Groundwater Issues, Remediation and Modeling

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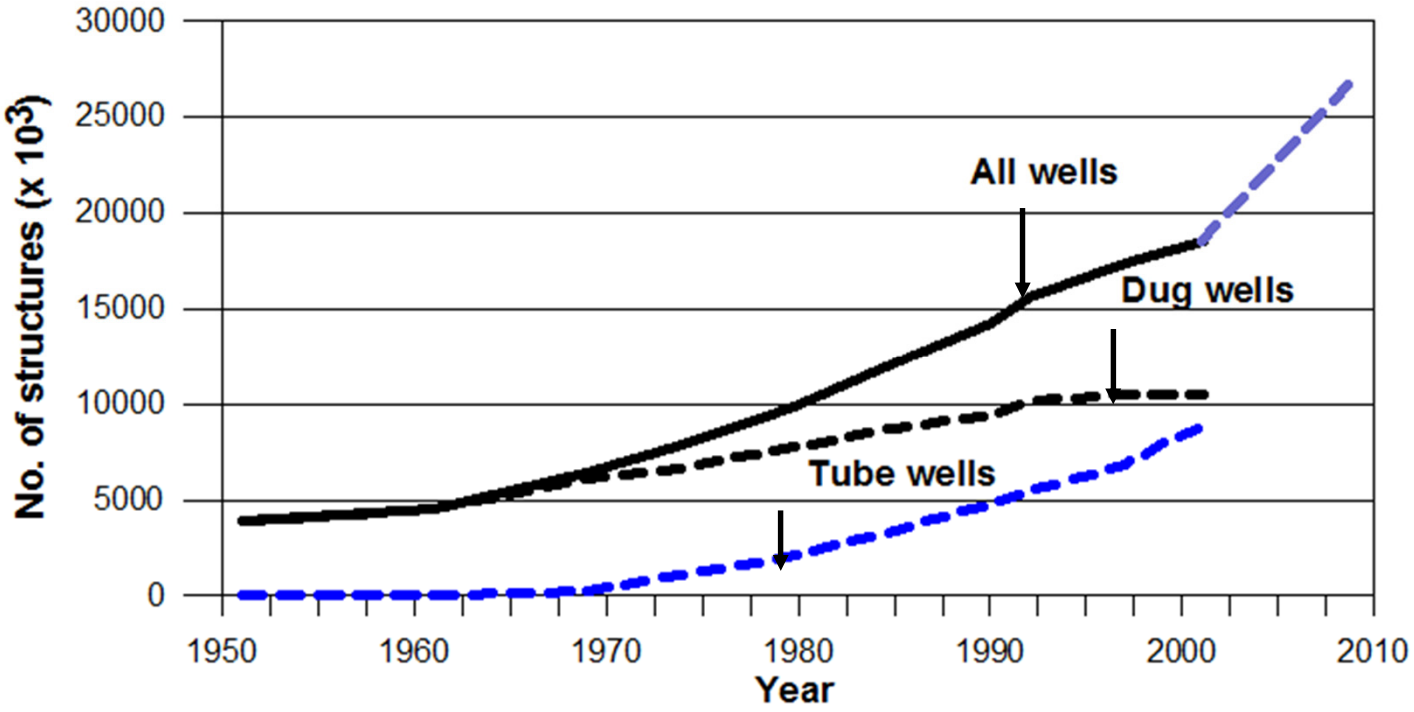
GW uses in India

- Highest in the World
- Meeting 85% of rural domestic requirements, 50% of urban water , and more than 60% of irrigation requirements

GW Structures

- 3.9 million in 1951
- 18.5 million in 2001
- 27 million in 2009 (projection)



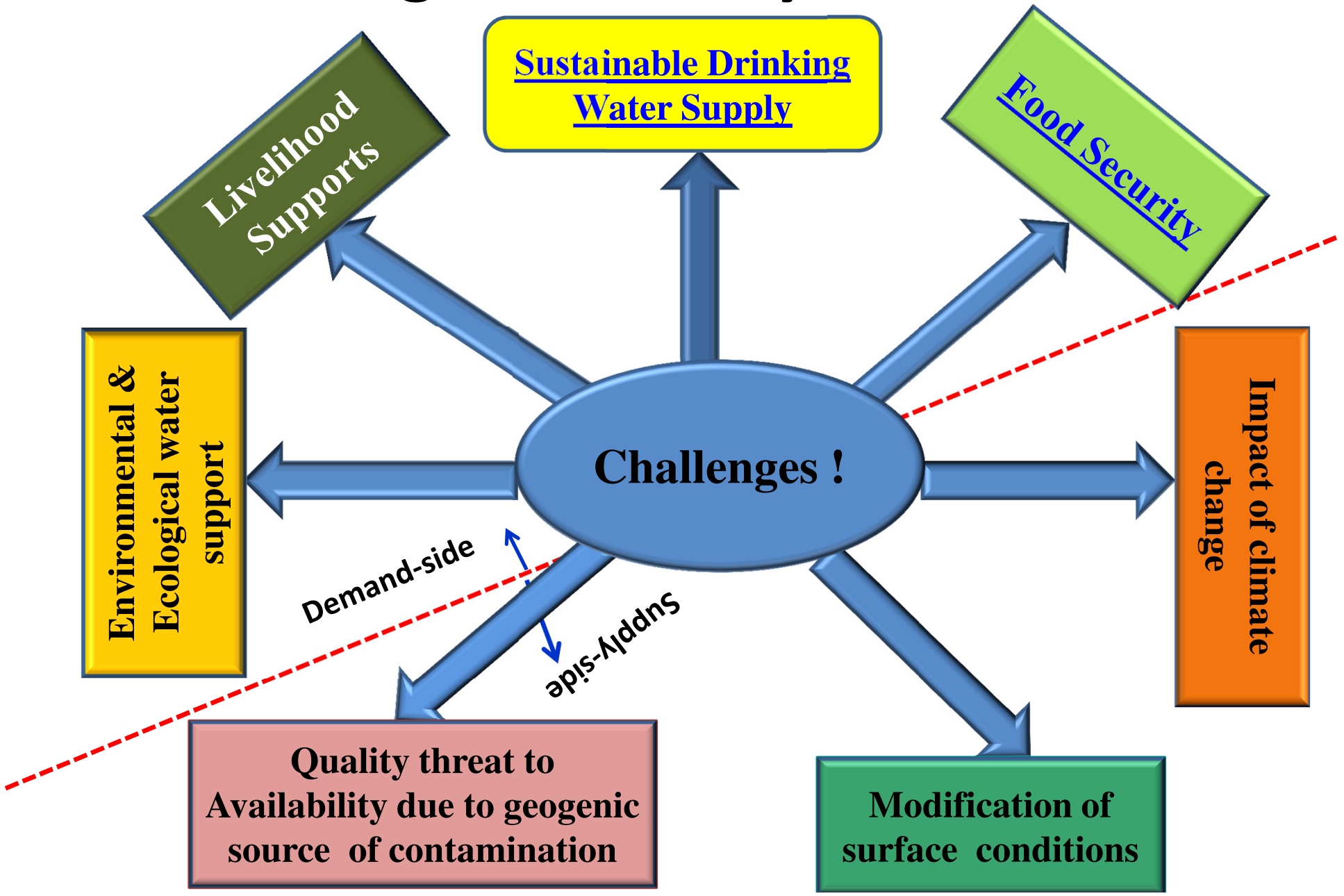
Growth of GW Structures

Hydrogeology of India

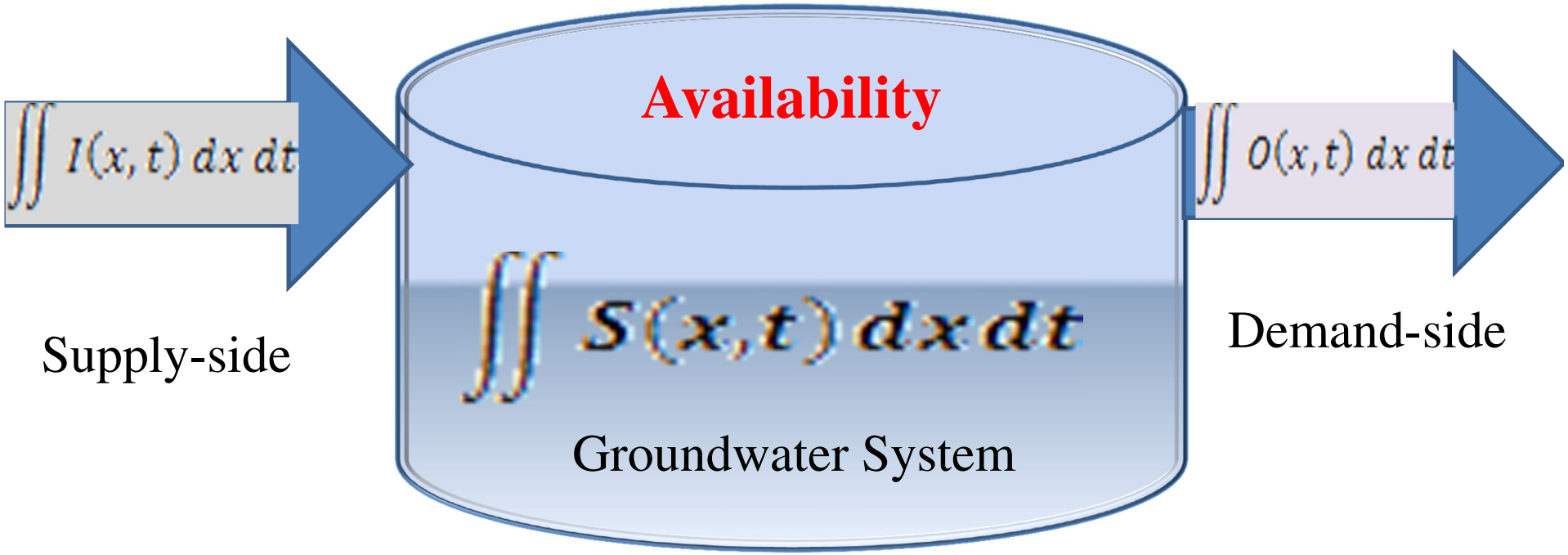
(CGWB, 2006)

Groundwater provinces	% extent of total geographic area
Himalayan highland province	12.50
Ganges-Brahamaputra alluvium province	15.27
Alluvium & sandstone discont., and Precambrian sedimentaries	14.25
Precambrian crystalline province	44.45
Deccan trap province (Basalt)	12.13
Gondwana sedimentary province	1.40

GW Challenges – Broadly 7 Cs



GW Issues in India



Supply-side Issues:

- Modifications of surface conditions,
  - *transformation of open lands into paved areas, sedimentation and siltation of water bodies, closure of water bodies, etc.*
- Impact of climate change on hydrological variables.
  - *modification in rainfall pattern, intensity & duration, reduction in natural GW recharge, etc.*
- Leaching of contaminants from surface sources.

