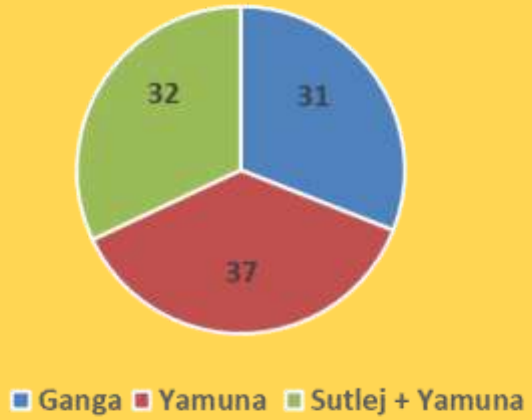
{ Cost of Munak 102 Km parallel lined concretized canal from Munak to Haiderpur to save 80 MGD water loss by seepage was about Rs.545 crores in 2013, then from Haiderpur to Okhala, Bawana and Dwarka WTP additional about a 1000 crores }

DJB's RAW WATER SOURCES AND WATER PRODUCTION

S.No.	Name of WTP	Installed Capacity of WTP (in MGD)	Average Production (in MGD)	Source of Raw Water
1	Sonia Vihar	140	140	Upper Ganga Canal
2	Bhagirathi	100	100	Upper Ganga Canal
3	Chandrawal I & II	90	95	River Yamuna
4	Wazirabad I, II & III	120	123	River Yamuna
5	Haiderpur I & II	200	210	BhakraStorage & Yamuna
6	Nangloi	40	40	Bhakra Storage
7	Okhla	20	20	Raw water from Munak Canal
8	Bawana	20*	15	
9	Dwarka	50*	40	
10	Recycling Plants	45	40	Process waste water in the existing plants
11	Ranney wells & Tube wells	80	80	Ground Water
	Total		900 MGD	

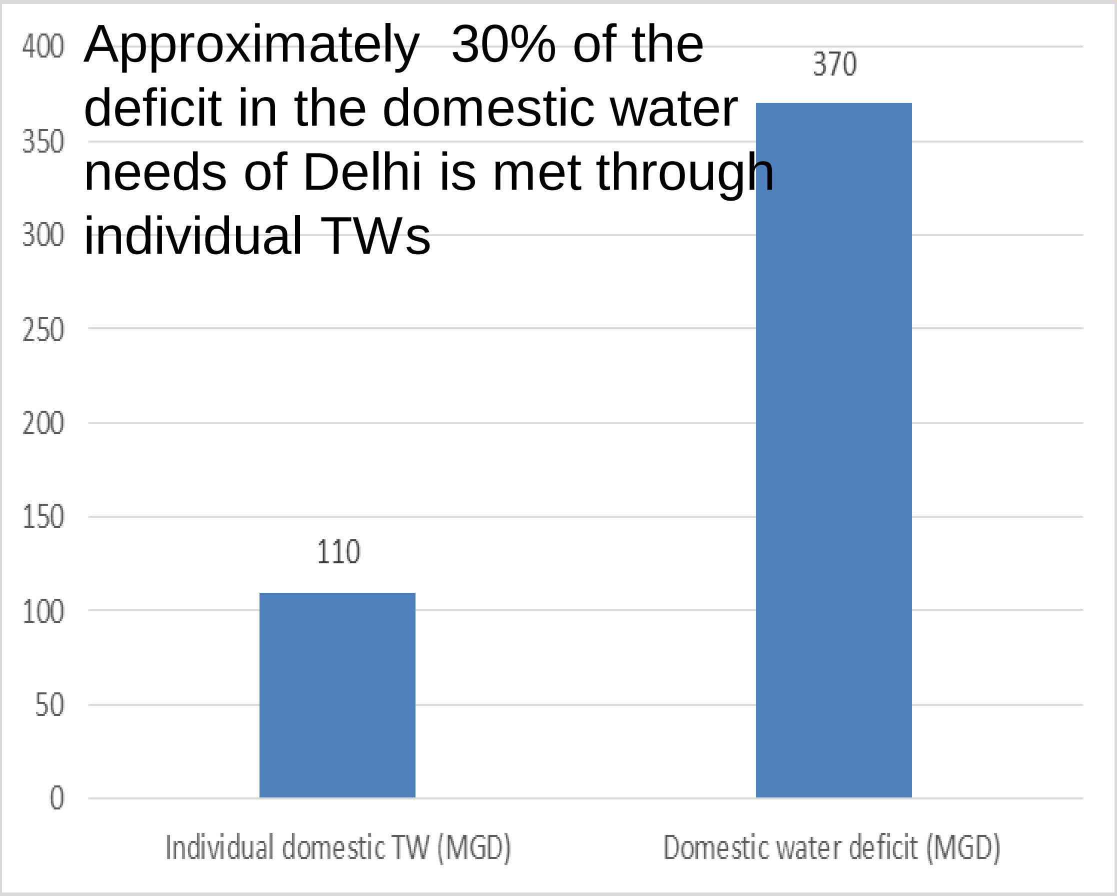
Source: DJB

- 9 % is GW contribution in DJB water production
- 87% (783 MGD) is River water contribution



- 4% is recycled water contribution
- These figures are only DJB production, they do not include water production at individual level (domestic/irrigation), industrial uses etc.

Individual GW extraction for domestic uses (CGWB 2021)



- Total GW extraction for the domestic uses (110+80=190 MGD)
- ~20% of the total water production by DJB
- ~16% of the water demand of 2022

[CGWB (2021). Dynamic Ground Water Resources OF NCT, Delhi, as on March 2020, Report, Central Ground Water Board, New Delhi]

