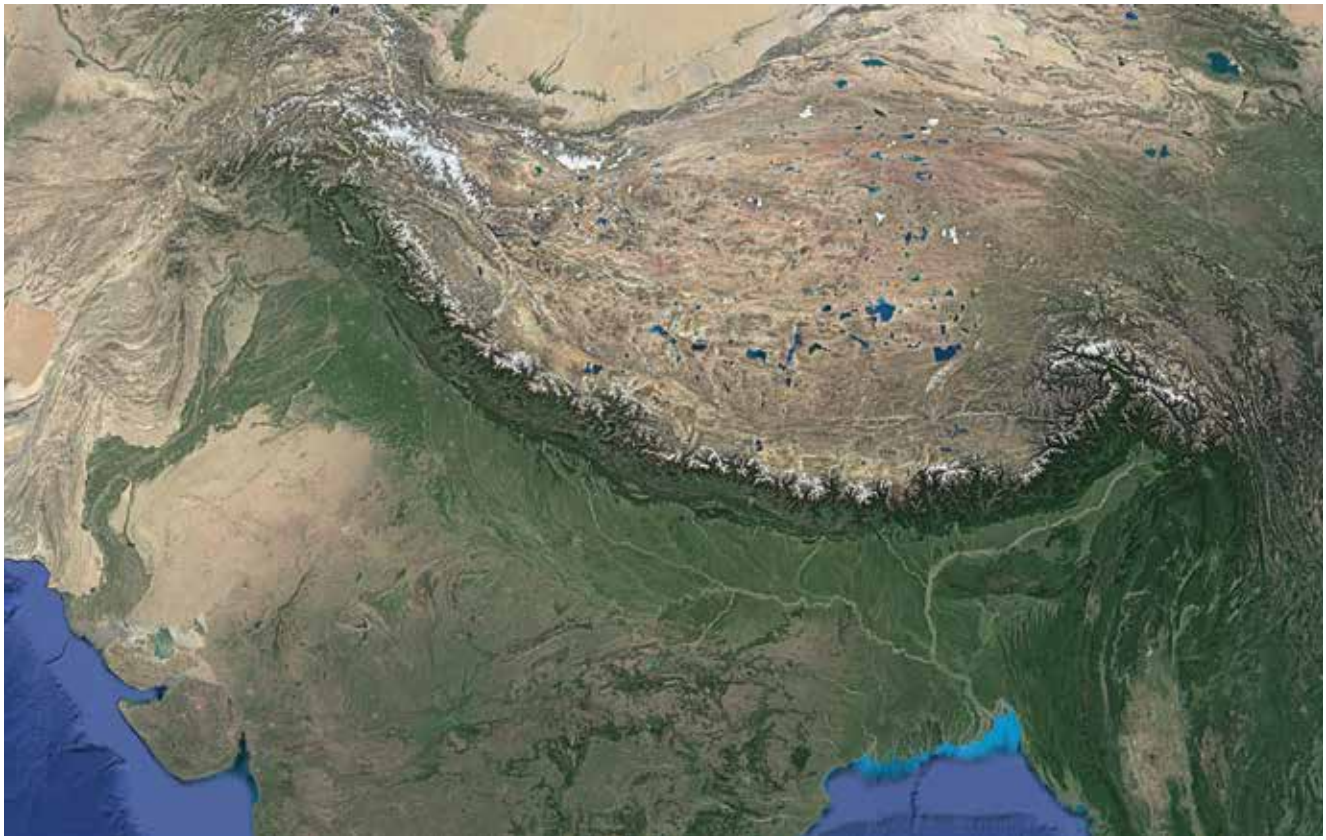
NITI Aayog

Report of Working Group V

Data for Informed Decision Making



Contributing to

Sustainable Development in Indian Himalayan Region

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NITI Aayog, August 2018

Cover photo: Satellite image showing the Himalayan Region

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2nd August 2018

Preface

NITI Aayog (Rural Development Division), Govt. of India vide letter No. P. 12018/12/2016-RD Dt. 2 June 2017 constituted five working groups for Sustainable Development in Mountains of Indian Himalayan region (IHR) and identified the G.B. Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD) as Lead Institution and Convener of the Working Group V "Data/ Information for Informed Decision Making by Multiple Stakeholders" along with members from leading national and international organizations with the following terms of reference: (i) to assess data requirement and availability across multiple sectors/ institutions and gaps for monitoring of key conservation and development issues including climate change, cryosphere, disaster, biodiversity and socio-ecological dimensions, and ways to address the same through cross-sectoral and interdisciplinary institutional collaboration and data sharing; and (ii) to suggest data generation, management, sharing and end-user accessibility and use, with a view to ensure quality (the data set on the Himalayas needs to be developed to the level of fidelity), formats, access and sharing at different levels including local, state, national and regional (Annexure-I).

The Working Group adopted a systematic approach of consultations and survey. A wide range of stakeholders within and outside the IHR engaged in data generation and data utilization for policy prescriptions in the IHR were consulted. In general, it was found that several methods and approaches are being followed for collection, collation, and dissemination of data and information. It was found that except for a few agencies/ organizations, no definite protocol for data quality control and sharing exists. Therefore, there is an urgent need to put in place a user-friendly mechanism for data access for policy and planning use. There are also severe data gaps, and the authenticity and quality of data also needs to be addressed. In this report, the typology of data requirements, data availability, data gaps and proposed measures for quality control/ check of data and mechanisms for its access to end-users have been suggested to make it usable for development planning/ informed decision making in the IHR. This assignment of dealing with a new domain of data management has been quite challenging and provided us the opportunity to critically look into the key developmental issues of the IHR. Managing data is an evolving process and hence, there is an ample scope for suggestions and improvement. GBPNIHESD and all participating Institutions are thankful to NITI Aayog for assigning this important task to the Group. We hope it will be useful for informed decision making in developmental planning and environmental conservation in the IHR.

10 July, 2018
Almora

Authors

Acronyms and Abbreviations

MoEF&CC	Ministry of Environment, Forest and Climate Change
GBPNIHESD	G.B. Pant National Institute of Himalayan Environment and Sustainable Development
CSIR	Council for Scientific and Industrial Research
UGC	University Grants Commission
DST	Department of Science and Technology
WII	Wildlife Institute of India
WIHG	Wadia Institute of Himalayan Geology
ICIMOD	International Centre for Integrated Mountain Development
BSI	Botanical Survey of India
ZSI	Zoological Survey of India
IMD	India Meteorological Department
NDMA	National Disaster Management Authority

Executive Summary

Mountain ecosystems play an important role in shaping the sustainable development of India. Realizing the importance of the Indian Himalayan Region (IHR) as a unique treasure of environmental goods and services and a rich repository of biodiversity and cultural diversity, and considering its sensitivity to natural disasters and climate change, the Government of India has accorded the highest priority to IHR and safeguarding of Himalayan ecosystems. Sustainable development planning and decision making in the IHR needs information and access to data on important conservation and development issues. The NITI Aayog, Govt. of India constituted a Working Group with G.B. Pant National Institute of Himalayan Environment & Sustainable Development (GBPNIHESD) as Lead Institution with the following ToR: (i) To assess data requirement and availability across multiple sectors/ institutions, and gaps for monitoring of key conservation and development issues including climate change, cryosphere, disaster, biodiversity and socio-ecological dimensions, and ways to address the same through cross-sectoral and interdisciplinary institutional collaboration and data sharing; and (ii) To suggest data generation, management, sharing and end-user accessibility and use with a view to ensure quality (the data set on the Himalayas need to be developed to the level of fidelity), formats, access and sharing at different levels including local, state, national and regional.

Consultations with member organizations was organized and data and information available with them were obtained. Additionally, information was collected from the websites of various organizations. A structured questionnaire was circulated to 96 institutions and departments of IHR states. Additionally, another questionnaire was circulated to Chief Secretaries of 12 IHR states for obtaining information on state-specific issues and data required for informed decision making to address these issues. Based on the synthesis of the information received/ collected from different organizations sector-wise issues, data requirement, availability and gaps were identified. The report is structured into different chapters covering the important sectors/ subject areas in individual chapters. The recommendations of the Working Group for different sectors are:

- In the climate change, cryosphere and disaster sectors the report recommends: (i) data collection by increasing number of observational stations, particularly in high altitude areas for better forecasting; (ii) promoting use of space-based observations in the harsh high altitude areas and areas inaccessible for instrumentation; (iii) improve collection of real time data on glacier melt and associated hydrological processes; (iv) documentation of diverse climate change adaptation practices for mitigation of climate change impacts; (v) development of pan-Himalayan disaster vulnerability maps (landslides/ forest fire/ flood/ seismic zone) at block and district level for disaster preparedness; (vi) improvement in IT infrastructure for real time data collection and dissemination for better disaster preparedness; and, (vi) augmentation of facilities and development of a network for recording low magnitude earthquakes.
- In the biodiversity sector the report recommends: (i) collection of location-specific and geocoded data on habitat ecology, population dynamics of biodiversity elements (particularly rare, threatened and endemic species) with edaphic, environmental and climatic attributes; (ii) preparation of biodiversity distribution data at spatial (grid basis) on lower scale/ resolution as input for integrative analysis along

with related climate, topography, soil, socio-economic data for effective decision making; (iii) documentation of ethnobotanical/ traditional knowledge on best practices in biodiversity conservation and sustainable use; (iii) mapping of biodiversity rich (having endemic elements) areas earmarked for their conservation values; (iv) quantification and valuation of bioresources (such as NTFPs) and their use patterns for estimation of ecosystem services and to promote sustainable use.

- The major recommendations in the socio-ecological sector are: (i) promotion of development research in universities/ institutions through involving inter-institutional and inter-departmental collaborations and patronage to institutions mandated for such research so that the decision making on conservation and development issues is facilitated with appropriate information/ database; ii) prioritization of key conservation and development issues of IHR and promotion of multi/ inter-disciplinary focussed sponsored research on such issues in time-bound/ mission mode manner by transforming the existing research culture; (iii) inventory and documentation of the existing TIK on health care, and NRM practices at village/ village clusters/ and eco-cultural zone levels; (iv) safeguarding IPRs/ patent issues and simplified procedures to implement access and benefit sharing of the practicing/ custodian community; and, (v) capacity building of planning agencies for optimal use of such data through the specialized nodal institutions.
- The report also highlights constraints related to use of available data, authenticity, compatibility, validation, user charges, archiving paid data, non-availability of unpublished data, and policy regarding time-frame for bringing unpublished data to public domain. Convergence of existing analogue data into digital form suitable for data collection, compilation and access was emphasized. Need for appropriate benefits for data sharing, standardization of data formats, user-friendly data submission tools, formats for different types of data, and compatibility of databases was underscored. Issues such as willingness to share the data, quality of data, and need to overcome duplication of data to utilize the intellectual/ capital/ material resources in the best interests of the region were raised as major concerns. In this context the Working Group recommended a citizen science approach which ensures participation of a range of stakeholders for data collection, data compilation and public interface.

The Working Group has provided following recommendations

i. The National Data Sharing and Accessibility Policy (NDSAP), Govt. of India needs to be fully utilized through regular feedback from the designated State and Central agencies; for this purpose a nodal point in the NITI Aayog may be considered to ensure implementation and follow up of NDSAP with amendments as deemed appropriate;

ii. There is a need to create a "Data Centric Architecture" for IHR to address data gaps, data quality control, data management and data access to end-users for sustainable development planning and decision making. GBPNIHESD has been proposed as an accredited Central Govt. organization to act as Central Data Management Agency (CDMA) for IHR and given the responsibility to maintain dedicated data centre on IHR. It will receive regular data from sector-specific designated state and central agencies. The linkages with other R&D organizations/ universities/ voluntary organizations to augment the data through participatory and incentive based approach should be strengthened through funding agencies.

iii. Harmonizing and digitization of data in terms of scale and formats for its effective use in their planning and decision making is required and accordingly a clause to this effect may be added to NDSAP guidelines.
iv. Skill and capacity building of various stakeholders including youth be promoted for systematic data generation in gap areas.

Action Points

The actionable points from the Working Group exercise are:

Policy

- There is a need to promote data centric developmental research across universities and research organizations on key prioritized issues in a time-bound and mission mode through inter-departmental/ inter-institutional collaborations by appropriately changing their mandate and academic policy for awarding Ph.D. to a group of students for such projects.
- Decision making requires multidimensional visualization of scenarios and alternatives, and therefore there is a need for promoting a culture of science based policy planning at the State level.
- A mechanism should be built to pool data/ information particularly traditional knowledge available at the community level into the central data pool (CDMA at GBPNIHESD) after giving due benefits to data owner.
- Some incentive mechanisms such as incorporating the credit system in assessment policy of researchers should be evolved in institutional policies to bring this primary data/ information to public domain and encourage its compilation for various decision making contexts.

Institutions and Processes

- The GBPNIHESD is proposed as the lead agency in IHR responsible for data/ information housing, compilation, and access; a separate centre under GBPNIHESD (as CDMA-IHR) could be created for this work and strengthened with adequate trained manpower.
- All the departments, institutions and universities should also have a dedicated data cell to act as a repository of all the data available in their domain; data from such cells could be housed at a state level cell which would provide information/ data to CDMA-IHR through web-linked network. CDMA-IHR at GBPNIHESD would archive the data/ information/ metadata from different organizations/ institutes or otherwise would facilitate the data dissemination to the end users through mutual agreement of data dissemination with other nodal agencies. Moreover, for archiving and hosting the data collected by community/ voluntary organizations, GBPNIHESD would also act as the collaborating agency including for traditional knowledge.

Capacity Building

- A large number of the actions suggested focus on capacity building, which would involve training of the decision makers, planners and implementing agencies for optimal utilization of the cross sectoral data/ information for informed decision making.

- Also training of the researchers, other stakeholders and also the community will be required through subject specific programmes and workshops on collection/ generation and quality check of field data. In this regard, synergy with Working Group 4 on Skill Building would be essential and beneficial. Some premier institutes of IHR and the country such as NRSC, WIHG, NEERI, IEC, ICSSR, NIH, BSI/ ZSI, ICFRE, GBPINHESD, and ICIMOD can also be involved in capacity building.

Research, Science and Technology

- RS-GIS is a very useful planning tool that can help in scenario visualization and guiding decision making on complex conservation and development issues; therefore, there is a need to strengthen the RS-GIS wing in all R&D institutes and universities, and higher courses on the subject should include enhanced application of RS-GIS information/ data for decision making. ICIMOD can greatly help by bringing in latest technology for the Centre.
- Establishment of the CDMA-IHR would require setting up Linux based data centre protected by firewalls facilitated with high end server for faster data dissemination. Also the data centre would be equipped with sufficient space using Solid State Drives (SSD) for faster data archival and distribution. A data dissemination geo-portal would be required to link the data centre for carrying out the data management through friendly user interface, for data archival, hosting and dissemination.

Finance and Market

- Setting up of dedicated data centre (CDMA) in GBPNIHESD would require special funding in the form of one time corpus and minimal recurring costs. A project can be submitted to MoEF&CC and other agencies for funds and manpower. ICIMOD being a regional agency can provide help in generating financial support to GBPNIHESD. The state level data centres can be funded by state governments and UGC can leverage funds for university data cells; the respective ministry/ state government can also provide fund support to departmental data cells. User charge may be levied for data supplied under the approved benefit sharing mechanism.
- Considering the strong need to make the research more data centric, useful for problem solving and amenable to policy and decision making, all funding agencies like DST, MoES, DBT and MoEF&CC should fund such exploratory research in IHR through existing missions and schemes like NMSHE and NMHS.

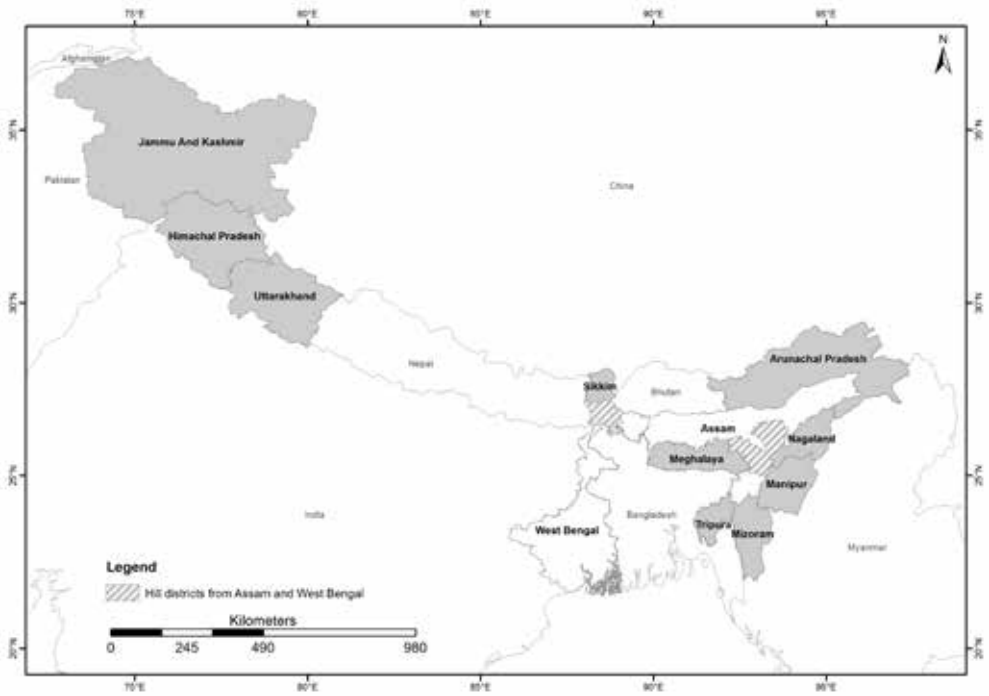
Chapter 1
Himalayan Environment and Sustainable Development: Key Issues

To start with, it is important to understand the state of Himalayan environment and concerns relating to sustainable development. The widely used definition of sustainable development put forward in the UN Report of the World Commission on Environment and Development *"Our Common Future" is: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland Report, 1987). It contains two key concepts: (i) the concept of 'needs', in particular the essential needs of the poor, to which overriding priority should be given; and, (ii) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. It has been further emphasized that development involves a progressive transformation of economy and society. A development path that is sustainable in a physical sense could theoretically be pursued even in a rigid social and political setting. But physical sustainability cannot be secured unless development policies pay attention to such considerations as changes in access to resources and distribution of costs and benefits. Even the narrow notion of physical sustainability implies a concern for social equity between generations, a concern that must logically be extended to equity within each generation. With the increasing realization that the natural resources of mountain areas are vital for both upland and lowland people, the Global Agenda for sustainable development has brought mountains to sharp focus. But the major concern remains that this development should not be at the cost of the environment. Development in the mountains should have a different approach[1], given the fragility and vulnerability of the Himalayan ecosystems due to the uniqueness of mountain specificities[2].

The Indian Himalaya region (IHR) is vast, diverse and the youngest mountain system on the Earth[3]. It constitutes a unique geographical and geological entity comprising a diverse social, cultural and environmental set-up. Spread over more than 2,500 km in length and 80 to 300 km in width and rising from low-lying plains to over 8,000 masl, the Himalaya produces a distinctive climate of its own and influences the climate of much of Asia. The IHR is spread over the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, and two districts each of Assam and West Bengal[4] (Fig. 1). It has a total geographical area of approximately 591 thousand sq. km (18% of India) inhabited by about 3.8% of the country's population. The literacy rate (7 years and above) of IHR (about 79.4%) is markedly higher than the national average (74%) recorded in the 2011 census. Over 170 ethnic communities with distinct socio-cultural milieu live in the IHR.

[1] Anonymous. 2010. Report of the Task Force, submitted to Planning Commission, Govt. of India. GBPIHED, Almora
[2] Singh, J.S., 2006. Sustainable development of the Indian Himalayan region: Linking ecological and economic concerns. Current Science90 (6): 784-788.
[3] Valdiya, K. S. (1997). Developing a Paradise in Peril. VII G.B. Pant Memorial Lecture, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora, pp. 1-26.
[4] Anonymous, 2009. Governance for Sustaining Himalayan Ecosystem (G-SHE): Guidelines & Best practices, GBPIHED, Almora.

Figure. 1: **Indian Himalayan region**



Traditionally, indigenous communities in the region have been dependent on bioresources to meet basic sustenance needs, notably food, fodder, fuel, fertilizer, fibre, shelter, and health care. More than 80% of the population in the region is involved in agriculture, animal husbandry, forestry and other biodiversity dependent vocations. Among other bioresources with direct economic value, the IHR is well recognized for its diversity of medicinal plants, wild edibles and other non-timber forest produce (NTFPs).

The Himalayas constitute the principal basis for the climate system that prevails over India. This region encompasses diverse biomes/ climatic zones (e.g., tropical, sub-tropical, temperate, sub-alpine, and alpine) and is among 34 global biodiversity 'hotspots' with 32% endemic flora. This region is a vast reservoir of water and referred to as the "Water Towers of the Asia". Approximately 10–20% of the area is covered by over 9,000 glaciers storing about 12,000 km^3 of freshwater[5], feeding the headwaters of important north Indian rivers and influencing the well-being of millions in the Indo-Gangetic plains. The beautiful landscapes, numerous rivers and streams cascading down the mountain slopes, diversity of cultures and religions, and colourful festivals of indigenous/ ethnic communities present strong attractions for people from all over the globe, including nature lovers, pilgrims, tourists, or seekers of peace and truth. The Himalayas have contributed substantially to the security of its people and economic development of the country. However, a complex interplay of climatic and geological processes, unsustainable patterns of resource use and economic marginalization have led to the situation of heavy resource degradation and associated environmental consequences for the highly diverse and fragile Himalayan eco-system[6] .

[5] Bahadur, J., 2004. Himalayan Snow and Glaciers – Associated Environmental Problems, Progress and Prospects, Concept Publishing Co, New Delhi.

[6] Khoshoo, T. N., 1992. Plant diversity in the Himalaya: Conservation and utilization. II Pandit Govind Ballabh Pant Memorial Lecture, G.B.

Plate 1: Seasonal herding of sheep and goats to high altitude pastures, a means of traditional livelihood, is declining .

In recent decades climate change has added a new dimension to the environment and development debate in the IHR. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change[7] has concluded that there is unequivocal evidence that current trends of global warming of earth's atmosphere are caused by anthropogenic emissions. The geologically young and geo-tectonically active Himalayas are most vulnerable to the impact of climate change. Temperature trends in most Himalayan regions substantially exceed the global mean trend of 0.85°C (between 1880 and 2012)[8], with winter season temperature trends being generally higher than those of other seasons[9], and an increase in warming rate with altitude[10]. IPCC predicts that average annual mean temperature over the Asian land mass, including the Himalayas, will increase by about 3°C by the 2050s, and average annual precipitation will increase by 10-30% by 2080s (IPCC AR4). Effects of climatic change on the environment and people's livelihoods could impact health, agriculture, forests, water resources, coastal areas, species and natural areas. Therefore, the region deserves priority for environmental conservation and sustainable development.

Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora

[7] IPCC, 2007. Climate change mitigation. In: Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and USA, p. 841.

[8] Shrestha, U.B., S. Gautam & K.S. Bawa, 2012. Widespread Climate Change in the Himalayas and Associated Changes in Local Ecosystems. PLoS One 7(5): e36741. doi:10.1371/ journal.pone.0036741

[9] Schickhoff, U., Bobrowski, M., Böhner, J., Bürzle, B., Chaudhary, R. P., Gerlitz, L., Heyken, H., Lange, J., Müller, M., Scholten, T., Schwab, N. &Wedegärtner, R., 2015. Do Himalayan treelines respond to recent climate change? An evaluation of sensitivity indicators. Earth System Dynamics 6: 245–265.

[10] Singh, J.S., 2006. Sustainable development of the Indian Himalayan region: Linking ecological and economic concerns. Current Science 90 (6): 784-788.

This IHR is endowed with rich vegetation and dominated by forested landscapes, an important repository of biodiversity (flora and fauna). More than 41.5% of the geographical area of IHR is under forests representing one-third of the total forest cover of India and nearly half (47%) of the "very good" forest cover of the country[11]. These forests generate a wide range of goods and services that provide protection against soil erosion, regulate water flows in the rivers connecting the Indo-Gangetic plains, prevent flooding and provide sinks for atmospheric carbon. The Himalayan ecosystem is also vital to the ecological security of the Indian landmass and occupies a strategic position along the entire northern boundary (North-West to North-East) of the country. Therefore, any developmental intervention at the cost of forests could have severe ecological repercussions. Not surprising, therefore, that the complexity of such issues continues to receive considerable attention at global forums like the WSSD (World Summit on Sustainable Development, Johannesburg, August 2002) and Bishkek Global Mountain Summit (October 2002) which emphasized that mountains would require specific approaches and resources for sustaining livelihood needs and improving the quality of life. This would require an integrated approach, which gives due consideration to closely intertwined aspects of human socio-economic systems and natural ecosystem components/ processes. Dr N. S. Jodha, identified hill specificities such as inaccessibility, fragility and marginality as major constraints to sustainable mountain development; he proposed diversity, niche and human dimensions as key opportunities to uplift the livelihoods of mountain people[12].

