

Climate resilient development for sustainable water, food and energy security for India



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Chamoli disaster of Feb. 2021 due to a break in a glacier



- A crack had formed at the side of a glacier, caused a massive block of rock and ice to fall onto valley on 7th Feb. 2022.
- Size of block over two million cubic m.
- Flood generated hit Rishiganga power project, also severely damaged another project on Dhauliganga river, near Tapovan village.
- Flood carried mud which trapped many workers in a tunnel of a project.

Sikkim GLOF disaster of 2023



- **GLOF washed away Chungthang dam in Sikkim (a ROR hydroelectric project, commissioned in 2017) and damaged two hydropower projects of NHPC (Teesta-V and Teesta-VI);**
- **More than 70 people were killed, 14 bridges washed away or damaged, 1320 houses severely damaged, drinking water supply lines and sewage networks damaged, and highways suffered widespread damage.**

Himachal Pradesh and Uttarakhand Floods 2023



Water-related disasters are on the rise

- **Severe damages in districts Bilaspur, Mandi, Solan, Una, Shimla, Hamirpur, Kangra, Bageshwar, Garhwal, Kashipur, and Chamoli.**
- **Many bridges and roads in HP and Uttarakhand were severely damaged.**
- **Overall death toll exceeded 280 in more than 50 incidents of landslides and dozens of flash floods in the hilly regions.**
- **Many bridges were damaged, more than 1,000 roads rendered unusable.**
- **Serious disruption of infrastructure and communication.**

Some situations when water use becomes unsustainable and mitigation

- When the diversion from a river exceeds the safe diversion limit – Ganga, Yamuna, Palar, ... **Determine safe diversion limit based on average water availability and the needs for a healthy river.**
- When the annual groundwater withdrawals exceed annual recharge rate – Punjab, Haryana, Rajasthan, Maharashtra,
- Largest groundwater use in India is for agriculture. **Attempts be made to reduce demands them by planting less water demanding crops.**
- When the annual water withdrawals from a pond/tank exceed the annual net inflows (inflows – evaporation – other losses). **Reduce withdrawals.**
- Contamination of surface and ground water sources – Yamuna, Hindon, Delhi **Strict monitoring and regulation. Polluter should pay.**
- When the health of ecosystems is deteriorated, they are unable to provide ecosystem services including water supply – Western Ghats, Lesser Himalayas, Dal lake, Husain Sagar. **Keep ecosystems in healthy conditions.**
- ...
- **Above causes of unsustainability can be reversed.**
- **Timely, well-planned and scientific management, when carried out over a long time, can help overcome these causes of unsustainability.**

Are the WRD pathways in India adequate to meet likely challenges?

- At the time of independence, India had very limited hydro-infrastructure.
- Food production in India in 1950s was inadequate to feed the then population.
- Hence, due emphasis was given to increase food production by increasing irrigation potential by harnessing river flows.
- Country had small water storage capacity and only a small number of canals had been constructed.
- In 1950s, India's storage capacity \approx 15 BCM. Currently, gross capacity \approx 325 BCM.
- **Tubewells (in 1951) \approx 3000. Sixth MI Census: # shallow, medium and deep tube wells is about 13.7 million – unsustainable withdrawals.**
- **Uncontrolled use of chemical fertilizers and pesticides is causing problems such as soil degradation, pollution and eutrophication of water bodies, food contamination, groundwater pollution, and spread of different diseases.**
- ...
- **Many developmental pathways are not ecosystem friendly, lack resilience.**
- **After a damage, system recovery time and efforts are large, e.g., Ganga.**

Climate Resilient Development (CRD)

- CRD is a process of implementing GHG mitigation and adaptation options to support sustainable development for all.
- IPCC: climate action and sustainable dev. are interdependent and CRD is promoted when this interdependence is leveraged.
- CRD involves reducing exposure and vulnerability to climate hazards.
- For efficient CRD, action in one area should not adversely impact others – nexus approach.
- CRD isn't achieved with a single decision; it is result of all the choices we make about climate risk reduction, emissions reductions and SD.
- Addressing risks and impacts of climate change successfully involves a diverse set of actors.
- E.g., changes in agriculture: a combination of effective government policy, regulation, informed daily decisions by farmers, traders and agricultural companies are required for CRD.
- Biodiversity conservation be given high priority in decision-making and policies for energy, industry, health, water, food, urban development, housing and transport.