GW Issues in India .. Contd.

GW Availability Issues :

- Excessive withdrawal leading to groundwater level depletion in many areas,
  - *2009 report: Out of 5842 assessment units, 802 units over-exploited, 189 unit 'critical', 523 unit 'semi-critical, 70 blocks underlain by saline groundwater.*

- Quality deterioration due to geogenic source of contamination,
  - *Arsenic , Fluoride, Fe^{2+}, and Inland salinity contaminated aquifers.*

- Constrains in geological formations,
  - *12.5 % Himalayan highland province, 15.3% Ganga & Brahmaputra alluvium province,14.2% semi-consolidated, and about 58% hard rock formations.*

- Seawater ingress threat in many coastal aquifers,
  - *Out of 6100 km coastlines along mainland, Saline water ingress recorded in Minjur area in Tamil Nadu; Porbandar in Saurashtra region in Gujarat, 8-10 km in Subarnarekha, Salandi, and Brahmani outfalls in Orissa, Pondicherry region, east of Neyveli Lignite mines.*

GW Issues in India … contd.

Demand-side Issues :

- Dependability on GW in rural sector is more,

  - *easily accessible, less risk free, self ownership and no obligation of withdrawal*

- Demand increasing in all sectoral uses,

  - *More than 20 million modern groundwater extraction structures reported up to 2001, By the year 2009, it is expected to be more than 27 million. Data of 2001 showed 57% of tube wells (out of 9 million) in India are in Punjab, Haryana & Uttar Pradesh*

- Conflicts of interest increasing,

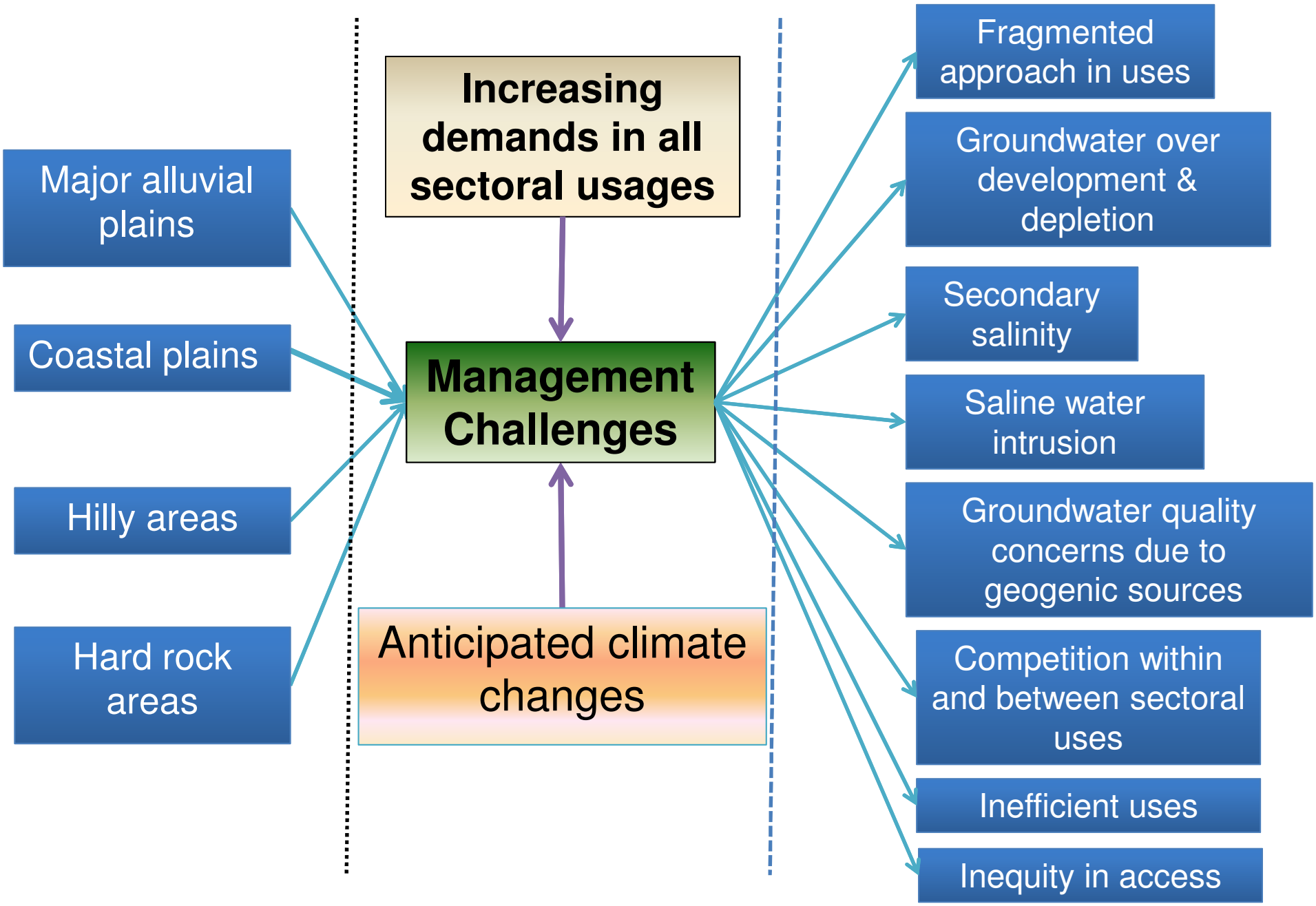
  - *Equity in access in different sectoral usages, conflicts in sharing of GW in local level, etc.*

Scientific Issues:

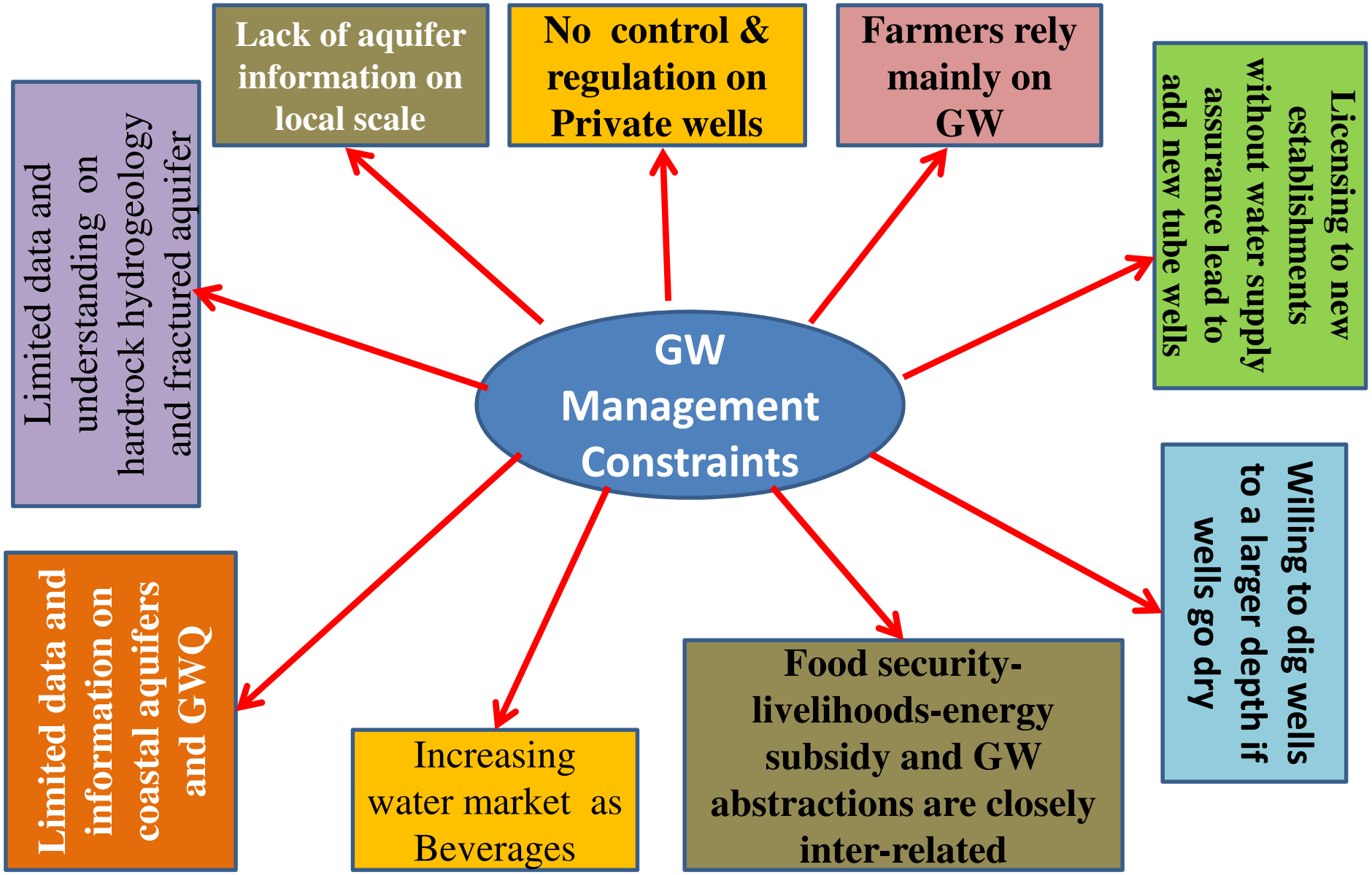
- *Uses indiscriminately as a common pool resource- a number of private players involved – lack of data & information- therefore, a lot uncertainties associated with analysis.*

