2nd Regional UIBN Annual Meeting (RUAM)
26-27January 2021

Dynamic groundwater resources of upper Indus basin Ladakh

Dr. Gh. Jeelani
Professor and Head

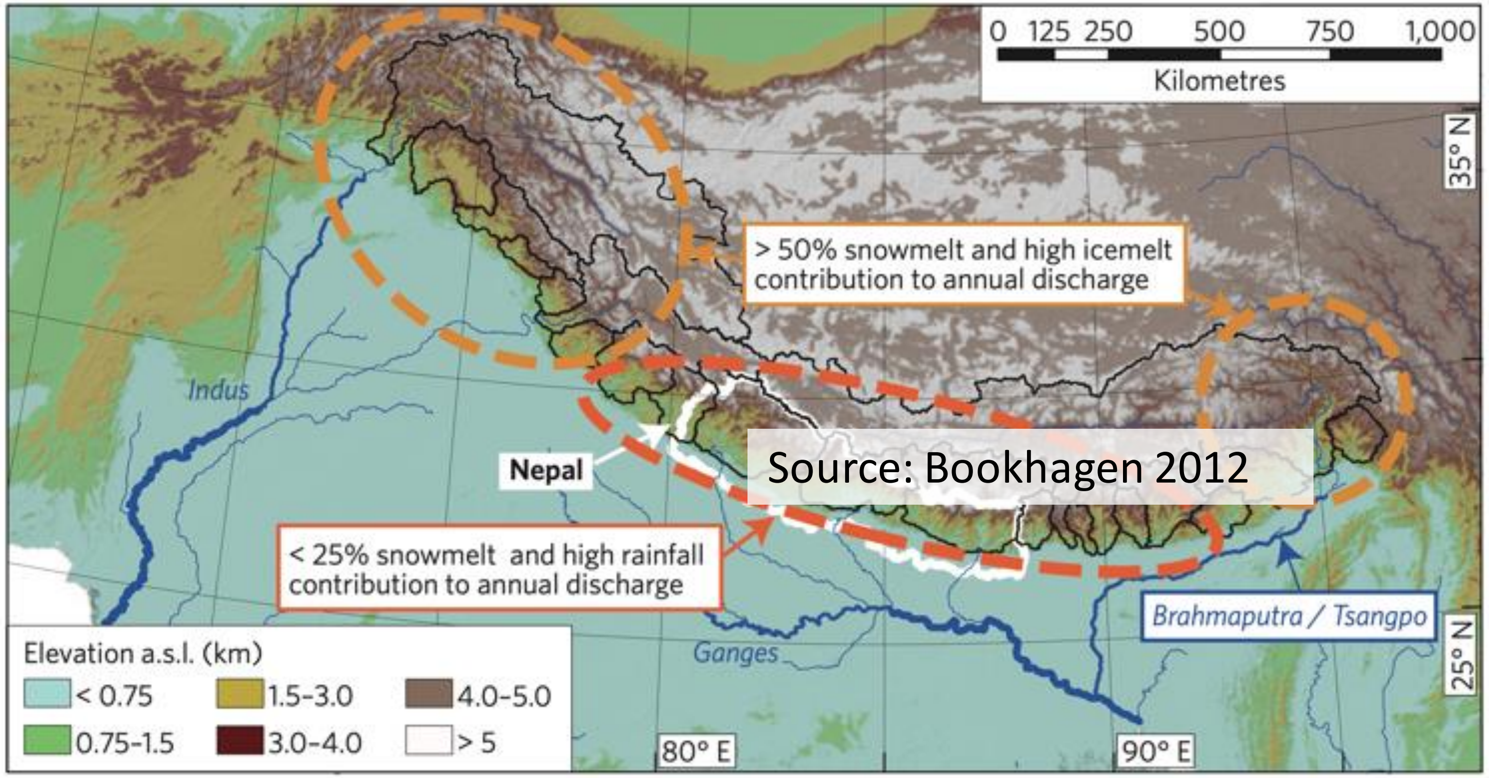
DEPARTMENT OF EARTH SCIENCES
UNIVERSITY OF KASHMIR
HAZARATBAL SRINAGAR (J&K) 190006

Pangong Lake

How to enhance the effectiveness of data collection…?