In the above context, the National Environment Policy[13] envisages a few policy measures for conserving the mountain ecosystem: (i) adopt appropriate land-use planning and watershed management practices for sustainable development of mountain ecosystem; (ii) adopt "best practice" norms for infrastructure construction in mountain regions to avoid or minimize damage to sensitive ecosystems and destruction of landscapes; (iii) encourage cultivation of traditional varieties of crops and horticulture by promotion of organic farming, enabling farmers to realize a price premium; (iv) promote sustainable tourism through adoption of "best practice" norms of eco-friendly and responsible tourism, creation of appropriate facilities and access to ecological resources, and multi-stakeholder partnerships to enable local communities to gain livelihoods, while leveraging financial, technical, and managerial capacities of investors; and, (v) take measures to regulate tourist inflows into mountain regions to ensure that visitor numbers remain within the carrying capacity of the destinations.

The IHR has been facing various environment and developmental problems and challenges due to its undulating topography, difficult terrain, inclement weather conditions and natural hazards, sparse population, and poor infrastructure[14]. Also, due to poor infrastructure facilities there are limited opportunities for resource utilization to generate revenue and livelihood support. Particularly, owing to the poor connectivity and remoteness in the north-eastern states, the cost of delivery of public services is much higher compared to other parts of the IHR. In view of poor resource availability and opportunities for

[11] Anonymous, 2015. India State of Forest Report - 2015. Forest Survey of India, Dehradun. pp. 1-73.
[12] Anonymous, 1992. Issues in Sustainable Mountain Development: The Himalayan Experience. International Centre for Integrated Mountain Development (ICIMOD), Nepal.
[13] Anonymous, 2006. National Environment Policy- 2006. Ministry of Environment, Forest & Climate Change (Approved by the Union Cabinet on 18 May, 2006).
[14] Gulati, A.K. & H.K. Gupta, 2003. An Analysis of policy framework for mountain development in the north-west Himalayas, India. www. FAO. org/ docrep/ Article/ wfc/ XII/ 0759-C1

mainstreaming development, three states in the IHR (Jammu & Kashmir, Nagaland, and Assam) were initially accorded special category status and covered under special assistance programme of central government. In the Fifth Plan, this list was extended to include the states of Himachal Pradesh, Manipur, Meghalaya, Sikkim, and Tripura. In 1990, the number of special category states was increased to 10 with the inclusion of Arunachal Pradesh and Mizoram; now Uttarakhand is also in this category of states. Thus, all the IHR states fall in the special category status, or the state is eligible for assistance under Hill Area Development Programme.

Past Efforts on Development Policies for IHR

Mountain agenda of SDC & CDE (2002) (http://www.un.org/esa/dsd/ resources/res_pdfs/ga-66/SG%report_Sustainable%20Mountain%20Development) have identified the following seven key principles for mountain policy development: (i) recognize mountain areas as important and specific areas of development; (ii) compensate for environmental services and goods provided to low lands; (iii) diversify into other livelihood options and provide benefits of complementarities to communities; (iv) take advantage of local potential for innovation; (v) preserve cultural change without loss of identity; (vi) conserve mountain eco-system and its early warning functions; and, (vii) institutionalize sustainable development of mountain areas[15]. IHR has attracted the attention of policy makers and planners and as a consequence various task forces/ work groups were constituted by the Planning Commission to formulate policies for development of Himalayan region. These were based on a recognition of the importance of IHR and the need to integrate environment, climate change and development concerns. Among these some of the important ones are given in Box I.

BOX I

Various Task Forces/ Workgroups/ Committees on IHR Issues

- National Commission on Development of Backward Areas (1981)
- Task Force for the Study of Eco-development in the Himalayan Region (1982)
- Working Group on Hill Area Development Programme for VII Five Year Plan (1985)
- Expert Group on National Policy on Integrated Development of Himalaya (1993)
- High level Commission on Transforming the North-Eastern Region (1997)
- Task Force on Mountain Ecosystems for the 11th Five Year Plan (2006)
- Task Force to look into Problems of Hill States and Hill Areas and to suggest ways to ensure that these states do not suffer in any way because of their peculiarities (2010)
- The Working Group on Improvement and Development of Transport Infrastructure in the North-East for the National Transport Development Committee (2012)
- Committee to study development in hill states arising from management of forest lands with special focus on creation of infrastructure, livelihood and human development (2013)

[15] Mountain Agenda, 1997. Mountains of the World: Challenges for the 21st Century. United Nations. Switzerland.

In the last decade the "National Mission for Sustaining Himalayan Ecosystems (NMSHE)" is one of India's eight missions under National Action Plan on Climate Change (NAPCC, 2014). It identifies measures that promote developmental objectives while also addressing climate change. The broad objectives of NMSHE include: understanding of the complex processes affecting the Himalayan ecosystem and evolve suitable management and policy measures for sustaining and safeguarding it; creating and building capacities in different domains; networking of knowledge institutions engaged in research and development of a coherent database on Himalayan ecosystem; detecting and decoupling natural and anthropogenic induced signals of global environmental changes in mountain ecosystems; studying traditional knowledge systems for community participation in adaptation, mitigation and coping mechanisms, including farming and traditional healthcare systems; and, developing regional cooperation with neighbouring countries, to generate a strong data base through monitoring and analysis, to eventually create a knowledge base for policy interventions (http://www.knowledgeportal-nmshe.in). Similarly, the task force on Mountain Ecosystem for Environment and Forest Sector constituted by the Planning Commission (now NITI Aayog), has prepared an account of state-of-art knowledge and institutional capacities associated with the Himalayan ecosystem. The task force set up by the Planning Commission on Mountain Ecosystems (Environment & Forest Sector) had observed and highlighted an apparent need for coordination, networking and cohesiveness among the institutions working for conservation and development in the mountains.

In 1990s DST executed a programme on 'Bio-Geo Database and Ecological Modelling for Himalayas' with an aim to assess the potentiality of various sectors of natural resources. Under this programme a data base was generated for selected micro-watersheds in the states of Uttarakhand and Himachal Pradesh for application oriented scenarios aimed at the decision makers. DST has set up Natural Resource Data Management System (NRDMS) Centres across 40 districts across the country (including the IHR) aiming at developing and demonstrating the use of spatial decision support tools for integrated planning and management of resources at the local level[16].

In its efforts to address environmental and developmental issues of IHR the MoEF&CC established G.B. Pant Institute of Himalayan Environment & Development (GBPIHED) in 1988 at Kosi-Katarmal, Almora with a mandate of achieving sustainable development and environmental conservation in the IHR. This Institute has been identified as a focal agency to advance scientific knowledge, to evolve integrated management strategies, demonstrate their efficacy for conservation of natural resources, and to ensure environmentally sound development in the entire IHR. In 1992, GBPIHED published "Action Plan for Himalaya" and in 2009 an important document "Governance for Sustaining Himalayan Ecosystems (G-SHE)" was published. In 2010, the National Planning Commission entrusted the Institute with the task of compiling a Task Force report: "To look into problems of hill states and hill areas and to suggest ways to ensure that these states and areas do not suffer in any way because of their peculiarities". This Institute is also the nodal agency for National Mission on Himalayan Studies implemented by the Ministry of Environment, Forest and Climate Change (MoEF&CC), which focuses on creation of natural and human capital in IHR and finding science based solutions to burning problems of Indian Himalaya (Box II).

[16] http://www.dst.gov.in/natural-resources-data-management-system

BOX II

National Mission on Himalayan Studies (NMHS)

The Twelfth Plan priorities include up to 13 monitorable targets related to environment, forests, wildlife, and climate change. The NMHS is expected to support these priorities specifically in the context of IHR and help in developing understanding on effectiveness of laws and policies in the IHR. The 12th plan goals covering environment, forests and livelihood; wildlife, ecotourism, and animal welfare; and, ecosystem and biodiversity are proposed to be addressed by this Mission. It is expected that this mission will address the data deficit on glaciers, landslides, sustainable methods of building roads and tunnels, weather and other related issues. In the 12th Plan outlay of 2014-2015, Rs.100 crore has been allocated for NMHS aimed at contributing to the sustainable development of IHR. The broad objectives of the mission are: (i) to build a body of scientific and traditional knowledge on the indicative thematic areas, (ii) to build a network of practitioners (individual and institutions) engaged in working solutions to problems in the thematic areas, and (iii) to demonstrate workable/ implementable/ replicable solutions to the problems in the thematic areas. GBHNIHESD, Kosi-Katarmal, Almora is the nodal agency to execute the NMHS. Presently, 104 projects have been supported under this mission in the 12 Himalayan states on various priority issues of environmental conservation and sustainable development of IHR.

The people of the IHR aspire for economic growth and development. Like in other mountain regions, the people in IHR are heavily dependent on their immediate natural resources and production from primary sectors such as agriculture, forestry and livestock for their livelihood[17]. The dependency of the continually growing population on finite resources, lack of viable technologies to mitigate the mountain specificities and enhanced production to meet the demands are depleting the natural resources along with increasing marginality of farmers, ultimately leading to poverty and degradation of natural resources[18]. Despite its rich biological and cultural resources, the region is underdeveloped. In addition, the inherent fragility of the mountains as well as the increased vulnerability of the Himalaya to human-induced environmental impacts make people live under the continued threat of natural hazards. Large number of studies carried out in the region focusing on development interventions report the unscientific exploitation of resources leading to environmental degradation. It is well understood that the problems in the Himalaya are complex, having intricate social, economic and ecological linkages. The solutions, therefore, cannot be addressed in isolation. Sectoral approaches to development will not work and the only approach which will work is a holistic one consistent with ecological and social principles. Therefore, the basis of any planning for sustainable development in mountain areas has to be centred on man's relationship with nature and governed by a sense of justice and equity. There is need to evolve a new paradigm to restore balance between economic interests and ecological imperatives to achieve ecologically sustainable development.

Data/ Information Required for Developmental Planning in IHR

The IHR due to its vast geographic diversity, is rich in many aspects (physical, biological, social, anthropological and economic) and needs to be thoroughly researched and documented. It has been

[17] Singh, S.P., G.C.S. Negi, M.C. Pant & J.S. Singh, 1992. Economic considerations in the Central Himalayan agroecosystems. In: The Price of Forests (ed. Anil Agrawal), Centre for Science and Environment, New Delhi, pp. 291–296

[18] Kandel, P., Janita Gurung, Nakul Chettri, Wu Ning, Eklabya Sharma, 2016. Biodiversity research trends and gap analysis from a trans-boundary landscape, Eastern Himalayas. Journal of Asia-Pacific Biodiversity 9: 1-10.

BOX III

Himalaya is a Data Deficient Region?

The IPCC in its Fourth Assessment Report (AR4) described the Himalayan Region as data-deficient in terms of climate monitoring. The Himalayas are described as a 'white spot' due to lack of sufficient data on natural ecosystems. Now, as scientists prepare for IPCC's sixth assessment report (AR6), they seek more systematic information on the Himalayas and the river basins.

pointed out that Himalaya is probably the least understood, researched and documented areas in terms of scientific studies[19]. In this context, it has been pointed out that our understanding of Himalayan ecosystems remains rudimentary, and that poor data, hasty conclusions, and bad science plague Himalayan research. For example, the IPCC (2007) report erroneously predicted widespread glacier recession and exposed how little was known about the Himalayan region (Box III). In the 1980s, the 'Theory of Himalayan Degradation' warned of complete forest loss and devastation of downstream areas, an eventuality that never occurred. More recently, the debate on hydroelectric dam construction appears to be driven by passions rather than science.

Across the IHR, various researchers have pointed out data gaps and data requirement for conservation planning. The NITI Aayog also recognizes that there is a gap between data availability and use for sustainable development of IHR and there is need for creating data sharing mechanism in addition to fresh research for collecting data. Unwillingness to share data is another major issue which is hampering integration of data for conservation and developmental planning. An international survey conducted to ascertain the attitudes, experiences, and expectations to biodiversity data sharing and archiving of research show that whereas most respondents are willing to share article-related biodiversity data, more than 60% of respondents are unwilling to share primary data before publishing in the absence of appropriate mechanisms to ensure benefits/ credits accruing from data sharing[20]. Expectations for biodiversity databases include standardization of data format, user-friendly data submission tools, formats for different types of data, and coordination among databases. It must be emphasized that to address the "Himalayan Dilemma" characterised by growing population and poverty, degrading resource base and increasing pressure on marginal resources, prompt action should be taken to improve the livelihood of mountain communities. National and international policies and development priorities should be harmonised. Therefore, rigorous sampling, involvement of civil society in data collection, and long-term collaborative research involving institutions from across the Himalaya are essential to improve knowledge of this region.

[19] Singh, S. P., & Thadani, R. (2015). Complexities and controversies in Himalayan research: a call for collaboration and rigor for better data. Mountain Research and Development, 35(4), 401–409.

[20] Huang, X., Bradford A. Hawkins, Fumin Lei, Gary L. Miller, Colin Favret, Ruiling Zhang, Gexia Qiao, 2012. Willing or unwilling to share primary biodiversity data: results and implications of an international survey. Conservation Letters 5: 399-406.

Process/ Approach of WG-V

To begin this task a series of brainstorming meetings were held by Convener of the WG-V wherein the requirements of the NITI Aayog were contextualized. An expert group consisting of six scientists of GBPNIHESD with different subject expertise was constituted to deal with multiple sectors and key conservation and development issues (Box IV).

BOX IV

Key conservation and development issues in the IHR

- Accelerated soil erosion and landslides
- Deforestation and land degradation
- Scarcity of fodder and fuel wood
- Forest fires and wildlife attacks
- Rainfed farming, declining soil fertility and crop yield
- Water scarcity for drinking and household use
- Increasing waste land
- Invasion of alien weeds
- Lack of infrastructure and market for processing and sale of farm produce
- Limited job opportunities
- Lack of civil amenities
- Disasters – natural and anthropogenic
- Loss of biodiversity and uncontrolled exploitation of biodiversity
- Unplanned urbanization and hydropower development
- Destructive/ unsustainable tourism including pilgrimage

The expert group followed a systematic approach and held over half a dozen interactive sessions/ meetings. A chronology of the course of action/ approach followed to carry out this task is given in Fig. 2. The first step was to flag sector-specific issues of environmental conservation and sustainable development (Box IV). It was followed by making a list of various institutions/ organizations both within and outside the IHR engaged in R&D activities (Annexure II). Following this, a questionnaire pertaining to data requirement, data availability and data sharing was developed for each sector (Annexure III). This questionnaire was circulated among the Member Institutes of the WG-V identified by NITI Aayog along with a few co-opted member institutions for their inputs. The final questionnaire incorporating inputs from the member institutions was sent to various institutions/ organizations (listed in Annexure II) for their response. The responses were compiled and analysed in terms of sector-wise data availability, source of procurement of data, difficulty in data accessibility, data gaps, quality check, data sharing policy etc. (Annexure IV). Also, sector wise issues and data required to address those issues were identified (Annexure V A-D).

In this process a meeting was held by NITI Aayog on 3 July 2017 in which progress of WG 5 was presented and suggestions/ inputs from officials of NITI Aayog/ Conveners of other Working Groups were received and incorporated into this report (Annexure VI). Subsequent meetings were held at NITI Aayog. The minutes of the meetings are attached in Annexure VII – IX.

This draft report contains the information obtained from different sources and its syntheses in the overall context of Sustainable Development of Mountains in the Indian Himalayan Region. The report was finalized after incorporating suggestions/ recommendations of different stakeholders and analysis of data/ information collected to make this document useful for policy makers and development planners from the 12 IHR states (Annexure X – XII).

Figure. 2: **Approach adopted by GBPNIHESD for compiling the report of WG-V**

Chapter 2A
Climate Change and Cryosphere

1. Introduction

The Himalayan region constitutes the principal basis for the climate system that prevails over Indian subcontinent. It prevents cold, dry Arctic northerly winds blowing into the subcontinent, keeping South Asia much warmer than regions along similar latitudes in the other continents. Therefore, it is often referred to as the 'climate regulator' or 'weather maker' or 'ecological buffer' of South Asia. With reference to climate and cryosphere characteristics, there are contrasting features of eastern Himalayas and western Himalayas as rainfall distribution decreases from east to west (300 to 150 cm). In the current context of climate change, this highly fragile region is expected to respond irregularly in almost all aspects. Rapid climate-induced changes in the region directly affect the water resources and food production systems of more than 1.3 billion people, as well as services such as electricity. Projected and observed impacts include disruption of the annual monsoon, changes in runoff from river basins, and an increased risk of flooding and landslides such as the flooding in northern India in June 2013 that killed nearly 6,000 people, and in which rainfall-induced heavy melting of the Chorabari Glacier was also implicated.

While the long-term impacts of rapid regional climate change and air quality on the monsoon may continue to be uncertain for some time, the very introduction of much greater uncertainty in water supply for local agriculture – in many cases, marginal to begin with – is itself an impact to be avoided. Shrestha et al. (2000)[21] studied precipitation fluctuations in the Nepal Himalaya and its vicinity and found a large inter-annual and decadal variability in all-Nepal precipitation records. Similarly, precipitation pattern over the Indian Himalayan region showed an increasing trend in rainfall pattern up to 1964, followed by a decreasing trend in 1965-1980 with A dominant cycle of ~ 2.7 years of high frequency of extreme rainfall events [22,23]. Bhutiyani et al. (2008)[24] have shown that there is a significant increase in the number of high magnitude flood events in the rivers of the northwest Himalayas in the last three decades. Dimri and Dash (2012)[25] studied climatic indices based on wintertime data for the period 1975–2006 and found slightly decreasing trends in precipitation, whereas winter frequency of WDs and precipitation indices over Himachal Pradesh was found to have decreasing trend. Similarly, annual mean surface temperature across the Himalayan region has increased by 1.5°C over pre-industrial average temperatures—similar to increases seen in the Arctic and Antarctic[26]. Measurement of the impacts of this temperature rise on the Himalayan cryosphere has proved challenging because of the

[21] Shrestha et al. (2000): Precipitation fluctuations in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters. International Journal of Climatology 20:317-327
[22] Basistha et al. (2009): Analysis of historical changes in rainfall in the Indian Himalayas. International Journal of Climatology 20:317-327 30(4): 555-572
[23] Mukherjee et al. (2015): Summer monsoon rainfall trends in the Indian Himalayan region. Theoretical and Applied Climatology 121:789-802
[24] Bhutiyani et al. (2008): Changing stream flow patterns in the rivers of northwestern Himalaya: implications of global warming in the 20th century. Current Science 95(5):618-626
[25] Dimri and Dash (2012): Winter climatic trends in the western Himalayas. Climatic Change 111:775-800.
[26] Shrestha et al. (2012): Widespread climate change in the Himalayas and associated changes in local ecosystem. Plos One 7(5):e36741

complicated topography that makes each glacier and region unique and difficult to study, even using satellite imagery[27].

Despite the complexity of observations and the lack of on-site measurements, an overall pattern of warming and melting has been apparent, with evidence of glacier and snow cover decrease recorded across most of the Himalayan region. There are studies which show that 67% of glaciers are retreating at a startling rate in the Himalayas mainly due to climate change[28,29]. There are studies by Indian glaciologists (Geological survey of India, Jawaharlal Nehru University, Wadia Institute of Himalayan Geology, and National Institute of Hydrology) which also indicate that major glaciers in the Indian Himalayas have been receding between 5m to 30 m per year since 1960. It is estimated that a large number of the glaciers in the Himalayas have been retreating in the past three decades. The most extreme melting has occurred in the eastern Himalayas, where the mean glacial thickness of Chinese glaciers decreased by nearly 11 metres during 1985 to 2005. A more mixed pattern is evident in the far Northwest and the Karakoram region, which are further north, colder, and more remote from large human populations and from monsoon precipitation impacts, receiving greater humidity from the west and the winter monsoon season.

Many glacial lakes have formed or expanded during the rapid melt process in the Eastern and Central Himalayas. These have led to catastrophic floods — so-called glacial lake outburst floods (GLOFs) — especially in Nepal and the Tibetan region. Some GLOFs have been narrowly averted by implementing measures like siphoning off melt water, both in Bhutan and Tsho Rolpa in Nepal.

The importance of melt water from greater Himalayan glaciers and snowpack to human water supplies varies widely, with the semi-arid regions of western China, Pakistan and Central Asia most clearly dependent on a regular, predictable melt season. Estimates range from 80 percent dependency of overall river flow on melt water in these western regions (especially the Indus and Tarim river basins) to under 20 percent in the Yangtze, Ganges, and Yellow Rivers. A 2013 report by the Asian Development Bank categorized Pakistan as one of the most water-stressed nations in the world, largely due to changes already seen in the supply to the Indus River (Asian Development Outlook 2013). In such situations of water stress, even seemingly small changes can have large impacts on human populations, where changes in timing or just a few percentage points in flow may make the difference between adequate irrigation and crop failure for that season.

Therefore, under this changing climatic regime impacting socio-economy of the Himalayan region to certain degree, it is clear that necessary steps should be taken for sustainable development of the region. Subsequently, this chapter identifies key conservation and development issues related to climate change and cryosphere of Himalaya followed by a concise compilation of associated data requirements, availability and gaps. The report concludes by highlighting ways to address these issues through cross-sectoral and interdisciplinary institutional collaboration and data sharing, followed by a few recommendations.

[27] Fujita and Nuimura (2011): Spatially heterogeneous wastages of Himalayan glaciers. Proceedings of National Academy of Sciences 108(34):14011-14014

[28] Ageta and Kadota (1992): Predictions of changes of glacier mass balance in the Nepal Himalaya and Tibetan Plateau: a case study of air temperature increase for three glaciers 16:89-94

[29] Yamada et al. (1992): Fluctuations of the glaciers from the 1970s to 1989 in the Khumbu, Shorong and Langtang regions, Nepal Himalayas. Bulletin of Glacier Research 10: 11-19.

2. Conservation and developmental issues related to climate and cryosphere of Himalayan region

As discussed earlier, based on the quasi continuous observations of climate and cryosphere of Himalaya, there is a significant change in temperature, rainfall and snowfall over the region. Impacts of this changing climate and cryosphere can have multifaceted consequences on conservation and development of the region. Some major conservation and development issues of Himalaya related to climate and cryosphere are identified and briefly discussed (Box 1). As the trends in climate and cryosphere parameters show large scale spatial and temporal variations, the water cycle of the Indian Himalayan region is expected to respond more severely than water cycles in the tropics. This changing water cycle is expected to accelerate soil erosion, landslides and flash floods in this region. However, due to insufficient monitoring and observational data, such catastrophic events over Himalayas are hard to predict, resulting in limited opportunities for adaptation and mitigation. A significant number of Himalayan flash floods are generally caused by cloudbursts and, until now, there is no detection tool for cloud bursts. Moreover, countries around this region have already started suffering serious water stress, while infrastructure projects, including dams, are raising cross-border tensions and may have severe environmental implications. Similarly, changes in cryosphere due to climate regime is now being considered as one of the catalytic factors for dramatically impacting human and ecological regimes that depend on ecosystem services from Himalaya. The factors and mechanism of changes thus caused are not yet scientifically understood but consequences of changing Himalayan cryosphere on rivers originating from Himalaya need to be addressed immediately so that contingency plans can be drawn up before it is too late.

Changing climatic conditions are expected to result in frequent floods and droughts. As the Himalayas are a source of fresh water for both rainfed and irrigated agriculture, crop yield in the Himalayan region as well as adjoining plains is expected to be affected severely. Better monitoring and prediction of these extreme events across time scales, from short to medium and extended (2 weeks), will help farmers and government

Box 1

Major conservation and developmental issues related to climate and cryosphere of Himalayan region

- Extreme weather events (heavy rainfall, snowfall, thunderstorm, hail storm, lightning, cloud burst etc.) causing socio-economical loss
- Melting and retreat of glaciers, including Glacial Lake Outburst Floods (GLOF)
- Accelerated soil erosion, landslides and floods/ droughts
- Rainfed farming and decline of crop yield
- Water scarcity for household use

to optimize the crop yield by scheduling farm level interventions w.r.t. different stages of the crops. For this, there is a need for an enhanced observational network, compilation of available data, availability of data in a common domain for use by various stakeholders, and providing information on observations and forecasting with respect to agriculture.