- *Inconsistency with the data collected by different Institutions, Lack of aquifer formations and aquifer data, No appropriate mechanism for data sharing, etc.*

Groundwater Management Challenges



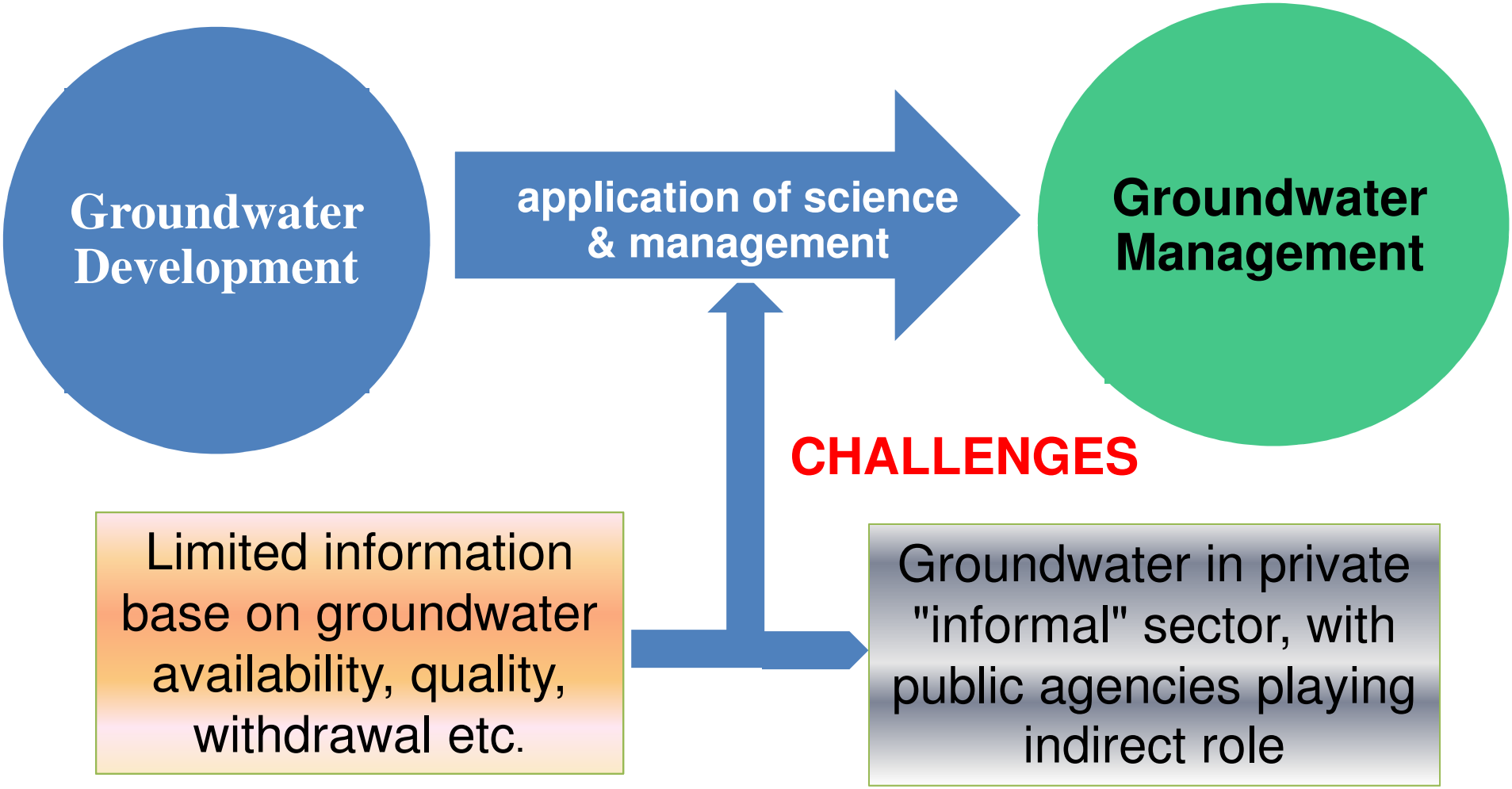
GW Management Constraints



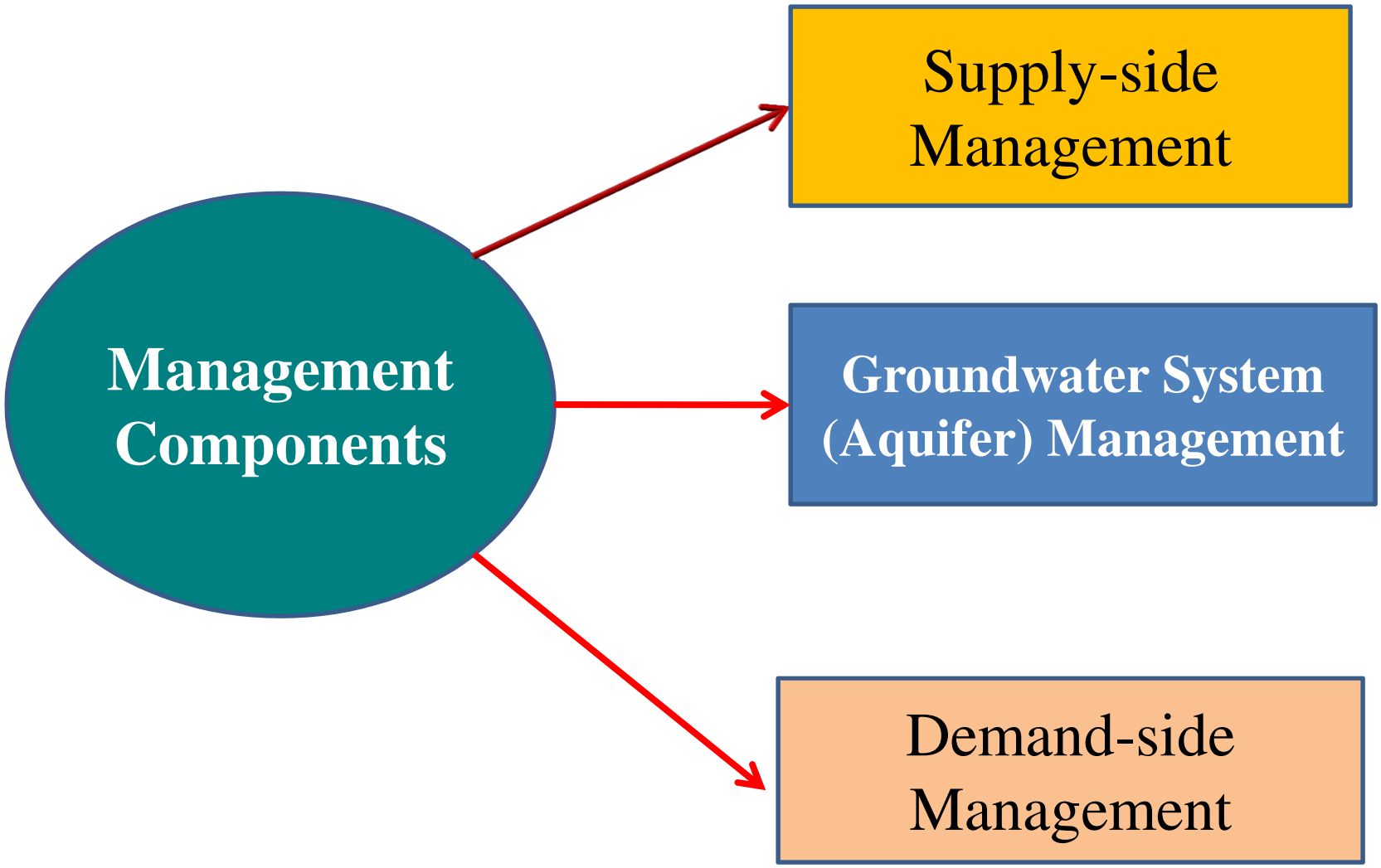
Few Experts view on GW

- Municipal demands are not function of urban population but of economic status as well,
- Lack of basic information/data is one of the causes of GW depletion, pollution and environmental concerns,
- Lack of a suitable framework for collecting GW data is another reason.
- Large credit subsidies to agricultural sector have also given rise to groundwater Structures.
- Groundwater resources likely to be relatively robust in the face of climate change compared with surface water due to buffering effect of groundwater storage.