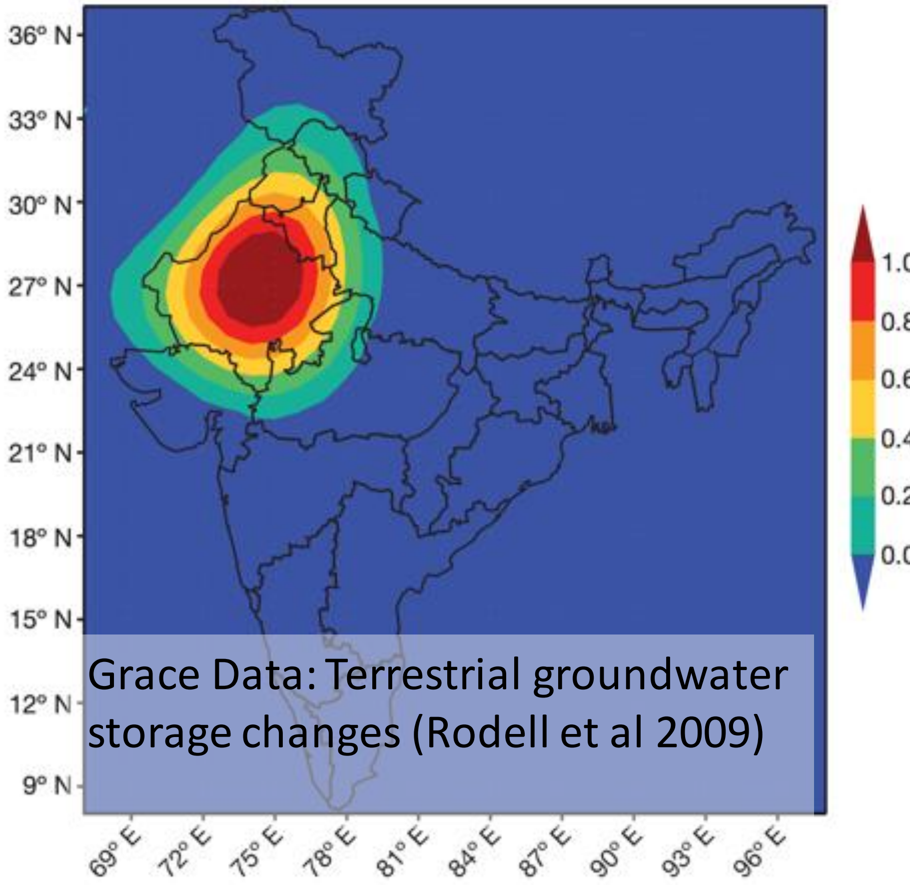
How will climate change and Cryospheric dynamics impact the water availability..?

- Himalayas: fresh water towers of the world
- Five major rivers of south Asia-supply fresh water to 1.5 billion people
- Western Himalayas->50% snow and ice melt to annual discharge

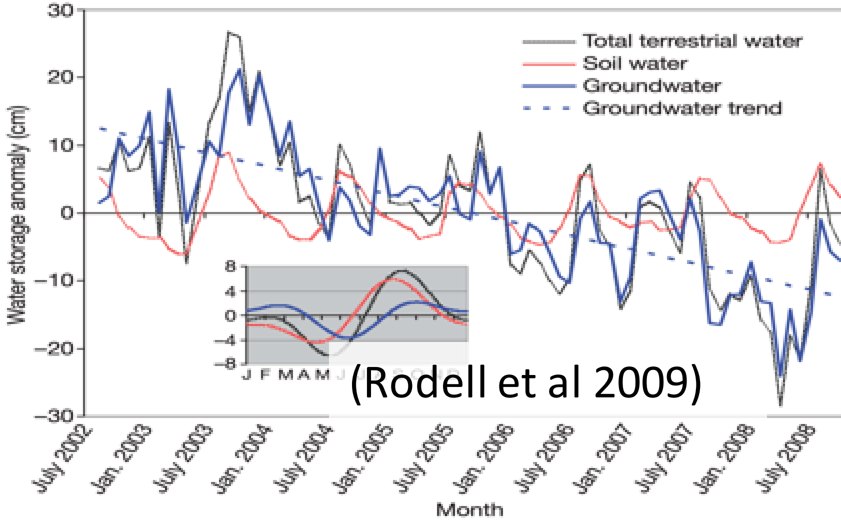


- Supply critical water resources for agriculture, hydropower generation, and other purposes.
- Shift from surface water to groundwater-led to the depletion of groundwater resources in the down stream areas.