Climate Resilient Development

- CRD involves everyone.
- Governments at all levels to work with citizens, civil society, educational bodies, scientific institutions, media, investors and businesses; form partnerships with weaker groups.

USAID presented a five-stage framework for CRD.

- **Scope:** establishes development context and assesses vulnerability at an appropriate level to support initial analysis.
- **Assess:** conduct more detailed assessment of the vulnerability of key inputs and the broader system, identified in scoping stage to climate and non-climate stressors.
- **Design:** identify, evaluate, and select actions to reduce the impact of climate and non-climate stressors.
- **Implement and Manage:** puts actions selected in design stage into practice.
- **Evaluate and Adjust:** analyze implementation progress and adjust strategy, program, as needed; provide more support if needed.

Climate Resilient Development Pathways

(a) Societal choices about adaptation, mitigation and sustainable development made in arenas of engagement

Dimensions that enable actions towards higher climate resilient development

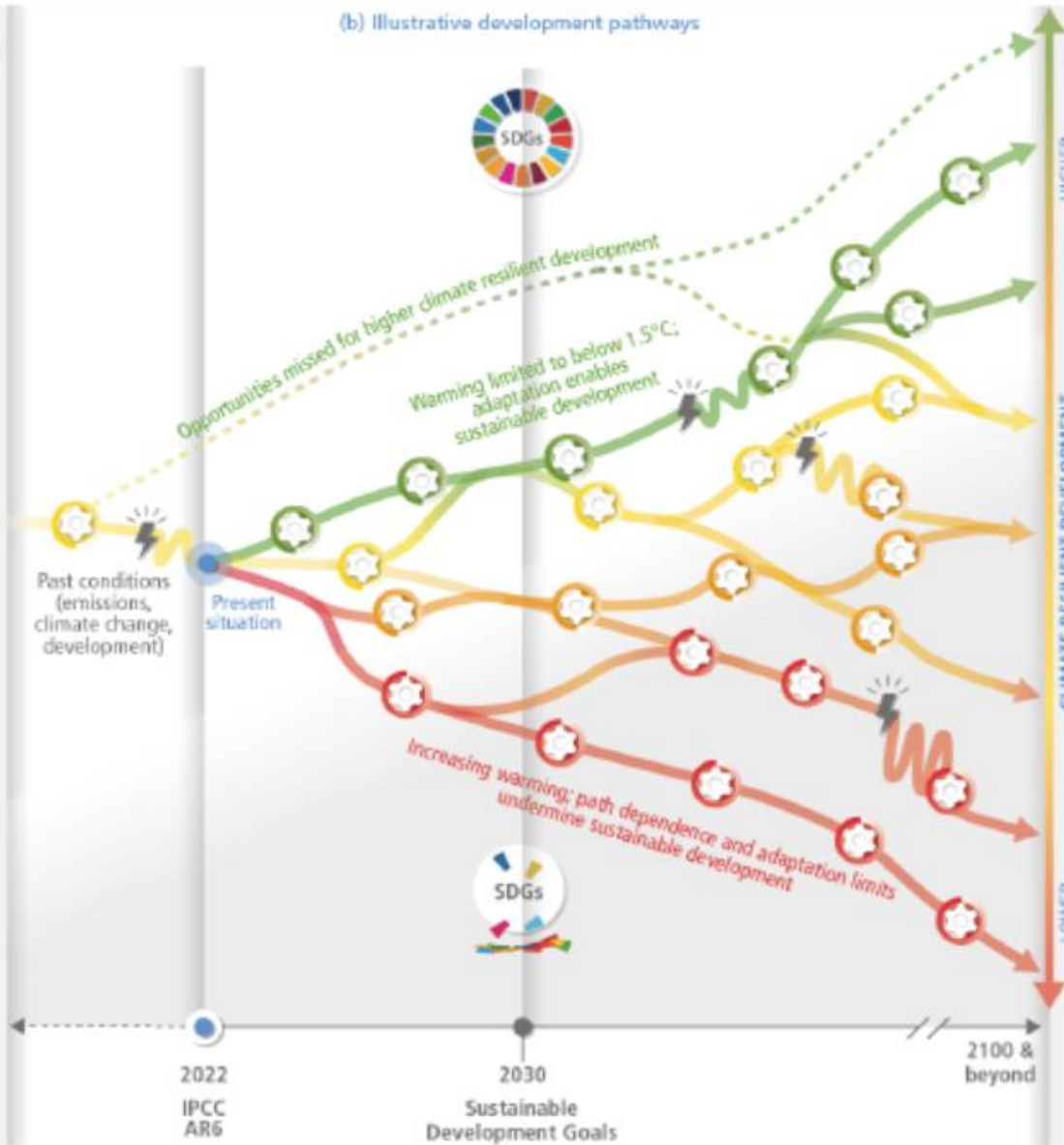


Arenas of engagement:
 Community
 Socio-cultural
 Political
 Ecological
 Knowledge + technology
 Economic + financial



Dimensions that result in actions towards lower climate resilient development

(b) Illustrative development pathways



(c) Actions and outcomes characterizing development pathways



Narrowing window of opportunity for higher CRD

Illustrative climatic or non-climatic shock, e.g. COVID-19, drought or floods, that disrupts the development pathway

Action Domains to Promote CRD in India

- **Policies, Practices and Strategies**
 - **Governance Aspects**
 - **Data and Analysis**
 - **Institutional Strengthening**
 - **Infrastructure**
 - **IWRM for improved management of water and associated resources**
 - **Involvement of Stakeholders**
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- **Water resiliency requires preparedness and quick response to emergent conditions – need to conserve resources.**
 - **It is achieved by increasing capacity to prevent, mitigate, be ready, respond, and quickly recover from hazards.**
 - **Five pillars of resilience: threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity.**

(Some) SDG targets relevant to water sector

SDG Target	Description	SDG level and trend (Sachs et al. 2023)