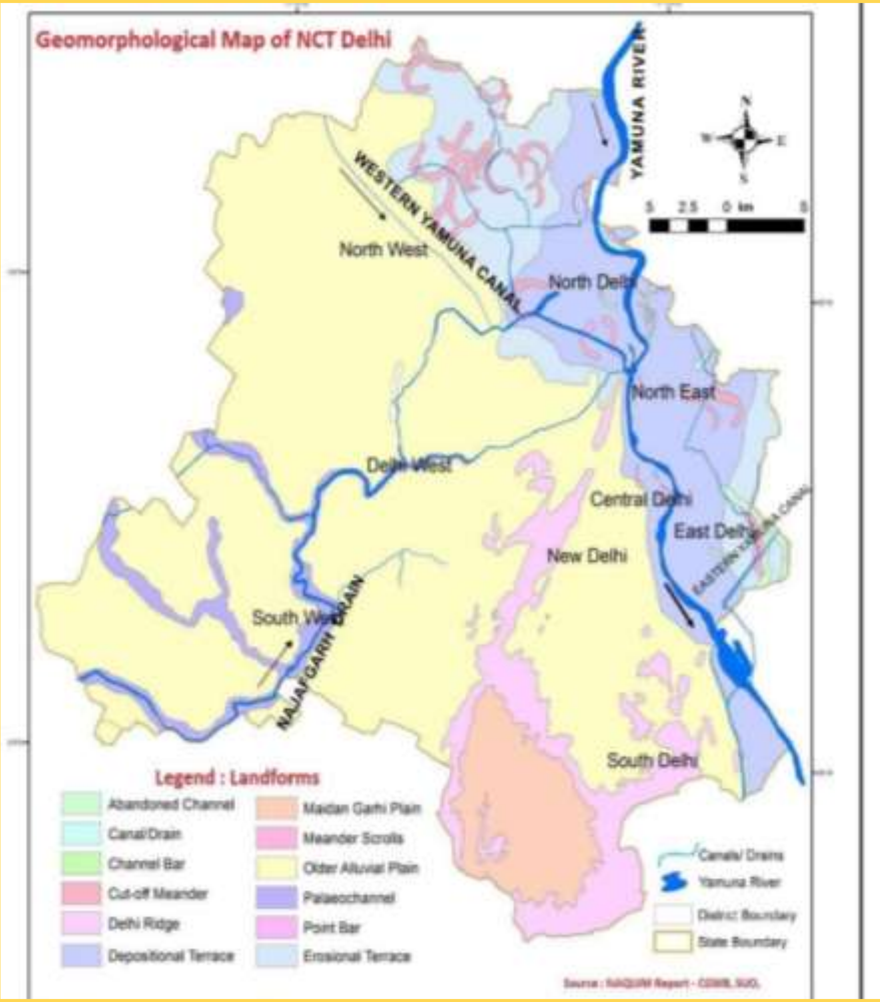
GW extraction for industrial & irrigation uses (CGWB 2021)

Irrigation Annual (Ham)	Irrigation Annual (MG)	Irrigation (MGD)	Industrial Annual (Ham)	Industrial Annual (MG)	Industrial (MGD)
7183.62	15801.75	43.29248	3660	8050.874	22.05719

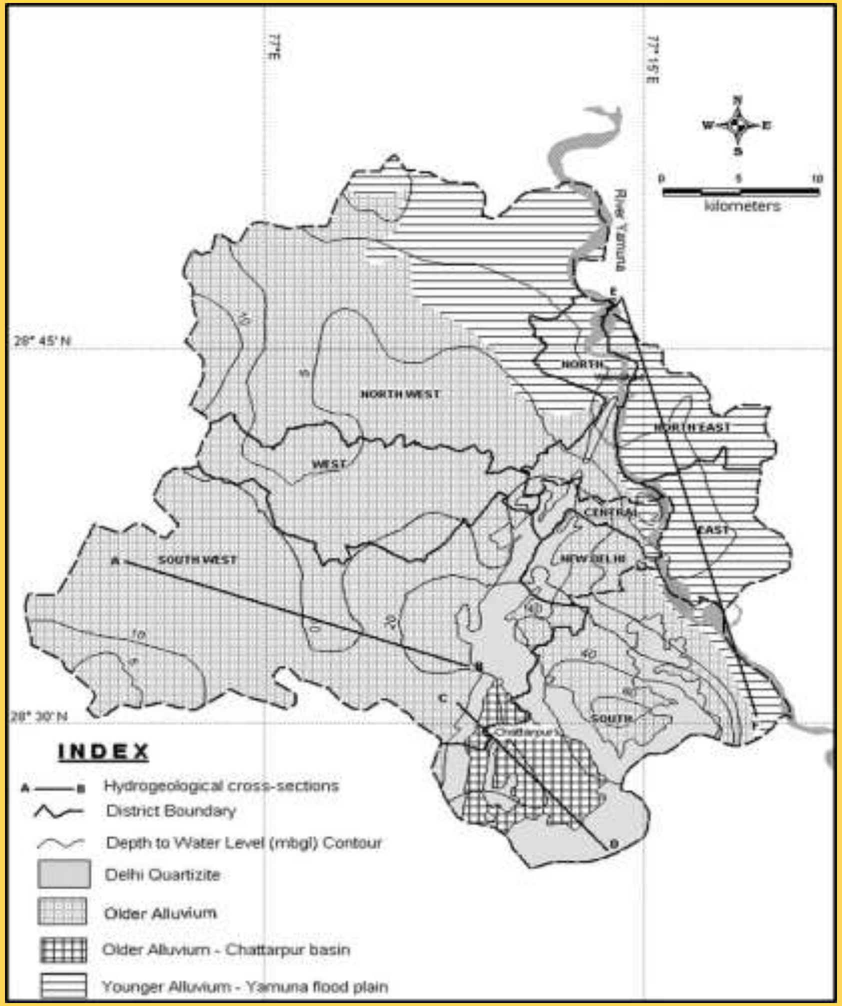
A LOOK AT THE GROUNDWATER OF DELHI

Geomorphological & Hydrogeological map of Delhi

Geomorphological map
(CGWB 2019-20 GW Year book of Delhi)