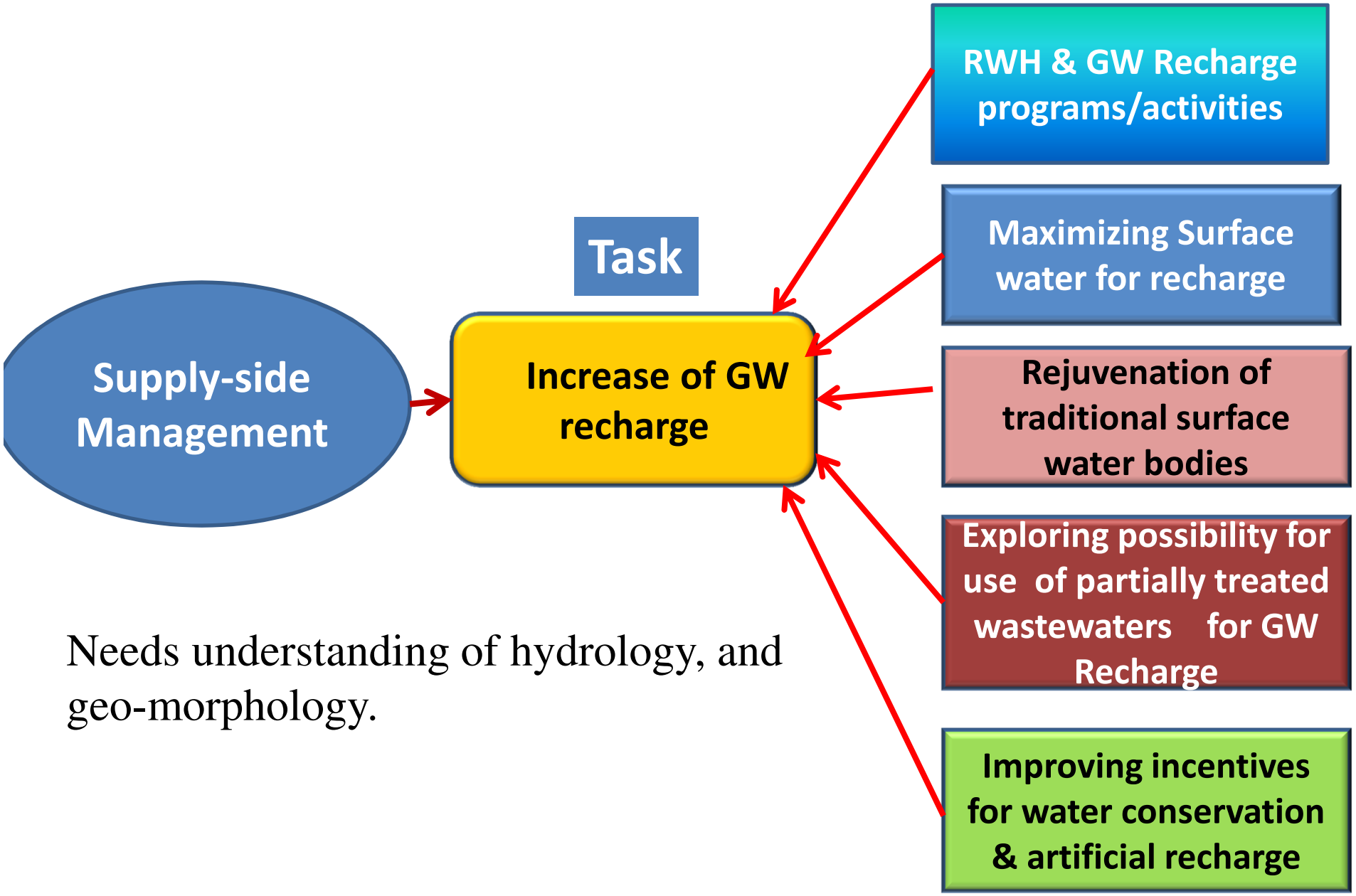
Changeover from Development to Management Mode



Components of GW Management

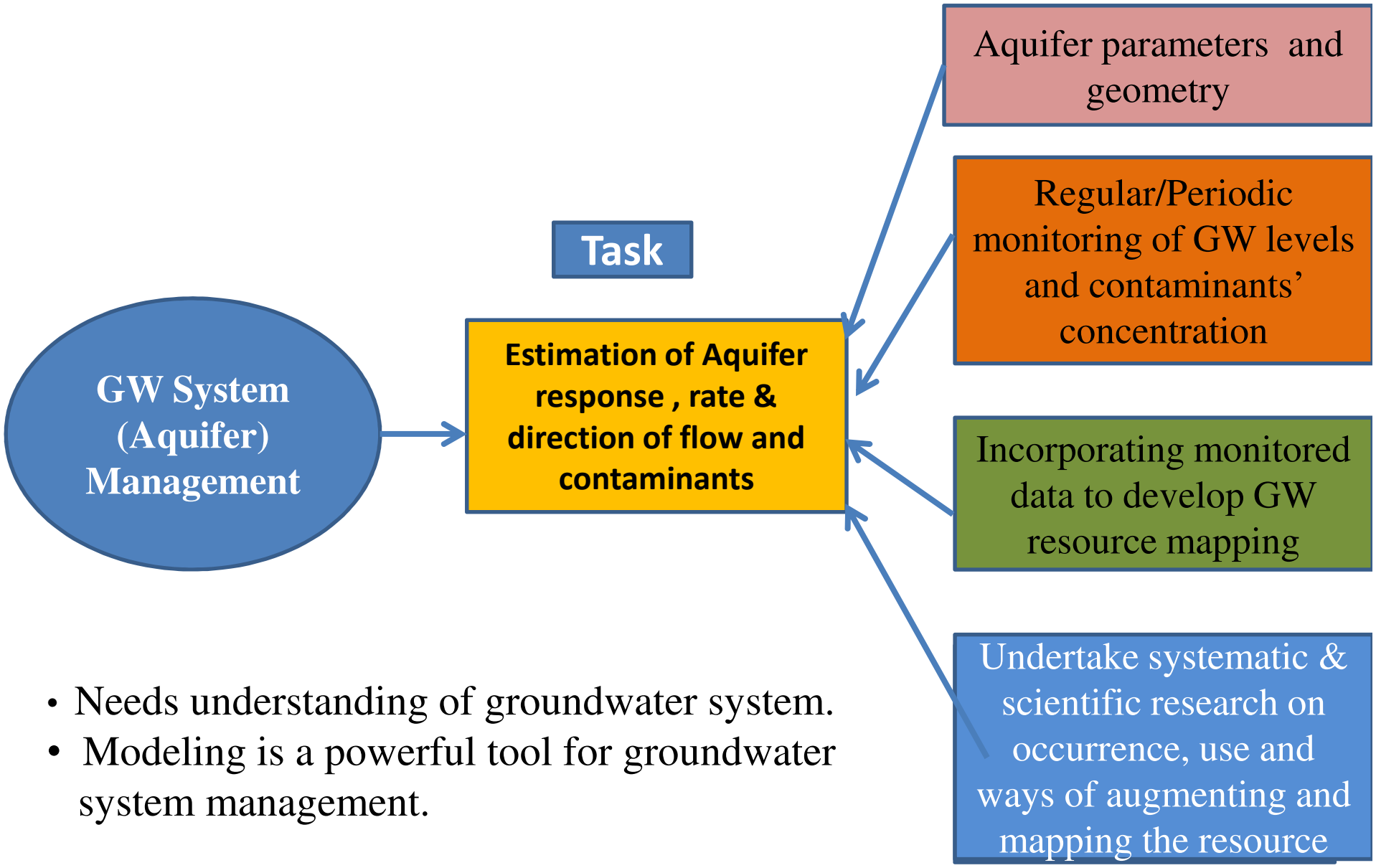


Components of supply-side Management



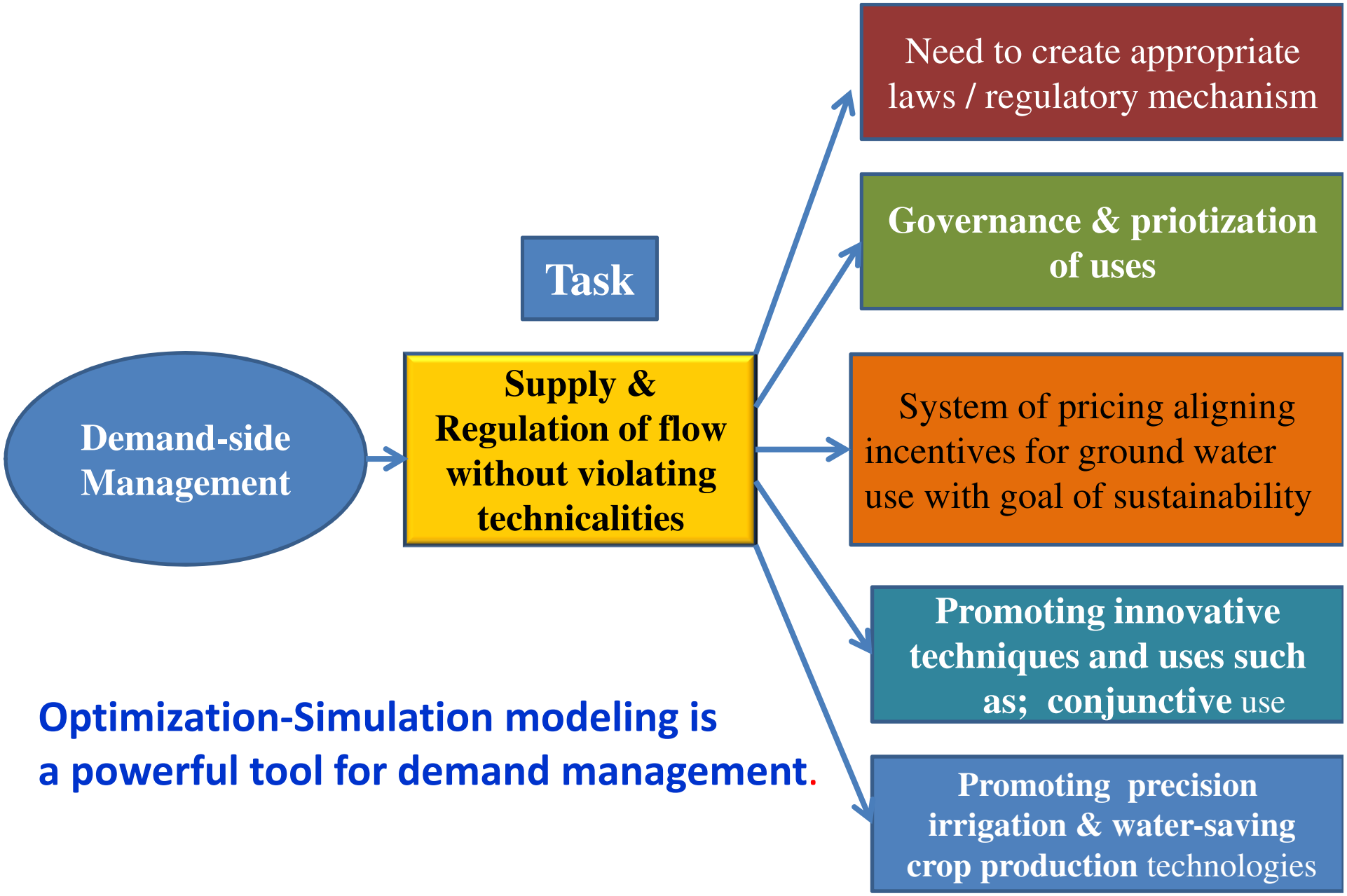
Needs understanding of hydrology, and geo-morphology.