- The rate of groundwater withdrawal (global) is more than the aquifer replenishment.
- Irrigation-some IRF but most of the GW withdrawn is lost in the form of runoff or/ evapotranspiration.
- Groundwater withdrawal for irrigation and other purposes in Rajasthan, Punjab and Haryana are depleting the groundwater reserves @ 4.0 cm yr^{-1} (17.7 $km^3 yr^{-1}$) (Rodell et al 2009)
- Effective measures should be taken to minimize the continuous depletion (Rodell et al 2009)



Grace Data: Terrestrial groundwater storage changes (Rodell et al 2009)



(Rodell et al 2009)

- The contribution of melt water to groundwater storage is difficult to estimate in complex mountain terrain (Himalayas).

- Spatiotemporal resolution of the current satellite system is too coarse to fully distinguish between groundwater, ice melt, and sedimentological and tectonic processes (Bookhagen, 2012).

- Need to have more observational and field data.

- Need to put more instrumentation in representative catchments to generate more baseline data for hydrological modelling and transferring the data/knowledge to other least accessible catchments of the upper Indus basin.
- Impact of climate change and cryospheric dynamics on water availability will be better addressed.

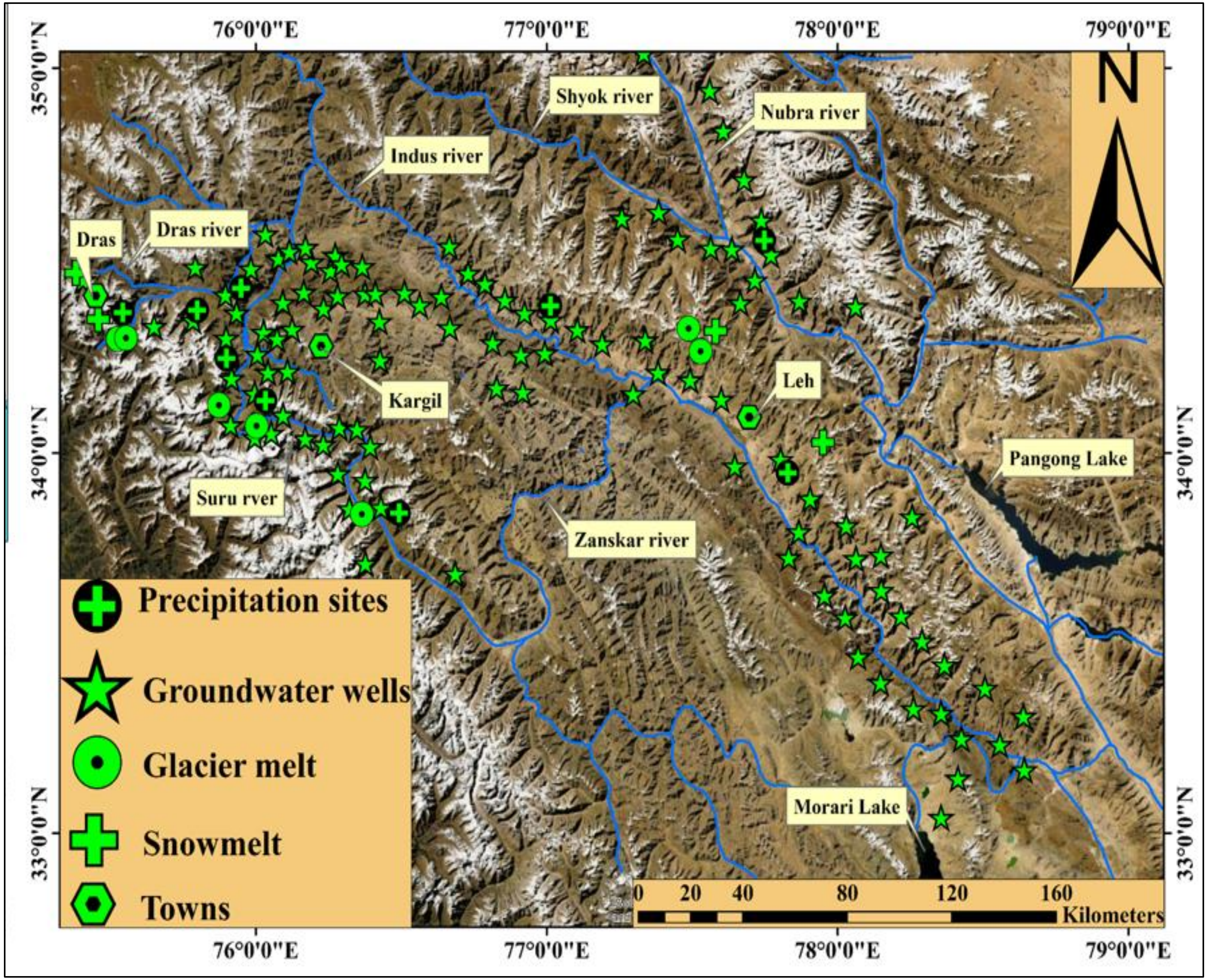
Field Campaigns

We used hydrogeological data and stable water isotopes of meteoric waters:

1) to estimate the dynamic and static groundwater resources of UIRB –Ladakh

2) To identify and estimate the sources of groundwater

(Lone et al 2021)