2.1	By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.	Major challenges remain, stagnating
3.9	By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.	Major challenges remain, moderately increasing
6.1	By 2030, achieve universal & equitable access to safe and affordable drinking water for all.	Major challenges remain, moderately increasing
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.	
6.4	By 2030, substantially increase water-use efficiency in all sectors; ensure sustainable withdrawals and supply of freshwater to address water scarcity; substantially reduce number of people suffering from water scarcity.	
6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.	
6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.	
6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities, including water harvesting, desalination, wastewater treatment, recycling and reuse technologies.	
6.b	Support and strengthen the participation of local communities in improving water and sanitation management.	

(Some) SDG targets relevant to water sector

SDG Target	Description	SDG level and trend (Sachs et al. 2023)
9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes.	Major challenges remain, moderately increasing
9.a	Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support.	
11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the economic losses relative to gross domestic product caused by disasters, including water-related disasters.	
11.6	By 2030, reduce adverse per capita environmental impact of cities, including by paying special attention to air quality, municipal and other waste management.	Major challenges remain, moderately increasing
11.b	By 2020, substantially increase number of cities and human settlements adopting & implementing integrated policies and plans for inclusion, resource efficiency, mitigation & adaptation to climate change, resilience to disasters.	
12.2	By 2030, achieve sustainable management & efficient use of natural resources.	Achievement, on track
13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.	Achievement, stagnating
13.2	Integrate climate change measures in national policies, strategies and planning.	
15.1	By 2020, ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands.	Major challenges remain, decreasing
15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.	
17.14	Enhance policy coherence for sustainable development.	Challenges remain, increase

Why Urgency for CRD ?