3. Climate and cryosphere data requirement and availability

A generic list of parameters associated with identified issues of climate and cryosphere, their requirement, availability and scale is described in Table 1, based on the questionnaire survey and meetings carried out by GBPNIHESD. It is to be noted that although climate and cryosphere data collection over Himalaya has been going on for last few decades using multifaceted approach for several purposes by many organizations, there is no Himalaya specific centralized institution responsible for climate and cryosphere data collection and dissemination. Although availability of high resolution past climatic data over Himalaya remained a major constraint, futuristic (year 2020-2100) gridded spatial data is available from many modelling resources across various spatio-temporal scales. The Centre for Climate Change Research (CCCR) of Indian Institute of Tropical Meteorology (IITM), MoES, GOI is the nodal agency for disseminating futuristic climate data including precipitation and temperature and data could be retrieved from http://cccr.tropmet.res.in/home/cordexsa_datasets.jsp. ICIMOD has also mentioned availability of future projections of climate data at 5 x 5 km resolution for the Hindukush-Himalaya region and the data can be accessed from the ICIMOD Regional Database System (http://rds.icimod.org/).

Table1: **Details of data requirement and availability on identified conservation and developmental issues related to climate and cryosphere of Himalayan region**

Climate and cryosphere related issues	Required parameters	Data availability	Notes on spatio-temporal scales of available data
1. Extreme weather events causing socio-economical loss	1. Rainfall rate, amount[A,B] 2. Snowfall rate, amount 3. Wind speed and direction[A] 4. Cloud cover 5. Temperature[A,]	1. Geospatial data (rainfall and temp.) available through IMD, GOI and can be purchased. 2. Geospatial data (snow cover; albedo, lakes and water bodies) available through NRSC, GOI and SAC-ISRO, GOI *(Book: Monitoring snow and glaciers of Himalayan Region; www.sac.gov.in)*; No data fee is included. 3. Point source data available from R&D institutes through request and after publication. User charges may be applicable. 4. Few gridded climate and cryosphere data are available from International resources as mentioned in notes below can be obtained free of charges. 5. Data of ground water and drinking water supply is available with state level water and irrigation dept.	1. Gridded data at 0.25 x 0.25 deg or above on daily temporal scale of 1901-2015 for precipitation and temperature is available from several sources. 2. Gridded 3 x 3 min snow cover data since 2014 to present is available. 3. Gridded 5 x 5km albedo data since 2015 to present. 4. Selected catchment specific river/ spring/ stream discharge and sedimentation rate data is available with R&D institutes and CWC. 5. Scatter point source data predominantly over north western Himalaya of research grade climatic parameters are available with few R&D institutes.
2. Melting and retreating of Glaciers including Glacial Lake Outburst Floods (GLOF)	1. Snowfall rate, amount 2. Snow density 3. Snow cover [E] 4. Snow albedo[E] 5. Geospatial distribution of glacial lakes and water bodies 6. Temperature		
3. Accelerated soil erosion and landslides	1. Rainfall rate, amount 2. Snowfall rate, amount 3. Soil temperature 4. Soil moisture[D] 5. Surface runoff		
4. Rainfed farming and decline of crop yield	1. Rainfall amount 2. Snowfall amount 3. Soil moisture 4. Temperature 5. Radiation[C]		
5. Water scarcity for household use	1. River/ spring/ stream discharge 2. Sedimentation rate 3. Rainfall amount 4. Snowfall amount 5. Panchayat-wise groundwater level and trend 6. Availability and supply of safe drinking water in rural and urban areas		

Notes:
[A] These parameters are also available from a few international sources: (i) NCEP, USA reanalysis products (CMAP- rainfall, GPCP-rainfall) (ii) CRU, UK products (iii) ECMRWF, EU reanalysis products at 0.5 x 0.5 deg at daily and monthly time scale or more.
[B] Rainfall and temperature products are also available from: (i) APHRODITE, Japan during 1951-2007 (2015) at 0.25 x 0.25 deg; rainfall products are available from (ii) TRMM-GSFC at 0.25 x 0.25 deg 2000-2017 3 hourly and more.
[C] Radiation products (Photosynthetically Active Radiation) are also available from: MODIS-terra Products (USA)
[D] Gridded soil moisture products are available through ESA-CCI, EU
[E] Snow cover and albedo data are available through (i) NSIDC, USA at 500 m x 500 m grid during 2002 to present

There are a few agencies in the country dedicated to monitoring, prediction-warning services and dissemination of climate and cryospheric parameters over the Himalayan region. A non-exhaustive list of such nodal agencies is presented in Table 2. The major data sources for climate and cryosphere over Himalayas are: India Meteorological Department (IMD), Central Water Commission (CWC), Snow and Avalanche Establishment (SASE), Dehradun, Indian Space Research Organisation (ISRO) and various research and development institutes in the region (Ref to Appendix A for details). It can be noted from Table 2 that these designated agencies in the country are providing various observational and forecast data for the region. However, there are still constraints w.r.t. spatial and temporal coverage, quality, availability and accessibility and accuracy of data. A brief description of activities of these four institutes responsible for climate and cryosphere data generation and disseminations are provided further below. It is to be noted that IMD is the dedicated institute for collection of meteorological data and most of the meteorological data dissemination through IMD requires user charges. Similarly, ISRO-NRSC is an important source for few cryospheric parameters and the related data can be obtained free of charge. However, such data is insufficient for decision making on conservation and developmental issues of Himalaya for several reasons. A questionnaire survey amongst the various research and developmental institutes of India (Table 3) aimed at compilation and assessment of climate and cryosphere data requirements and availability reveals the following:

- Some basic gridded data on climate and cryosphere (i.e. temperature, rainfall, soil moisture etc.) is available from reputed Indian and international organizations for free. Such data is long-term and quality checked but coarse in spatio-temporal resolution.
- Some climate and cryosphere data (typically for research purposes) is available with institutes and universities.
- Data for research purpose is mostly collected for point locations and collected over the duration of a project; hence, very few long-term data are available.
- Data obtained for research purpose are partially available as published material and occasionally in digital format.
- Published climate and cryosphere data are checked for quality; however, degree of quality check varies.
- Published research data are reported to be free of cost but occasionally requires permission from GOI ministries and/ competent authorities.
- Research grade data is predominantly digital; however, some hard copy data from older experiments need digitization.
- There is little or no mechanism for systematic research grade data submission to a centralized data repository for wider availability.

Table 2: **Details of data provided by major dedicated agencies of India for the Himalayan region**

S.N	Name of Agency	Type of Data	Parameters
1.	India Meteorological Department (IMD) under MoES, GOI	All meteorological and climatological data	Temperature, precipitation, radiation, soil temperature, soil moisture, river/ spring/ stream discharge
2.	Central Water Commission (CWC)	Hydrological data	River gauge, water level, highest flood level, warning level
3.	Snow & Avalanche Study Establishment (SASE)	Snowfall, avalanche, glaciers	Depth of snow, occurrence of avalanche, movement of glaciers
4.	Indian Space Research Organisation (ISRO)	Spatial data base on climate and cryosphere	Depth of snow, snow cover, precipitation etc.

Table 3: **Brief compilation of data available with Indian institutes based on survey responses.**

Sl.No.	Name	Type of data being collected	Type of data being disseminated	Data format	Data quality check	Whether user charges applied
1	India Meteorological Department (IMD)	Meteorological: point/ grid	Meteorological: point source and gridded	Digital	yes	User charges applied with few AWS free data
2	National Centre for Antarctic and Ocean Research(NCAOR)	Meteorological: point source Cryospheric: point source and basin-wise	Cryospheric published data	Digital	yes	Free
3	National Institute of Remote Sensing (NRSC)	Meteorological: satellite gridded product Cryospheric: satellite gridded product	Meteorology and cryospheric: Gridded product	Digital	yes	Free
4	Wadia Institute of Himalayan Geology	Meteorological: point source Cryospheric: point source/ intermittent/ campaign mode/ research purpose	Cryospheric published data Geophysical data	Digital	yes	Cryospheric data: free Geophysical data: after consultation with respective ministry

5	GBPNIHESD, Almora	Meteorological: point source Cryospheric: point source/ intermittent/ campaign mode/ research purpose	Meteorological: point source on demand basis	Digital	Quality checked in case of published data	Free after approval of competent authority
6	National Institute of Hydrology	Meteorological: point source Cryospheric: point source/ intermittent/ campaign mode/ research purpose	Meteorological: point source on demand basis	Digital	yes	
7	IIT Mandi	Meteorological: district level Cryospheric: district level	Meteorology and cryospheric: district level on demand basis	Digital	yes	Free
8	NBRI- Lucknow	Meteorological: point source Cryospheric: point source/ intermittent/ campaign mode/ research purpose		Digital	No	
9	IHBT- Palampur	Meteorological: point source	Meteorological: point source on demand basis	Digital	yes	User charges applied
10	SKAUST	Meteorological: point source	Meteorological: on demand basis for academics	PDF	yes	Free
11	University of Jammu	Meteorological: district level Cryospheric: district level	Meteorological: on demand basis for academics	PDF	yes	Free
12	JNU, Delhi	Meteorological: Cryospheric:				
13	ICAR-NRCY, Dirang	Meteorological: point source	Meteorological: on demand basis for academics	Digital	No	Free
14	HFRI - Shimla	Meteorological: point source	Meteorological: on demand basis	Digital	No	

4. Climate and cryosphere data gaps and issues

Following the questionnaire survey of various research and developmental institutes working on climate and cryosphere of Himalaya in India, data gaps in climate and cryosphere data relevant to conservation and developmental issues are compiled in this section (Box 2). Lack of spatio-temporal continuity and coarse resolution of gridded data are some of the major identified gap areas. Inadequate observational network and lack of data sharing with respect to climate, cryosphere extremes and related disaster management planning and preparedness are also identified as important gaps for the Himalayan region.

Some important climate and cryosphere data related issues such as: format, sharing, dissemination, quality checks, real time collection for decision making over rugged and high altitude terrains of Himalaya, as indicated by several agencies in the survey, are compiled as follows:

- Except for the dedicated institutes collecting climate and cryosphere data, i.e. IMD, ISRO and CWC, it is noted that no standard format for data collection, incorporating standard parameters required for developmental decision making, is followed by individual agencies.
- There is no consensual uniform spatio-temporal scale for the Himalaya that can support and deemed appropriate to help decision-making.
- There is no dedicated Himalaya specific centre for data collection, compilation, dissemination and monitoring of climate and cryosphere which could cater to the data needs of policy makers.
- Inadequate security for instruments and unavailability of proper sites for standard station establishment and maintenance is an issue affecting continuous data collection.
- Harsh terrain and tough climatic conditions are major constraints for regular sensor calibration and maintenance leading to substantial data loss on temporal scale.
- Insufficient and irregular teleconnection is a constraint for real time data collection and early preparedness for disaster mitigation.

Box 2

Significant gaps in Himalayan climate and cryosphere data relevant to conservation and developmental issues

- Coarse spatial scale of gridded climate data.
- Uncertainty of gridded data for higher altitude is high to very high.
- Lack of temporally continuous high-resolution climate data.
- Climate data of higher altitude (> 2500 m) region is very sparse.
- No concerted scientific monitoring effort of extreme climate events such as cloud burst or GLOF exists at national level.
- Lack of data on crucial themes like climate change adaptation and mitigation.
- Lack of river discharge data for mid-Himalayan basins.
- Limited glacier monitoring data available for the entire Himalayas.
- Site specific basic supporting data for disaster assessment is not enough for inferences.

It is also noted by India Meteorological Department, as member of the Working Group, that real time data is very useful in the operational analysis and numerical weather prediction process which helps in issuing timely warnings so that the climate and cryosphere related disaster management can be efficiently carried out by the concerned agencies. Since data collection and issuing weather forecasts are IMD's prime responsibilities, it is acknowledged that extensive monitoring of weather parameters is necessary for surface as well as upper air through dense networks. It is also necessary to establish a very robust and highly reliable telecommunication and processing network for real time collection of data and dissemination of weather forecasts and warnings for the entire north eastern region. This will require enhancement of the existing data collection network, which will in turn aid in the accurate analysis and improved weather forecasts for the region.

There is an urgent need to adopt an integrated approach for improving meteorological services over the Himalayan region. High resolution state-of-the-art meso-scale models need to be run with variable grid size. More precise local forecasts need to be generated by assimilating additional observations locally and running a very high resolution model. The flow within the valley has to be simulated using terrain hydrodynamic models. This will explain the microclimatology of the region which is important for studies of several processes which affect weather over the region. It is also essential to run a 3 km resolution weather model which requires data from a very dense network of observatories over the entire region with minimum 2-3 observatories at very high altitude. The entire observational network needs to be augmented to improve the weather and forecasting skills over the region by commissioning of state-of-the-art systems like Doppler Weather Radar, GPS sonde systems, and Snow Gauges, and augmenting Automatic Weather Stations and Automatic Rain Gauges.

5. Ways to address these issues through cross-sectoral and interdisciplinary institutional collaboration and data sharing

Following the formation of the working group on "Data/ information for informed decision making by multiple stakeholders" by NITI Aayog, GBPNIHESD Almora, as a nodal institute, conducted a questionnaire survey and hosted meetings with several stakeholders to collect and compile information regarding climate and cryosphere data requirements, availability, gaps and bottlenecks related to data sharing on conservation and developmental issues of Himalaya. It was noted that cross-sectoral and interdisciplinary institutional collaboration is limited in case of Himalaya specific data procurement and sharing for conservation and development issues. Therefore, the following suggestions are made to improve cross-sectoral and interdisciplinary institutional collaboration:

- Climate observations from State authorities and different research organizations having observational network should be made available to all user agencies through formation of proper policy guideline for data dissemination. Incidence and casualties of disaster events from state and central government authorities should also be made available to correlate the occurrence and intensity of climate and cryosphere related disasters so that the monitoring, prediction and warning services can be further improved.

- Very little information on cryosphere data is available for the entire Himalayas, and even the processed information in the form of publications is not available for decision making. It is suggested that some pooling mechanism for data generated under different projects and held by different agencies/ institutions should be initiated and such information made available through a central archival/ platform for future use and planning. The need for identification of institution/s that can be made responsible for collection/ collation of data is stressed.
- Isolated project based studies are not of much help for decision making. Instead area-wise/ region-wise/ macro level data sets are required to be generated at a much higher spatial scale. There is a need to merge this project based data with regular data collected by nodal agencies.
- There is need to identify institutions that can provide past data for data reconstruction and for filling data gaps. Therefore, there is an urgent need to improve the mutual collaboration and dialogue between institutes and agencies working in the Himalayas.

6. Suggestions and recommendations

With respect to identified data gaps in the climate-cryosphere sector, the help of particular nodal institutes may be solicited for filling these gaps. Identifying collaborating institutes for individual gap areas may provide further information or data for better understanding. NITI Aayog may consider the information presented in Table 4 for such deliberations. Some other generic suggestions are listed below.

Table 4: **Identified data gaps in climate-cryosphere sector and possible nodal and collaborating institutes**

Data gaps in climate and cryosphere to be addressed	Nodal and collaborating institutions
1.Coarse spatial scale of gridded climatic data 2.Uncertainty of gridded data for higher altitude is high to very high. 3.Lack of temporally continuous high resolution climate data. 4.Climate data of higher altitude (region > 2500 m) is very sparse. 5.No concerted scientific monitoring effort on extreme climate events such as, cloud burst or GLOF, exists at national level.	India meteorological Department (IMD) as nodal institute and ISRO-NRSC as collaborating institute
Lack of river discharge data for mid-Himalayan basins.	Central Water Commission (CWC) as nodal institute and ISRO-NRSC as collaborating institute
Very few glacier monitoring data are available for the entire Himalayas.	Geological Survey of India (GSI) as nodal institute and ISRO-IIRS, WIHG, NIH as partnering institutes
Lack of data on crucial themes like Climate Change adaptation and mitigation	Himalayan State Climate Change Cells, GBPNIHESD and ICIMOD as collaborating institutes

- In view of the complexity of the Himalayan terrain and paucity of sufficient climate and cryosphere data, further efforts must be made for collection of suitable data, identification and filling data gaps, and collation/ compilation of data to appropriate decision support formats.
- Improved data collection, forecasts and warnings, especially in respect of heavy precipitation/ cloudbursts will help army operations, agriculture, tourism, mountaineering, aviation, roads and communications, power generation, water management, environmental studies, sports and adventure, transport, government authority, NGOs and the public in general over the Western and Central Himalayan region.
- Considering the existing observational network, the gaps and future needs, there is a need for augmentation of observational network for better monitoring of both climate and cryospheric processes. Though the proposed projects of MoES, indicated in Appendix B, and other organisations are aimed at augmentation of the meteorological network to a large extent, the gap in cryospheric observations remains a challenge. There is a strong need to augment cryospheric observations by a nodal agency.
- As it is difficult to manually record observations in the high altitude regions with harsh terrain and sub-zero temperatures, attempts should be made to enhance space based observations over the Himalayas. However, as there are quality issues with respect to remotely sensed observations, an optimum network of automated instruments and manned observatories should be established to validate the space based observations and their applications.
- Changing water cycle over this 'third pole' region needs to be studied in detail with real time and archived data involving hydrosphere, biosphere and cryosphere of the region.
- There is limited paleo-climatic data available in the region to address climate change issues as well as changing water cycle. Even this data is not accessible on a common platform, thus limiting the activities and applications in developing a physical understanding of the processes in climate and cryosphere. Hence there is a need for intensive collection of the paleo-climatic samples to study past changes and project future scenarios.
- The polar region as well as the Himalayas, the third pole, play a dominant role and are the driving forces for climate and climate variability. The role of the Himalayas is very crucial in the regional climate scenario. Hence, for understanding and predicting these changes in the climate and the cryosphere, special effort should be made to collect the past and real time data. The nodal agencies responsible for climate and cryosphere data collection should take a lead in this direction.
- Special emphasis is needed for collection of real time and past data with respect to hydrology and glaciology to address the issue of climate and climate change. In addition, it will help in understanding the interaction of the cryosphere with the river system and hydrological modelling in different spatial and temporal scales resulting in better management of water resources and related disasters.
- Interdisciplinary and intergovernmental experience on sustainable mountain development policies and observations on best practices needs to be compiled from across the Himalayas. Hence, it is suggested to prepare a roadmap for sustainable development of mountains of Himalayas through assured data availability and quality not only in India but also from countries in the Himalayan region through bilateral or multilateral arrangements. An institution working on the Himalayan region should be considered as nodal agency for collection, collation and dissemination of data.

Appendix A

Current activities of national Institutes for data collection and dissemination

1.A. India Meteorological Department

IMD is a national agency for weather related activities under Ministry of Earth Sciences (MoES), GOI. The mandate of IMD is to take meteorological observations and provide current assessment and weather forecast information for optimum operation of weather based service activities like agriculture, irrigation, shipping, aviation, and offshore oil explorations, including warnings for severe weather phenomena like tropical cyclones, nor'westers, dust storms, heavy rains, snow, cold and heat waves, which cause destruction of life and property. IMD also provides climate information required for agriculture, water resource management, industries, oil exploration and other nation-building infrastructure development activities. The measurement of various atmospheric parameters through surface and upper air is a prime requirement for operating the hydro-meteorological services. Current services by IMD over Himalayan region include:

- Providing synoptic scale weather forecast bulletins, data, satellite inputs and advisories on twice daily basis.
- Coordinated weather, climate monitoring and advisory services with SASE, Army, and IAF etc.
- Spatial weather bulletins for Mountaineering Expeditions, Amarnath Yatra, Road Forecast etc.
- Development of Climatology on Himalayan Region.

The data available with IMD is presented in Table 5 and 6 for fundamental meteorological parameters and disasters. The cryosphere data of IMD is available for snow depth only, and IMD also needs data on several aspects of climate change.

It is to be noted that IMD collects some selected data on climate, cryosphere, disaster, and paleo-climate for the Indian Himalaya Region. The weather data is available on 'real time' basis and in archived forms. The real time data can be accessed by anyone through IMD website, while archived data can be obtained through requests. The data required by government institutions for research purposes is available free of cost while data for commercial use is charged as per the department policy.

IMD through its Mountain Meteorological Division collects real time data for 7 regions of 3 states i.e. J&K, Himachal, and Uttarakhand of the Himalaya. This real time data is used to make 5 to 7 day weather observation forecasts for the entire Himalaya with almost 75% accuracy, under normal circumstances.

Table 5: **Data availability in MoES, GOI particularly, IMD and NCAOR, Goa**

Type of Data	Format (Digital/ Geospatial Report/ PDF/ Hard Copy/ Any Other)	Level at which data is available (Village/ Block/ District/ State/ Watershed/ Sub-watershed/ Point Source/ Grid)	Timescale of acquisition (Hourly/ Daily/ Weekly/ Monthly/ Annually/ Any Other	Period of data availability (DD/MM/YY to DD/MM/YY, Years)	Quality Checks
Temperature	Digital/ ASCII	Point Source	Hourly/ daily	1969 -2017*	Yes[1]
Humidity	-do-	-do-	Hourly/ daily	1969 -2017*	Yes[1]
Rainfall	-do-	Point Source	Hourly/ daily	1969 -2017*	Yes[1]
Wind Speed	-do-	Point Source	Hourly/ daily	1969 -2017*	Yes[1]
Radiation	-do-	Point Source	Hourly/ daily	1969 -2012*	Yes[2]
Heat Flux	Not Available	--	--	--	--
Soil Temperature	Digital	Point Source	week	1969 -2015*	Yes[2]
Soil Moisture	Digital	-do-	week	1969 -2015*	Yes[2]
Snow depth (Water equivalent)	Digital/ ASCII	Point Source	Daily	-	Yes

Note: *Period differs from station to station; 1 for AWS data, gross errors only; 2 checks done at radn./ agri. Units. Data is supplied/ shared as per departmental policy.

Table 6: **Data availability at IMD with respect to Meteorological Disasters**

Type of Data	Format (Digital/ Geospatial Report/ PDF/ Hard Copy/ Any Other)	Level at which data is available (Village/ Block/ District/ State/ Watershed/ Sub-watershed/ Point Source/Grid)	Timescale of acquisition (Hourly/ Daily/ Weekly/ Monthly/ Annually/ Any Other	Period of data availability (DD/MM/YY To DD/MM/ YY, Years)	Quality Checks
Flash Flood/ Flood	Report (Hard Copy)	For the country	Annual	1981-2015	Yes
Land Slides	Report (Hard Copy)	For the country	Annual	1981-2015	Yes
Cloud Burst	Report (Hard Copy)	For the country	Annual	1981-2015	Yes
Heat wave, Cold wave, Squall, Gale etc.	Report(Hard Copy) Annual Disaster Events)	For the country	Annual	1981-2015	Yes

1.B. Indian Space Research Organisation

The BHUVAN Portal of NRSC Hyderabad provides real time and archived satellite based data on climate and cryosphere. A reference is made to NICES (National Information System for Climate and Environment Studies), a separate portal of NRSC, which contains data/ information on climate and environmental studies. The main objectives of NICES are:

- To build long term database on climate variables.
- Establish and develop linkages with appropriate observational networks, calibration and validation sites
- Acquisition and processing data of international satellite missions for other relevant parameters in addition to Indian EO data for generation of long term database.
- Establish necessary infrastructure including hardware and software for NICES
- Geophysical parameter retrieval and generation of methodologies for essential climate variables (ECV)[30] for Indian EO and other international mission
- Generation of spatio-temporal blended products
- Develop science plan for climate change impact assessment, adaptation and mitigation studies with different organizations.
- Develop outreach and interaction mechanism for effective dissemination and utilization of NICES information base; establishment of NICES portal and capacity building.

A brief compilation of essential data available with NICES-NRSC on climate change, cryosphere, and land use/ land cover is provided in Table 7.

Table 7: **Brief description of available relevant climate, cryosphere and terrestrial data in NICES-NRSC required for informed decision making for conservation and developmental issues of Himalaya**

S. No.	Data product	Observed/ Model product	Availability	Quality check	Temporal scale	Spatial scale
1	Albedo	Observed	Jan, 2013 onwards	Yes	1 Km	15 day
2	Spatial distribution of surface water	Observed	Jan, 2014 onwards	Yes	1 Km	15 day
3	Surface soil moisture	Observed	2002-2011 and 2012 onwards	Yes	0.25 x 0.25 deg	2 day
4	Snow melt and freeze	Observed	2000-2013	Yes	2.225 km	monthly
5	Snow cover fraction	Observed	Mar 2014 onwards	Yes	3 x 3 min	15 day

[30] The identified ECVs related to climate and cryosphere of ISRO-NRSC are: surface air temperature, near surface wind speed and direction, surface precipitation, earth's radiation budget, surface radiation budget. Few of these ECVs are/ will soon be part of Global Observing system (GCOS).