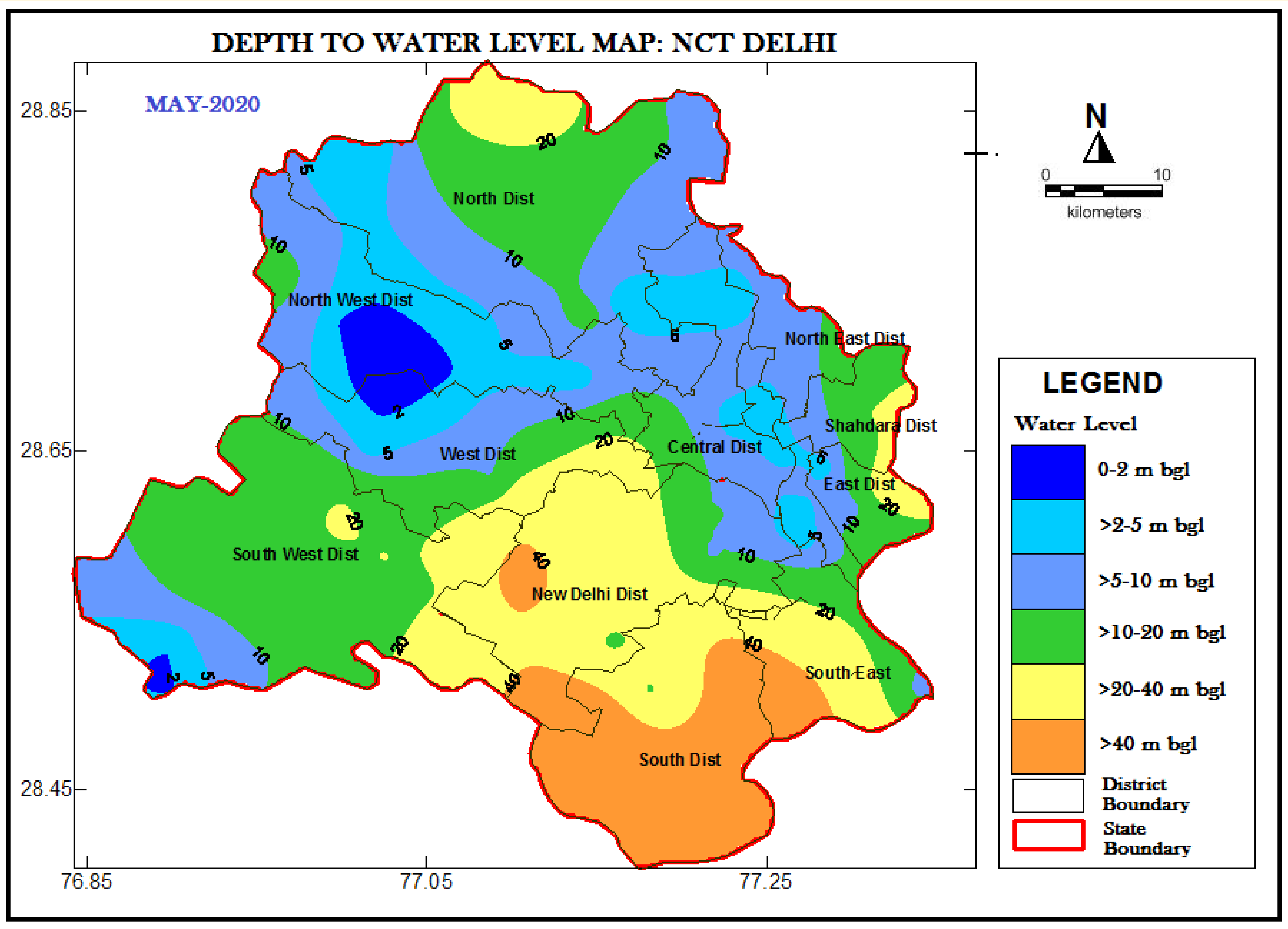


Hydrogeological Map, Delhi
(Chatterjee et al 2009)



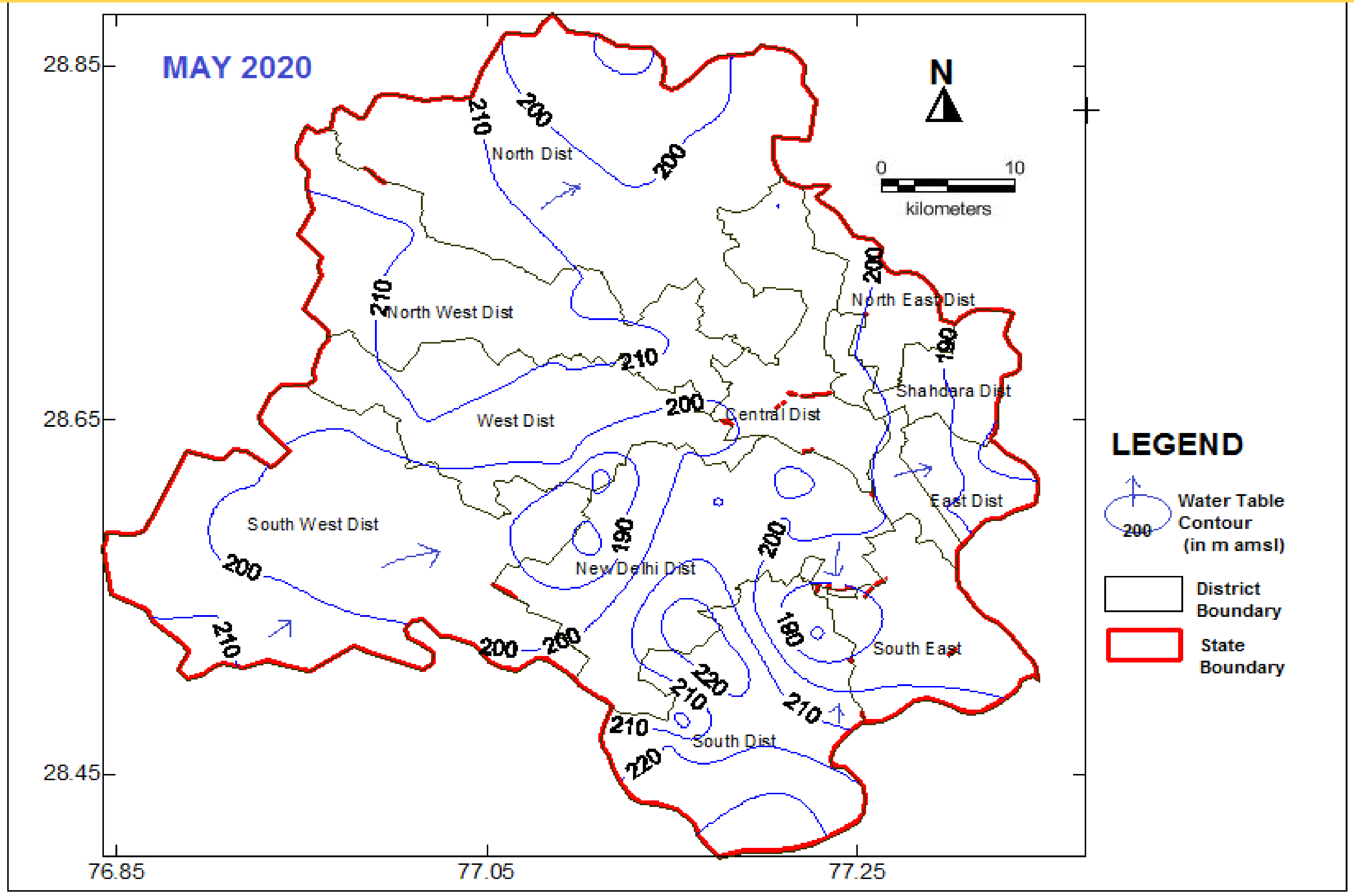
Chatterjee, R., Gupta, B.K., Mohiddin, S.K., Singh, P.N., Shekhar, S. and Purohit, R., 2009. Dynamic groundwater resources of National Capital Territory, Delhi: assessment, development and management options. *Environmental Earth Sciences*, *59*(3), pp.669-686.