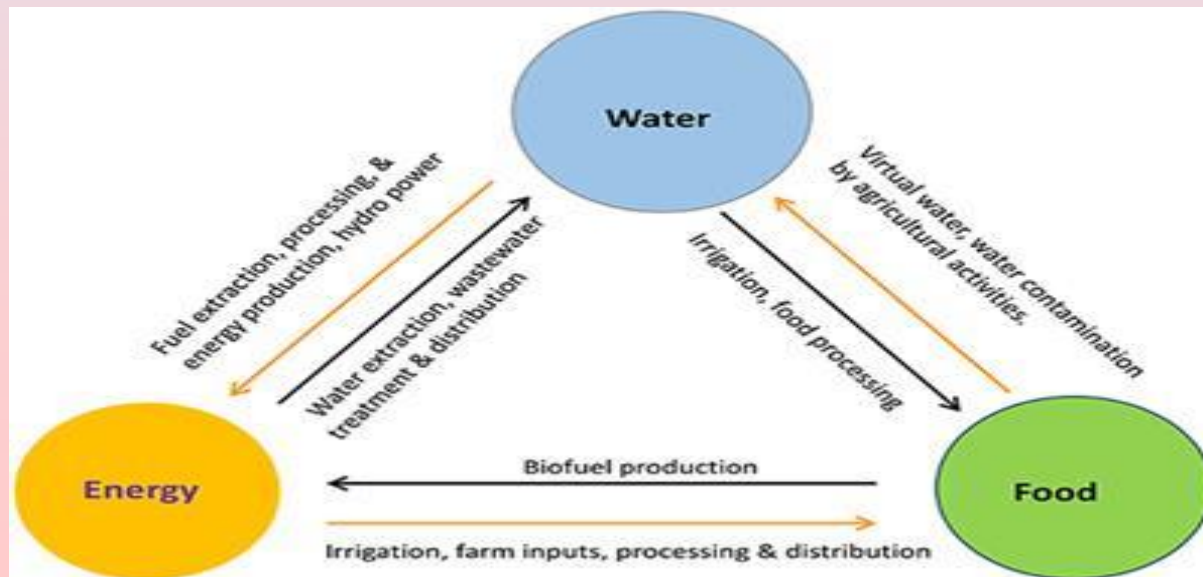
- Paris Agreement (2015) - Overarching goal: hold “increase in global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “to limit the temperature increase to 1.5°C above pre-industrial levels.”
- Concept of remaining carbon budget (RCB): it is the net amount of CO₂ that humans can emit while keeping global warming below a given limit with a given probability, considering effect of other anthropogenic climate forcers.
- RCB for a 50% chance of keeping warming to 1.5 °C is ≈ 250 GtCO₂ (Jan. 2023) : equal to ≈ 6 years of current CO₂ emissions.
- At current rate of GHG emissions, RCB will exhaust in next 6 years.
- Window of opportunity to implement system transitions needed to enable CRD is rapidly narrowing.
- Meanwhile, disasters are hurting population, economy, infra, ...



Actions Needed to promote CRD in India

Policies and Strategies

- India had developed a water policy in 1987; revised in 2002. Updated in 2012.
- Covers sustainability but a focused approach and policy would be required.
- A comprehensive policy covering water conservation, harvesting, efficient use in all major sectors, recycle, reuse, etc. is necessary.
- Nexus: India has many programs in water, food, energy, and environment sectors. Missing interlinkages and interconnection among the programs are needed.



Actions Needed to promote CRD in India

Water and environment management: two basic principles.