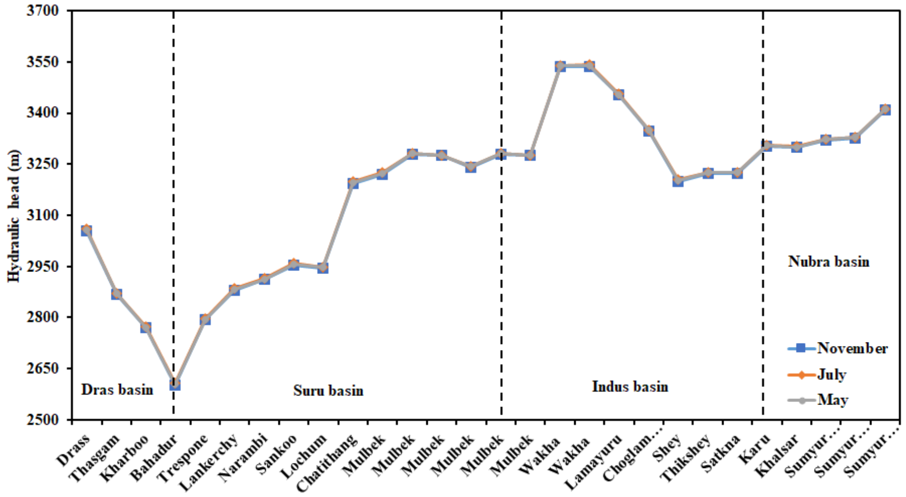


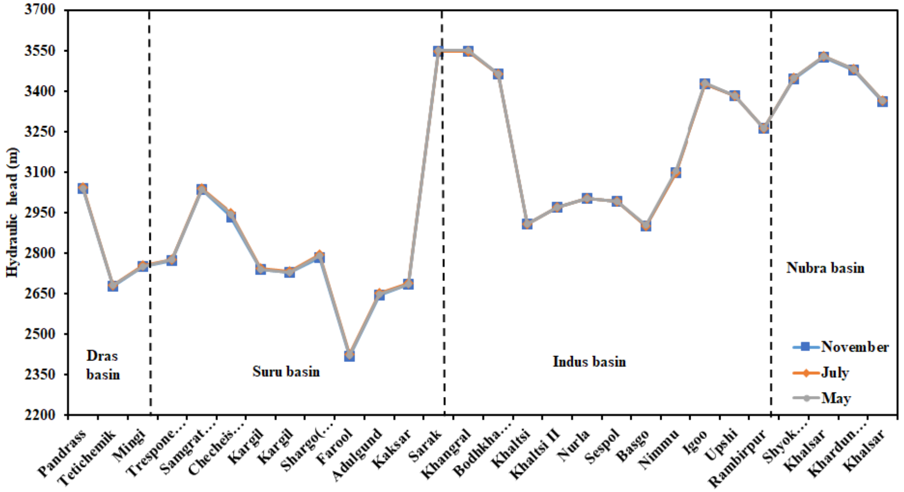


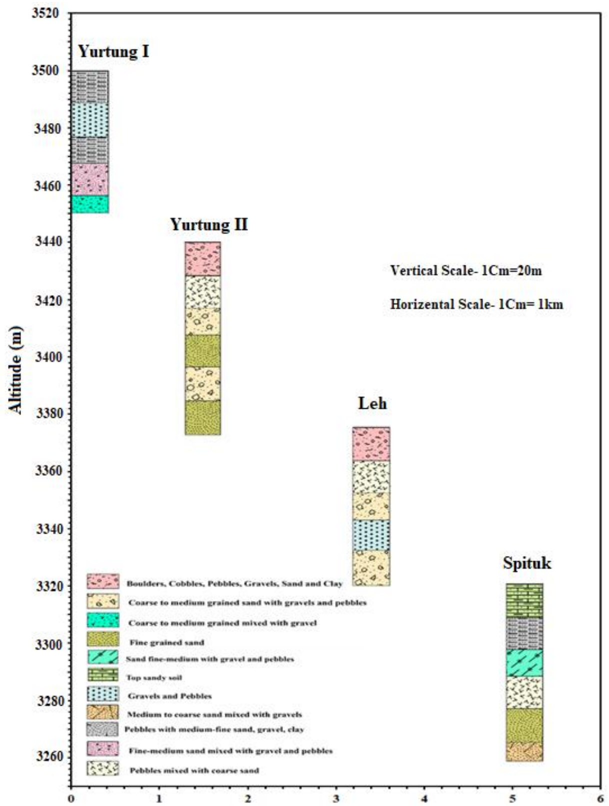


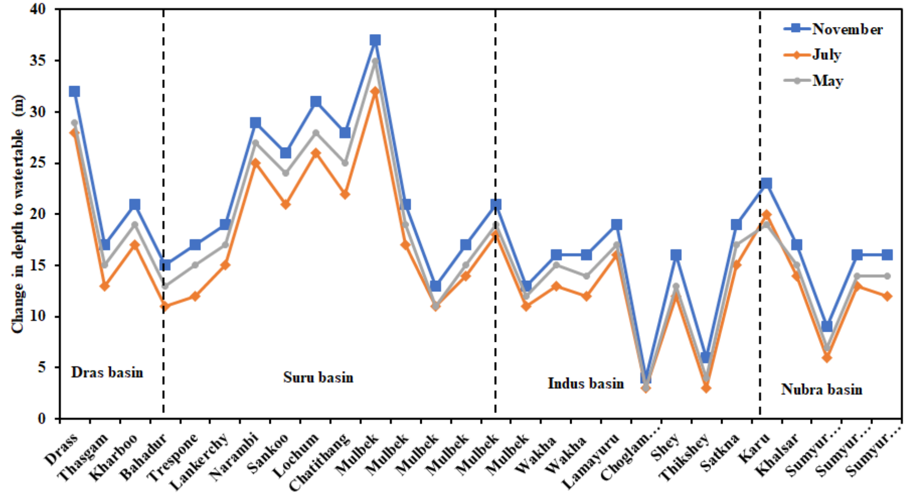

Major Results

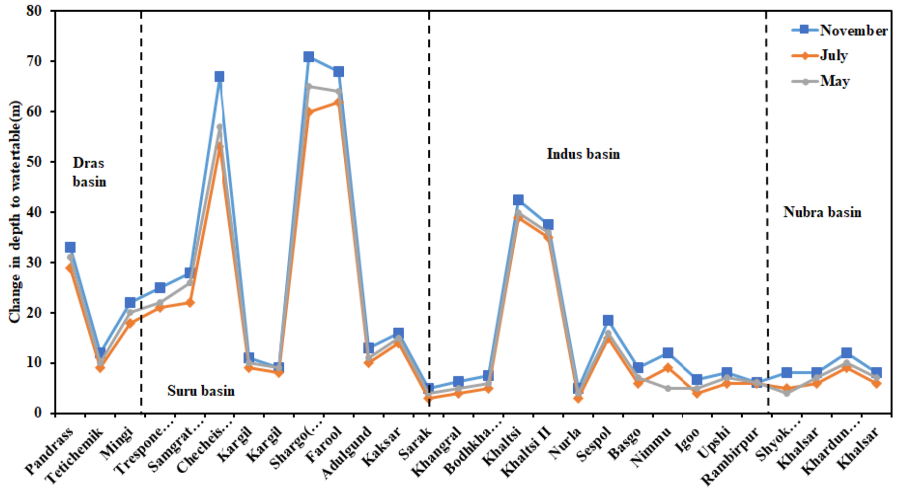
Hydrogeology and Water table fluctuation in
(a) Alluvium
(b) Hard rock