Source: CGWB 2020-21 GW Year book of Delhi

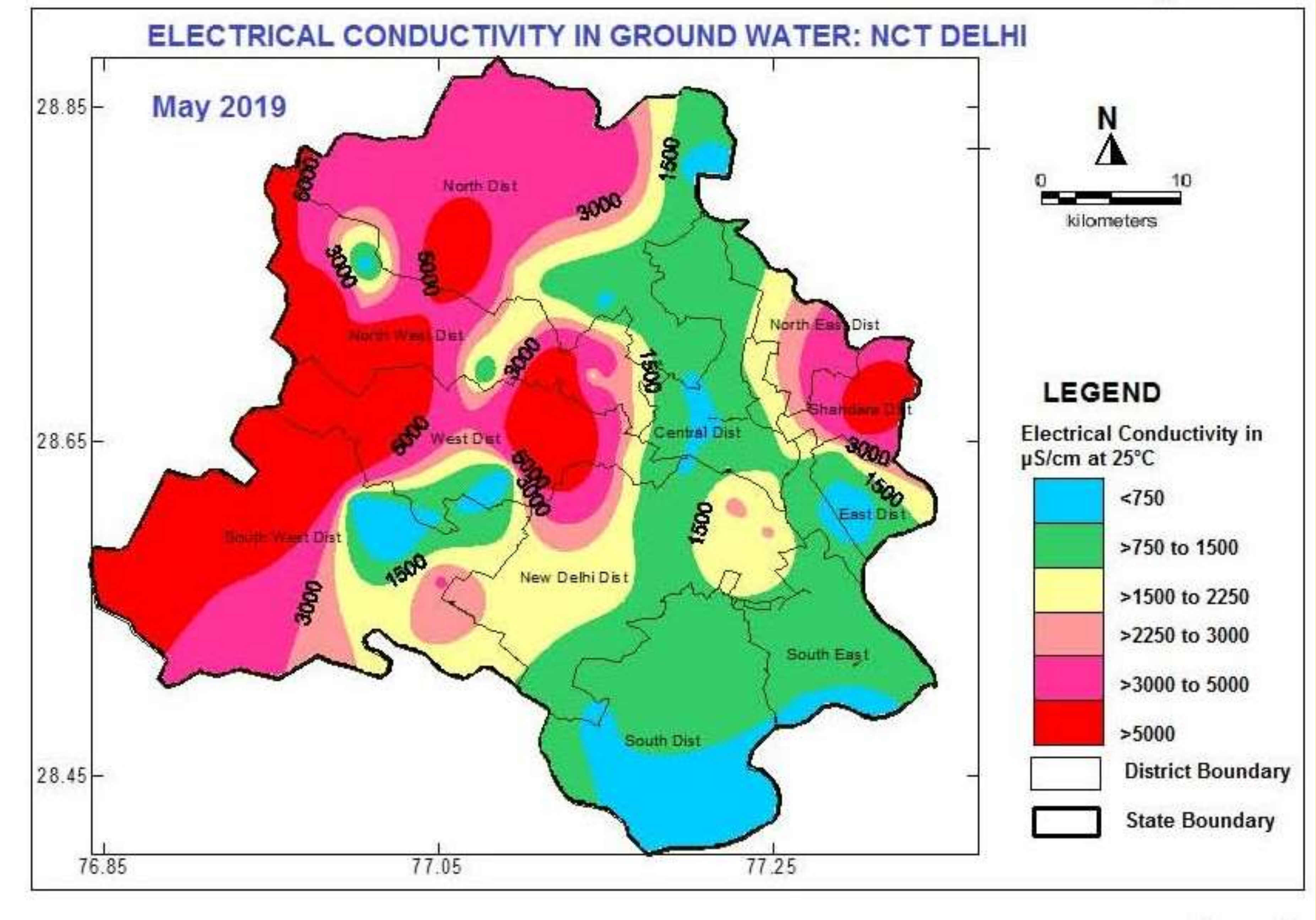


Depth to water level May 2019

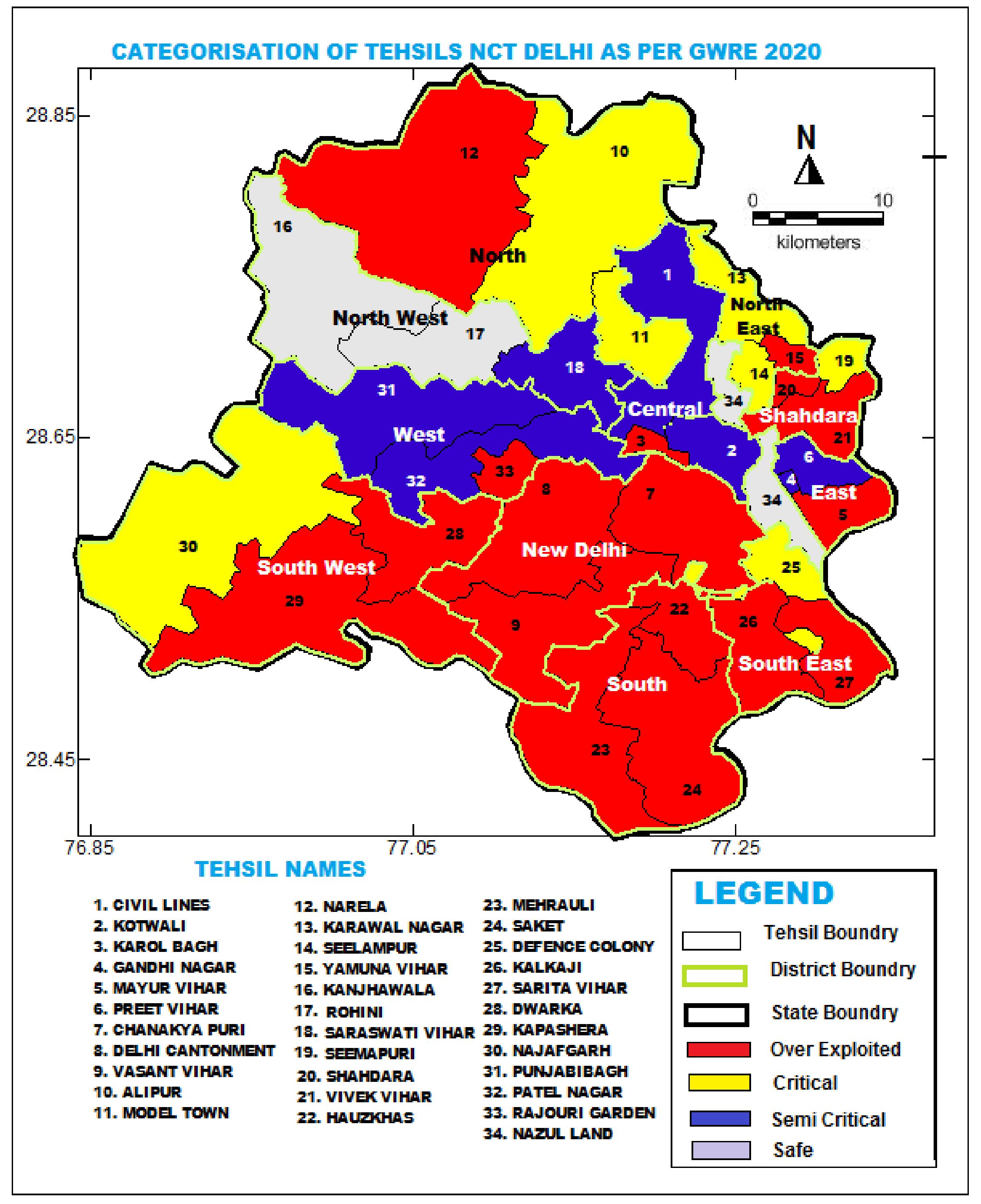
Water table contours

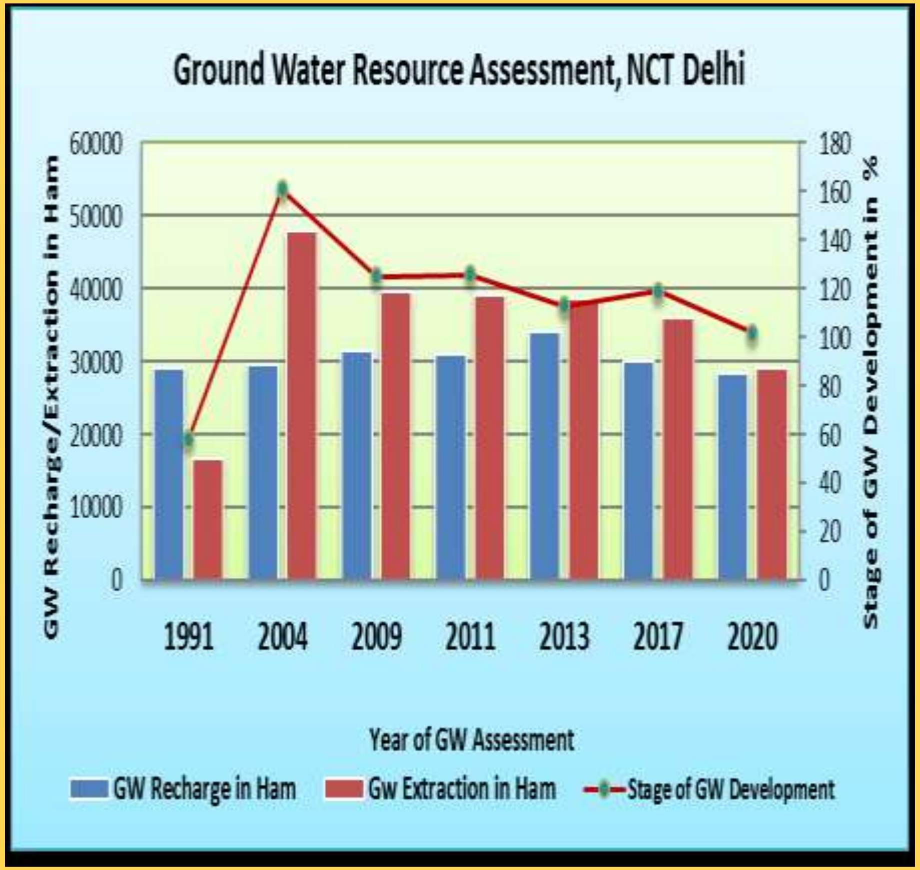


Source: CGWB 2019-20 GW Year book of Delhi



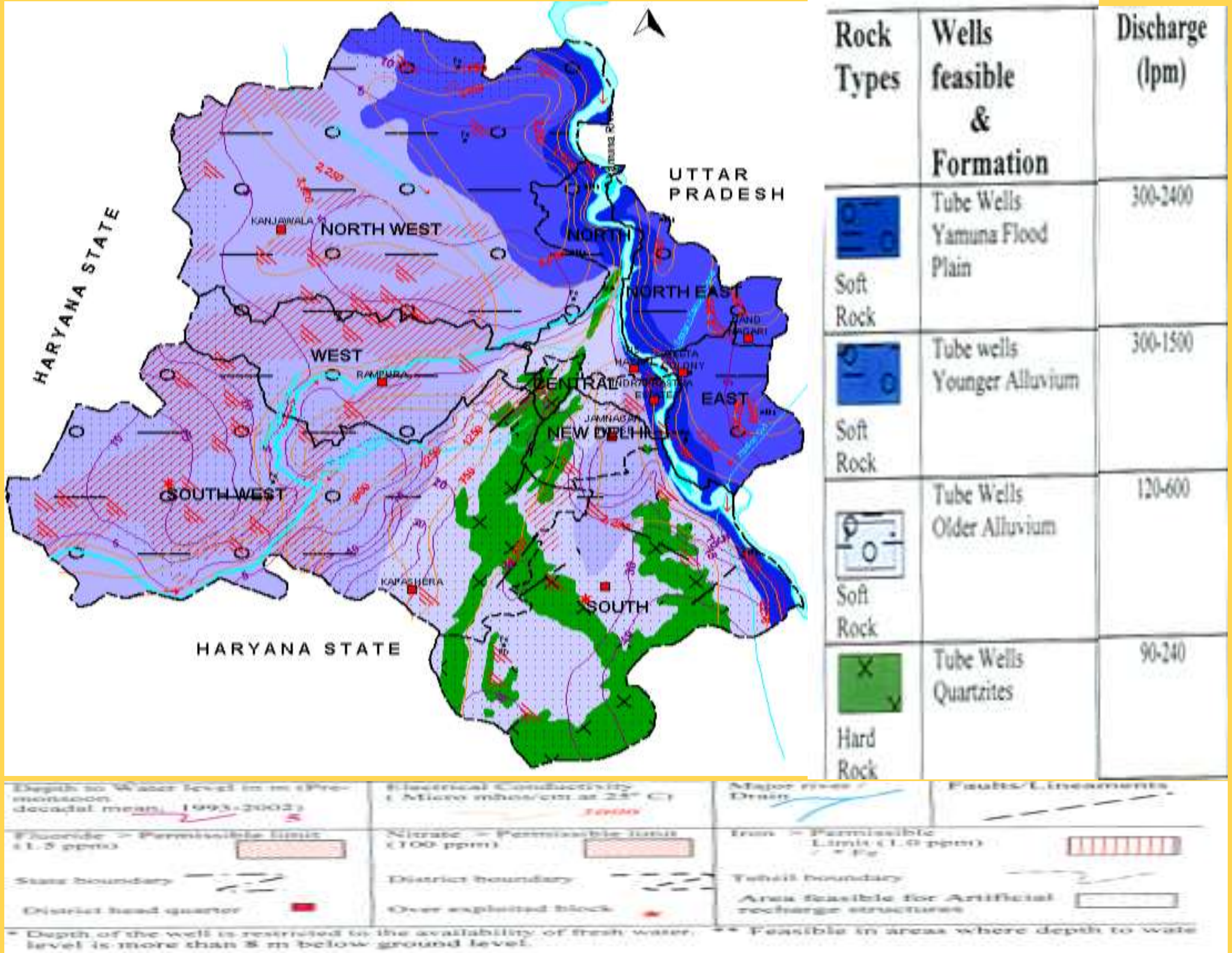
DYNAMIC GROUND WATER RESOURCES OF DELHI



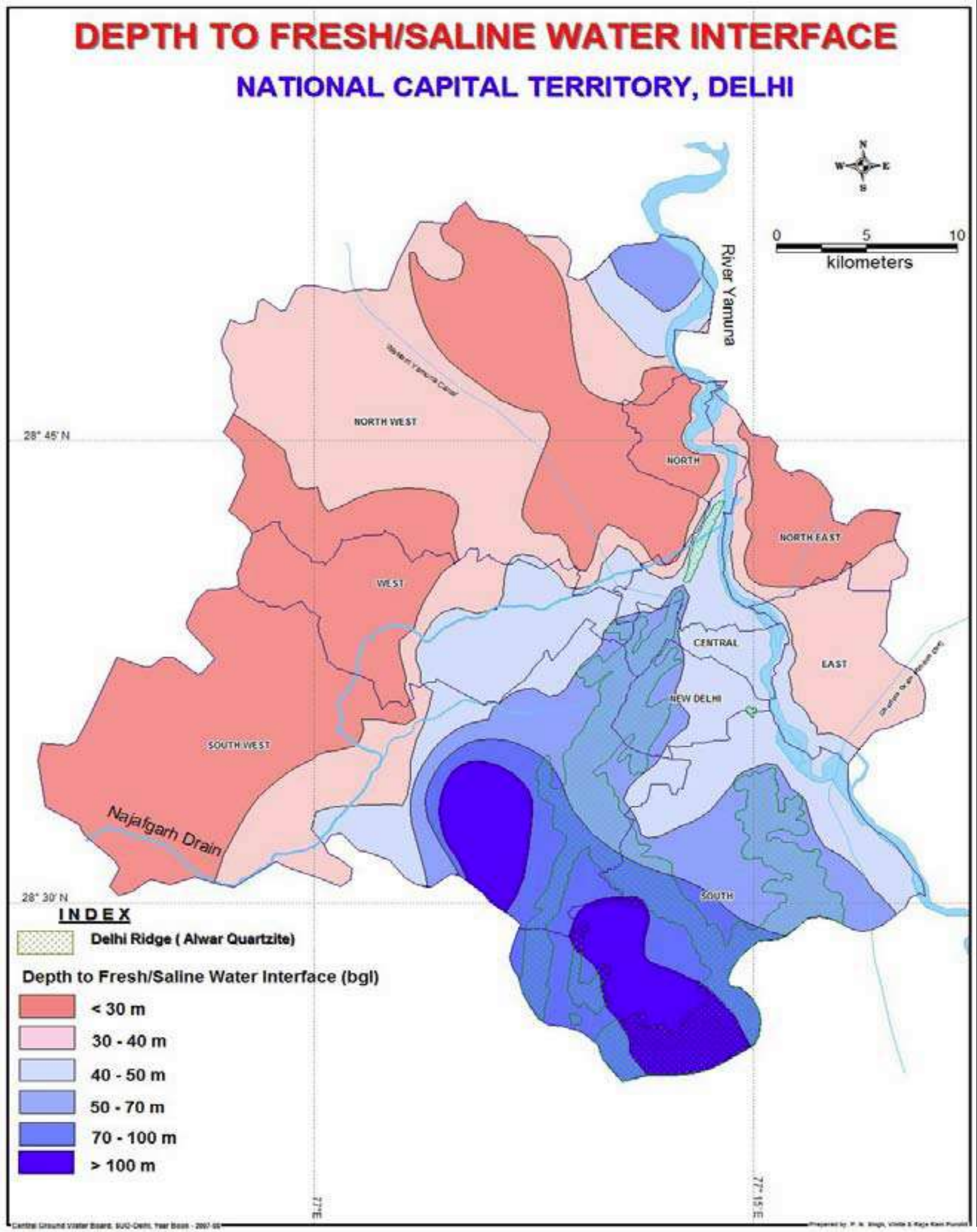


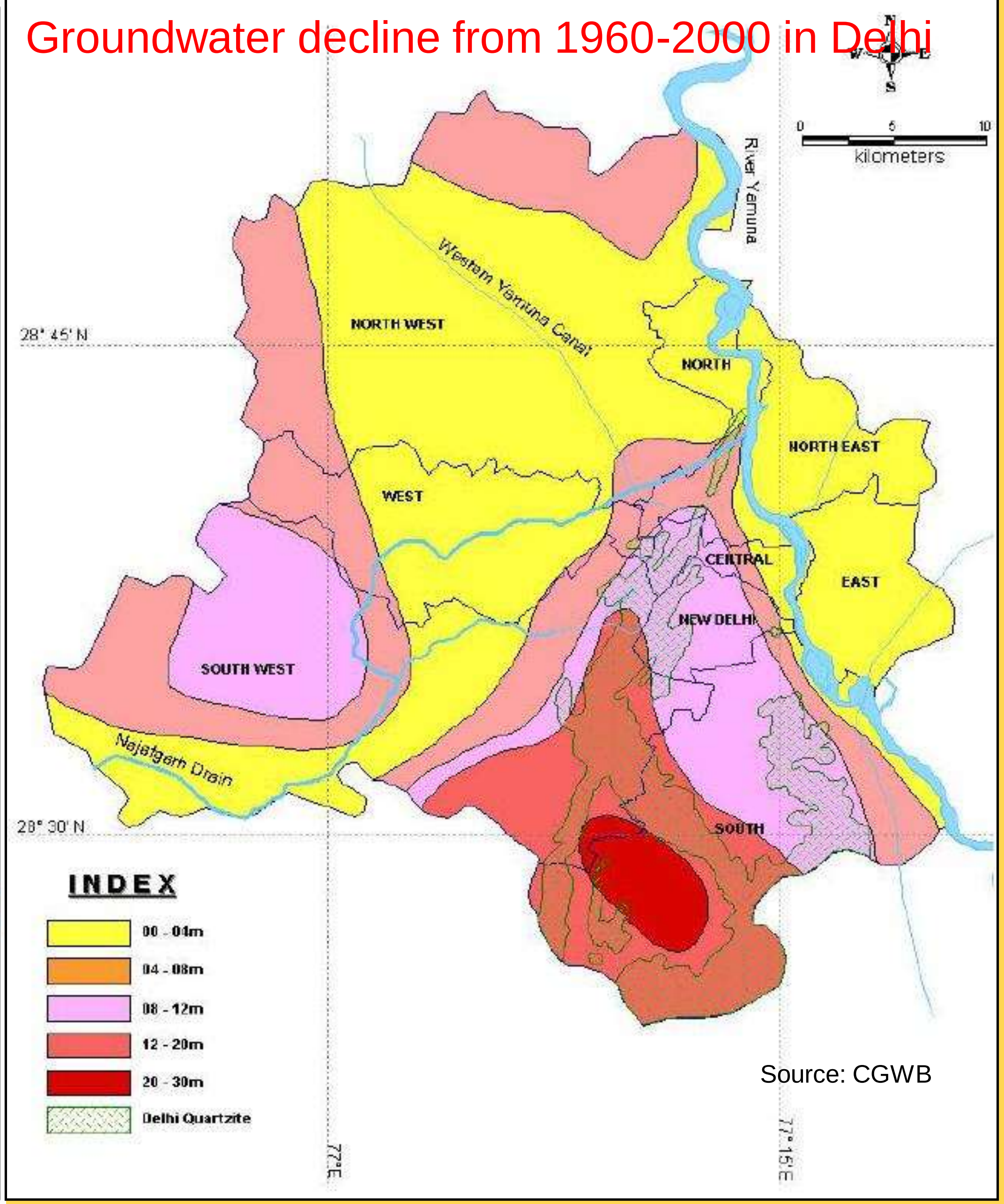
SOURCE: REPORT, DYNAMIC GROUND WATER RESOURCES OF NCT, Delhi
(As on March 2020)
Central Ground Water Board, Delhi.

Ground Water User Map of NCT Delhi
Gupta & Shekhar (CGWB Atlas)