Components of GW System Management



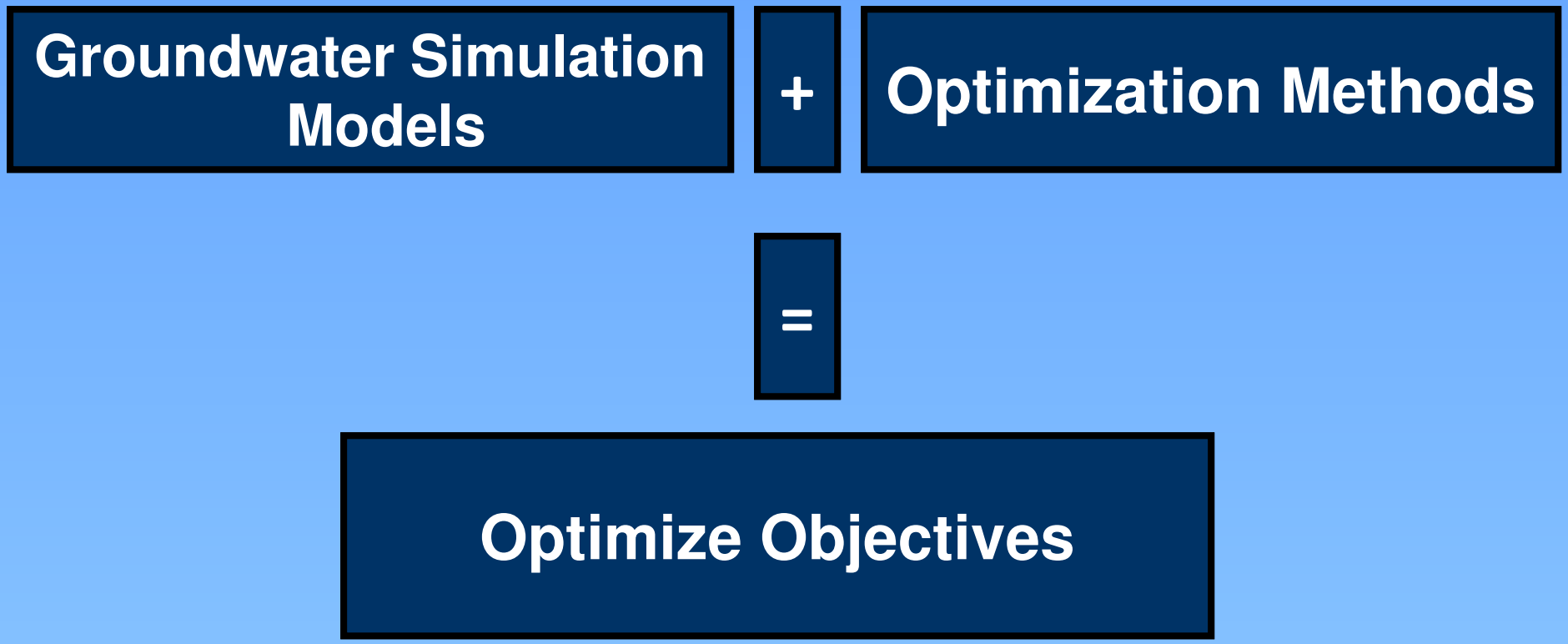
- Needs understanding of groundwater system.
- Modeling is a powerful tool for groundwater system management.

Components of Demand-side Management

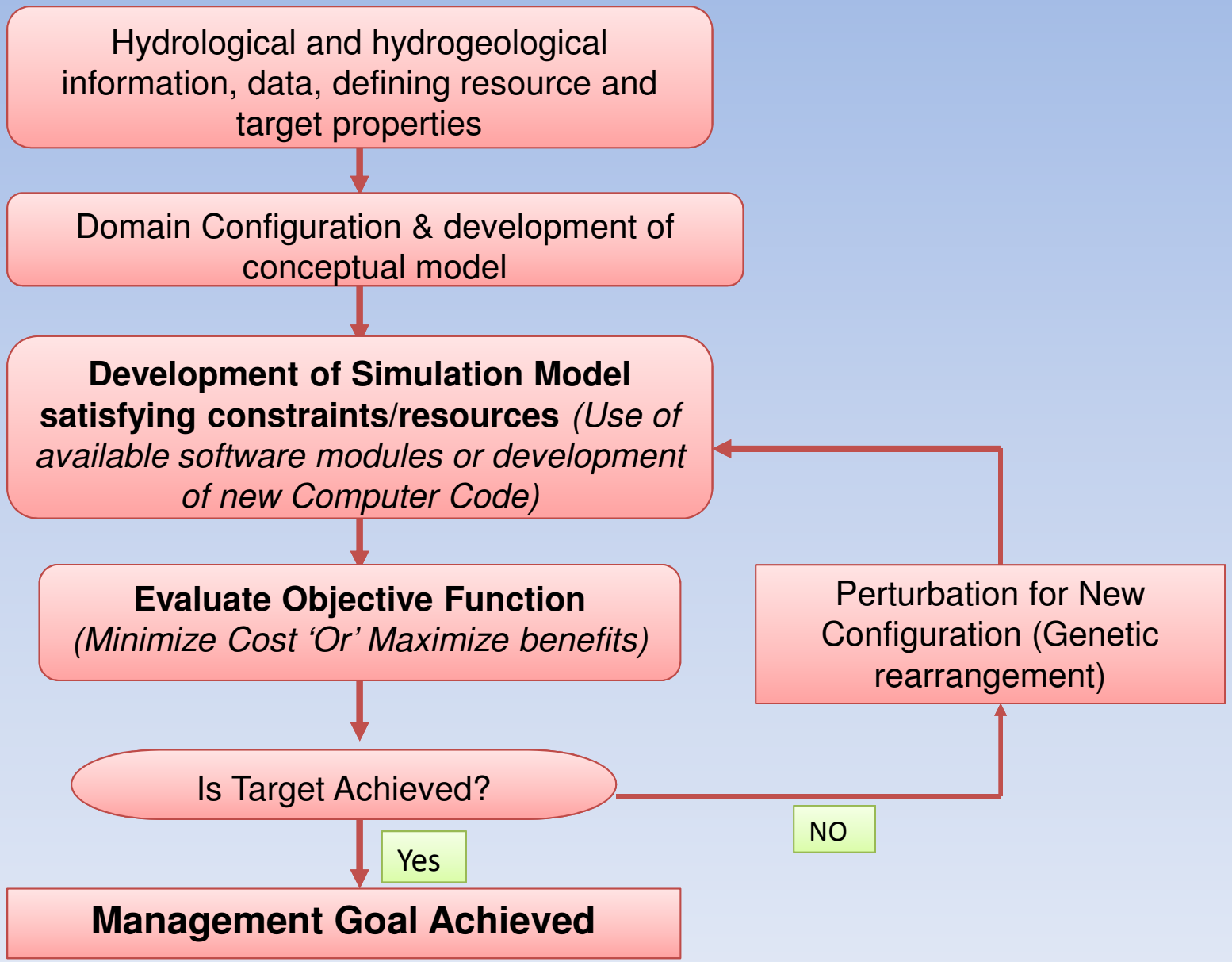


Optimization-Simulation modeling is a powerful tool for demand management.

MANAGEMENT MODEL



Structure of Simulation-Optimization Framework



Our Weaknesses

- Groundwater is a hidden resource; it exists with geological formations; its space-time availability can precisely be calculated when there are good databases.
- Lack in good and comprehensive framework of databases, and institutional mechanisms in sharing of data.
- There are number of Groundwater stakeholders working in isolation, and duplicating collection of data, and viewing on GW issues in fragmented ways.
- Lack in coordinated approach between and among major stateholders of GW resources.
- Our sectoral policies related to water do not coherently supplement one-another issue.

➢ There is a need to develop a comprehensive "**Hydro-geologic Information System**" .