Dynamic Groundwater resources: Based on water table fluctuations

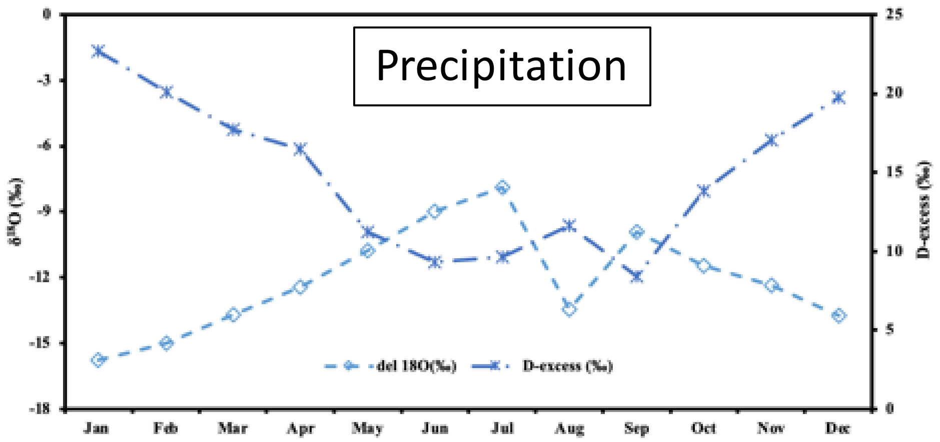
Basins	Alluvium		Hard rock	
	(mm yr^{-1})	$Km^3 yr^{-1}$	(mm yr^{-1})	$Km^3 yr^{-1}$
Drass	91.7	0.31	73.92	0.25
Suru	98.07	0.83	91.72	0.77
Indus	43.18	0.90	22.90	0.46
Nubra	83.33	0.000012	47.88	0.000068
Total	316.28	2.04	236.42	1.48

