An Introduction to the National Programme on

Isotope Fingerprinting of Waters of India (IWIN)

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Isotope Fingerprinting of Waters of India (IWIN)

To isotopically fingerprint various water sources of India representing the entire **hydrological cycle** over India

Atm. Moisture
Precipitation
Stream runoff
Groundwater
and
Surface Waters
of AS & BOB

Precipitation and Atmospheric Moisture
IMD
CRIDA

Rivers, Streams and Surface Reservoirs
CWC
CPCB

Groundwater
CGWB

Radiosonde



NIO/ PRL

Data
Weather, Volume Flow,
Quality, Water Level

~20, 000 Samples

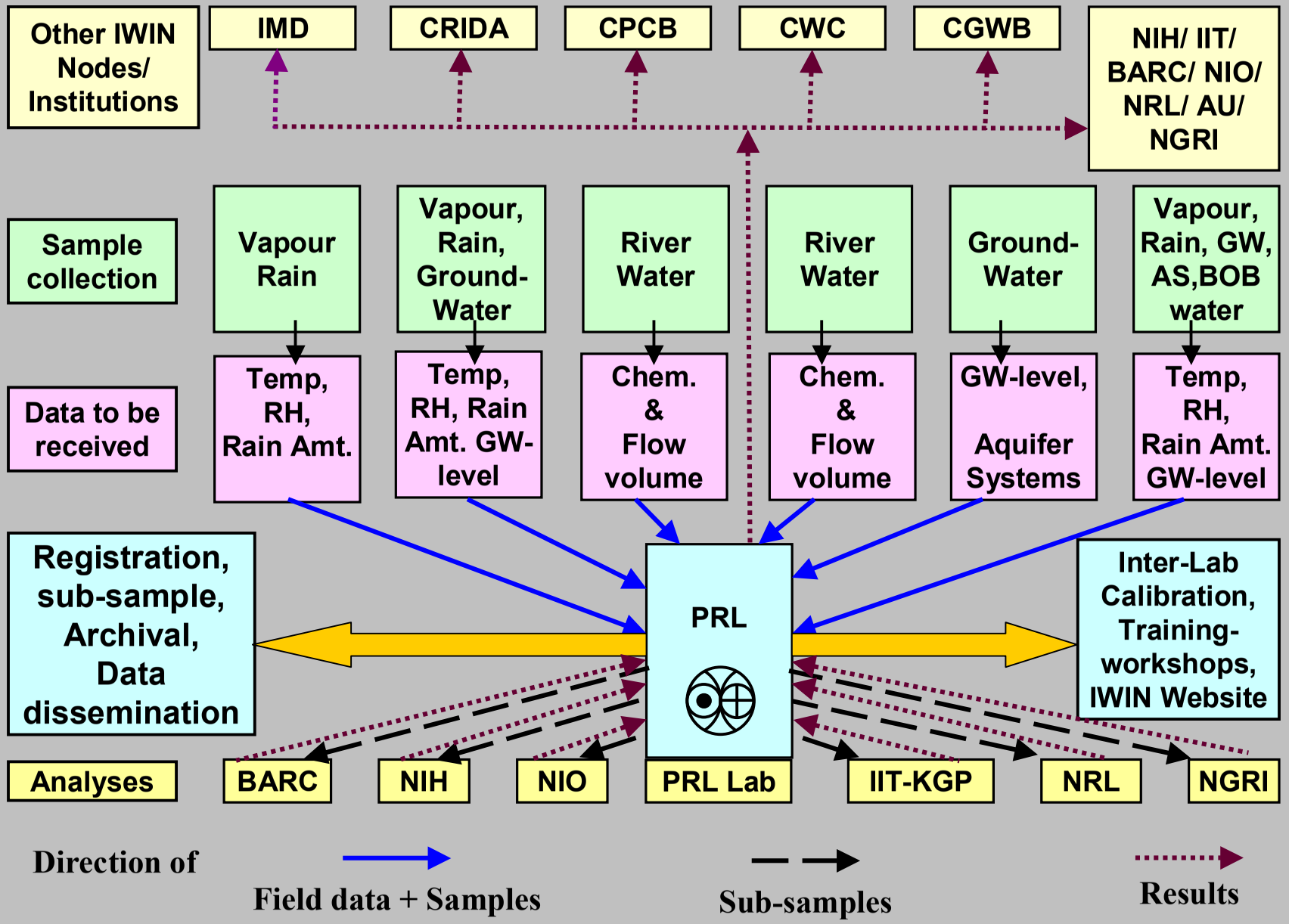
For analysis

IWIN
Research Team

PRL, NIH, IIT-Kgp, NGRI, BARC, NRL, **NIO**, AU

> 40,000 Isotopic Results

Task Organisation



The Proposal