6	Himalayan glacial lakes and water bodies	Observed	Jun-Oct of 2011-2016	Yes	1:250,000 scale	monthly
7	Snow albedo	Observed	Jan 2015 onwards	Yes	250 m	-
8	Soil moisture	Model	1976 -2005 and Jun 2013 onwards	NA	9 x 9 min	Daily
9	Runoff	Model	1976 -2005 and Jun 2013 onwards	NA	9 x 9 min	Daily
10	Cloud fraction	Observed	Jan 2015 – Apr 2017	Yes	0.25 x 0.25 deg	Half hourly

1.C. Central Water Commission (CWC)

CWC is charged with the general responsibility of initiating, coordinating and furthering schemes for the control, conservation and utilization of water resources in the respective State for the purpose of flood management, irrigation, drinking water supply and water power generation. This is done in consultation with the State Governments concerned. The major activity with respect to precipitation monitoring and hydrological forecasts are as follows.

- To collect, compile, publish and analyse the hydrological data relating to major rivers in the country, consisting of rainfall, run-off and temperature, and to act as the central bureau of information in respect of these matters.
- To collect, maintain and publish statistical data relating to water resources and its utilization including quality of water throughout India and to act as the central bureau of information relating to water resources.
- To provide flood forecasting services to all major flood prone inter-state river basins of India through a network of 175 flood forecasting stations.
- To advise the Government of India and the concerned State Governments on basin-wise development of water resources
- To undertake necessary surveys and investigations as and when required and prepare designs and schemes for the development of river valleys in respect of power generation, irrigation by gravity flow or lift, flood management and erosion control, anti-water logging measures, drainage and drinking water supply.

The work of monitoring glacial lakes/water bodies was taken up by Central Water Commission (CWC) during the XIth plan period (2007-12). As this work involved processing of satellite imageries and use of remote sensing and GIS techniques, CWC signed an MoU with National Remote Sensing Centre (NRSC), Hyderabad in 2009 for inventory and monitoring of glacial lakes/ water bodies in the Himalayan region catchments which contribute to rivers flowing in India. Satellite images of Advanced Wide Field Sensor (AWiFS) of Indian Remote Sensing Satellite Resourcesat-1 were collected for the Himalayan region during

May-November 2009. Glacial lakes and water bodies were delineated based on the visual interpretation of above satellite imageries using ERDAS Imagine and Geographical Information System (GIS) software. The inventory of glacial lakes/ water bodies having water spread area more than 10 ha was prepared and published in June 2011 (Inventory and Monitoring of Glacial Lakes/Water Bodies in the Himalayan Region of Indian River Basins Report). The information in the inventory includes location of the lake (Latitude, Longitude and Elevation), name of lake (if available) and water spread area. . The main conclusions of the study are:

- There are 2028 glacial lakes and water bodies having water spread area more than 10 ha in the Himalayan region catchment which contribute to rivers flowing in India. Of these, 503 are glacial lakes and 1525 are water bodies.
- 1169 glacial lakes/ water bodies are located in the elevation zone from 4000 m to 500 m above sea level.
- Basin-wise details of Glacial Lakes/ Water Bodies (having water spread area more than 10 ha) in the Himalayan region catchment which contribute to rivers flowing in India are presented in Table 7.

1.D. Snow and Avalanche Study Establishment (SASE), DRDO

SASE is the nodal agency for Cryospheric Science and Technology and facilitates high operational mobility for troops in snow bound regions of Himalayas. SASE is using various technologies to develop products for combating avalanche and other cryospheric hazards in snow bound regions. Major technologies such as optical and microwave satellite imageries are used to retrieve information about snow cover from inaccessible snow bound regions. Avalanche prone areas are identified using Remote Sensing & GIS techniques and developed avalanche hazard data cards (a pocket size folded hardcopy containing the terrain, climatology, detail avalanche information). GIS-based Digital Avalanche Atlas containing the information about avalanche prone terrain e.g. area, slope, aspect, ground cover, location of avalanche sites, track profile, cross-sectional/ longitudinal profile and other information related to avalanches has been developed for some areas and under development for some more areas. 3-D multi-perspective fly-through models of the areas of interest have been generated using digital elevation model (DEM) and high resolution satellite imageries. SASE has designed and developed various types of control structures for controlling avalanches in formation, middle and run-out zone. Control structures e.g. snow bridges, snow nets, wind baffles, snow fence, jet roof, terrain modification, and terrace cutting are designed for prevention of avalanches in formation zone. These structures have been installed in the formation zone of D-10 near Jawahar tunnel (J&K) along NH-1A. Snow gallery and avalanche diverting structures are designed for the control of avalanches in middle zone.

SASE is using latest hardware and software technologies for simulation and modelling. Avalanche Forecasting Models, Weather Forecasting Models, Snow Cover Simulation Model, Avalanche Dynamics Model, and Snow Characterization Model are developed using these technologies. Acoustic emissions (AE) are feeble acoustic signatures produced by materials during the microscopic deformation/ failure processes which finally may result into catastrophic failure of the snowpack in the form of avalanches. SASE has done extensive work in this direction over the last few years through various lab and field based experiments on AE behaviour of snow. Snow-sensor coupling, short range nature of AE signals, selection of sensor sensitivities, operating frequency range and interference of noise components were tackled by using a multi-sensor coupling through acoustic arrestors and waveguides. Unmanned aerial vehicles are being used for snow cover information extraction from inaccessible and remote snow bound areas.

SASE is using state-of-the-art technologies for data observations in cryospheric regions. SASE has installed automatic weather stations in various Himalayan ranges (e.g. Pir Panjal, Great Himalaya, Ladakh, Karakoram etc.) and Antarctica for continuous data recording. Ground Penetrating Radar has been used on ground as well as air borne mode for assessment of snow cover and glacier thickness. Various instruments have been developed for data observations in cryospheric regions.

The Parallel Probe Snow Profiler (PPSP) is an indigenously developed, state-of-the-art, multi-parameter probing device developed by SASE, DRDO to record the vertical distributions of moisture content, temperature, penetration hardness corresponding to precise depth positions and geographic locations of a large snow or soil cover. This instrument is a remotely operated device using a handheld RCD and can profile up to depth of 2 m with precise depth resolution of 5 mm.

Ground Penetrating Radar has been used in cryospheric regions of Himalaya and Antarctica for various snow and glacier related studies. It also has state-of-the-art upper air observations and computerized reconstructions of the 3-D snow microstructure using X-ray Micro-Tomography. SASE is providing services to the users in snow bound areas by avalanche forecasting, weather forecasting, designing of avalanche control structures, avalanche diverging structures, snow gallery, instrumentation for data collection in cold regions, guidance for safe camp siting, preparing avalanche atlases, avalanche hazard data cards and training materials for combating avalanche hazards.

The SASE has following Avalanche Forecasting Models

- eN10 is a web-enabled Avalanche Forecast System. The system is based upon popular k-nearest neighbour method with many enhanced features. The major enhancement has been brought about by applying Principle Component Analysis for removing data redundancy and Neural Networks for decision making. In general, 10 neighbours from the past data are picked up and analysed for decision making.
- Expert System (XAF) based avalanche forecast model. Model is based upon expert's generated rules for Avalanche prediction.
- Snow cover simulation model (SCSM) simulates the properties of snow pack which are useful in avalanche forecasting. SCSM is an important tool to describe the evolution of the internal state of the snowpack. It is a 1-D model which solves the mass and energy balance equations using a Finite Difference numerical scheme. The model has been developed in Visual Basic programming language on a windows based platform.
- Hidden Markov Model (HMM) for avalanche forecasting is based on properties of Markov Chain. There are different states and observations in the model derived from snow-meteorological parameters. The model predicts avalanches in four days advance.

1.E. Research and Academic Institutes:

Wadia Institute of Geology, Dehradun is monitoring 4 Himalayan Glaciers for retreat, mass-balance, ice-volume, hydro-meteorological observations, and glacial lake inventory through funded research projects and national missions. The institute has meteorological data for Dokrani and Chaturangi glaciers, and 'Ice-thickness map indicating ice volume *vis-a-vis* retreat' for the Dokrani Glacier. Such data/ information is available in published form in PDF format.

As part of the Indian government's initiatives for better understanding of glacier-climate inter-relationship and quantify the Himalayan glacier responses to climate change, National Centre for Antarctic and Ocean Research (NCAOR), Goa, under the Ministry of Earth Sciences has established a high altitude research station in Himalaya called HIMANSH. This is a dedicated Research Station established at Sutri Dhaka, Chandra Basin, Lahaul-Spiti valley, Himachal Pradesh at an altitude of 4080 mamsl. The station was unveiled on 9 October 2016 and since then the station has been made functional round the year. However it was closed during winter (15 November to April 2017). A total of six glaciers (280 km^2 glacier area) of Chandra basin name Sutri Dhaka (25 km^2), Batal (5 km^2), Bara Shigri (137 km^2), Samudra Tapu (95 km^2), Gepang Gath (14 km^2) and Kunjum (4 km^2) have been monitoring for mass, energy and hydrological balance including surface flow, ice flux, terminal fluctuation using this station. In addition, two Automatic Weather Stations (AWS) and five Water Level Recorders (WLRs) have been installed over glacier surface and along a stretch of 120km of Chandra River respectively for energy and hydrological budget calculation. The data generated will help to understand glacier behaviour with respect to climate including quantification of hydrological contribution to Chandra basin (upper Indus basin).

The studies on interaction between climate and cryosphere are limited mainly due to lack of observational data in the region. Four Universities namely Jawaharlal Nehru University, New Delhi, University of Kashmir, Srinagar J&K, University of Jammu, Jammu, J&K and Sikkim Central University, Gangtok, Sikkim came together to form a consortium named 'Inter-University Consortium on Cryosphere and Climate Change (IUCCCC)' to look into Cryosphere- Societal interactions, within the framework of integrated science-social science research. The consortium's partner universities cover most of the northwest, central and northeast part of the Indian Himalaya. The IUCCCC intends to bring in field data for scientific explanation of climate and cryosphere changes over time and space, and evaluate societal needs and capabilities for adaptation to such changes, if any, in the coming decades.

The objectives of IUCCC include:

- To investigate, assess and measure changes in cryosphere cover due to climate change on standardized format.
- To build on the field data repository on climate and cryosphere changes over space and time.
- To comprehend the impact of such changes on human and ecological regimes with a special emphases on the Himalayan Rivers
- To build state-of-art laboratories to achieve the above goals in each of the partner institutions

The National Institute of Hydrology (NIH) and GBPNIHESD are also exploring the hydro-meteorological variations of mid-Himalayan river basins and glaciers of northwest Himalaya and a glaciated basin in Arunachal Pradesh. However, their primary research interest is on sediment transport and production, meteorological variation and runoff, degree-day factor for snow and ice and melt water chemistry of few selected glaciers and river catchments of Uttarakhand, Himachal Pradesh and Arunachal Pradesh. Therefore, most of the climate and cryosphere data are research grade and available through published material.

Appendix B

Initiatives of India Meteorological Department for enhanced climate monitoring in the western,central and eastern Himalaya.

To address the sector-wise issues related to hydro-meteorological events, India Meteorological Department, Ministry of Earth Sciences initiated two projects namely, **Integrated Himalayan Meteorology Programme for Western and Central Himalayas**, and **Integrated Meteorological Services for North-eastern Region** with the consultation of several other government organizations/ institutions working on weather, climate, and hydrological, ecological and environmental aspects of the Himalayas region. It will be implemented in all Himalayan states including Jammu & Kashmir, Himachal Pradesh, Uttarakhand, West Bengal, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Mizoram, Tripura and Sikkim to improve the weather services of the region.

Some of the major objectives of these projects are as follow:

- To improve and upgrade mountain weather and climate services over Himalayan region by establishing optimal state-of-the-art surface and upper air observatories for real time observations and failsafe communication.
- Improving the understanding and prediction of weather and climate processes in complex terrain.
- Development of appropriate system for 24×7 monitoring and early warning for extreme weather taking into consideration the requirements of all users and sectors in the region.
- To improve upon the spatial and temporal density of aviation weather observational network particularly in the mountainous terrain focused towards providing safe and effective meteorological service for helicopter operations.
- To improve understanding of physical processes leading to heavy rainfall, heavy snowfall, and cloudburst in mountain region and to build appropriate services.
- To develop improved climatology for the region to cater to the requirements of all users.

State-wise distribution of observational network to be implemented under Integrated Meteorological Services for north-eastern region is presented in Table 8.

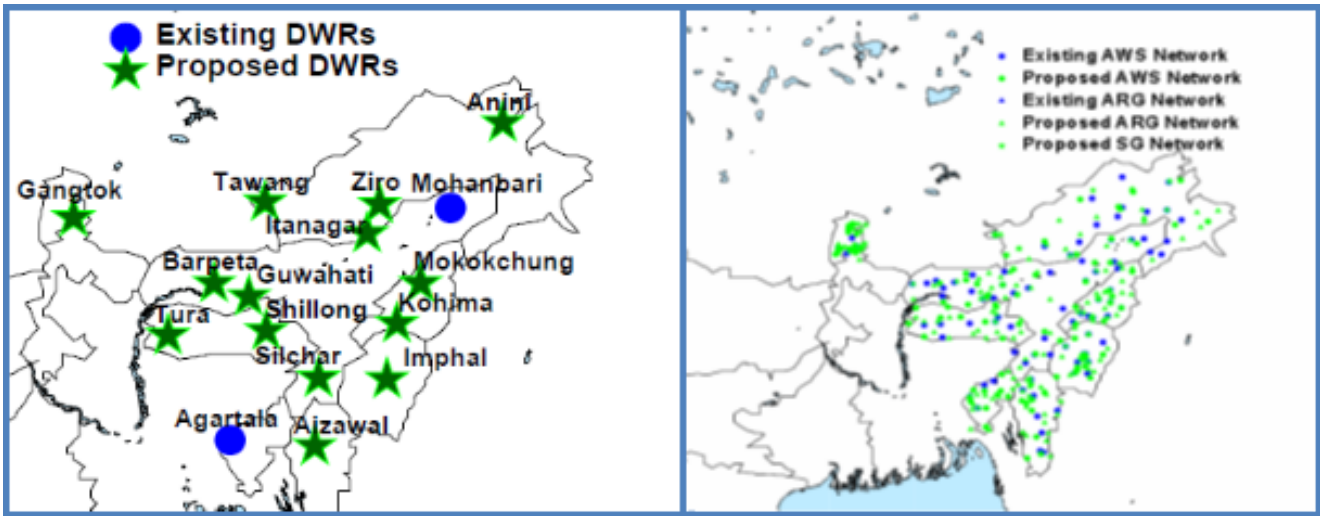
Table 8: **Proposed state wise distribution of observational network**

States	DWR	AWS/ ARG/ SG	MR	WL	HAWOS	M-AWS
Arunachal Pradesh	4	35	NIL	NIL	9	4
Assam	3	50	3	3	1	4
Meghalaya	2	30	NIL	NIL	NIL	2
Nagaland	2	30	1	1	3	2
Manipur	1	30	1	1	1	2
Mizoram	1	30	1	1	4	2
Tripura	NIL	30	1	1	NIL	2
Sikkim	1	35	1	1	1	2
TOTAL	14	270	8	8	19	20

Notes: DWR: Doppler Weather Radar, AWS: Automatic Weather Station, ARG: Automatic Rain Gauges, SG: Snow Gauge, MR: Microwave Radiometer, WL: Wind Lidar, HAWOS: Heliport Automated Weather Observation Systems.

At present, DWRs are installed at Mohanbari and Agartala. 14 X-band DWRs will be installed to cover the entire region under the proposal as shown in Fig.3. Proposed AWS, ARG and snowgauge (SG) network for the region is also shown in Fig.3.

Figure. 3: **Existing and proposed (a) DWRs and (b) AWS, ARG, SG network over north-eastern states**

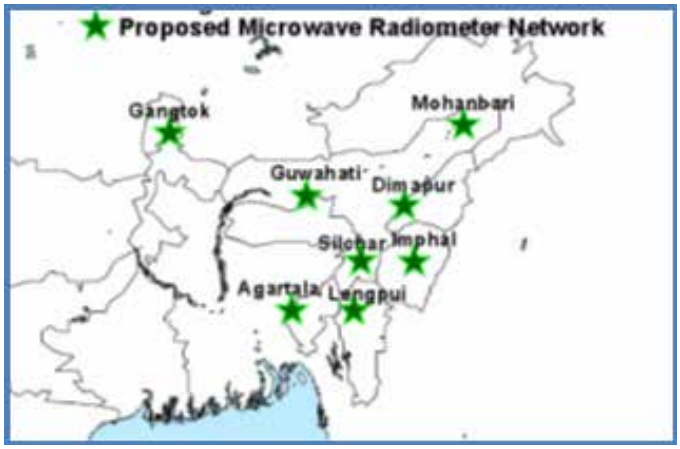


Doppler Weather Radar (DWR) observations are used for now-casting of severe weather systems. The information of reflectivity, wind speed and spectrum width obtained from DWRs helps the forecasters in issuing forecast and warnings for severe weather events like thunderstorms, gale winds, and hail. Aviation and agriculture sector can benefit from forecast of severe weather in and around or on flight routes of aircrafts and rainfall occurrence time and quantum of rain may enable farmers to plan the agriculture activities which in turn may improve yields. Doppler Weather Radars are also very useful in flood forecasting and water management.

Automatic Weather Stations (AWSs), Automatic Rain gauges (ARGs) and Snow Gauges (SGs) are used to measure the weather data, rainfall data and solid precipitation snow data respectively. The systems typically consist of weather-proof enclosure containing the data logger and the meteorological sensors mounted upon a mast. The data logger automatically collects observation data from all attached sensors at every user-selected time interval, stores the data in its memory, and periodically transmits the data to a server through the GSM/ GPRS communication link, thus providing the data to users through the server.

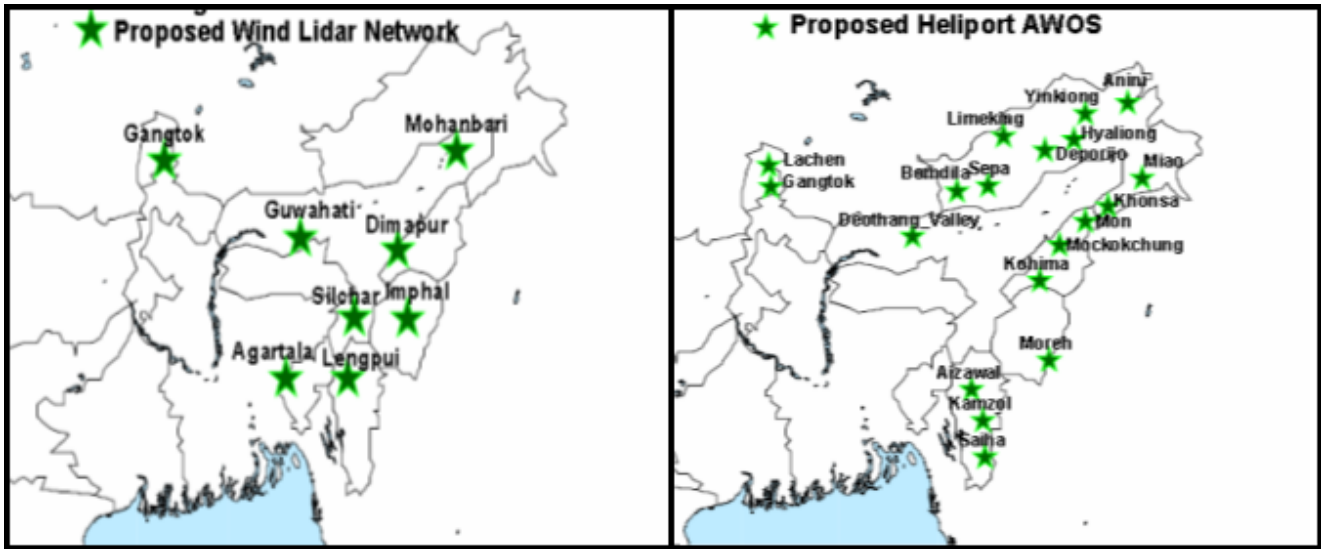
Quantitative precipitation forecasting is currently limited by the paucity of observations on sufficiently fine temporal and spatial scales. In particular, convective storms observed to develop in regions of strong and rapidly evolving moisture gradients that vary on mesoscales. Therefore, measurements of water vapour along with high time resolution and sufficient spatial resolution have the potential to improve forecast skill for the initiation of convective storms. The main objective of the microwave radiometer is the measurement of atmospheric humidity as supplementary information for troposphere, which is influenced both by the integrated atmospheric water vapour content and by liquid water. Microwave radiometer in the upper air network can provide the measurement of vertical profiles of atmospheric temperature, High-precision vertical profiles of boundary-layer temperature and atmospheric humidity, column-integrated total amount of water vapour and liquid water, vertical profiles of cloud liquid water, atmospheric stability (now-casting of convection, thunderstorms and measurement of fog). At present, microwave radiometers are not installed over the region; eight of these systems will be introduced in the network as presented in Fig. 4:

Figure. 4: **Proposed microwave radiometer network over north-eastern states**



Winds are the most important variable when studying dynamics and transport in the atmosphere. Wind measurements are critical to improvement of numerical weather prediction models. They can be used to study planetary atmospheric dynamics and can also detect clear air wind shear. Among the measurable atmospheric variables, wind velocity is most important for weather forecasting, air pollution control, climate studies or aviation safety. In all those areas, Wind Lidar can provide wind velocity measurements with higher resolutions both in space and time than those of traditional techniques such as radio soundings. LIDAR (Light Detection and Ranging) is an optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the target with light, often using pulses from a laser. A Wind LIDAR (Doppler Lidar) is the most promising of the wind measurement concepts under consideration and would be used to measure atmospheric winds. The LIDAR sensor measures velocity by determining the Doppler shift of laser radiation from atmospheric aerosols carried by the wind. The main objective of the Wind Lidar is to provide accurate, global tropospheric wind data for both climate studies and weather forecasting. At present, Wind Lidars are not installed over the region; these systems will be introduced at eight places. Proposed Wind Lidar and Heliport AWOS network over north-eastern states is presented in Fig. 5.

Figure. 5: **Proposed Wind Lidar and Heliport AWOS network over northeastern states**



Integrated Himalayan Meteorology Programme for Western and Central Himalayas covers four states namely Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Sub Himalayan West Bengal (SHWB). Type and number of observational equipment was decided by taking into consideration the existing network of IMD, other organizations and the future requirement in order to meet the minimum network for capturing the synoptic and meso-scale variability in weather latitude-wise, longitude-wise and altitude-wise. The network plan was drawn from the discussions in the scientific committee meetings of the programme. In addition, specific inputs were obtained from all the concerned Regional Met. Centres (RMC) and State Met. Centres (MCs) regarding the requirement of network for operational weather forecast in nowcast, short and medium range. The frequency, location, intensity and the period of occurrence of the extreme events were considered, while planning the network. Requirement of State Government authorities including disaster managers were also taken into consideration. Effort was made to cover all the districts of the region by installing any type of equipment as per the forecast requirement. The State-wise observational network planned is presented in Table 9.

Table 9: **Proposed state-wise observational network for western and central Himalayas**

State	DWR	Compact Systems	HAWOS	AWS/ ARG/ SG	M- AWS	SFO	Radiometer
J & K	3	4	5	75	5	NIL	1
HP	3	4	0	65	5	NIL	1
UK	3	4	3	75	5	15	1
SHWB	NIL	NIL	1	15	NIL	NIL	NIL
TOTAL	9	12	9	230	15	15	3

Notes:
DWR: Doppler Weather Radar, HAWOS: Heliport Automated Weather Observation System, AWS: Automatic Weather Station, ARG: Automatic Rain Gauges, SG: Snow Gauge, SFO: Surface Field Observatories, Proposed DWR network in western Himalaya is presented in Fig. 4.

At present, one DWR has been installed at Srinagar in western Himalayan region. All the proposed DWRs are X-band, the proposed locations.