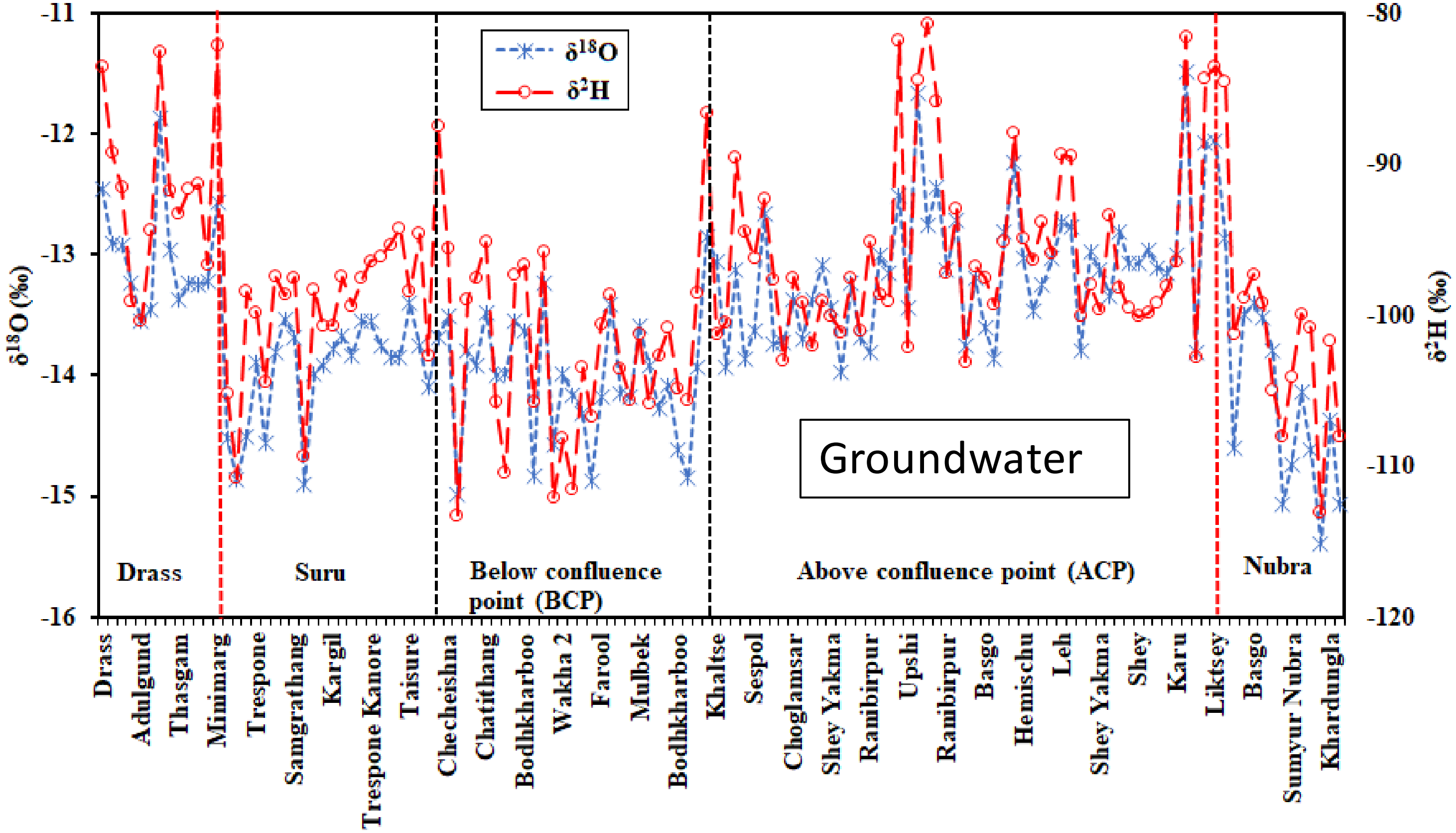
Total Groundwater resources

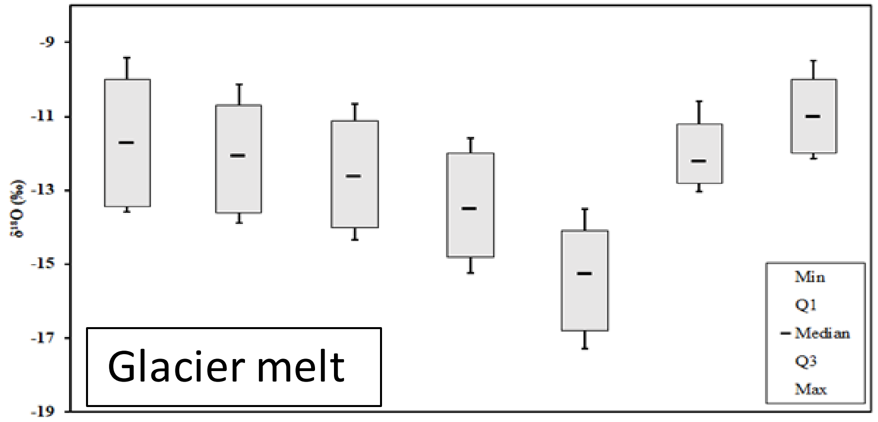
Basin	Alluvium		Hard Rocks	
	MCM	Km^3	MCM	Km^3
Drass	31,746	31.7	4,48,419	448.41
Suru	33,744	33.7	5,94,856	594.85
Indus	61,085	61.0	6,68,246	668.24
Nubra	29,995	29.9	4,00,122	400.12
Total	1,56,570	156.3	21,11,642	2322.6