Developing a spatially distributed network, for periodic collection and analyses of water isotopes from atmospheric moisture, rain, river and groundwater across the country and from parts of Arabian Sea and the Bay of Bengal.

Motivation

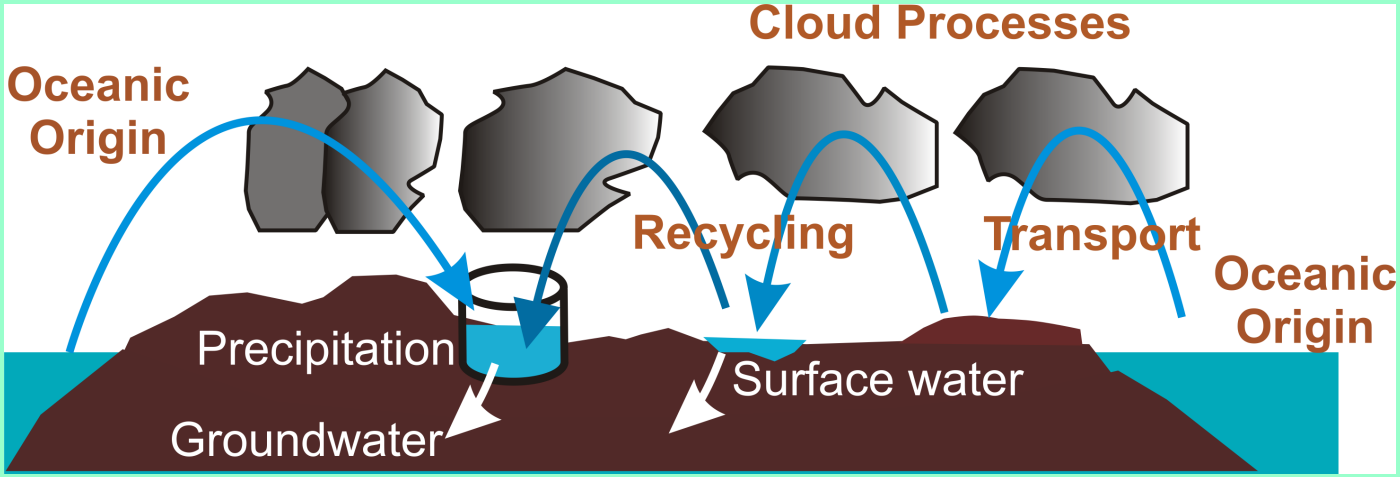
Meeting the estimated water demand (~1450 km^3/yr by 2050) will necessitate large-scale alterations of the hydrological cycle and the associated ecological systems.

Quantified data on hydrological cycle components/ processes and their controls can help predict, analyse and minimise alterations with adverse impacts to our natural, agricultural and urban environments.

Why Isotopes?

Stable isotopes (^{18}O and ^{2}H) undergo predictable transformations in the hydrological cycle depending on the hydrologic process and its extent, thereby allowing tracing of sources and geographical origin, reconstruction of climate, and calculation of energy balance and evaporation.