National Project on "Aquifer Management"

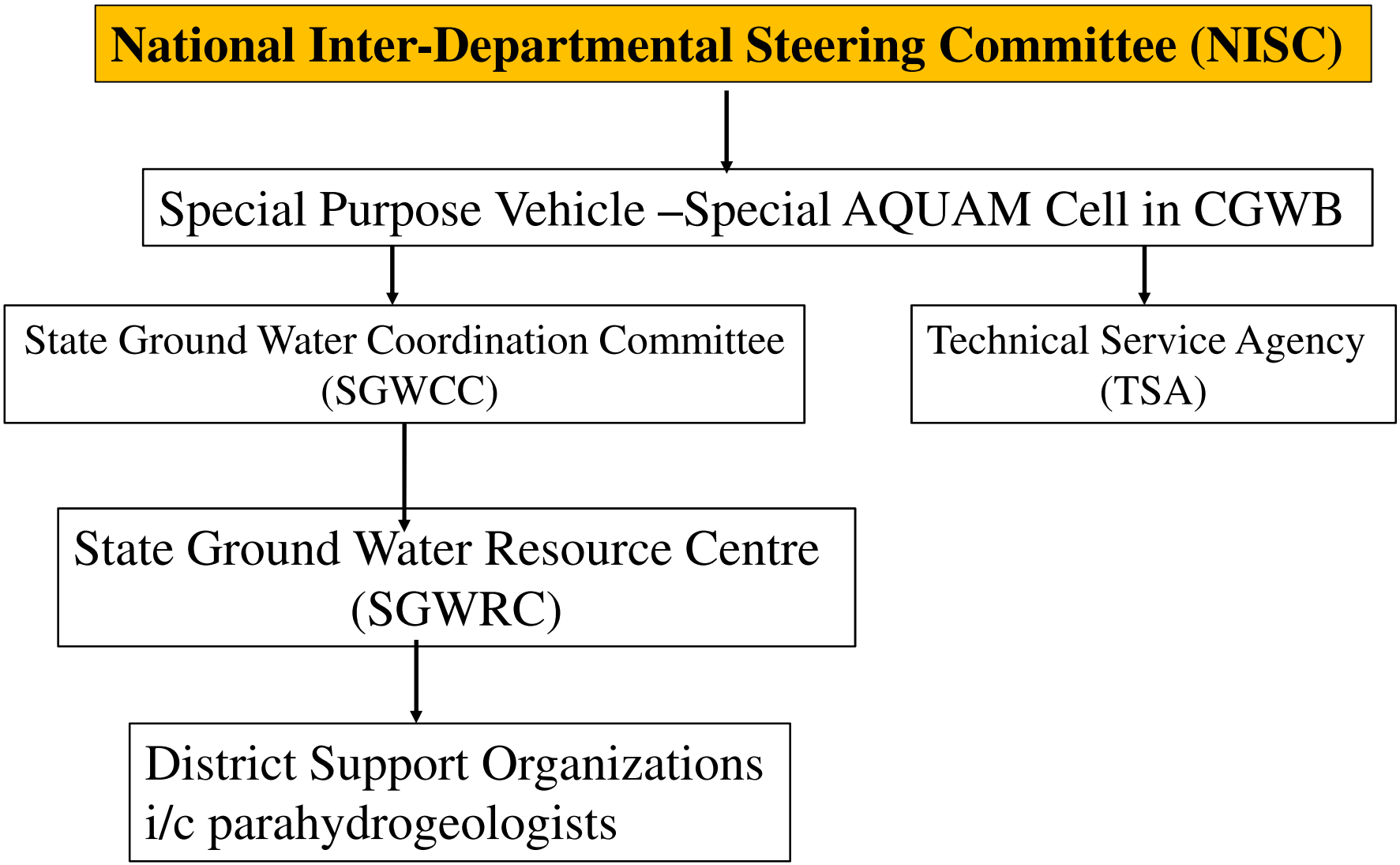
Launched by Ministry of Water Resources, Govt. of India under 12th Five Year Development Plan.

Objectives :

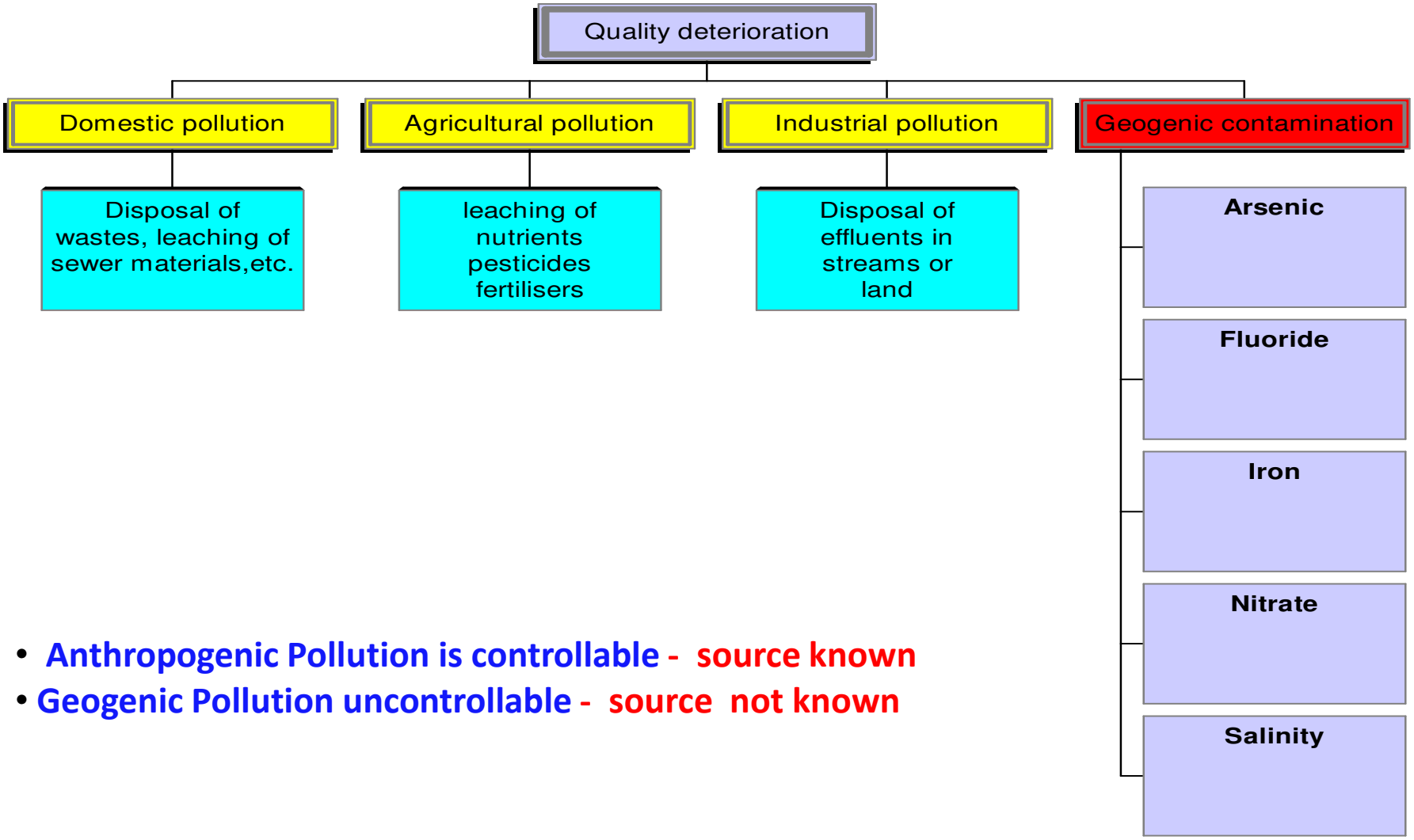
- identify and map aquifers,
- Quantify available groundwater resources potential,
- propose plans appropriate to scale of demand,
- characterize aquifer and identify institutional arrangements for management.

❑ A Noteworthy step towards generating **"Hydro-geological Information System"**

Organogram for the NAQUAM



Ground Water Quality Issues



- **Anthropogenic Pollution is controllable - source known**
- **Geogenic Pollution uncontrollable - source not known**

Arsenic contamination in Groundwater

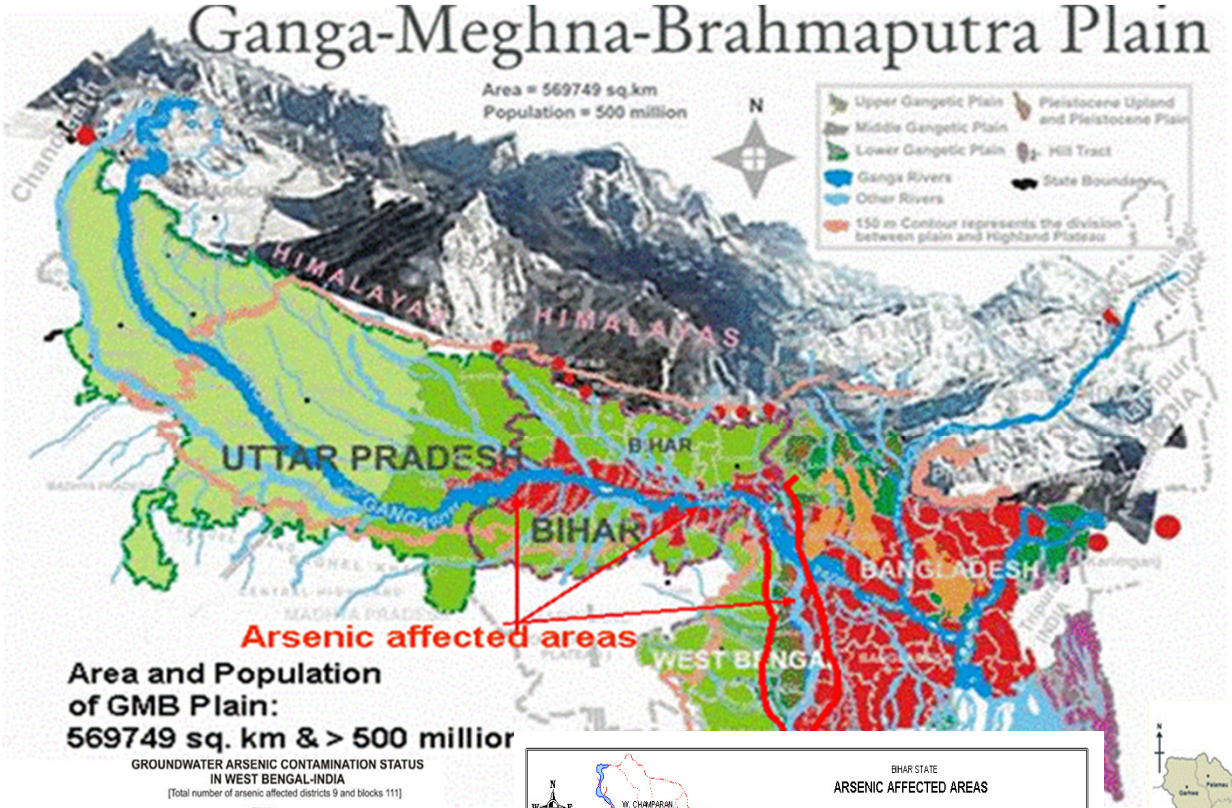
7 States namely : West-Bengal, Jharkhand, Bihar, Uttar Pradesh in flood plain of Ganga River; Assam and Manipur in flood plain of Brahamaputra and Imphal rivers ,and Rajnandgaon village in Chhattisgarh reported Arsenic Affected.