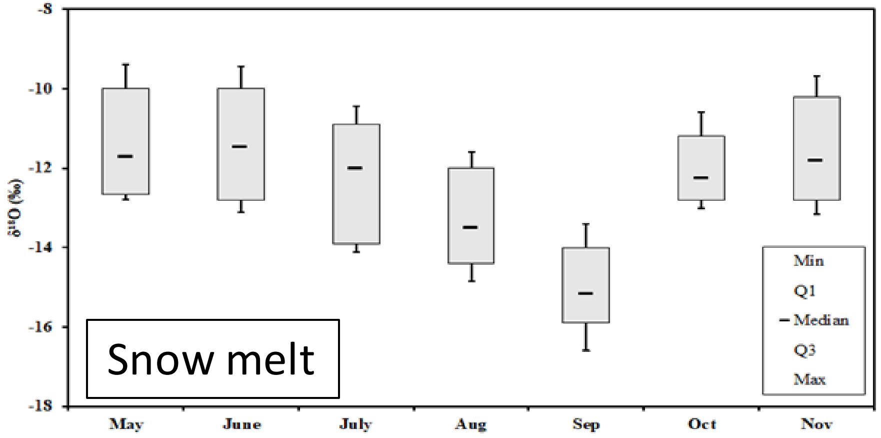
- ✓ Average saturated thickness in unconsolidated material=45m
- ✓ * Average saturated thickness in consolidated material=60m

Variation of δ18O and δ2H in precipitation, Glaciers, Snow and Groundwater









EMMA:
Two component and three component mixing model:
Contribution of rain, snow and glacier melt to groundwater estimated

Basin	April			August			October		
	Snow	Glacier	Rain	Snow	Glacier	Rain	Snow	Glacier	Rain
	(%)								
Dras	48±5.1	38±3.2	14±2	29±2.3	53±4.3	18±1.4	21±2.2	66±11.3	13±2.1
Suru	51±7.1	39±3.4	10±1.2	27±2.1	55±3.7	18±1.9	25±2.4	59±9.3	16±1.8
Indus	49±4.2	31±2.5	20±2.2	34±2	43±2.9	23±2.1	22±1.6	64±13.1	14±2.6
Nubra	48±6.1	36±3.2	16±2.1	34±3	49±2.1	17±2.1	23±2.7	61±8.9	14±1.2

Lone et al.. Under review (STOLEN)

- The glaciers in the Himalayas are thinning and retreating - spatially variable and complex (Fujita and Nuimura, 2011; Scherler et al 2011, Bolch et al 2012)
- Like climate change, glacier responses are heterogeneous, oscillatory, and trending as well (Kargel et al 2011).
- Snow in western Himalayas (brought by the western disturbances in winter) contribute significantly (~60%) to the stream/river flow (Jeelani et al 2012, 2017…) and groundwater.
- Glacier contribution to discharge is significant (Kaser et al 2010), key contributor in summer.
- Keeping in view the significance of melt water to water resources (surface and GW)-any decrease in Cryospheric reserve as a result of climate change, will have a strong impact on the timely availability of fresh water across the basin.
- Decrease in GW storage could have strong impact on river flow in late summer and winter (when GW contribution maintains the flow)—water availability, hydropower generation, etc.

Outcome

- Baseline study in Upper Indus Basin
- Gives an idea of the importance of different sources of groundwater
- Significance of snow and glacier melt in the region
- How vulnerable are the groundwater resources under changing climate-thinning of glaciers and decrease in the seasonal snow cover?
- Help modelers to design and calibrate the models for detailed understanding of hydrology of whole upper Indus basin

- Collaboration with other country chapters is needed to better understand the groundwater system in Upper Indus Basin across the political boundaries

Drung-Durung Glacier