Surface observing equipment consisting of Automatic Weather Stations, Automatic Rain Gauges and Snow Gauges sensors will be commissioned across the entire region to obtain surface observation data as displayed in Fig.6:

Figure. 6: **Existing and proposed Automatic Weather Station, Automatic Rain Gauge and Snow Gauge Network**

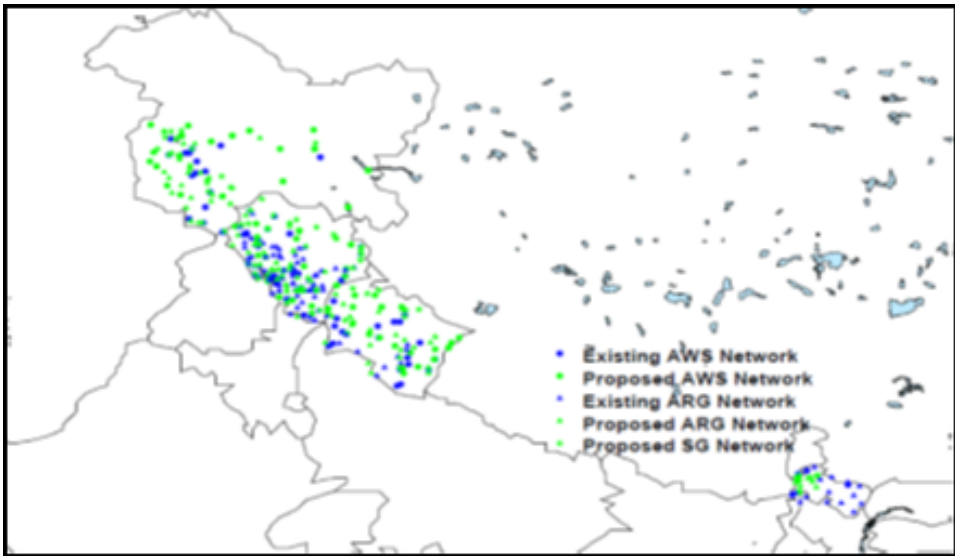
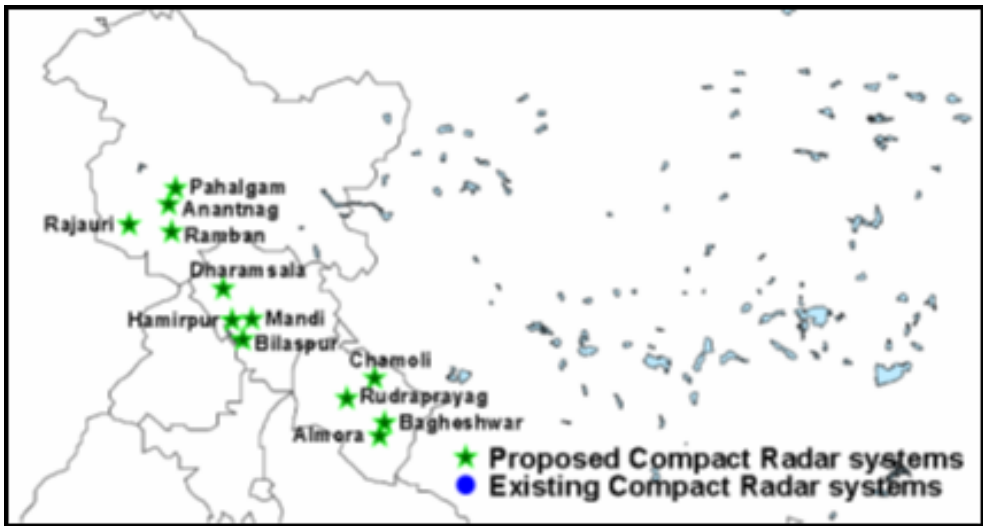


Figure. 7: **Proposed and existing network of compact Radar systems**

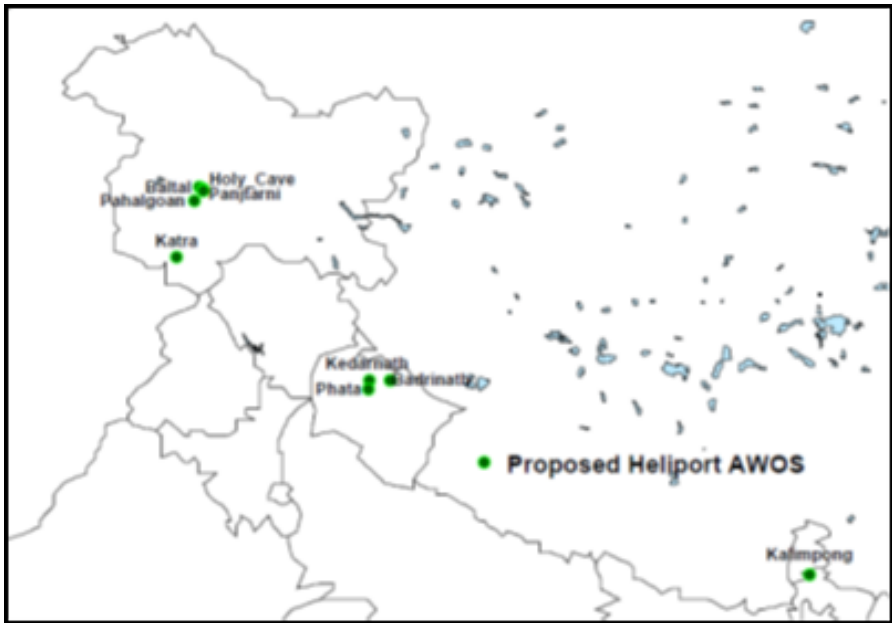


Compact severe weather detection radar systems are used for the detection of rainfall intensity at short ranges and ideally suited to provide forecasters with detailed information about local rainfall and early warnings of approaching storms for operational forecasting. These systems can show minute-by-minute information on the path and intensity of rainfall and are suitable for gap filling in existing radar networks and can also be used as a mobile application. Compact severe weather detection radar systems will be established at 12 stations over the Himalayan region as presented in Fig. 7.

Four each of these systems will be commissioned in the states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

Helicopter operations in India have been a challenge ever since such operations commenced. The need for helicopter operations, particularly over the mountainous areas where roads, railways and runways are difficult and expensive to build, population density is low and journey time by surface transport are necessarily long, has increased manifold in recent past primarily because such operations are both cost effective and convenient. Helicopter operations in general and in the mountainous region are vulnerable because most flights are non-scheduled, small size of aircraft, absence/ limited weather observations in the remote locations, sudden development of adverse weather in mountainous region and narrow valleys often make U turns and avoidance of adverse weather very difficult. This necessitates the need for meteorological support to helicopter services which is lacking at present. Therefore, it is proposed to install specialized Heliport Automated Weather Observation Systems (HAWOS) with aviation specific sensors at 7 heliport locations as shown in Fig. 8.

Figure. 8: **Proposed network of AWOS**



Sometimes abnormal weather conditions are reported by state administration/ media over a particular area. 15 mobile observing systems shall be procured and kept ready for field survey to assess the scenario and formulate a suitable action plan. These may be installed temporarily for extensive monitoring over a particular area for carrying out studies.

Surface meteorological measurements generally refer to observations of meteorological elements made near the surface of the Earth with the aid of passive sensors such as barometers, thermometers and rain-gauges. Information on atmospheric pressure, air temperature, humidity, wind speed and direction, rainfall, visibility, cloud is used operationally in day-to-day weather analysis and forecasting. This information is essential for many fields of studies including climatology, hydrology, agriculture and civil engineering design. Surface Field Observatories will be established at 15 locations under the Army/ITBP establishments.

Absorption, emission, and scattering of radiation within the atmosphere are critical processes that impact our climate and allow the remote sensing of key atmospheric properties. Measurements of solar radiation are usually made using thermopile type radiometers with a flat spectral response. In a solar monitoring station, the short-wave radiation is measured in three ways:

Global Solar Radiation is measured by a 'Pyranometer', which is a radiometer with a glass dome that has a hemispherical view of the whole sky. Direct Solar Irradiance is measured by a 'Pyrheliometer'. This is a radiometer with a 5° view that is pointed accurately at the centre of the sun by an automatic Sun Tracker. It only sees the sun and its aureole. Diffuse Solar Radiation is scattered by aerosols in the atmosphere and reflected by clouds. It is measured by a Pyranometer mounted on a sun tracker with a shading mechanism to block the direct solar irradiance. The output signals are normally acquired by a high accuracy multi-channel data logger that is programmed with the sensitivity of each radiometer. Therefore, it is proposed to install a set of equipment composing Pyranometer, Pyrheliometer and data logger one each in Jammu & Kashmir, Himachal Pradesh and Uttarakhand. Locations of the proposed network are tentative and some locations may change as per the circumstances/requirement at the time of installations.

The specific targets proposed to be achieved out of the above two projects are as follows.

- Implementation of this project will help to accurately identify various weather systems affecting the region and provide better weather forecasts and warnings.
- Improved data collection and archival will help in preparation of better climatology for the region.
- With the availability of additional ground trothed information, verification of forecasts of numerical models can be carried out more realistically which will in turn help in further improving the mountain meteorological services.
- With the availability of additional observational network in the remote mountainous terrain, it will in turn, help in further improving the mountain meteorological services, in particular for helicopter operations.

Improved data collection, forecasts and warnings in respect of heavy precipitation/ cloud bursts will help many sectors like army operations, agriculture, tourism, roads and communications, power generation, water management, environmental studies and the general public. It will also help in disaster preparedness and mitigation.

Chapter 2B
Disasters in IHR

1. Introduction/ Background

Hazard assessment is a prime concern for sustainable development in IHR. Therefore, it is vital to understand the processes and causes of various natural hazards occurring in IHR, which requires crucial data of various levels and magnitude. Such an understanding is essential for mitigation and risk reduction. The elastic strain energy built due to the movement and collision of the Indian and Asian tectonic plates is a continuous process, and has resulted in four great earthquakes in the Himalayan region over the last 120 years. Adjustments of crustal blocks to the accumulating strain also trigger micro-earthquakes in the Himalaya, which can further stimulate other hazards such as landslides. Seismic monitoring, source processes and subsurface investigations are being carried out using data obtained from various geophysical parameters such as seismic, gravity, magnetic and electrical methods. Agencies like IMD, WIHG, IIT, Roorkee, National Geophysical Research Institute (NGRI), Kumaun University and CSIR- North East Institute for Science and Technology (CSIR-NEIST) operate various geophysical observatories in IHR. A regional network of seismic stations and an earthquake precursory observatory is being operated by Wadia Institute of Himalayan Geology (WIHG), Dehradun.

There has been an increase in developmental activities in the IHR in the form of road widening and construction of new roads, townships, tunnels, bridges and hydropower projects. Often, these activities lead to destabilization of slope and sometimes results in catastrophic landslides and related mass movement activities. In addition, climate change including extreme rainfall also effects slope stability resulting in mass movement under gravitational force. Therefore, studies are required for active and chronic landslides and slopes vulnerable to landslides. In the Himalayan context, the data so far available on these aspects are limited and site specific. In addition, cloudburst, flash flood and forest fire are not uncommon in the IHR. Cloudburst and flash flood result from extreme amount of precipitation in a short period of time, whereas forest fires occur mainly in dry season during pre-monsoon period, often because of human intervention.

Disasters are often triggered by multiple factors and therefore prediction is very difficult. Although various institutes are engaged in developing early warning systems to assess and predict disaster scenarios, effective systems have not yet been developed. For now, preparedness is the best way to mitigate the socio-economic losses resulting from disasters. Government of India has set-up dedicated institutes to deal with disaster, namely National Institute of Disaster Management (NIDM) for providing trainings to various stakeholders; National Disaster Management Authority (NDMA), for establishing guidelines about pre and post disaster response; National Disaster Response Force (NDRF); and, similar institutes at the state level. The primary goals of these institutes are monitoring of disaster scenarios, development of action plans, and responding to the after effects to minimize the loss in best possible way in the disaster affected areas. Besides, many Himalayan states have established their own Disaster Management Cell, like for Uttarakhand it is Disaster Management and Mitigation Centre Uttarakhand.

2. Disaster and associated Issues

The Himalayan region is highly prone to disasters resulting from extreme climatic events, undulating topography and unstable mountain ranges. The list of potential disasters that generally occur or might occur in near future fit two broad categories:

- Natural Geological Disasters which are again classified into Geological Disasters such as landslides, earthquake, avalanche, and sinkholes; Hydrological Disasters such as flash floods; and, Climatological/ Meteorological Disasters such as Cloudburst, Glacial Lake Outburst Flood (GLOF), and forest fires.
- Man-made or technological disasters occur as the result of human interventions such as unplanned/ unscientific growth/ development or augmentation of infrastructure, urban sprawl, and human induced forest fires.

The following section describes the potential disasters which are common to IHR:

2.1. Natural Disasters

Earthquake/ Seismic Hazard

The Himalayas are most vulnerable to earthquake hazards. Earthquakes are being studied by geophysical observatories spread across the IHR. However, the density of the observatories is inadequate for precise seismic investigations. Therefore, more multi-parametric earthquake precursory research observatories need to be established.

Landslides

The data on landslides and related phenomena are dynamic in nature as new landslides develop each year and old landslides get stabilized. The data collected by various agencies are not in the same format, and hence collation of data from different sources becomes difficult. Most of the old data is analogue, mainly in tabular form or on the map, so there are limitations to reference the data geospatially. Much of the data related to landslides and related phenomenon not affecting human habitation/ infrastructure are not being reported. Therefore, regular updating of data is important, as very old data may not represent present ground conditions.

Cloudburst

A cloudburst is an extreme amount of precipitation in a short period of time[31] which is sometimes accompanied by hail and thunder. A cloudburst is capable of heavy rainfall rate equal to or greater than 100 millimetres (3.9 inches) per hour. In India a cloudburst usually occurs when the monsoon cloud drifts northwards from the Bay of Bengal or Arabian Sea across the plains and then onto the Himalaya and bursts, bringing rainfall as high as 100 millimetre per hour[32]. Major impact of the cloud burst may be flash flood and mass movement on the slopes.

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[31] International Glossary of Hydrology. World Meteorological Organization and UNESCO. 2011

[32] Weathernotebook.org

Flash Floods

IHR often faces extreme hydro-meteorological conditions that results in flash flood and its devastating consequences on the ecosystem. A flash flood is a rapid flooding of low-lying areas or valleys of the mountains which is normally caused by cloud burst, GLOF, collapse of ice sheets or a human structure such as dam or its reservoir including landslide lake outburst. Such events are site specific with restricted geographical extensions, and occur in few minutes to few hours. Record of these events, related metrological data and topology is required to analyse the causes of flash flood events and the extent of impact.

Avalanches

Avalanches occur in the upper reaches of the snowbound IHR belt. An avalanche can destroy life, property, forest and disrupt road communication. However, it is less discussed because of its occurrence in remote and mostly uninhabited higher reaches of IHR. Snow and Avalanche Study Establishment (SASE) is nodal agency to monitor and study on avalanches. However, because of strategic importance, access to the data is restricted.

GLOF (Glacial Lake Outburst Flood)

The massive flood disaster in Kedarnath, Uttarakhand in 2013 was caused primarily due to a combination of extreme rainfall event and GLOF. There has been rapid increase in the number of glacial lakes in the IHR. Many glacial lakes have formed or expanded during the rapid melt process in the Eastern and Central Himalayas. Some of these lakes vanish in due course of time, but there is a need to monitor expanding and newly formed lakes. These have led to catastrophic floods — so-called glacial lake outburst floods (GLOFs) — especially in Nepal and the Tibetan region.

Forest fire

Forest fires in IHR mostly occur in pre-monsoon period during May and June, before the onset of rains. The fires are mainly caused by natural reasons such as lightning, friction between rolling stones/ stems of falling trees, but some incidents are also human induced and result from agricultural practices such as shifting cultivation, and tribal traditions. Chir pine areas are most susceptible to forest fire, followed by oak and mixed oak forests. Observation of the direction and rate of the fire spread require real time monitoring. According to a report by Parliamentary Standing Committee on Science and Technology, India, the country has seen a 55% rise in the number of forest fires as on December 2016. The other effects of forest fires include release of greenhouse gases, soil erosion, loss of forest cover and habitat and destruction of properties and livelihoods of tribal and rural people.

2.2 Technological or Manmade Disasters

Uncontrolled growth has resulted in devastating consequences in the form of so called manmade disasters due to anthropogenic activities. These disasters are not area specific, stimulus at one point source may trigger a cascading chain of disasters affecting distant locations. Combustion of fossil fuels result in high emission of carbon compounds and other particulate matter which are suspended in the atmosphere above

the glaciers of IHR. The carbon compounds and aerosols along with the greenhouse gases trap the sun's radiation within the earth's atmosphere which is one of the primary reasons for increasing temperature (climate change) and glacier retreat. This is substantially increasing the temperature of the region leading to higher degree of glacial melt. Another example of manmade disasters in the IHR are human-induced landslides resulting from unplanned expansion of urbanization and infrastructure including hydropower projects, construction of new roads, where explosives are used to blow off part of the mountain or unplanned cutting of the mountains takes place.

Environmentalists have attributed the unprecedented destruction by rainfall witnessed in Uttarakhand state to unscientific development activities undertaken in recent decades. With unscientific and unplanned roads, construction of resorts and hotels along the fragile river banks and more than 70 hydroelectric projects in the watersheds of the state this was a "disaster waiting to happen" according to environmentalists[33].

IHR has several tourist destinations which attract tourists from around the globe. Large amounts of solid waste are dumped haphazardly by the tourists. Uncontrolled influx of tourists has become a huge problem for the IHR as increased anthropogenic activities and tourism related development increase the risk of disasters/ hazards and aggravate the water crisis.

Unplanned expansion of urban areas or urban sprawl in the IHR is also a serious issue. This may not be directly linked to causes of disaster but it has consequences for disaster. Valleys are being disturbed, water channels are shifting, geology of the region is being altered, and land use to land cover ratio is increasing. All these human interventions have been creating the conditions for disasters of unprecedented scale and loss.

3. Data availability and constraints

- Site specific data for different hazard events is collected by various agencies on local scale for focused studies. Therefore, site specific data on a limited time frame is available for many hazard events.
- Geophysical data obtained from continuous monitoring through geophysical observatories of various agencies (IMD, WIHG, IIT-Roorkee, NGRI, CSIR-NEIST) are available for different durations.
- Data on landslides and related phenomena like outburst flood, cloudbursts are collected as and when there is an event. There is no systematic data repository of these events with the recognized data agencies/ organizations. The data collection is project specific and mainly published in the form of research paper or report.
- Events that do not affect human habitation or any infrastructure go unnoticed and unreported. Yet maintaining a repository of such events is essential as they might be the early signs to trigger a disaster in near future. However, there is plenty of data available with various agencies along the roads/ national highways such as zone of landslides and land subsidence, accidents, etc. which might be important to record.
- Data for cloudburst is generally focused after the event.

[33] Shadbolt, Peter (25 June 2013). "Indian floods a man-made disaster, say environmentalists". CNN. Retrieved 26 June 2013

- Data collected by various agencies are not in the same format and thus is not always possible to collate data from different sources.
- Most of the old data is analogue, mainly in the tabular form or on the map. At times, it is difficult to reference the data geospatially.
- Different terminologies are being used for the same feature in many disaster related issues. Many times, these create confusion and are not understood by all.

4. Nodal Agencies for Disasters

Table 10: **Ministries entrusted as nodal agencies in the event of particular disaster in India**

Disaster	Nodal Agency (Ministry)
Floods	Ministry of Water Resources, CWC
Cyclones	Indian Meteorological Department
Earthquakes	Indian Meteorological Department
Landslide	Geological Survey of India
Epidemics	Ministry of Health and Family Welfare
Chemical Disasters	Ministry of Environment and Forests
Industrial Disasters	Ministry of Labour
Rail Accidents	Ministry of Railways
Air Accidents	Ministry of Civil Aviation
Fire	Ministry of Home Affairs

5. Data gaps and additional data requirements

- In addition to spatial distribution on any hazard, it is also pertinent to know the causes of such events. Therefore, it is important to collect comprehensive data about that particular hazard event.
- Seismic data is required for understanding the seismic activity in IHR, gaps and trends. This is also vital for earthquake precursory studies. In order to record lower magnitude earthquakes, there is a need to increase the density of the observation network.
- Seismic zone maps at district level are unavailable.
- Large scale landslide zonation maps are required for important river valleys, highways/ roadways and vulnerable townships. Event specific data is useful for analysis, inferences and implications.
- Data related to cloudburst, flash flood data and their repository of records for Himalayan region is required. These events are responsible for huge socio economic losses in the region.
- For avalanche and Glacial Lake Outburst Flood (GLOF) data and repository of records in Himalayan region, SASE is monitoring avalanches. However much of their data is strategic and restricted for security reasons.
- Forest fire data and forest fire maps and the identification of forest fire prone zones is a data gap area.
- Data related to relief and rehabilitation, amount of financial loss to individuals/ families and physical infrastructure loss should be compiled after each disaster.

Table 11 presents the different types of disasters in IHR and different data/ information that are required for early warning or preparedness to minimize the after-effect of disaster in form of socio-economic loss and for informed decision making for sustainable development in IHR. It also mentions the data/ information that is readily available and data gaps that are required to be addressed by data collector/ generators.

Table 12 lists the agencies/ institutes that are involved in data/ information generation or collection as shown in Table 11. It also details the spatio-temporal scale and frequency of data collection, time period for which the data is available, format for the data dissemination, and whether or not the data has been passed quality checks.

Table 11: **Disaster related issues and data requirement, availability and gap analysis**

Disaster Related Issues in IHR	Parameters/ Data required	Data Availability	Data Gaps as per survey responses	Remarks
Natural Hazards 1) Geological *(Earthquake, Land/ Mountain slides, Land subs idence and Avalanches)*	1.Seismic Zone map	Event specific geospatial data[1], Local and regional grid wise in the Himalayan region for site specific events[2]	Fine resolution seismic zone map at district level	
	2.Land/ Hill slide prone areas/ Land Subsidence	Event specific geospatial data. For Uttarakhand District level data[3]. For the entire country[4]	Potential hill slide/ land subsidence location data along Roads and highways	
	3.Avalanche data		Event specific data with attributes	No response on Avalanche data.
2) Climatological/ Meteorological *(Forest fire, Flash Floods, Cloud Burst)*	4.Forest fire map	Geospatial data with temporal scale of 4 alerts/ day. District level data for Uttarakhand3	Zone of influence and loss analysis, Damage assessment to biodiversity	Traditional coping mechanism may be collected
	5.Flash flood data/ GLOF/ Floods	Opportunistic satellite data availability site specific studies*, may include large area along the rivers. For the Entire Country[4].		
	6.Cloud burst: Rainfall related data	Data is collected after the disaster for few site specific area[2]. For the Entire Country[4].	Cloud burst data for Himalayan and especially North eastern region	Continuous data for prone area to be generated
Technological or Man made *(Road/ Rail Accidents)*	Road accident data			

Notes:
[1]As per the response of NRSC, [2] Data with Wadia Institute of Himalayan Geology (WIHG), Dehradun; [3] Three district only that includes Almora, Tehri and Nainital, [4]Indian Meteorological Department (IMD)

Table 12: **Disaster related Data/ Information availability across various institutes, its spatio-temporal scale and format of dissemination**

Data/ Information	Agency/ Institute	Level of Data Availability	Frequency	Time Period	Format – Quality Check (Y/N)
Earthquake/ Seismic Hazard Zonation data	i. NRSC, Hyderabad	State	Event specific	NA	Geospatial - Y
	ii. Wadia Institute of Himalayan Geology, Dehradun	Local and regional grid wise in the Himalayan region for site specific events	Daily	01/07/2007 till 20/07/2017	PDF/Reports- Y
	iii. JNU	NA	NA	NA	PDF - NA
Landslide data	Indian Meteorological Department	For Entire Country	Annual	1981-2015	Report/ Hard Copy - Y
	NRSC, Hyderabad	State/ Grid – Event Specific	NA	NA	Geospatial - NA
	Wadia Institute of Himalayan Geology, Dehradun	Site specific studies, may include large area along the rivers	Data is collected after the disaster or if area is prone to disaster	The year/ month/ day of the disaster occurrence	Research Papers in PDF formats - NA
	UCOST, Dehradun	District	NA	NA	PDF – Y
	IIT Mandi	Point Source	Hourly	Ongoing	PDF/ reports/ Geospatial – Y
	JNU	NA	NA	NA	PDF – NA
Cloud Burst	Indian Meteorological Department	For Entire Country	Annual	1981-2015	Report/ Hard Copy - Y
	Wadia Institute of Himalayan Geology, Dehradun	Site specific studies, may include large area along the rivers	Data is collected after the disaster or if area is prone to disaster	The year/ month/ day of the disaster occurrence	Research Papers in PDF formats - NA
	JNU	NA	NA	NA	PDF – NA

Flash Flood data	Indian Meteorological Department NRSC, Hyderabad	For Entire Country District	Annual Opportunistic satellite data availability	1981-2015 NA	Report/ Hard Copy - Y Geospatial - Y
	Wadia Institute of Himalayan Geology, Dehradun	Site specific studies, may include large area along the rivers	Data is collected after the disaster or if area is prone to disaster	The year/ month/ day of the disaster occurrence	Research Papers in PDF formats - NA
	JNU	NA	NA	NA	PDF - NA
Forest Fire data	Forest Survey of India, Dehradun	District	Daily	20014 to 2017 (Jan – June)	Geospatial (Point) - Y
	NRSC, Hyderabad	Point Source/ Grid	Daily 4 Alerts	2006 to till date	Geospatial – Y
	UCOST, Dehradun	District	Hourly	NA	PDF – Y
	IHBT, Palampur	Kangra District	One time (forest fire prone areas)	2015	Geospatial – Y
	JNU	NA	NA	NA	PDF – NA
Avalanche	SASE, IMD	NA	NA	NA	NA
Road Accidents	UCOST	District	Event Specific	2008-15	PDF – Y

6. Ways to address these issues through cross-sectoral and interdisciplinary institutional collaboration and data sharing

- Density of the geophysical observatories needs to be enhanced (Table 13).
- A system can be evolved whereby the data, after a defined period from the date of data generation/ acquisition, can be shared without hampering the interests of the organization.
- Data collected by various agencies are not in the same format and it is not always possible to collate data from different sources. Therefore, a standard module can be framed for use by different agencies.
- The hazard data, particularly related to landslides and related phenomena are dynamic in nature as every year new landslides are developed and old landslides get stabilized. Therefore, data must be updated regularly, as very old data may not represent the actual state of ground conditions.
- Most of the earlier data which is analogue, mainly in the tabular form or on the map, may be digitized.
- It is difficult for any single institution to collect data in all the areas, so involvement of more than one institution may be useful. It is also not easy to share data because (i) the career growth of the scientists is linked with the research output/ publication based on the data collected/ generated by them, and (ii) policies of the institutions restrict data sharing. Addressing these issues may be useful.
- A nodal agency may record and study forest fire to strengthen preventive measures. Since most forest fires are due to human intervention or activity, active awareness programmes would be useful.
- For generation of reliable data by some agencies/ organisations that can be shared by other organizations, some multi-organizational national programmes may be initiated.