As of 2008;

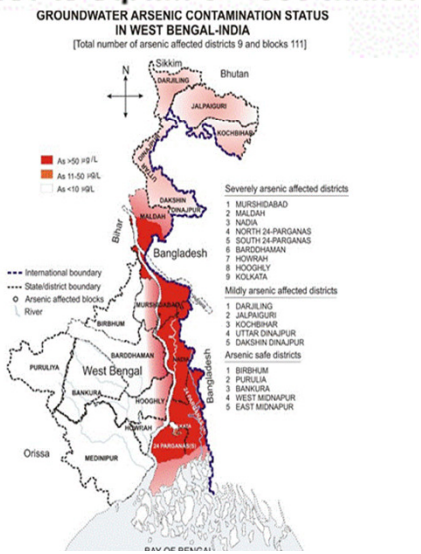
- **9 districts in West Bengal,**
- **15 districts in Bihar,**
- **3 districts in Uttar Pradesh,**
- **1 district in Jharkhand,**
- **3 districts in Assam,**
- **4 districts in Manipur, and**
- **1 district in Chattisgarh**

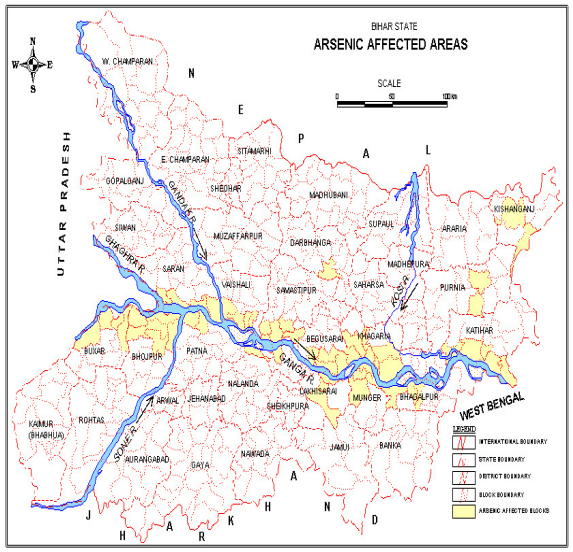
detected for groundwater arsenic contamination > permissible limit of 50 μg/L.

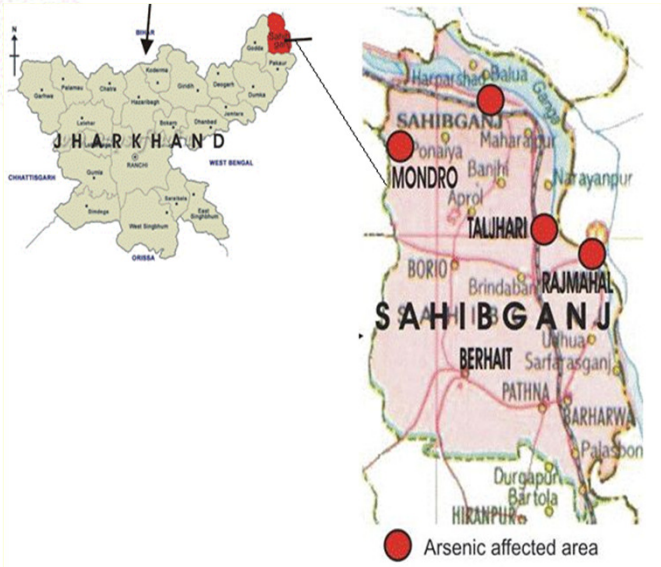
Arsenic contamination in GW



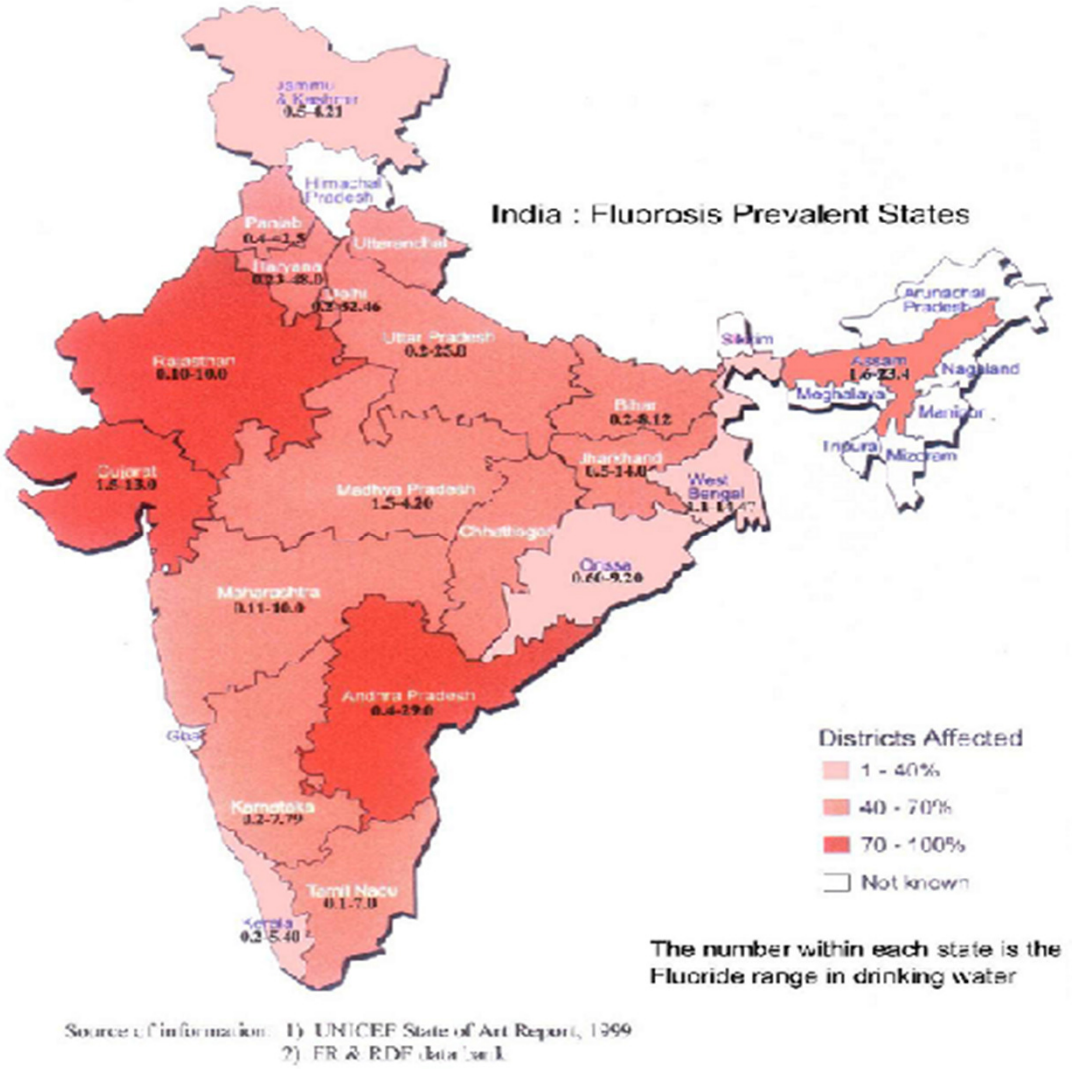
All arsenic affected river plains have river routes originated from the Himalayan region.







Fluoride contamination in GW



Source of information: 1) UNICEF State of Art Report, 1999
2) FR & RDF data used.

Permissible limit : 1.5 mg/l

25 million population of 16 states are affected by Fluoride contamination in GW. 6 million children below the age Of 14 years.

Assam, J & K, Kerala, Delhi, Orissa,Bihar, Haryana, Karnataka,Maharastra, M.P., A.P., Gujarat, Rajasthan, Tamil Nadu, and U.P.

Other Groundwater quality Problems

- **Salinity** – parts of Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, M.P., Chhatisgarh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil nadu, U.P., NCT Delhi. (15 States)

- **Nitrate -** 11 states, covering 95 districts**.**

- **Iron** – Assam, West Bengal, Orissa, Chattisgarh, and Karnataka and localized pockets in state of NE, Bihar, **UP,** Punjan, Rajasthan, Maharastra, Madhya Pradesh, Jharkhand, Tamil Nadu and Kerala. (15-States).