Water memorises its origin and path



Isotopic fingerprints are imparted during:

1. **Phase change: fractionation during evaporation and condensation – temperature & humidity dependent.**
2. **Mixing of different water/ vapour masses.**
3. **Selection of rain events during runoff and groundwater recharge**

Stable Isotopes in Water (^1H_2O)

$^1H_2{}^{18}O$ $\delta^{18}O(‰)$

$^1H^2H^{16}O$ δD (‰)

δ (‰) = $(R_x/R_s - 1).1000$

R=Ratio ($^{18}O/^{16}O$; $^2H/^1H$

Specific Objective

To monitor isotopic fingerprints of major water sources in spatial and temporal domain to:

1. **Quantify vapour supply (Arabian Sea/ Bay of Bengal/ Local and long distance oceanic/ continental sources) at different locations during different seasons.**
2. **Estimate partitioning of rain into evapo-transpiration, soil moisture, stream flow and groundwater.**
3. **Estimate the extent and rates of interactions across hydrological boundaries and the controls exercised by geographical and climatic factors.**

Evolution of IWIN-Project Proposal

International

- IAEA/WMO-GNIP (45yrs) Network of Isotopes in Precipitation has provided important insights into:
- Global atmospheric circulation patterns, groundwater management and protection, determination of groundwater origin and age, and calibration of flow and transport modelling.
- Other regional networks are: CNIP- Canadian (5 yrs); NISOT-Swiss (15 yrs); Moisture Isotopes in the Land Ecosystems (MILE); SIBAE-BASIN etc.

National

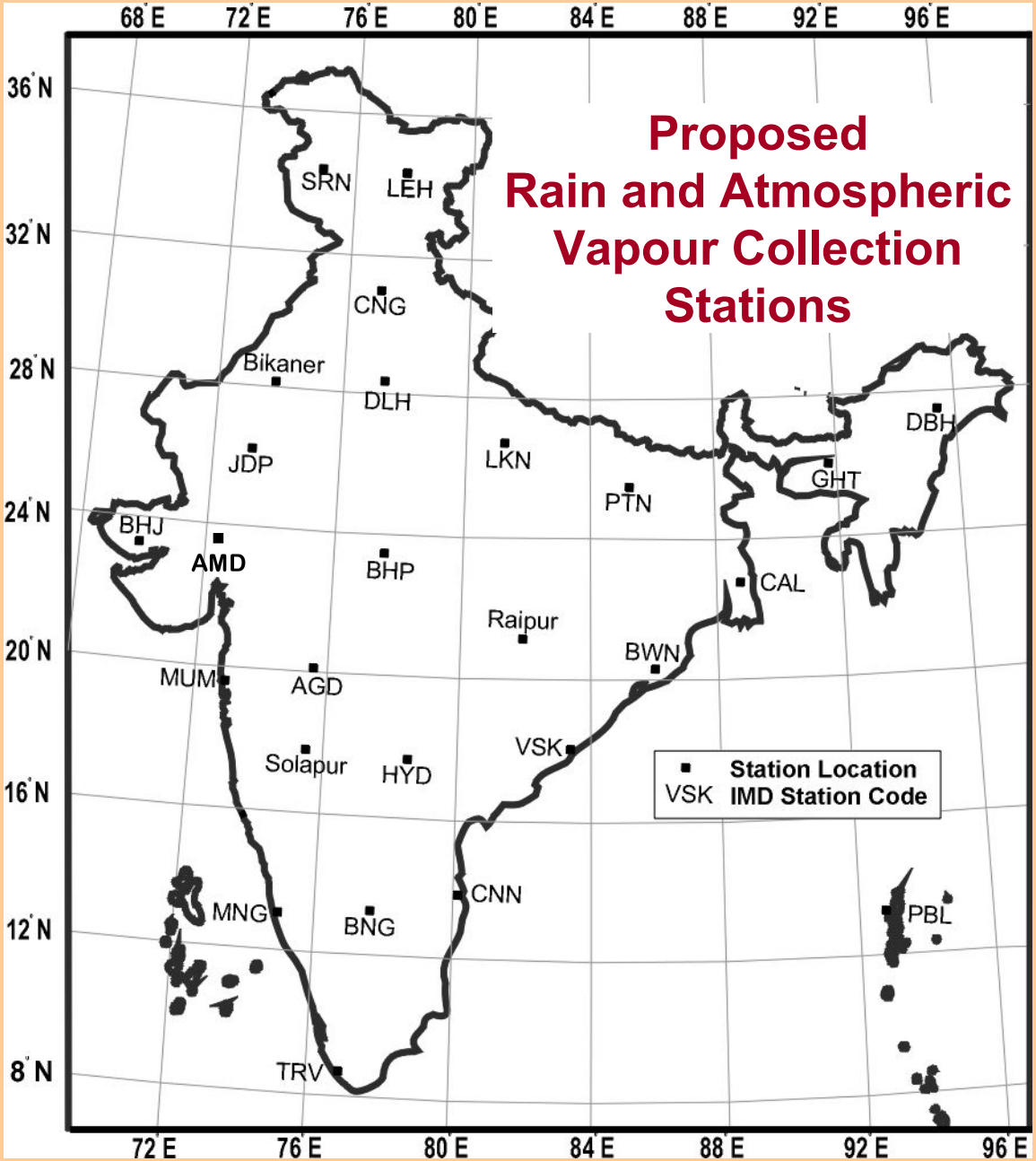
- Water Isotope applications in India constrained by limited water isotopic measurements (~ 1,000) made over a period of 30 yrs.
- Bombay and New Delhi are the only two stations with >5yr precipitation isotope data.
- ~80% measurements made by PRL. ~40 Publications from PRL, BARC, IARI, NGRI, NIH.
- IWIN has evolved through extensive dialogue between Researchers, National Agencies, and User Groups over a period of 4 yrs including 3 DST Review Committee meetings.