Table 13: **Suggested Institutes to be involved to address the data gaps in Disaster sector**

Disaster Type	Data Gaps as per survey responses	Nodal Institute	Collaborating Institutes
Earthquake/ Seismic	Fine resolution seismic zone map at district level	IMD - Ministry of Earth Sciences	GSI, ISRO (IIRS/ NESAC/ NRSC), WIHG, IMD
Land Slide/ Land Subsidence	Potential hill slide/ land subsidence location data along Roads and highways	Geological Survey of India	IMD, ISRO (IIRS/ NESAC/ NRSC), WIHG, UCOST, IIT Mandi
Avalanches	Event specific data with attributes	SASE, Ministry of Defence	IMD, ISRO (SAC/ NESAC/ IIRS)
Forest Fire	Zone of influence and loss analysis, Damage assessment to biodiversity.	Ministry of Environment, Forest & Climate Change	FSI, NRSC, UCOST, IHBT
Cloud Burst	Continuous data for prone area to be generated especially for North eastern region	IMD	WIHG, ISRO
Flash Flood	Flash flood	IMD	ISRO (IIRS/ NESAC), WIHG

7. Suggestions and recommendations

i. Ways to generate the data, level of generation (local, state, regional and national), Spatio-temporal scale of data and its management

- Sector wise responsibilities of different agencies/ organizations may be fixed for generating data and repository keeping.
- There can be nodal agencies for various kind of data generation (Table 3) and keeping records.
- Collection and sharing of the data for a disaster event must be in a time bound manner.
- Currently large volume of data is generated in project-mode by different agencies for a particular area, and therefore a systematic data management would be suitable.
- Incidences of and casualties resulting from disaster events from State and Central government authorities should be made available to correlate the occurrence and intensity of climate and cryosphere related disasters, and so that monitoring, prediction and warning services for these disasters can be improved.
- Improved IT infrastructure for real time data collection and dissemination for early disaster preparedness.
- Sector specific single central data management agency for disaster warning and real time information availability.
- Some data is categorized as classified or strategic and has not been reviewed for decades. A timely review mechanism should be in place to ensure revaluation of certain classified data into public domain.
- Certain data are available at 1:10k, most of them are available at 1:50k, and few parameters are being collected as point locations. There should be uniform scale or level of data generation/ collection to ensure uniformity and format.

ii. Formats and quality checks

Experienced and reputed agencies do standard quality checks regularly. However, there needs to be a standard format for data collection/ generation and the quality of the data should be checked regularly. A third party review of data quality may be useful. Nodal agencies must generalize the format and threshold of the quality of accepted data against various data/ information being acquired nationally by different organizations. This will ensure availability of wide range of data throughout IHR in a uniform format and with less ambiguity for data compilation.

iii. Sharing, retrieval and end-user accessibility

Limited data may be open source for facilitating end-user accessibility. A system can be evolved whereby the data can be shared without hampering the interests of the organization.

Chapter 2C
Biodiversity Conservation

Background on Biodiversity of IHR:

Mountains are remarkably diverse and globally important as centres of biological diversity. In Chapter 13 of Agenda 21, adopted at the United Nations Conference on Environment and Development (UNCED 1992), mountains are defined as "storehouses of biological diversity and endangered species". Mountains have been recognized as important ecosystems by the Convention on Biological Diversity and a programme of work on mountain biodiversity was specifically developed in 2004, aimed at reducing the loss of mountain biological diversity at global, regional and national levels by 2010. The growing global recognition of mountains as (i) hotspots for biodiversity, and (ii) providers of goods and services to nearly half of the world's human population has put mountains at the centre of the global debate on environmental conservation and development. It has been felt that mountains have largely remained marginalized from sustainable development perspectives. In this context, and on account of species richness, representativeness and uniqueness, mountain biodiversity elements have attracted the attention of scientific community in recent decades.

This great wealth of biological diversity is attributed to the wide variety of environments in the mountains, particularly the Himalayas which is one among 34 biodiversity 'hotspots' of the globe. The IHR constitutes a large proportion of this hotspot and, therefore, contributes greatly to richness and representativeness of its biodiversity components at all levels (i.e., genes, species and ecosystems). There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world. The IHR harbours nearly 50% of the total flowering plants of India, of which 30% are endemic to the region[34] (Table 1). Of the total plants, the species richness is maximum in herbs (1,020 spp.) followed by trees (339 spp.) and shrubs (338 spp.). Using IUCN criteria, about 121 species have been recorded in the Red Data Book (RDB) of Indian plants from the IHR[35]. Similarly, out of the total records from India, 65% mammals, 50% birds, 35% reptiles, 36% amphibians and 17% fishes are reported from the IHR. Moreover, 29 out of 428 species of reptiles from India, 35 species of amphibians (out of 200) and 36 species of freshwater fishes (out of 1,300) are endemic to this region[36]. The Eastern Himalaya is one of the four biodiversity hotspots of India and known as the 'centre of origin of cultivated plants', as over 50 important tropical and sub-tropical fruits, cereals, and types of rice originated in the region. This region serves as a rich repository of plant and animal wealth in diverse ecological systems.

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[34] Singh, D.K. & P.K. Hajra, 1996. Floristic diversity. In: Gujral, G.S. and V. Sharma (eds.). In: Changing perspectives of Biodiversity Status in the Himalaya. British Council, New Delhi, pp.23-38.

[35] Nayar, M.P. & A.R.K. Shastry, 1987, 1988, 1990. Red Book of Indian Plants, Vol. I, II, III, Botanical Survey of India, Calcutta.

[36] Ghosh, A.K., 1997. Himalayan fauna with special reference to endangered and endemic species. In: Himalayan Biodiversity: Action plan (ed. U. Dhar). GB Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora, pp. 53-59.

Table 14: **Representativeness and richness of Biodiversity in IHR**[37]

Categories	Representation	
	Total Number	% of India
Angiosperms	8000	47
Gymnosperms	44	81
Pteridophytes	600	59
Bryophytes	1737	61
Lichens	1159	59
Fungi	6900	53
Mammals	300	69
Birds	979	79
Reptiles	176	38
Amphibians	105	34
Fishes	269	10
Specific groups		
Medicinal	1748	23
Wild edible	675	67
Trees	723	28

The uniqueness of biodiversity of IHR includes: (i) Considerable contribution in the form of wild relatives of several crop plants and domesticated animals. Of the total 8 sub-centres of plant origin, the region represents 3 sub-centres (viz., Western Himalaya, Eastern Himalaya and North Eastern Region). These sub-centres respectively contribute 125, 82, and 132 species of wild relatives. (ii) The region contributes a large number of medicinal and aromatic plants with their origin in the region, including the wild progenitors of a number of ornamentals like Primula, Rhododendron, in addition to a huge diversity of orchids. Among wild and domesticated faunal elements, the region harbours wild chicken, zebu, mithun, and yak. (iii) The prevailing primitive agricultural system of raising crops and locally selected cultivars under stress conditions in the specialized habitats in the region have resulted in much variability, particularly in physiologically adaptive traits. (iv) The IHR nurtures an amazing faunal diversity which is one of the richest in the country. Foothills of this region are habitats for three major terrestrial flagship species (tiger, elephant, rhino) out of five across the globe, and the aquatic flagship species, the river dolphin. High altitude habitat nurtures some of the charismatic and unique faunal species (e.g., snow leopard, red panda, hangul, chiru, musk deer, serow, and Himalayan tahr). (v) Endemism is yet another important attribute of the region. Among floristic elements, besides nearly 32% of species being endemic, the region represents 71 endemic genera and five endemic families (i.e., Tetracentraceae, Hamamelidaceae, Circaeasteraceae, Butomaceae, and Stachyuraceae). A few families, e.g., Berberidaceae and Saxifragaceae represent >90% species endemic to the Himalaya. A large number of orchids, many representing neo endemic taxa, have been recently reported from Sikkim and Arunachal Pradesh. Likewise, of the nearly 300 recorded mammal species across the region, 12 are endemic to the Himalaya. Of the 979 bird species recorded from the region 15 are endemic, including the Himalayan quail (Ophrysia superciliosa) (Table 14).

The wealth of biodiversity of this region supports the livelihoods of people directly and indirectly through a range of ecosystem goods and services. In this region, over 675 wild plant species (Angiosperms 647, Gymnosperms 7; Pteridophytes 12; Fungi 7 and Lichens 2 species) are used by different communities as food/ edible plants on account of their nutritional and pharmaceutical potential that meets the protein, carbohydrate, fat, vitamin and mineral requirements of rural poor and also generates employment and income. The unique diversity of medicinal plants in the region is manifested by the presence of a number

[37] Rawal, R.S., I.D. Bhatt, K. Chandra Sekar & S.K. Nandi (eds), 2013. The Himalayan Biodiversity: Richness, Representativeness, Uniqueness and Life-support Values. Almora, Uttarakhand, India.

of native (31%), endemic (15.5%) and threatened elements (14% of total Red Data Book plant species of IHR). The economic potential of Himalayan medicinal plants and their contribution towards novel biomolecules is well recognized. Over 200 species of Himalayan medicinal plants are consumed raw, roasted, boiled, fried, cooked, or used in the form of oil, spices, jams or pickles[38]. About 1,743 plant species of medicinal value are *found in the IHR[39], of these Aconitum heterophyllum, A. balfourii, Gentiana kurrooa, Picrorrhiza kurrooa, Podophyllum hexandrum, Taxus baccata, Valeriana jatamansi, etc. provide lifesaving drugs* and are of immense economic importance. Apart from human use, many plant species are the primary source of healthcare of livestock.

Traditional agriculture in the IHR is a rich repository of agro-biodiversity that is resilient to crop diseases and climate variability. For example, in Uttarakhand over 40 different crops and hundreds of cultivars selected by farmers, comprising cereals, millets, pseudo-cereals, pulses and tuber crops are cultivated. Mixed cropping of 12 crops *(baranaja)* is an example of rich on-farm diversity in the region. These crops are adapted to the local environmental conditions and possess the inherent qualities to withstand the environmental risks and other natural hazards and has potential to adapt to climate change. However, the area under traditional crops has drastically declined (> 60 %) particularly during the last three decades and many of the crops are on the brink of extinction *(Glysine spp., Hibiscus sabdariffa, Panicum miliaceum, Perilla frutescens, Setaria italica, Vigna spp., to name a few)*. It is anticipated that the onslaughts of climate change will have a cascading impact on biodiversity, as well as on plant reproduction, growth and plant populations, impacting people's livelihoods and developmental planning.

Issues relating to Conservation of Biodiversity

The richness of the Himalayan biodiversity is threatened by various drivers of human induced changes such as biomass removal, deforestation, forest fire, livestock grazing and agricultural expansion into forest lands, land fragmentation, illegal trade of timber and MAPs, and above all climate change (Box I). Global climate change, along with continued habitat loss and fragmentation has been recognized as a major threat to biodiversity. Climate change is likely to have impacts from ecosystems to species level and these are not yet fully understood. Warming in the Himalayan region could indicate moderate to large-scale shifts in vegetation types, with implications on plant dieback, change in the timing of phenological events of plants, change in species abundance and range, shifts in habitat, etc. Spread of alien invasive species such as *Lantana, Eupatorium* and *Parthenium* spp. in the natural forests has also been linked with climate change, which will have a competitive impact on native species. The high altitude species are now facing the additional threat of warming temperatures, and most vulnerable are the species in transition zones between subalpine and alpine biome, as they have limited scope to move up further, such as rhododendron species in Arunachal Pradesh. A rise in temperature and water stress due to reduced snowfall may advance seed maturation, which might result in the breakdown of synchrony between

[38] Samant, S.S. & U. Dhar, 1997. Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. International Journal of Sustainable Development and world Ecology4: 179-191.

[39] Samant, S.S., U. Dhar & L.M.S. Palni, 1998. Medicinal Plants of Indian Himalaya: Diversity Distribution Potential Values. Gyanodaya Prakashan, Nainital. pp. 1-163.

monsoon rains and seed germination leading to compositional changes in forest flora. It is expected that with climate change, scenario of the forests, both in terms of structure and functioning, is likely to change substantially.

BOX-I

Issues relating to Conservation of Biodiversity

- Deforestation and loss of biodiversity
- Spread of invasive alien species
- Forest fire
- Land fragmentation for developmental projects
- Over-exploitation of bioresources
- Pests and diseases
- Lack of corridor connectivity for wildlife movement

There has been much harm to natural habitats and biodiversity over the past few decades because of increasing anthropogenic disturbances, tourism, air and water pollution, industrialization, urbanization and infrastructure development. Forest loss and fragmentation negatively affect species diversity. Deforestation and land degradation/ increasing waste land and extraction of fuel wood from forests is also causing tremendous pressure on forests. A survey of fuel wood use pattern in the region revealed that non-commercial energy formed 98.59% of the total household energy demand. Thus, the commercial energy component formed only 1.41% of the total, comprising of kerosene and electricity[40]. Forest fire is another major issue. Forest fire in IHR is causing colossal damage to forest ecosystems. The accounting of loss of forest wealth grossly underestimates the loss to biodiversity and micro-habitats. Related to the loss of habitats and food availability is wild human-wildlife conflict which has emerged as a major issue. For example, in Uttarakhand, during the past ten years over 722 leopards, 81 tigers and 241 elephants died, many due to unnatural causes. On the other hand, leopards, tigers and elephants killed over 338 humans and injured another 460 during the same period[41]. Similar situation prevails in many other states, making management of human–wildlife conflict challenging. Poaching is a major threat to wildlife in IHR, especially endangered species like musk deer, snow leopard, tiger, and Himalayan black bear which have a high commercial value in the illegal trade. Retaliation against tigers and snow leopards for killing livestock, and against elephants for raiding crops, is prevalent and continues to intensify as humans and wildlife compete for land and other resources. In the recent years unplanned urbanization and hydropower development has also emerged as a major conservation and development issue[42]. The creation of dams without due environmental impact assessment could lead to the submergence of arable lands and biodiversity hotspots. Not only would valley habitats be inundated by the creation of reservoirs, but villagers would be displaced. For example, according to Pandit & Grumbine (2012), there are 109 dams in the Brahmaputra, 89 in the Ganga, and 94 in the Indus River basins. Submergence would result in direct elimination of species, and a high density of dams and associated construction activities would also change land cover and thus be detrimental to species survival. Altered flow regimes due to river regulation often result in the destruction and fragmentation of riverine and riparian ecosystems and extirpation of fishes, other freshwater fauna, crocodiles, molluscs, mayflies, benthic

[40] Kumar, S. & M. Kumar, M., 2015. Fuelwood Consumption in Takoli Gad Watershed of TehriGarhwal in Garhwal Himalaya, India. Forest Res 4:138. doi:10.4172/2168-9776.1000138.

[41] Sundriyal, R.C. & Dhyani, P.P., 2014. Human Wildlife Conflicts. Curr. Sci. 107(3): 346-347.

[42] Pandit, M. K., & Grumbine, R. E., 2012. Potential effects of ongoing and proposed hydropower development on terrestrial biological diversity in the Indian Himalaya. Conservation Biology 26(6): 1061.

biota, and riparian vegetation. Therefore, conservation of the unique biodiversity of mountain ecosystems needs trans-disciplinary approaches to come up with management plans based on reliable data/ information on biodiversity of IHR.

Data requirement, availability and gaps

To address various issues prevalent in biodiversity conservation and sustainable development specific data sets are required. In Table 15 we have presented data sets required to address identified issues related to conservation based on responses from 23 institutions (out of 96 to whom the questionnaire was circulated). Also, their data requirement and data gaps are listed in Table 15. There are limited datasets on IHR and even these are scattered among various institutions. There is a need for a Himalaya specific centralized institution responsible for biodiversity data collection, integration, storage and dissemination. A synthesis of responses received from various intuitions indicates that most of the data/ information is confined to herbaria, museums, checklists, research papers, theses and technical reports. Large datasets like herbarium data of Botanical Survey of India and Forest Research Institute are not completely in digital forms. Also, data on ecological attributes and population dynamics of plant/ animals is mostly on activity/ project based mode and continuous long-term data are missing. Further, data collection is confined to only a few locations as per the R&D needs of institutions. The frequency and temporal scale of data collection is also not strategic and suited to the need of other users. There is hardly any mechanism for data sharing either free of charge or on payment basis except for a few organizations. It was felt that location specific geocoded data/ information on spatial and temporal scale is required for planning policies and programmes to address biodiversity conservation and sustainable development. Also, to save the plants/ animals from certain pests, parasites and diseases, knowledge on suitable control measures is important. Similarly, knowledge about migratory routes and corridors is essential for wildlife conservation and management planning.

There are a host of Institutions those are engaged in biodiversity research and conservation in IHR. Table 15 summarises information provided by 22 institutions (out of 96 institutions to whom the questionnaire was circulated). Most of these Institutions collect data as well as require data to meet their objectives. However, looking at the type of data collected by them it is apparent that most of the institutions are generating data of similar kind depending on their R&D need. There seems no mechanism to obtain baseline data/ information from other institutions which have worked on similar aspects in the past. Also, there is a possibility of overlaps in data collection due to lack of a mechanism to maintain a data bank and allow access by other stakeholders. At present, BSI and ZSI are the only organizations those are mandated with data collection on distribution of plants and animals across the IHR. Further, in terms of plant checklist BSI has data for Uttarakhand, Meghalaya, Nagaland, Tripura, Assam and West Bengal (Darjeeling part) but the entire Flora of Himalaya is not available. Also, as per the publication list of ZSI, checklist of State fauna is available but the complete list of Fauna of Indian Himalayan Region is not available. However, from a conservation planning standpoint the type of data/ information collected by them is inadequate with respect to its location specific details, coordinates, population dynamics of species, etc. Therefore, such data are not sufficient for decision making for biodiversity conservation planning. A major challenge in biodiversity

Table 15: **Details of data requirement, data availability and data gaps associated with identified biodiversity issues of the IHR**

Biodiversity related issues	Data requirement	Data availability	Data gaps
Deforestation and loss of biodiversity	• Grid based quantitative information on biodiversity/ species richness (flora/ fauna/ agro-diversity) • Location specific information on forest cover/ area under forest/ stock of timber, NTFPs, etc. • Rate of loss of species/ population change due to natural and anthropogenic activities • Detailed information/ data on biodiversity of PAs network • State wise complete list of plant/ animal taxa • Quantity and value of major forest products, growing stock and non-timber forest products • Soil microfauna	• Herbarium/ museum data sets • List of threatened and endemic plants and animals • Plant/ animal species conserved in ex-situ at different botanical gardens/ zoos • Checklist of biodiversity in limited states/ limited PAs (e.g., Nagaland, Meghalaya, Tripura, Assam, Cold Desert BR)	• Location specific and geo-coded datasets on flora/ fauna • Species/ community wise data on forests • Location specific data on rate of deforestation/ loss of plant/ animal species • Long-term changes in population status (including seasonal) of biodiversity (flora/ fauna) • Geo-coded specimens/ live repository in Herbaria/ Parks/ Arboreta, etc. • Protocols (in situ and ex situ) for conservation of selected species
Invasion of alien species	• Invasive/ pests; area of spread and loss to biodiversity/ forest wealth	• Checklist of Invasive alien plants • Impact of a few invasive plants/ animal species on native flora/ fauna	• Location specific and geo-coded datasets on invasive species • Quantitative information on impact/ adverse effect to other biota • Quantitative spread and control measures

Forest Fire	• Area damaged/ loss of biodiversity/ forest wealth due to forest fire • Causes of forest fire • Impact of forest fire on native biota • Map of fire prone area with control measures	• Data on forest fire affected area and damage to woody vegetation/ major fauna	• Location specific quantitative and qualitative information on damage/ loss of biodiversity/ forest wealth (including carbon sink) • Detailed information on causes of forest fire • Forest fire prone area and mitigation measures • Detailed impact analysis of forest fire on flora/fauna
Over-exploitation of bioresources	• Quantitative information/ data on bio-resource use/ pattern	• Resource use pattern of selected species	• Data on available stock of bioresources in different ecosystems • Quantitative information/ data on use (local/ commercial) pattern of bio-resource • Tools/ techniques/ approaches for promoting sustainable use of bioresources
Pests and diseases	• Grid based host/ location specific • quantitative information of pests and diseases • Quantitative information on damage caused by pest, parasites and diseases • Control measures	• Selected information on pest/ parasites/ diseases on crops and major forest trees • Control measures on selected species	• Location and host specific quantitative information on pests, parasites and diseases • Quantitative information on damage caused by pest, parasites and diseases • Control measures
Lack of connectivity of corridors for wildlife migration	• Geocoded information on wildlife migration and routes	• Migration of selected wildlife species	• Accurate/ geocoded information on wildlife migration and routes • Corridor delineation for monitoring wildlife migration

conservation planning is the lack of data set on quantum of bioresource available in the wild and its extraction and use by people. So far, availability of useful biomass/ plant parts of human use is confined to only a few species. Therefore, cooperation and collaboration among R&D organizations is urgently required to find synergy, dovetail their databases and come up with an action plan for biodiversity conservation and development issues in the IHR.

Data sharing is a major issue in the IHR. A major concern for researchers is appropriate benefits from data sharing. Expectations for biodiversity databases include standardization of data format, user-friendly data submission tools, formats for different types of data, and coordination among databases. Therefore, issues such data sharing, data quality, and duplication of effort and data will need to be overcome to utilize the intellectual, capital and material resources in the best interests of the region. In this context, a citizen science approach can be useful as it ensures participation of a range of stakeholders in data collection, data compilation and drawing useful inferences. This approach has been tested by GBPNIHESD by involving rural people in valuation of forest ecosystem services in community forests of Uttarakhand[43].

Ways to address these issues through cross-sectoral and interdisciplinary institutional collaboration and data sharing:

Our questionnaire survey/ consultations with 17 leading organizations and web search for other stakeholders engaged in R&D on biodiversity conservation and sustainable development of IHR reveals that this region is still data deficient in terms of biodiversity information. The data available so far is fragmentary

Table 16: **Summary of data on biodiversity of IHR with various Institutes/ organizations based on questionnaire survey responses.**

Sl. No	Name of the Organization/ Institution	Type of data being collected	Type of data being disseminated	Data format used	Data quality check	Whether user charges applied
A. GOVT. ORGANIZATIONS MANDATED FOR DATA COLLECTION/ DISSEMINATION						
1.	Botanical Survey of India, Kolkata	• Information on plant distribution • Herbarium specimens • Threatened and endemic plants • Checklist of plants found in selected states, PAs, Botanical Garden	• Location specific data on plants through herbarium specimens/ published literature • Identification of specimens by experts • Conservation techniques for selected plants/ Botanical gardens	• Standard format for data collection/ Herbarium • Published information is available on digital form (Red Data List)	Yes	Free (Charge for identification of plants)

[43] G.C.S. Negi, V. Arya, R.S. Rawal & P.P. Dhyani, 2016. Community Training Manual on Participatory Assessment of Forest Ecosystem Services (Hindi/ English) (isbn-978-81-927373-5-5).