- **Precautionary principle:** wherever possible, environmental damage must be prevented, it should not occur. **Rivers (Ganga) example.**
- **Polluter pays principle:** the polluter should pay for mitigating the damage caused by pollution.
- **European Union (EU) Water Framework Directive (WFD) - central instrument for water resource management since 2000.**
- **WFD is broad-based, aims at ensuring a good status of all waterbodies in the EU.**
- **WFD is supported by many sub-directives - Groundwater, Flood Risk Management, Urban Waste Water Treatment, and Environmental Quality Standards Directive.**
- **EU countries have incorporated WFD into their national legislation through acts and ordinances.**
- **Indian NWP be updated to provide push for adopting pathways to follow CRD and meet SDG targets.**

Actions Needed to promote CRD in India

Data and Analysis

- **A range of data are required for CRD - sectors cover water, land, agriculture, energy, vegetation, environment, social, economic, etc.**
- **Essential climatic variables (ECV) - 55 ECVs.**
- **Measure the data and share it.**
- **National Geospatial Policy (NGP) 2022, Ministry of S&T - goal is to make India a world leader in the global geospatial sector.**
- **Need for similar forward-looking policy for water data.**

Actions Needed to promote CRD in India

Governance



- Many ministries of Central and State governments deal with water and associated resources.
- Ministry of Jalshakti; Agriculture; Power; Science and Technology; Environment, Forests, and Climate Change; Rural development; Urban development; and so on.
- Research on water topics is carried out at numerous R&D academic institutes, funded by government.
- Many specialized UN agencies//MNCs/ NGO's, ...
- Some duplication can't be avoided; effective communication and sharing of data+ knowledge would help.
- Set up river basin boards for each major river basin.

Actions Needed to promote CRD in India

Water Pricing

- **If a resource is provided free, it typically leads to wastage.**
- **An efficient water-pricing mechanism is a tool to address water scarcity.**
- **Water pricing should depend on: capital expenditure, operations and maintenance cost, end use of water, and price of ecosystem service losses.**
- **Charges for irrigation water may depend on State, crop, season, and source of water.**
- **Water services should be reliable, equitable, and affordable to weaker sections.**
- **Paradox: price of bottled water vs domestic water.**
- **For sustainability, recover cost of providing services and have adequate funds for upkeep and expansion.**

Actions Needed to promote CRD in India

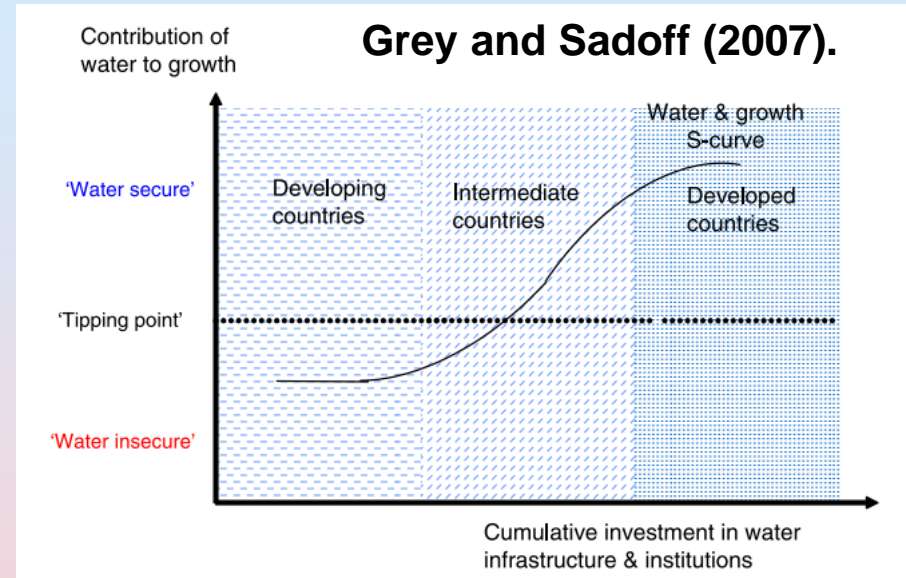
Institutional Strengthening

- **Depth and breadth of institutions is not commensurate with magnitude and severities of problems.**
- **Resources -- human capital, financial, equipment/tools -- not commensurate with problems.**
- **Expertise of many government institutions is declining due to retirement; replacement is inadequate.**
- **R&D budget for water sector in India is low and funding opportunities are limited.**
- **Presently most State level Irrigation / Water Resources /Public Works Departments, are construction and maintenance oriented.**
- **Water sector is not first choice of young people.**
- **Create attractive career growth prospects to attract talented people to this profession.**