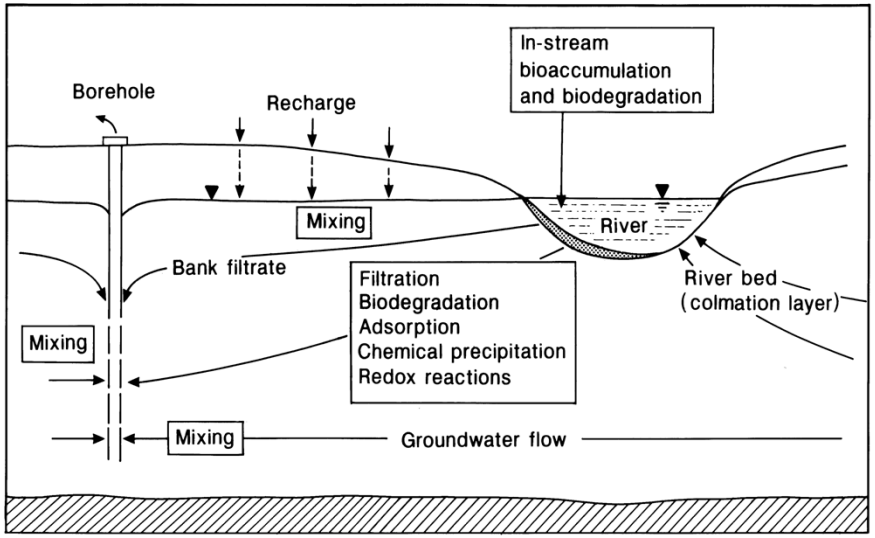
Few sustainable techniques

- **Bank Filtration for sustainable drinking water supply**

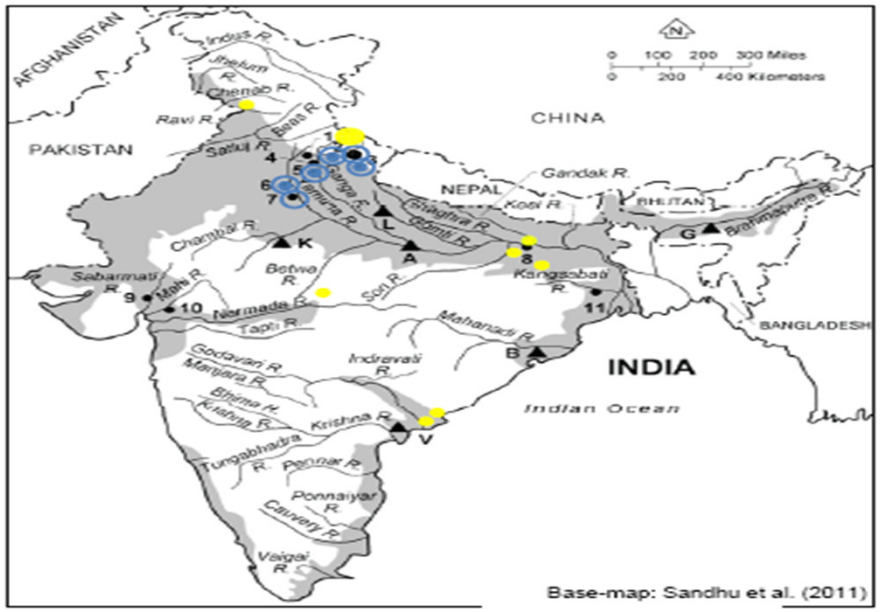
Advantages:
- Soil acts as filtering media;
- Naturally treated;
- Reduces post-treatment cost;
- Less expensive;
- No chemical addition,
- Reduce Pathogenic load.

Technicalities:
- Perennial stream/river
- Distance of well from riverbank
- Alluvial formations;
- Retention time.

Concerns :
- Riverbed Clogging;
- Aquifer Clogging.

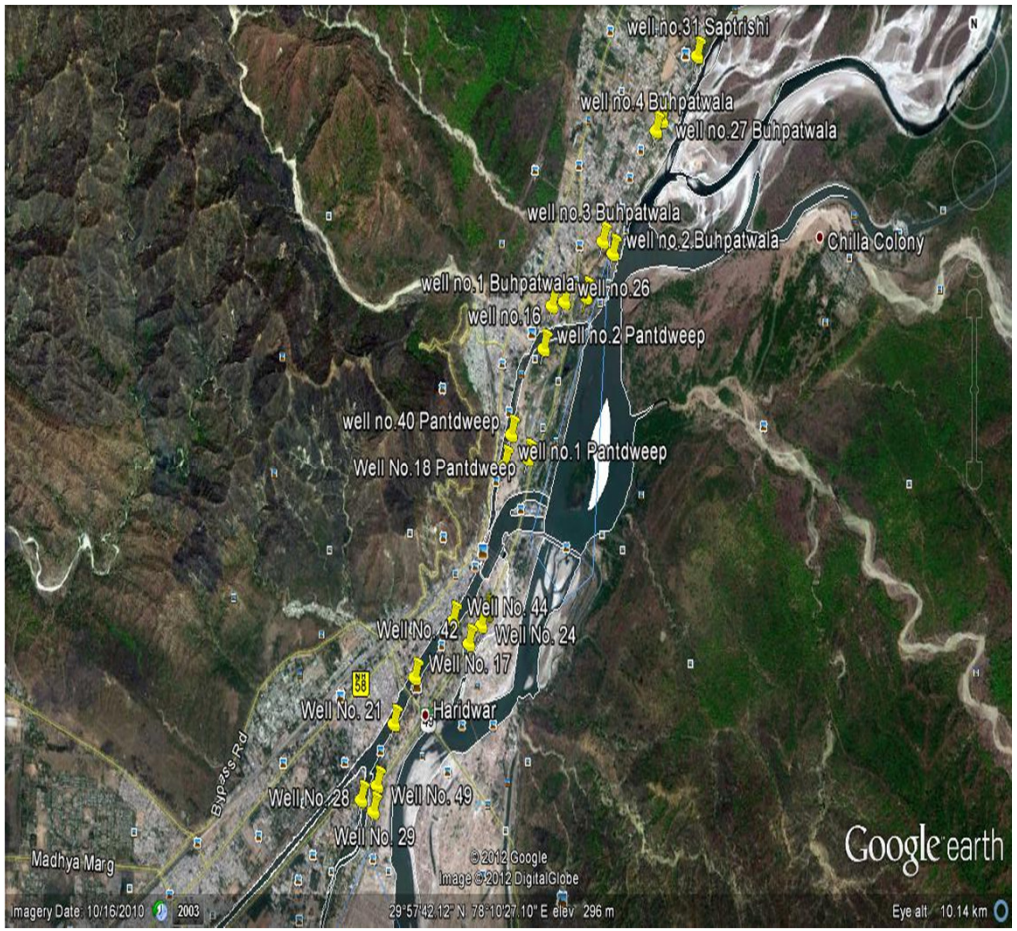


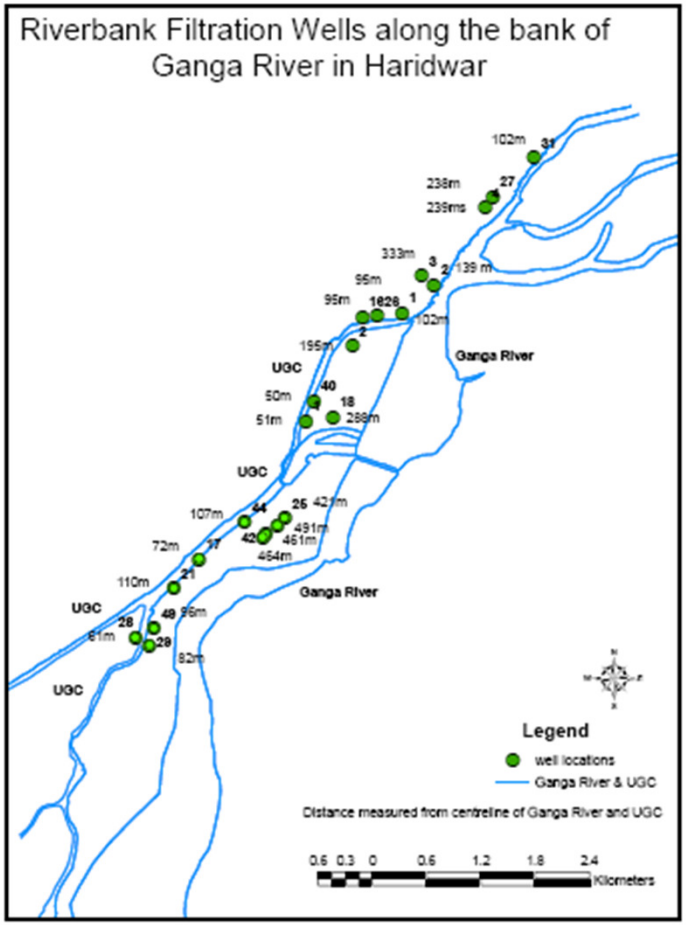
Potential RBF sites In India (Saph Pani)



Sustainable solution Contd..

- **22 Wells located 15 m – 250 m away from River & Upper Ganga Canal**





RBF site in Haridwar

- **Bottom well caisson : 7 – 10 m; Wells operated : 19 to 24 hours**
- **Travel time : 2 to 100 days**

Sustainable solutions contd..

- **Managed Aquifer Recharge and Soil Aquifer Treatment**

- Monsoon surface runoff conservation and recharge to potential aquifer after addressing water quality aspects and subsequent recovery of recharged water can provide a solution.

- Storm water conservation from urban areas after addressing WQ aspects can also be a potential source for aquifer recharge.

- Municipal wastewater from urban areas after appropriate treatment can also be considered for aquifer recharge and subsequent recovery of groundwater .

Conclusions

- India is the highest groundwater user in the World. Uses of GW will continue to rise in future due to competing sectoral demands.
- Until recently, the focus was mainly on groundwater development, emerging issues and challenges compelled to orient focus towards groundwater management.
- Objectives of groundwater management can not be achieved, unless there is enforced law on control and regulation.
- Groundwater related problems as that because of overexploitation , are more due to lack of 'knowledge and information'.
- Development of a comprehensive "Web enable Hydro-geologic Information System" will help reducing conflicts on uses of groundwater, and its judicious management.
- Optimization-Simulation modeling is a powerful tool that can be used as a Decision Support System for GW Management.

Leonardo da vinci stated;
“The greatest river of the planet earth flows underground”.

Thank You