Work elements -1

1. Monthly isotope monitoring of atmospheric moisture, rain, river and groundwater across the country and surface waters from the Arabian Sea and the Bay of Bengal.
2. Daily sampling of precipitation and atmospheric moisture from seven stations.
3. Spatially distributed groundwater sampling from shallow unconfined aquifers.
4. A new dedicated Stable Isotope Ratio Mass Spectrometer (IRMS) Laboratory at PRL.

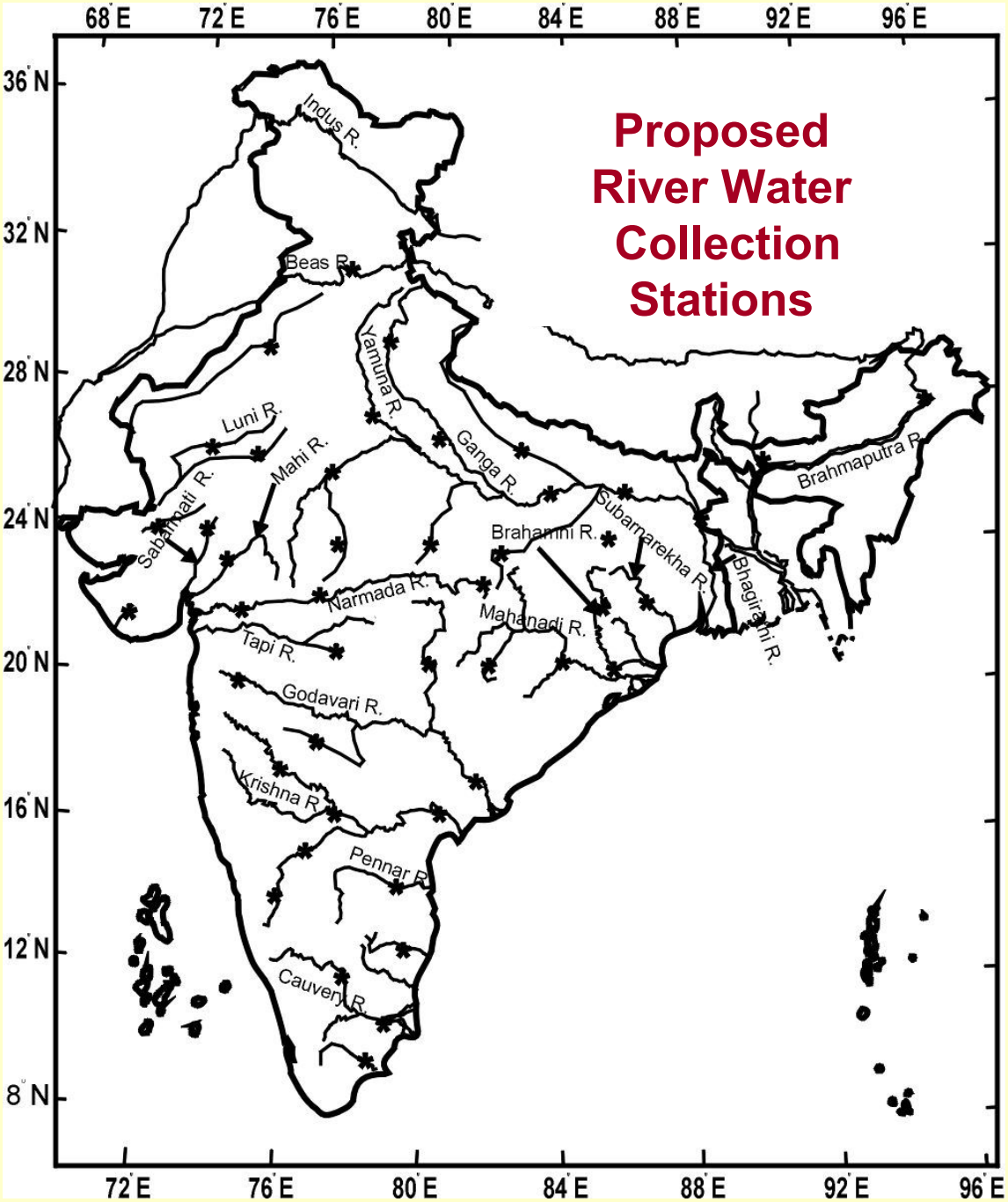
Work elements -2

5. Analyses of tritium (~800) and $\delta^{18}O$ & δD (~40,000) at PRL, BARC, NIH, NIO, IIT-KGP, NGRI and NRL.
6. ECMWF and Indian reanalysis datasets to be used in conjunction with isotope modules and analyses to validate models of atmospheric and ground surface hydrologic processes.
7. A new DigiCORA III Vaisala Radiosonde upper air system to be installed and operated (~75 launches annually) at NIO.
8. Additional 30 launches from PRL Ahmedabad.