Older alluvium has limited groundwater potential and is constrained by groundwater quality issues(Chatterjee et al 2009, Shekhar et al 2009, Shekhar and Sarkar 2013)





Shekhar et al (2009): http://cgwb.gov.in/documents/papers/INCID.html

Source: Sarkar Aditya, Ali Shakir, Kumar Suman , Shekhar Shashank, Rao SVN. 2016. Groundwater Environment in Delhi, India in book Groundwater Environment in Asian Cities: Concepts, Methods and Case Studies, Ed. S Shrestha; V Pandey; B R Shivakoti; S Thatikonda, Elsevier Inc. 77-108.

Water supply type areas of Delhi

1.High density multistoried societies:

Requires good volume of water supply and the premises aquifer's aerial extent can not sustainably meet it. So it needs either piped surface or groundwater supply from nearby areas. Often small supply deficit met through local tubewells.

2. Lowrise widely spread urban sprawls:

Requires good volume of water supply but the urban sprawl's aquifer extent is pretty good. If it is judiciously managed, the aquifer can sustainably either meet the demand or substantially fulfil the demand supply gap. A good portion of individual and DJB tubewells supply water here.

Water supply type areas of Delhi cont

3. Urban villages in rural belts:

   Requires relatively small volume of water supply. Localities are scattered. So mostly supplied by groundwater and if convenient through treated surface water. Good number of individual ownership of tubewells.

4. Recently regularized unauthorized colonies:

   Requires relatively small volume of water supply. Localities are scattered. So mostly supplied by groundwater. Good number of individual ownership of tubewells.

5. Unauthorized colonies:

   Requires relatively small volume of water supply. Localities are scattered. No institutional supply, only individual tubewells to meet water demand and private tankers.

Way forward

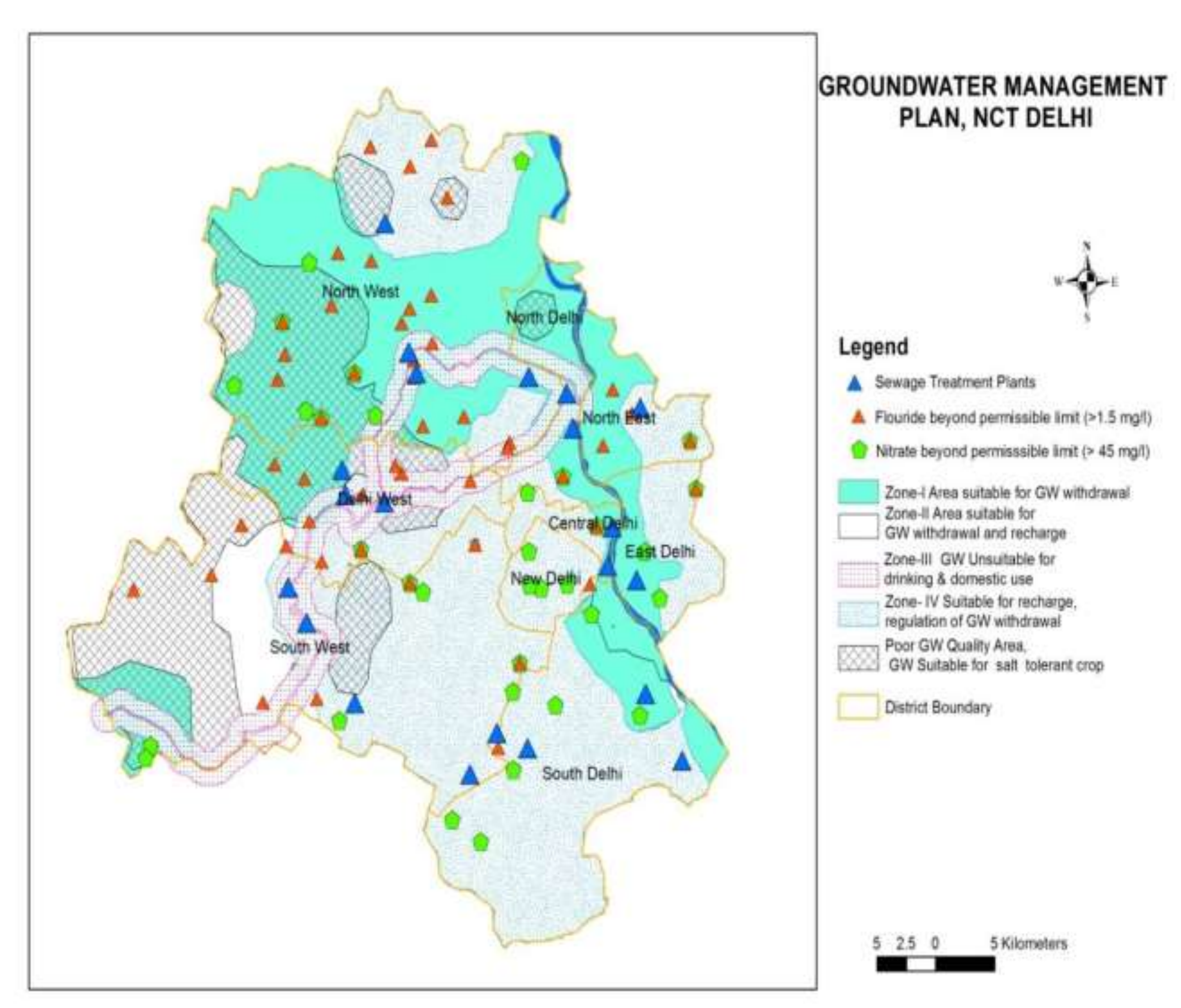
Planning to meet the projected demand of 530 MGD and the limitations