Actions Needed to promote CRD in India

Infrastructure

- Infrastructure is essential for harnessing raw water sources, store, treat, transfer and deliver water.
- Ability to regulate riverflows



- Climate-resilient infrastructure must be adaptable and quickly recover from disruptions. **Silkyara tunnel.**
- Two recent disasters - an under-construction project in Chamoli District was damaged due to a high flood; an existing project in Teesta Basin (Sikkim) was damaged due to a high GLOF.
- Design and maintenance standards for urban water systems need to be updated to take care of climatic changes.

Actions Needed to promote CRD in India

Recycle and reuse of water

- **Increasing demand and variabilities due to climate change - Need to find alternate water sources.**
- **Nexus between potable water scarcity and wastewater and solid waste management.**
- **Presently, less than 30% of wastewater generated is treated before discharging - contamination of water sources and degradation of environment.**
- **Improper management of solid waste reduces storage capacity of water bodies and conveyance capacity of drainage channels.**
- **Address twin problems of environmental degradation and water scarcity through recycling and reuse of treated wastewater for potable and non-potable purposes.**

Actions Needed to promote CRD in India

Ecological and Environmental Protection

- **Hydro-infrastructure should be designed and operated with river health and environmental flows as primary goals.**
- **Developmental activities should not diminish ecosystem services.**
- **Rivers draining agricultural areas are impacted by high nutrient concentrations due to excessive use of fertilizers, pesticides.**
- **Polluted rivers could emit significant GHG emissions, e.g., emissions from Adyar River Estuary (Chennai) are equivalent to emissions from vehicular traffic in one month.**
- **Integrated management of river flows and solid and liquid waste is necessary.**

Actions Needed to promote CRD in India

IWRM for improved management of water resources

- **Climate change does not respect geographical or sectoral boundaries and coordinated responses to strengthen climate resilience are essential.**
- **SDG Target 6.5 aims to implement IWRM at all levels, including transboundary cooperation.**
- **IWRM should be based on: integrated planning and operation of water supply infrastructure for different sectors, proper wastewater treatment and management.**
- **IWRM should consider recycling and reuse of treated wastewater for different purposes.**
- **IWRM should consider climate resilient design of all water and wastewater management infrastructure.**

Involvement of Stakeholders

- **Best outcome will be obtained by involving all sections of the society in decision making.**

Action Plan

- 1) Estimate water availability for 2050 and 2075.
- 2) Estimate water demand for various sectors for 2050 and 2075.
- 3) Make plans to meet the demands for 2050 and 2075. Ways to conserve.
- 4) Make plans for flood and drought management for 2050 and 2075.
- 5) Make plans for ecosystem rejuvenation for 2050 and 2075.
- 6) Manpower planning – planners, designers, construction, managers, researchers

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Some R & D Topics Concerning CRD

- **Collecting better data – more variables, more locations, higher frequency of observations.**
- **Hydro-met predictions with less uncertainty.**
- **High resolution runoff and groundwater simulations (smaller than 1x1 km).**
- **Disaster risk reduction – floods, droughts, analysis, Glacier Lake Outburst Floods.**
- **Monitoring glaciers – wider coverage, better glacier melt modeling.**
- **Better models to simulate and predict failures of moraine dams.**
- **Ecosystems thresholds, environmental flows.**
- **Solute transport, river-aquifer interaction.**
- **Improved technology to treat water (including emerging pollutants) by using local materials.**
- **Urban hydrology/ flooding.**
- **Improve water use efficiency in all sectors.**
- **Sub-basin level analysis for Himalayan region – to help with informed decisions, assess risks based on site-specific analyses.**



Questions ?