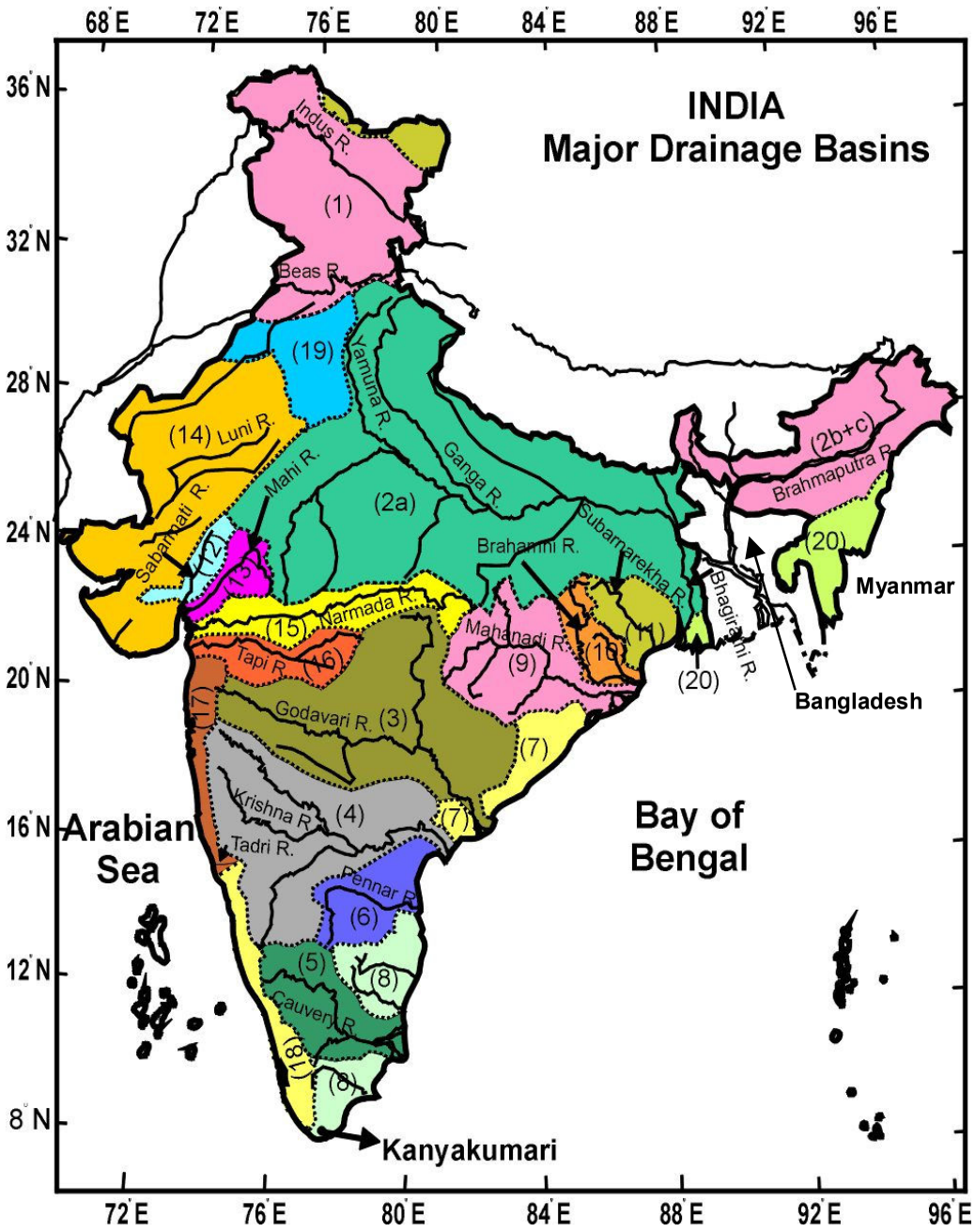
Stations

are selected from the existing networks of IMD/CRIDA based on the consideration of tracking isotopic changes up to 1 ‰ in $\delta^{18}O$ in monthly precipitation