2.	Zoological Survey of India, Kolkata	• Information on faunal distribution • Museum specimens • Threatened and endemic fauna • Checklist of fauna found in selected states and PAs	• Location specific data on fauna • Identification of specimens by experts • Conservation techniques for selected fauna	• Standard format for data collection • Published information is available on digital form (Red Data List)	-	(Not responded)
3.	National Remote Sensing Centre, Hyderabad	• Datasets on land use/ land cover, vegetation type, forest type, etc.	• Location specific data on forests	• Digital data set	Yes	Free (following official procedure)
4.	National Botanical Research Institute, Lucknow	• Information of Lichens, Bryophytes, Algae and Angiosperms in selected districts/ locations of Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Meghalaya, Sikkim, Uttarakhand , West Bengal (Darjeeling) • Phytosociological data of Oxytropis in selected locations of IHR	• Location specific data on Lichens, Bryophytes, Algae and Angiosperms	• Published information	Yes	
5.	Institute of Himalayan Bioresource Technology - CSIR, Palampur (HP)	• Data/ herbarium/ digital information of plants in selected locations • Population data of selected plant species • Location specific • Threat status of selected medicinal plants	• Location specific data on selected plants	• Digitized herbarium specimens • Published research papers	Yes	Yes

6.	G.B. Pant National Institute of Himalayan Environment & Sustainable Development, Kosi-Almora	• Location-specific information on plant/ animal diversity in selected areas of IHR • Location-specific information on forest cover/ area under forest/biomass, NTFPs • Checklist of invasive plants in IHR • Agri-diversity conservation practices in Uttarakhand • Propagation protocols of important plants	• Location specific data on flora/ fauna • Published information on important plants of IHR	• Herbarium specimen data • Digitized data on biodiversity	Yes	Free (following official procedure)
7.	Indian Council of Forestry Research and Education, Dehradun (UK)	• Information on biodiversity in different forest types	• Published information on biodiversity of different forests	• Published data	Yes	(not responded)
8.	Wildlife Institute of India, Dehradun	• Location details of selected wildlife available at variable scales	• Location specific data on wildlife	• Digital providing some details of the wildlife	Yes	Free (following official procedure)
9.	Himalayan Forest Research Institute, Shimla	• Floristic diversity of wildlife sanctuaries of Kullu, Mandi, Chamba, Shimla, Sirmaur, Lahaul-Spiti, Kinnaur	• Location specific data on flora	• Herbarium specimens	Yes	Free
10.	National Medicinal Plant Board, New Delhi	• Inventory of medicinal plant in different State • Trade/ utilization information of commercial medicinal plants • Regulations on medicinal plant resources	• Location specific medicinal plant resources • Regulation on traded plants	• Reports and published information	-	-

B. OTHER R&D ORGANIZATIONS/ EDUCATIONAL INSTITUTIONS/ UNIVERSITIES						
11.	Directorate of Mushroom Research, Solan	Information of Agaricus, Pleurotus and other edible mushrooms growing in different states of IHR	• Location specific data on edible mushrooms • Details of culture collection	• Yes	Yes	-
12.	Indian Institute of Technology, Mandi	Floristic diversity in selected regions of Himachal Pradesh Digitized herbarium specimens of identified plants growing in Botanical Garden, Kamand (HP)	• Location specific data on flora	• Herbarium format	Yes	-
13.	Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar (JK)	• Herbarium and published information on trees and shrubs of Nubra Valley, Ladakh, Anantnag and Kulgam • Digital database on Fishes of J&K	• Location specific data on woody vegetation and fishes	• Herbarium specimens and published papers	Yes	Free
14.	Department of Zoology, Kumaun University, Nainital	• Data on selected fish species and Molluscan fauna in Kumaun lakes	• Location specific data	• Published research paper	-	-
15.	Jawaharlal Nehru University, New Delhi	• Location specific data/ info. on selected forests plants	• Published information on location specific data	• Digital	Yes	Free
16.	G.B. Pant University of Agriculture & Technology, Pantnagar (UK)	• Data on agricultural crops • Information on conservation of different cultivars • Caryophyllaceae of Uttarakhand	Location specific data/ information	• Herbarium specimens	Yes	-

17.	Department of Botany, Kumaun University, Nainital (UK)	Dataset on forests vegetation of Uttarakhand Plant information on DSB Campus Published information on Bryophytes of Kumaun Documents on threatened angiosperms, ferns, fern allies, Liverworts, mosses in selected areas of Kumaun	Location specific data on plants/ forests	Herbarium specimens	Yes	-
18.	ICIMOD, Nepal	Information on biodiversity in Kailash Sacred Landscape and Kanchenjunga landscape region	Data sets related to Field surveys, GBIF	Survey and GBIF data	Yes	Free on Regional Database System
19.	Planning Commission - Arunachal Pradesh	Data generated by Satellite Based Monitoring System backed up by ground truthing	NRSA (NESAC) and FSI datasets	GIS based data	Yes	-
20.	Planning Commission - Meghalaya Shillong	Crop data sets related to Agriculture and Horticulture	Location specific datasets related to Agricultural and Horticultural crops	Survey based	-	-
21.	North-Eastern Hill University, Shillong	Information of biodiversity in North Eastern Himalaya Conservation protocols for different threatened flora/ fauna	Published information on biodiversity	Published information and thesis	Yes	Not responded
22.	H.N.B. Garhwal University, Srinagar (UK)	Biodiversity related data on High Altitude regions of Uttarakhand	Published information on biodiversity	Published and thesis data	Yes	Not responded
23.	Birbal Sahni Institute of Palaeosciences	Plant fossil records	Published information on fossil records	Published data	Yes	Not responded

and has many data gaps (Box I). The lack of data/ information such as location details, habitat, ecology, population dynamics of biodiversity elements, seasonality and frequency of data collection, documentation of ethnobotanical knowledge[11], quantification of bioresources (availability and human use pattern), threat to biodiversity and drivers of change makes it difficult to prepare policy/ plans for biodiversity conservation and management for sustainable development. Further, there is no strategy for long-term data collection and data is collected for a certain activity/ project. In this situation data gaps are hardly addressed. Data bank, data management and data sharing are grossly neglected. This leads to overlaps in data collection and leave out data collection for wider interest. Further there is a need to compile data in a uniform format to make it user-friendly, and mechanisms for data sharing and quality control of data/ information. All these issues could be handled by establishing a centralized data repository for use in biodiversity conservation and sustainable development.

Recommendations:

- Considering the general lack of location-specific biodiversity datasets for IHR, there is a need to have in place a systematic and robust data/ information generation mechanism for collection, collation and integration, and use-friendly interface for access to data/ information. This calls for an integrated regional biodiversity information system housed at a nodal organization of MoEF&CC with distributive linkages for easy storage, retrieval and dissemination, and linkages with the national database.
- Biodiversity distribution data at spatial (grid) scales are prepared as input for integrative analysis along with related climate, topography, soil, and socio-economic data. This data if available on a lower resolution can be effectively used for decision making and policy making. Such data must use internationally accepted protocols and state-of-the-art methodology, with suitable adaptations to local conditions, for ensuring continued availability of compatible datasets over a longer time frame.
- In the IHR, location-specific developmental planning calls for easy access to baseline data in a user-friendly format. Further, biodiversity rich (having endemic elements) areas need to be mapped. Planning agencies need to be capacitated for optimal use of such data through the specialized nodal institutions.

BOX-I

Data Availability

- Checklist of Flora/ Fauna in selected states/ protected areas
- Forest types/ forest cover/ forest growing stock at State Level
- Fragmentary list of economic and threatened taxa (however new additions continue)
- List of flora and fauna present in Botanical Gardens/ Parks/ Zoos/ Herbaria/ Museums/ Arboreta, etc.
- Conservation protocols/ management approaches on selected high value species
- Project based dataset on species/ population dynamics for few selected locations
- Checklist of selected high-value species of conservation importance

[11] S.M. Khan, S.E. Page, H. Ahamad & D.M. Harper, 2013. Sustainable utilization and conservation of plant diversity in montane ecosystems: the western Himalayas as a case study. Annals of Botany 112 (3): 479-501.

- In view of the long-standing wisdom of regional inhabitants there is a need to pay special attention to documenting the traditional knowledge on best practices in biodiversity conservation and sustainable utilization both for in situ and ex situ conservation. There are ample avenues to harness the income generating potential of bioresources and value addition and secure the participation of local communities in biodiversity conservation. This would require that national policies have a mountain perspective so that decisions taken for the rest of the country do not adversely affect the mountain environment, its resources and people (Task Force Report of Planning Commission of India, 2010).
- The IHR offers a variety of bioresources for human use and allied activities. However, quantification of bioresources (such as NTFPs) is limited to a few species. There is a strong need to promote sustainable use concepts which establish linkages between conservation and economic use, and recognize that bioresources represent a renewable source for sustainable income. There is also a felt need for considering holistic or ecosystem based approaches to management. This implies that management of biodiversity components in any ecosystem would require integration of research outputs and human dimensions.
- There has been a global effort to attach monetary value to biodiversity, specifically to ecosystem services, and make provisions for transfer of payments (compensations) to the protectors or stewards. Often the spatial and temporal dynamics are overlooked in such ecosystem services valuation. There is an urgent need to understand the intensity and direction of on-going and potential impacts of change on the structure and functioning of biodiversity elements, including humans, in the IHR.
- The present investigation suggests that the response to our questionnaire was only indicative and does not provide the spectrum or range of answers to the set of questions. However, it is suggested that information on the following aspects/ gap areas needs to be generated by the relevant institutions (Table 17). These institutions are mandated for various aspects of data generation on biodiversity conservation and sustainable management (Table 18). All the above datasets/ information can be stored in a centralized system (under the MoEF&CC or its nodal organizations in the IHR) for data management, quality control and accessibility to end users.

Table 17: **Data gaps that need to be addressed by Government Institutions in the IHR.**

S. No.	Data to be generated	Proposed Institutions
1	Location specific (geo-coordinates) and community dataset of different taxa of flora and fauna (including threatened, endemic, medicinal and invasive species) and soil microfauna	BSI & ZSI, WII
2	Long-term changes in population status, adverse effect to other biota, rate of deforestation (including carbon sink)/ loss of plant and animal species	ICFRE,GBPNIHESD,FSI
3	Digitization of specimens/ live repository in Herbaria/ Parks/ Arboreta, etc.	BSI & ZSI
4	Information on causes of forest fire, fire prone area, loss due to fire, control and mitigation measures	State Forest Depts. NRSC
5	Areas and host specific quantitative information on pests, parasites, diseases with damage caused to biodiversity and control measures	ICAR ICFRE
6	Quantitative information/ data on available stock of bioresources in different ecosystems, NTFPs & use pattern of bio-resources and sustainable use practices	State Forest Depts. GBPNIHESD ICFRE NMPB, SMPB
7	Data/ information on man-animal conflict, geocoded information on wildlife migratory routes, corridor delineation for management and wildlife protection, and	WII ZSI
8	Data on phytochemistry, pharmaceutical value, indigenous knowledge system, economic benefits to people, and protocols (in situ and ex situ) for conservation	DST/ DBT, NMPB NBA/ SBBs

Table 18: **List of Govt. organizations mandated for data generation, research and conservation on various aspects of biodiversity in the IHR (Source: websites of each of the organizations)**

S. No.	Name of the Institution	Objectives/ Mandate	Datasets available	Datasets needs to be collected/ Specific action agenda
1.	Botanical Survey of India Kolkata, West Bengal	• Undertaking intensive floristic surveys and collecting accurate and detailed information on the occurrence, distribution, ecology and economic utility of plants in the country; • Collecting, identifying and distributing materials that may be of use to educational and research institutions; and • Acting as the custodian of authentic collections in well planned herbaria and documenting plant resources in the form of local, district, state and national flora	• Herbarium records of plants of IHR (digitalization is under progress) • Document on medicinal, economic, threatened and endemic plants	• Geo-coded datasets on plants • Population of endemic, threatened, economically important and medicinal plants • Datasets on lower group of plants • Plant based resources and use pattern • Habitat ecology and associated flora
2.	Zoological Survey of India, Kolkata, West Bengal	• Exploration, Survey, Inventorying and Monitoring of faunal diversity in various States, Ecosystems and Protected areas of India • Taxonomic studies of all faunal components collected. • Periodic review of the Status of Threatened and Endemic species and Preparation of Red Data Book, Fauna of India and Fauna of States. • Bioecological studies on selected important communities/ species. • Preparation of databases for the recorded species of the country. • Maintenance & Development of National Zoological Collections. • Training, Capacity Building and Human Resource Development. • Faunal identification, Advisory services and Library Services. • Publication of results including Fauna of India and Fauna of States.	• Information on faunal distribution • Museum specimens • Threatened and endemic fauna • Checklist of fauna found in selected states and PAs	• Geo-coded datasets on Faunal habitats • Population of native, endemic and threatened and other fauna • Migratory pattern and areas of migration • Habitat ecology

3.	Forest Survey of India, Dehradun, Uttarakhand	• To prepare State of Forest Report biennially, providing assessment of latest forest cover in the country and monitoring changes in these. • To conduct inventory in forest and non-forest areas and develop database on forest tree resources. • To prepare thematic maps on 1:50,000 scale, using aerial photographs. • To function as a nodal agency for collection, compilation, storage and dissemination of spatial database on forest resources • To conduct training of forestry personnel in application of technologies related to resources survey, remote sensing, GIS, etc. • To strengthen research & development infrastructure in FSI and to conduct research on applied forest survey techniques. • To support State/ UT Forest Departments (SFD) in forest resources survey, mapping and inventory. • To undertake forestry related special studies/ consultancies and custom made training courses for SFD's and other organisations on project basis.	Biennial forest report and changes details Information on forest and non-forest areas Thematic maps of 1:50,000 scale, using aerial photographs Spatial database on forest resources Training information/ details related to forest survey	Location specific datasets on forest resources in Indian Himalayan Region Ground based approaches on Forest resources documentation Population structure of major forest types and its changes in denoted time frame More precise thematic map (i.e. 1:10,000 scale). Precise/ accurate forest loss in region wise, i.e. forest fire. Extended distribution of invasive trees in forest and forest disturbance indices.

4.	National Biodiversity Authority, Chennai, Tamil Nadu	• Advise the Government of India on matters relating to conservation of biodiversity, sustainable use of its components and fair and equitable sharing of benefit arising out of utilization of biological resources. • Regulate activities and issue guidelines for access to biological resources and for fair and equitable benefit sharing in accordance with sections 3, 4 and 6 of the Biological Diversity Act, 2002. Certain individuals/ nationals/ organizations require prior approval of NBA for obtaining biological resources and/or associated knowledge for use. • Take necessary measures to oppose the grant of intellectual property rights in any country outside India on any biological resource obtained from India or knowledge associated with such biological resource derived from India illegally. • Advise the State Governments in the selection of areas of biodiversity importance to be notified as heritage sites and suggest measures for their management. • NBA and SBB provide guidance and technical support to Biodiversity Management Committees for documenting People's Biodiversity Registers. • Perform such other functions as may be necessary to carry out the provisions of BD Act.	• Information on Biodiversity Heritage site in selected States • Notified threatened plants and animals on different States • Document on People's Biodiversity Registers (PBRs). • Regulations for Bioresources for commercial utilization • Notification of Bioresources normally Traded as Commodities • Guidelines on access to Biological Resources and Associated Knowledge and Benefit sharing regulations	• Precise location and diversity specific details on 'Biodiversity Heritage Site' • Quantifiable information and location specific availability of biodiversity on threatened elements and cause of threat, etc. • Retrievable datasets on PBRs to common public • Pictorial guidance on normally traded commodities for common people • Quantifiable use of Bio-resources in different States

5.	G.B. Pant National Institute of Himalayan Environment and Sustainable Development, Almora, Uttarakhand	Undertake in-depth research and development studies on environmental problems of the Indian Himalayan Region (IHR). Identify and strengthen the local knowledge of the environment and contribute towards strengthening researches of regional relevance in the scientific Institutions, Universities/ NGOs and Voluntary agencies working in the Himalayan region, through interactive networking. Evolve and demonstrate suitable technological packages and delivery systems for sustainable development of the region in harmony with local perceptions	Location-specific information on plant/ animal diversity in selected areas of IHR Selected information on forest cover/ area under forest/ biomass, NTFPs Checklist of invasive plants in IHR Agri-diversity conservation practices in Uttarakhand Propagation protocols of important plants	Ecological datasets on important biodiversity elements Location specific datasets on forest biomass/ NTFPs and invasive biota Accessible biodiversity information/ protocols/ resources/ datasets on biodiversity of Indian Himalayan Region
6.	Indian Council of Forestry Research and Education (ICFRE), Dehradun, Uttarakhand (Forest Research Institute; Himalayan Forest Research Institute & Rain Forest Research Institute)	To undertake, aid, promote and coordinate forestry education, research and their applications. To develop and maintain a national library and information centre for forestry and allied sciences. To act as a clearing-house for research and general information related to forests and wildlife. To develop forestry extension programmes and propagate the same through mass media, Audio-visual aids and extension machinery. To provide consultancy services in the field of forestry research, education and allied sciences. To undertake other jobs considered necessary to attain these objectives.	Information on forest diversity of different forest types Information of forest records and maintaining museum, herbarium and life repository of valuable elements Datasets on forest resources in selected areas	Location specific datasets on forest resources (including NTFPs) in Indian Himalayan Region Datasets on best forest practices for conservation of forest resources Datasets on threat on forest resources (i.e. forest fire, pest/ disease information, etc.) Datasets on Long-Term monitoring in Permanent Forest Plots established earlier. Datasets on inventory of forest resources Information on identifying forest resources to common people

7.	Council of Scientific and Industrial Research, New Delhi (National Botanical Research Institute; Central Institute of Medicinal and Aromatic Plants; Central Drug Research Institute, etc.)	Providing platform for research and market interface Optimization of the resource base of the country and the industrial sector Developing required infrastructure Focus on technology of the future	Location specific data on Lichens, Bryophytes, Algae and Angiosperms of selected region. Herbarium and published datasets on plant distribution Propagation protocols for high value plants Biochemical composition of different plants Conservation of plants through Botanical Garden	Geo-coded datasets on plant diversity Openly available digitized datasets on herbarium/ botanical garden Commercialized/ tested/ adopted protocols for high value plants specific to hilly region Information on marketing linkages in hilly regions for high value products
8.	Indian Council of Agricultural Research, New Delhi	To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, animal science, fisheries, agro-forestry and allied sciences. To act as clearing house for research and general information relating to agriculture, animal husbandry, fishery, agroforestry, home science and allied sciences through its publications and information system and instituting and promoting transfer of technology programmes. To provide, undertake and promote consultancy services in the field of research, education, training and dissemination of information in agriculture, animal science, fisheries, agroforestry, home science and other allied sciences; To look the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing cooperative programmes with other organisations such as the Indian council of social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre, state Agricultural Universities etc.; To do other things considered necessary to attain the objectives of the society.	Agri-biodiversity of different states of IHR	Datasets/ information on location/ environment specific quantitative agro-diversity in IHR

9.	Wildlife Institute of India, Dehradun, Uttarakhand	Build up scientific knowledge on wildlife resources. Train personnel at various levels for conservation and management of wildlife. Carry out research relevant to management including the development of techniques appropriate to Indian conditions. Provide information and advice on specific wildlife management problems. Collaborate with international organizations on wildlife research, management and training. Develop as a regional centre of international importance on wildlife and natural resource conservation.	Location specific data on wildlife on selected taxa	Quantitative datasets on wildlife resources on IHR
10.	National Remote Sensing Centre, Hyderabad, Telangana	NRSC provides data for natural resource management, geospatial applications and information services. NRSC facilitates several remote sensing & GIS application projects for natural resources and environmental management catering to food security, water security, energy security and sustainable development. NRSC is also providing single window, disaster management support services through the Decision Support Centre. Recently NRSC has started to give its services on Land use Land cover of India under an Information portal called 'Bhoosampada'	Datasets on Land use/ Land cover, vegetation type, Forest type, etc.	Location specific biodiversity maps on IHR

Chapter 2D
Socio-Ecological Sector

Introduction

The Himalaya is important for a wide range of ecosystem services it provides to its inhabitant population and areas outside its geographical extent. Himalayan ecosystems are also the most fragile areas both ecologically and geologically. The IHR is also relatively under/ less developed as compared to rest of the country. It is characterized by hill specificities and has several development needs. Developmental activities in fragile Himalayan ecosystems come with huge environmental costs, which also have adverse impacts on the ecology of the area and the quality and quantum of its ecosystem services flows for the plains of North India. Therefore, development in the area needs to be suited to its ecological capabilities with due consideration for environmental sensitivities and conservation. Hence, developmental decision making needs a holistic visualization of environmental impacts, conservation threats and priorities, and a balancing of conservation and development, for which comprehensive and accurate long-term time series data-sets across the IHR on various conservation and development issues is required. The IHR is a data deficient region, and the available information and data is scattered and not customized/ amenable to help decision making. This data deficiency is also considered as a major hurdle in use of the outcomes of scientific research for policy formulation, development planning and decision making.

Socio-Ecological dimensions/ issues

The socio-ecological dimensions of the 'conservation and development issues' relate to the issues that pertain to the social or/ and ecological impacts of 'conservation and development' projects/ activities and considerably matter in decision making process for the approval and viability assessment of such activities/ projects. Alternatively, they also cover the social/ ecological issues that have a bearing on conservation and development in the region. There are several socio-ecological issues/ themes that need consideration, some of them are covered under the sections on climate change, disaster and biodiversity. Those identified/ prioritized under the socio-ecological section are -

- Development of Hydropower
- Sustainable Rural Development (Components - agricultural development, outmigration, and female drudgery)
- Indigenous traditional knowledge

Perspectives on Socio-ecological Issues for Informed Decision Making:

The major themes identified in the context of possible decision choices, related data requirements/ availability and gaps for desired action points, are discussed below. The suggestions regarding collaborations for data development, sharing mechanisms, policy and formats are presented separately with each theme.

1. Development of Hydropower

The IHR has tremendous potential and scope for hydropower development and such projects, if optimally planned and harnessed, can provide a big boost to the growth of industries, agriculture, urbanization, rural development, and general well-being of the people of the region. It can also generate revenue for IHR states through sale of hydropower to other states of the country. But, development of hydropower in the region, especially large hydro-electric projects have also evoked controversies due to environmental fragility of the region, estimated benefits and life-span of the dam due to underestimation of sedimentation, displacement or relocation of people, and compensation issues. As the issue is crucial for the development of the region, as well as for agriculture and industrial growth of Indo-Gangetic plains, and supply of water for irrigation and drinking use to water scarce areas/ states of the country, it needs a thorough analyses of available decision choices in the wider context of the social welfare and economic well-being of the people. In view of climate change/ extreme events, the role of hydropower projects, i.e. the dam design and size, as a means of flood control has also become important.

The various decision aspects that need consideration for hydropower development are: (i) purpose of hydropower project options (electricity production or multipurpose), type of project (large/ small/ run-of-the river), site suitability, optimal number of projects in a basin (basin carrying capacity), post-project scenarios, upstream-downstream impacts, displacement issues and resettlement history (learning from previous experiences), vulnerability to disasters/ extreme events, and economic and ecological viability. The data/ information requirements and availability with respect to various decision situations is compiled in Table 1. The information regarding river/ river basin-wise optimal number of potential hydropower projects, their SEA/ EIA related appraisal information, the biodiversity/ natural resource inventory of the potential sites, their basin/ sub-basin-wise geological information, river flow and siltation information are major data gap areas, where data/ information needs to be generated.

Suggestions to address data gaps, Inter-institutional collaborations, data generation, formats

- The conventional decision making on hydropower development is usually based on the EIA exercise which involve interdisciplinary investigations into various types of socio-economic, socio-cultural, and environmental impacts of hydropower projects. Depending upon the type and the purpose of the hydro-project, these exercises also include the accounting of hydropower power benefits in terms of irrigation potential, electricity generation, and others such as fisheries, tourism, and flood control. Such exercises are need specific and after the formal planning for development of hydropower in an area, carried out for seeking environmental clearance only with proper appraisal outputs. Data/ information for such projects, in general, is rarely pre-existing/ ready-made with research carried out at university/ institutional level R&D, and developed afresh for each project. Therefore, there is a need to promote such information/ data development through university and institute level studies/ research and research collaborations.
- As such information and data development includes interdisciplinarity, and needs a multidisciplinary team of researchers for better understanding of issues, impacts, and merging of implications of extreme events/ disaster scenarios for decision inputs, there is a need to encourage a team-based developmental research in the area involving institutional collaborations, and a team based research culture. Also, the outputs of such endeavours should also be considered for the award of Ph. D. degrees to the team members by the

university/ universities. However, a cut-off for the size of such team, as appropriate can be decided, and contributions of researchers individually or as a team can be evaluated.