Seasonal Allocation of Yamuna Waters

Unit	July-October	November-February	March-June	Annual
MCM	580	68	76	724
MGD	1063	125	139	
All season present utilization of direct Yamuna River water by Delhi: 210 MGD				

- So except for the monsoon season allocation, we have no scope for utilization of the River Yamuna water.
- The Challenge is how to store the monsoon river flow for gainful utilization in the lean period.
- Also, under the Upper Yamuna Agreement Delhi is also bound to return 250 MGD of treated effluent into the river between Wazirabad and Okhla barrage.

Future scope of utilization of the groundwater in Delhi



CGWB (2016) Aquifer mapping and ground water management plan of NCT Delhi, Report, Central Ground Water Board, Delhi.

- Groundwater potential in zone-1 excluding active YFP: 120 MCM, assuming it to be yearly availability, it comes to be ~ 70 MGD

(Best suited for individual development and scattered need based augmentation by DJB)

- Besides existing Palla well field 30 MGD extraction, CGWB estimates additional potential from the remaining flood plain ~ 55 MGD.

- On the basis of WAPCOS study, scientifically designed and managed well field creation and operation may increase the additional YFP potential from ~55 to ~130 MGD

- At the best, additional groundwater potential of Delhi is only about 200 MGD.

Groundwater supply from Palla well field of Delhi

(A success story of GW exploration based management plan by CGWB and its field implementation by a chain of CGWB scientists)

•Around battery of 100 T.W & 5 Ranney wells supplies GW to Delhi for drinking & domestic uses.

•By GW Hydraulic consideration, 100 T.W can yield around 40-45 MGD & 5 R.W about 9-10 MGD, still mutually agreed yield is ~30 MGD from both(after Shekhar & Rao 2010). (A recent study suggest sustainable yield as 60 MGD from the area by increasing the number of T.W?)

Judicious utilization of the flood plain resources

Future role of groundwater in the water security of Delhi

- On a lumpsum basis, a scientifically managed and appropriately designed well field in 25 sq Km of Palla well field can yield about say 40-50 MGD on sustainable basis

- So a suitably managed about 100 sq Km of the flood plain can yield about 160 to 200 MGD towards water security of Delhi

- This adds up 130 to 170 MGD over and above 30 MGD present supply from the Palla well field

The aquifers of Delhi continued

- **Extrapolating the Palla economics, at the commercial tariff of DJB, each square kilometers of the YFP can yield water worth Rs.30 crores per annum.**

- **So it is wise to protect and conserve the flood plains.**

- **To arrest the declining water levels and sustain the groundwater supply from the safer aquifers, we need to adopt RWH & AR. Surplus runoff available for GW recharge in Delhi is ~95 MCM (Revised CGWB (2020) Master plan for AR to GW in India) and it should be gainfully utilized.**

- **The best approach would be conservation and rejuvenation of the about 1000 water bodies of Delhi.**

- **Any effort at creation of artificial water bodies should be scientifically designed and focused in the over exploited tehsils of Delhi with groundwater levels at least below 8 mbgl, otherwise the water body will not be useful for GW recharge.**

Now the question: How to source about 530 MGD of water in coming 8-9 years

- No further scope from the present day River Yamuna
- Kisau-Renuka-Lakhwar dams have environmental issues, water from them might not be possible
- Maximum available from GW ~ 200 MGD
- For remaining 330 MGD, the only hope lies in treated sewer water over and above 250 MGD, which Delhi is bound to return into the river between Wazirabad and Okhla barrage.
- We have 600 MGD (Present STP capacity)- 250 MGD = 350 MGD of treated waste water

WASTE WATER TREATMENT PLANTS

S.No.	Name of Plant	Capacity (in MGD)
1	Okhla	140
2	Keshopur	72
3	Coronation Pillar	30
4	Rithala	80
5	Kondli	70
6	Vasant Kunj	5
7	Yamuna Vihar	35
8	Pappankalan	40
9	Narela	10
10	Najafgarh	05
11	Mehrauli	05
12	Delhi Gate Nallah	17.2
13	Dr.Sen Nursing Home	2.2
14	Rohini	15
15	Nilothi	60
16	Commonwealth Games Village	01
17	Molarband	0.66
18	Kapashera	05
19	Chilla	09
20	Ghitorni	05
	TOTAL	607 MGD

530 MGD of water in coming 8-9 years can be sourced from YFP aquifers and treated sewer water

- Future of water security lies in groundwater of the flood plains and the waste water of Delhi
- However the operation of CETPs & ETPs are a challenge and needs to be addressed
- Society level STPs needs regular third party monitoring and so does DJB STPs
- Let us work with the available options

Some suggestions to Architects & Planners for water positive approaches

- Park with pond: source of may be diverted storm & suitable STP water.

- The local depressions in the natural landscape may be identified and the designed landscape should maintain the water ways for the local depression which can be developed as a pond surrounded by park.

- While approving the plan for Multistoried housing complexes please insist on water meters in individual flats like electricity meters.

Not to forget

- Dual water supply
- Assured and timely water supply
- Water efficient gadgets (Washing machines, flushesh etc.)
- Water positive lifestyle
- Effective water pricing , subsidies-----

Jal hi Jiwan Hai

Thank you for patience

shashankshekhar01@gmail.com