Stations

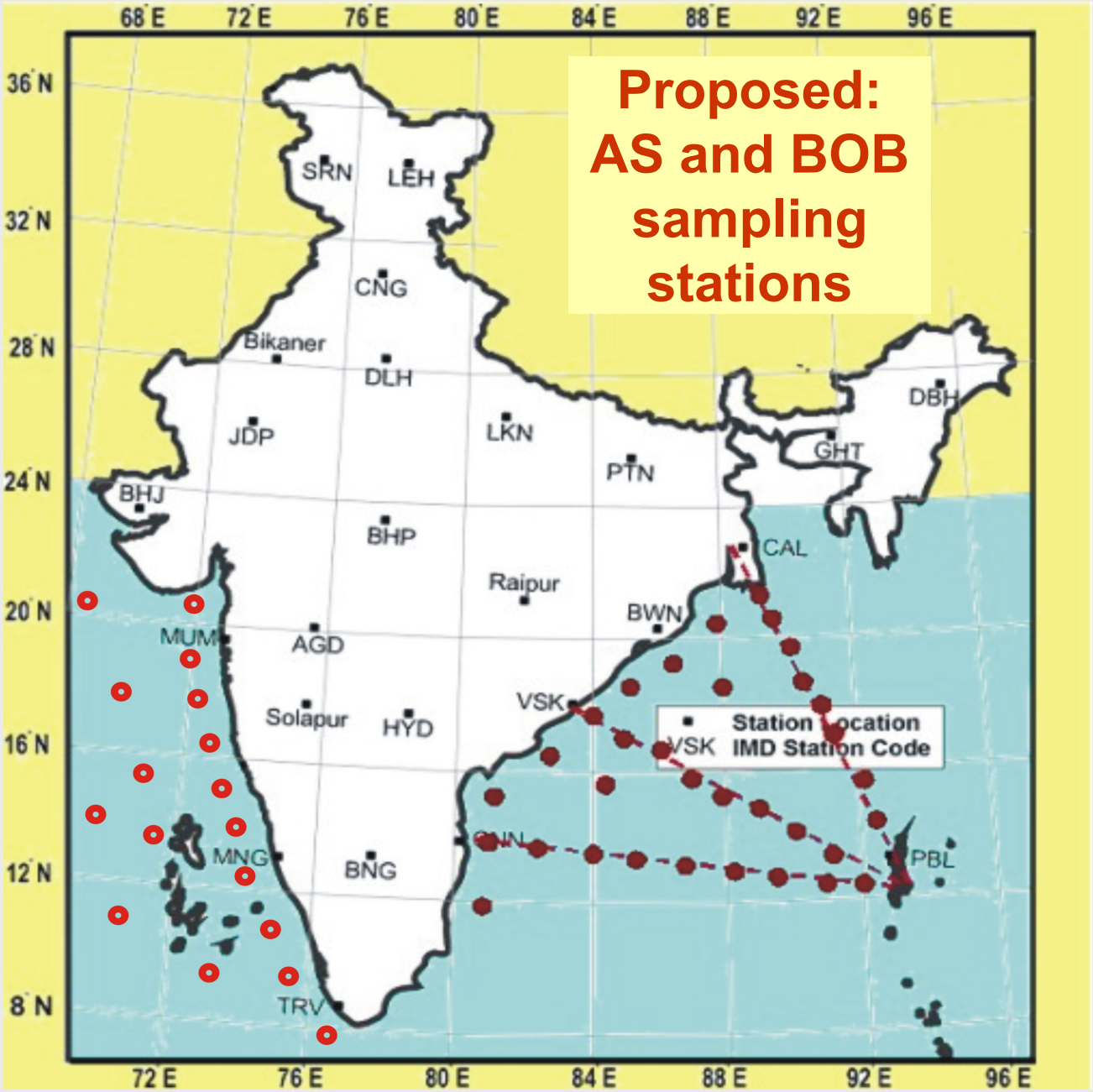
are selected from the existing networks of CWC/CPCB based on the consideration of tracking isotopic changes from headwaters to mouth of different river basins.



Groundwater

Samples (~1,000) from Shallow unconfined aquifers, representing most active GW phase will be analysed using the network of CGWB.

Isotope monitoring to provide inputs to study Basin-scale spatial variability across GW boundaries with (i) Atmosphere, (ii) Rivers and (iii) Lakes or constructed Reservoirs.



Most stations in BOB lie along commercial shipping routes. Locations not lying on these routes will be sampled less frequently depending on the availability of berth on NIO-Tech vessels.

AS stations will be sampled using DOD ships of opportunity.

Deliverables:

- Dedicated functional Stable Isotope Hydrology Laboratory.
- A functional network for collection and monitoring of water isotopes from major water sources of India.
- ~ 30,000 water stable isotope plus ~ 800 tritium analyses.
- Upper air Radiosonde profiles over Goa and Ahmedabad. Tracking relationship of moisture transport and precipitation processes to observed isotope variations.
- Maps showing spatial distribution and temporal variation of water isotopes in different components of the hydrological cycle over India.
- Seasonal maps and relationships of salinity-isotope distribution in the AS and BOB.
- Large number of international level research contributions.
- A new group of isotope scientists creatively applying isotope techniques in environmental sciences.

What New Will be Learned?

Estimation in spatial and temporal domain of:

1. **Relative contributions of water vapour from different oceanic (SO, AS, BOB, Pacific) and land sources.**
2. **Proportion of rain contributed by evapo-transpiration over land areas.**
3. **Recycling of water draining into the Bay of Bengal as BOB branch of SW monsoon.**
4. **Mixing of large volume of fresh runoff draining the Western Ghats in surface waters of Arabian Sea.**
5. **Contribution of rain and groundwater to stream flow and lakes and vice-versa.**
6. **Travel time of surface flow to stream in different parts of catchments.**
7. **Proportion of rainwater recharge to groundwater.**



Thanks…