- Promoting such research with inter-institutional and inter-departmental (intra-institutional) collaboration will help in generating a large database for a large number of sites across various Himalayan rivers, and expedite the process of information/ data development for developmental decision making; it will also create a better base for the science-policy and practice connect, and provide first-hand experience to researchers for participation in developmental planning processes of the region.
- The expertise available with the pioneer research institutions such as WIHG, GBPNIHESD, WII, FSI, FRI, BSI/ZSI, NEERI, TERI, NHPC, IIRS, NRSC, NIH, premier institutions/ universities of Himalayan states and subjects experts in the field can be used for better guidance of researchers and quality of research outputs for use in decision making.
- It is evident from Table 19 that most of the data related to hydropower development, whether geomorphic/ geological information of dam sites, appraisal statements for dam types, biodiversity of the hydropower affected sites, or river flow/ siltation information, are project specific, and related to EIA exercises of proposed/ implemented project sites only. There is a need to develop such information on river basin/ sub-basin levels through well planned regional level research policy targeted to generate component wise information/ data on the subject.
- The construction of most of the hydropower projects in the area has faced stiff opposition from the public/ environmental activists on grounds of environmental fragility of the area, the threats/ risks of dam breach, the seismicity of the area, the loss of culture, and the poor resettlement history of dam displaced people. These issues provide a cue for future decisions, and their documentation therefore is important.
- In the face of climate change, increased extreme events, and other disaster risks in IHR, hydropower projects have become more vulnerable to threats of dam breach and therefore future developments of hydropower should also incorporate disaster/ extreme event risks in hydro-power project planning and appraisals. This is a big data gap and includes visualization of threat/ risk scenarios; it will also help in identification of communities/ areas vulnerable to such risks, and provide leads for consideration of better designs/ dam choices for disaster safe hydropower project developments. Therefore, accounting for extreme events and disaster concerns i.e. risks, sensitivity, and vulnerability, should be an integral component of the standard EIA/ SEA/ CBA formats/ exercises.
- The data available with recognized data agencies on demography, land-use, agricultural production, house/dwelling type etc., can be useful for generating/ deriving baseline information for hydropower appraisal studies; yet a lot of information relating to EIA/ SEA/ CBA of the project, biodiversity, geomorphic structure of dam sites, river flow/ siltation, disaster susceptibility of projects, dam breach/ area of submergence simulations, upstream and downstream impacts, and political ecology issues needs to be generated for decision making use. The generation of this information for prioritized sites can be entrusted to different agencies/ departments. The Ministry of Water Resources should ideally be a nodal agency for hydropower development works, and prioritize the potential hydropower sites across IHR; the geological data of those sites should be the responsibility of GSI/ WIHG; data on biodiversity - BSI, ZSI supplemented by GBPNIHESD and WII; river flow/ siltation – CWC; disaster/ climate vulnerability/ risks accounting - NIDM/ ICIMOD/ State Disaster Management Agencies; and the learnings/ post-project EIAs/ upstream-downstream impacts can be entrusted to GBPNIHESD.

Table 19: **Arrangements for Addressing Data Gaps/Generation for Hydropower Development (Nodal Agency - Ministry of Water Resources, GoI)**

Data Type/ Component	Agencies responsible for data generation	Data supplementing Agencies
EIA/ SEA/ SIA/ CBA	NEERI	WIGH, CWC, ICAR, GBPNIHESD, WII, NIDM, State Disaster Management Directorate/Cell
Project Site Geology	WIHG, GSI	University research, MOES, DST
Biodiversity	BSI, ZSI	GBPNIHESD, WII, State Forest Departments, DST, NMHS
River Flow/ Siltation	CWC	NIH, NMHS Studies
Dam Breach/ Disaster/ Climate risk simulation	IIT Roorkee, IIT Guwahati, NIDM, State Disaster Management Cells	GBPNIHESD, University research/ Aid Agencies
Learnings, Post Project Periodic EIAs	GBPNIHESD, WII, IISSR	NMHS Studies

Table 20 : **Hydropower Development (Data/ Information Requirements, Availability & Gaps)**

Information Requirements	Data Requirements	Scale (Spatial/ Time) of Req. Data	Data Availability/ scale	Gaps	Data with Institutes
- EIA/ CBA/SIA etc. Appraisal statements for large/small, & run-off the river projects for various places & sites	• Consolidated appraisal statements/ Reports • Biodiversity/ Forests (population, density, endemism, Index, RET details)	• Micro/ medium/ large etc. projects for all potential sites • Grid based, basin/sub-basin & Season wise	• Limited, specific to commissioned/ proposed projects [A] • Limited context B site specific	• Systematic data for all rivers/ point locations • Needs to be generated	Not Reported • Study specific (Not relevant to context) – do –
- Submerged area/ Economic losses/ Displacement/ Impacts	• Demographic structure • Geomorphic structure of the dam area/ probable sites • River Flow • Siltation	• Village wise for project affected area/10 yr • Land use (village/ decadal) • Basin/ sub-basin level, & near confluence points of tributaries	• Village level/ 10 yr • Land-use (village)/5 yr • Not known, Sparse • (Limited [B])	- No Gap - • - Geological data/ Info.	– do – Not reported
- Displacement/ Resettlement/ compensation	• Area of submergence/ simulations(habitation, forests, other resources), HH/ villages affected/ Agriculture land	• Land-use (village/5 yr) • Demography/dwellings (village/10 yr), Agriculture (village/ 5-10 yearly)	• available/ can be derived - • available - • Needs to be developed - Vulnerability(few cases)	- Data Gap - - No Gap -	- do -
- Disaster/ Climate Risks Accounting	• Disaster History • Social vulnerability • Physical vulnerability • Risks accounting/ simulations	• for available years • Influence/ affected zone/ 5-10 yearly	• Agriculture/5 yearly • Fish (No data) • Published reports (Movement Issues) • Post EIA - No data	I • Data Gap I	Not Reported
- Learnings (political ecology, movements, long term monitoring)	• Issues of dam movements • Upstream/downstream impacts • Project performance (Periodic post EIAs)	• Agri production/ fish-catch • Specific to installed/ ongoing projects - 5 yearly EIAs)		• Fish (Data Gap) - Data Gap -	Not reported Not Reported

*A - Data availability restricted to commissioned/ proposed projects

*B - May be limited to proposed/ commissioned project sites

2. Sustainable Rural Development

The rural areas of IHR are economically backward pockets, where poverty is pervasive. These areas typically represent the peculiarities of mountain specificities. The areas are characterized by poor agricultural productivity and agriculture is a non-remunerative enterprise. The topography is the main constraint in the development of agriculture in the region, and water a limiting factor. Nearly 85% of the agriculture is rain-fed, and only 15% of the agricultural land is irrigated. Erosion, poor soil quality, and low cropping intensity, fragmented and small land-holdings are some other important factors responsible for poor agricultural returns. The poor productivity of agriculture is a major cause for outmigration of the male work-force for jobs in adjoining urban centres, and to areas outside the IHR. The poor social and basic infrastructure, medical, and educational facilities are other factors forcing outmigration from the rural areas. The spread of education and easy availability of jobs during colonial times, in initial stages, helped build sentiments and mindsets for jobs; later search for jobs became a coveted preference of the educated, and a tradition for the people in the region. Such developments restricted and adversely affected the growth of agriculture, and the workload of subsistence through agriculture became mainly the responsibility of the womenfolk. The reduced male participation in agriculture also limited the adoption of new technologies, and innovations; the over-engagement of women in agricultural work in addition to their daily chores and other social commitments further compounded the quality of agriculture/ output, and adversely affected the educational progress of women, and the evolution/ development of progressive farmers/ farming in the region. The agriculture sector forms the backbone of rural development and, therefore, bringing about rural development needs reforms in the agriculture sector, which requires considerations for type/ quality of land, the capacity of agricultural workforce, and the possibilities for technological applications. The agriculture in IHR is constrained by problems of topography, outmigration of male workforce, and female drudgery; therefore development decision making to reform agriculture or foster rural development needs to consider these aspects. Off late, damage to crops by climate change, and depredation by wild animals, particularly, monkeys and wild pigs has increased considerably, which is also making practicing agriculture in the area difficult, and leading to abandonment of agriculture, further exacerbating outmigration from the area. The depopulation, is also resulting in weakening of institutional structures responsible for conservation of resources and execution of participatory measures/ mechanisms that existed in past to protect their resources/ crops from such menace. The decision making also needs to look into appropriate policy choices to tackle such problems. The key issues of agriculture, reasons/ impacts of outmigration, the plight of rural women, and information on requirements of data sets for decision choices, available data sets, and gaps are compiled in Table 20. The data gaps and response of institute contacted are also shown in the relevant columns.

Suggestions to address data gaps, Inter-institutional collaborations, formats

Some issues pertinent to rural development, related data sets, and gaps with suggestions are presented below.

2a. Agricultural Development & Sustainability

- In hill agriculture the crop choices , crop-combination and timings vary with altitude and aspect; therefore in cropping decisions the altitude factor is very important, and for micro level decisions information at village level it is a must. The crop production/ productivity data at village/ block levels is a data gap, and compilation of such data at village/ block/ and altitudinal zone-wise on 5 yearly/ 10 yearly basis is required.
- The livestock and forests are important components of hill agriculture in IHR but livestock data at village level is presently not available with data agencies; compilation of such data at village/ block level on 5 year basis is required.
- The forests in vicinity/ above the villages are important source of nutrients for the agricultural fields and forest to agricultural land ratio can be an important indicator of agriculture status. Such data at village/ altitudinal zone/ sub-watershed basis could be an important input for decision making. The region lacks such data, and there is a need to derive/ generate such information from the existing data.
- The irrigation status data including source/ type of irrigation, and area under irrigation, are important information inputs and such data at village level is available on 5 yearly basis. In view of climate change, compilation of such data/ information also on watershed, and altitudinal zone basis would be more optimal.
- The choice of available technological options crop-wise on 5 yearly basis, and innovations and rate of adaptation to technologies, is an important statistic that can be a good indicator of agricultural progress. This is a data gap area, and there is a need for compilation of such information at village and zone level. Similarly, information on availability of seed and planting material at zone level is a gap area, and requires compilation.
- Information on requirements/ availability of market chains for agricultural produce/ value added products of an area/ cluster of villages, crop damage by wild-life and climate change impacts at village and zone level, and status of traditional crops i.e. type, production, lost biodiversity etc. at village/ zone level is a gap area/ missing link, and such information needs to be generated.
- The data gaps of the agricultural sector can be managed by incorporating such information as a part of data collected thru the routine survey conducted by the Directorate of Agricultural Statistics, which can also be supplemented/ further strengthened through R&D of agriculture research departments/ agriculture universities/ other universities and organizations working in related fields. Some directives for generation of such information through DST/ DBT/ ICAR/ NMHS/ IERP funded research can also be issued. Similarly, for climate data the information from IMD, state meteorological departments, and information from ICAR institutes, and other departments generating metrological data can be pooled; generation of such information from schools/ colleges at villages, and at farmer level in prescribed formats can also be encouraged.
- Most of the data relating to decision making for agriculture development and sustainability is either available or can be derived from the available data or by segregation of village level data that is used for compilation of data at district level. The synthesis/ compilation of livestock data (5 yr basis), and irrigation (source/ area - 5 yr basis), at village level or recognized zone-wise, can be entrusted to Directorate of Agricultural Statistics and Directorate of Economics and statistics of State Planning

Division (state governments) of the states. The data relating to technology choices/ applications, soil quality, planting material village-cluster/ zone-wise which is presently non-existent with recognized data agencies can again be entrusted to Directorate of Agricultural Statistics, while the efficacy of alternative agriculture options, community based market chain potential assessment and agriculture performance simulations under climate scenarios for technology/ policy intervention at village-cluster/ zone basis should be taken up by the Ministry of Agriculture, GoI/ ICAR and state agriculture department and through the process of sponsored research funded by the government/ development agencies. Human-wildlife conflict is a core research area of WII.

- The responses of Himalayan states to sector specific queries reveal establishment of - 'Effective system of land-use planning' and framing of effective policy to support 'Niche based high value farming and incoming generating options for hill farming communities' and 'Animal husbandry development in hill areas' (See Annexure - Meghalaya State Response). Also capacity building for data compilation and management of concerned department personnel was also suggested. (Annexure VIII - Himachal Pradesh).

2b. Outmigration & Depopulation of Villages -

The outmigration of villages of IHR is very intricately linked to the poor agricultural output/ performance in the region. In addition the poor social infrastructure, transport facilities, limited job/ livelihood options in villages, and need for cash incomes are some other reasons behind this. The outmigration results in loss of affiliation to native environment and resources, and also creates apathy and inferiority in the minds of those left out in the villages. This impact is weakening traditional institutions devoted for conservation and management, resulting in resource degradation and social and environmental impoverishment. Any strategy/ model to curb outmigration needs information about reasons, impacts, alternative livelihoods, and scope of supplemental income/ job opportunities in the area. The major observations on data requirements and gaps are:

- The recognized data agencies do not collect data on causes of outmigration and therefore there is a need to generate such data. Generation of this data can be achieved through research carried out by universities, developmental research organizations, social science/ agricultural research institutes, and through sponsored research for enterprise development, or by incorporating these aspects in the survey schedules of the data agencies.
- Similarly information on other data gap areas i.e. livelihood development scoping, SWOT analyses, enterprise development appraisal which are not covered in conventional data collection systems, should be generated through research programmes/ sponsored research by college, university, R&D institutes, state/national/ international level funding agencies. There is a need to identify/ prioritize the areas and allocate the work components to these organization in accordance to their core expertise.
- The data on reasons for outmigration can be entrusted to NSSO or Directorate of Economics and Statistics of State Planning Division; however the information on livelihood and enterprise scoping for assessment of alternative livelihood options village cluster/ zone basis at 5 yr cycle, needs exploratory work and should be covered through sponsored research. Such tasks can also be shared by ICAR, the state agriculture department, ICSSR, and GBPNIHESD.

2c. Status of Women (Minimizing Female Drudgery)

The drudgery of women in IHR is an outcome of non-remunerative agriculture, and male outmigration; it is also an indicator of rural poverty and economic backwardness. Drudgery is evident in terms of excessive workload, and time and efforts invested in collecting and carrying heavy head-loads/ back-loads of fuelwood and fodder from distant forests. Besides, they also perform their routine family duties, and also contribute to household agricultural activities from early childhood. The drudgery of women is a typical problem of IHR and has nutritional and health implications for the women folk, and inflicts huge costs in terms of missed out/ lost opportunities. The data set required for drudgery reduction is compiled in Table 21, and the recommendations on data requirement, availability, and gaps are -

- The data on female literacy, occupation, rural electrification status, LPG connections at village level is available in census and state level survey reports; however, data on women health, nutritional status, time spent on household chores, distance travelled for collection of water/ fuelwood/ fodder, and related opportunity costs is not available with data agencies. Such information is limited to some case studies from a few areas only. Therefore, this is a data gap and data on such parameters may be collected through collaborative efforts through allocation of areas to different institutions/ organizations in a planned manner. The help of premier institutions like IIFM, IEG and IIRD can be sought in this respect.
- Similarly data on appraisal of drudgery reduction measures is not collected by data agencies, and such information from very limited contexts and confined to few case studies in report/ published form may be available in public domain. But this is a big data gap for decision making, and there is need to sponsor research to generate such data sets for various alternative options on 5-10 yearly planning horizon basis.
- The generation of data on women health, nutritional status, and time spent on different chores, can be entrusted to State Department of Health Statistics, or NSSO which can be compiled by Directorate of Economics and Statistics of State Planning Division. The opportunity cost estimation, and generation of information on appraisal of drudgery reduction measures needs analysis and can be generated through study of representative villages from all the Himalayan states. As indicated above the work can be assigned to IIFM, IIRM, IEG and State Forest Departments. The information from sampled representative villages can also be developed through sponsored research funded by DST, NMHS, IERP and others. ICIMOD experience and programmes can be used for this work.

Table 21: **Arrangements for Addressing Data Gaps/ Data Development for Rural Development**

Decision Subject	Data type	Primary Agency	Supporting Agencies
Agriculture Development	Crop production/ Irrigation/ Livestock/ Forest to Agriculture Land ratio - village/ Block level - 5 yr	Directorate of Economics and statistics of State Planning Division (state govt.)	Directorate of Agricultural Statistics (State Govt.); NSSO; Economic Statistical Division of ministries of Rural Development of the states; NRSC
	Seed/ Planting Material, Technological Options & Efficacy, Market Chain Scoping, Status of Traditional Crops	Economic-Statistical Division of ministries of Rural Development	ICAR, State Agriculture Departments/ Directorate of Agricultural Statistics, Economic-Statistical Division of ministries of Rural Development of states, State councils of science & Technology,
	Agricultural Performance under Climate Scenarios/ Village/ Alt. Zone - 5-10 yr	Economic-Statistical Division of ministries of Rural Development	ICAR, State Agriculture Departments/ Directorate of Agricultural Statistics, Economic-Statistical Division of ministries of Rural Development of states, State Councils of Science & Technology
	Human Wildlife conflict	MoEF&CC	State Forest Department, WII, ICAR
Outmigration	Reasons for outmigration	Directorate of Economics and statistics of State Planning Division (state govt.)	NSSO, ICAR, State Councils of Science & Technology GBPNIHESD, ICIMOD
	Alternative Livelihood scoping, Enterprise Development Potential Scoping, Agri Reform Appraisals	Ministry of Agriculture GoI	ICAR, State's Directorate/ Department of Agriculture, sponsored research ICAR, DST, ICIMOD, GBPNIHESD (NMHS)
Status of Rural Women/ Female Drudgery	Women Health, Nutritional Status,	Directorate of Medical Health of States	State Departments of Health Statistics, Sponsored research by funding agencies - ICIMOD
	Time Spent in Daily Chores, & Fuel-Fodder etc. collection	Directorate of Economics and statistics of State Planning Division (state govt.)	NSSO
	Opportunity cost of Drudgery, Appraisal of Drudgery reduction measures	State Forest Departments	Sponsored research - IIFM, IEG, CSSR, ICAR, GBPNIHESD, Ministry of New and Renewable Energy Resources, State Renewable Energy Development Agencies/ Departments

Table 22: **Strategy for Sustainable Rural Development (Issues/ Data/ Information Requirements, Availability & Gaps)**

Issues/ Information Requirements	Data Requirements	Scale (Spatial/ Time) of Req. Data	Data Availability/ scale	Gaps	Data with Institutes
2a. Agriculture Development & Sustainability (Non-remunerative agriculture/ poor Agricultural returns) • Crop productivity under different farming practices • Irrigation & nutrient, energy environment • Seeds/ Planting material (Traditional/ out-sources), disease • Technology choices/ applications • Efficacy of Alternative agriculture/ technology options • Climate scenarios	• Crop production/ productivity under different farming practices • Per HH Landholding and livestock holdings • Soil Quality • Irrigation Status (Irrigated/ un-irrigated agri area ratio) • Agricultural workforce/ labour • Vicinity forest type (uphill)/ Forest to Agri land ratio • Technological options zonewise • Wildlife conflicts (Crop damage, invasion statistics) • Seed/ planting material availability • Market chain options/ Linkages • Status of traditional crops Type/ production • Climate conditions(Precipitation, Temp, Humidity	• village level/ block level/ District; 5yr/10yrs • Village level/ 5 yr • Village/ 5 yr • Village basis/ 5 yr • Village/ zone/ 10 yr • Village/ Zone/ Sub-watershed; 5-10 yrs • Village & crop wise/ 5 yrs • Alt Zone-wise/ 5 yr • Zone-wise/ 5 or 10 yr • • Village/ Village cluster/ 5yrs • Village/ Village cluster/ 5yrs • Zone wise/ village • Village/ sub-watershed/ Alt. Zone; yearly	• District/ block/ village 5 yr • L. StockDist/ 5yr No data (village level) • Village/ 5yr • Village/ decadal • Village/ 10 yr • Not available • No data/ case specific • Case study based • No data • No data • No data • No data • Very sparse	Village/ block level compilations | Data Gap | Data Gap | | Data Gap | Data Gap -	Case study based/few areas Not reported

2b.Out-migration/ depopulation of villages • Time series data on outmigration • Growth data on social infrastructure • Livelihood opportunities • SWOT & livelihood/ enterprise scoping	• Population statistics over a time scale • Reasons for outmigration • Infrastructural facilities • Transport & communication • Health facilities/ PHCs • PDS • Schools/ Colleges/ Education Electrification Alternative Livelihood/ Income Options • On farm • Off Farm • Industrial • Eco-tourism • SWOT/ Livelihood/ enterprise developmental scope, Agri. reform appraisals	• Village level/ 5 yr or 10yr • Village/ sub-watershed • Village level/ Alt zone/ 5 or 10 yrs • village level/ 10yrs • Village/Village cluster/ 5 yr • Village/ cluster/ eco-cultural zone/ sub-watershed/ 5-10 yr	• -Village/ 10 yr • Likely (Few cases; report form) • Village (available-10yr) • No Data • No Data	Available Data gap Available Data Gap Data Gap	Case study based (Not reported; * may be in report form) Not Reported
2c. Status of Rural Women &minimizing drudgery of female workforce	• -Female Literacy/ Levels • Woman health • Nutritional status • Time spent in Daily chores • Distances travelled for collection of fuelwood/ fodder etc. (Opportunity costs/ impacts) • No. of LPG Connections • Electrification status • Appraisals of drudgery reduction choices/ measures	• Village/ • Village/ Village cluster/ distance remoteness basis/ 5 -10 yearly • Village/ Village cluster/ 5-10 yr • Data/ info need	• Village/ yearly • -Case study based only few cases (Po) • Data/ Info 5yr basis required • Village/ cluster/10 yr • Mid term Planning basis/ 510yr	Data Gap Data Gap Data Gap	Not Reported Not Reported

3 Traditional Indigenous Knowledge:

The IHR is a land of diversity of landscape, culture, and environment; besides, the region also exhibits high degree of climatic variability. With the passage of time, the Himalayan communities living in different environmental conditions, based on their experiences and locally available resources, developed several sets of adaptations for their survival and subsistence. This knowledge in due course of time became refined and persisted through a system of traditions. The high spatial and climatic variability in Himalaya, helped in evolution of a large body of such knowledge. Under the climate change scenario, such knowledge has gained importance, where changing climatic conditions and niche regimes, enhanced the scope of replication and relevance of traditional/ indigenous knowledge of one area/ region in other areas/ regions. Such knowledge relating to various fields such as traditional healthcare, preservation and storage of agricultural produce, water resource conservation, plant breeding, though very useful, has mostly remained undocumented, and is eroding or losing ground under the influence of modernization, globalization, and lack of patronage. The documentation and revival of such knowledge systems is not only important from a cultural perspective but could also holds answers to many modern day problems. This knowledge also needs to be validated for its efficacy and scientific content.

Suggestions to address data gaps, Inter-institutional collaborations, formats

The data requirements, availability, and gap status based on information received is compiled in Table 22. The main suggestions are as under -

- There is need for category based inventorization and documentation of the existing TIK, identification of such knowledge systems on periodic basis and region-wise status documentation on 5-10 year cycle basis for different village/ village clusters/ and eco-cultural zones. This will also help in capturing efficacy and importance of such knowledge systems, and their use in the face of new knowledge and changing cultural regimes.
- Some case study based information on different knowledge systems in published form is available, and some information in digital database form has been attempted/ exists. However, we still do not have a well-organized documentation of TIK, and there are huge data gaps.
- Procedures for registration of IPRs/ patent filing should be simplified and the safeguarding of rights and benefits of the practicing/ custodian community be strictly ensured.
- The DST can be nodal agency for TIK database, the related agencies of different TIK fields i.e. documentation/ database development of Health Care based knowledge systems can be entrusted to Directorate of Unani, Ayurveda & Siddha; natural resource conservation and management to ICAR/ GBPNIHESD/ WII/ state ministries of rural development, the state forest department and the agencies of ministry of tribal affairs/ development. As this is huge field a lot of such knowledge can be developed through sponsored research. The DST and centres identified at state level should provide a portal for registration/ documentation of such knowledge, wherein the knowledge base generated through various research agencies can be recorded and displayed. The knowledge documented by the various research agencies should be linked to the DST webpage dedicated for this purpose.

Data Availability with Recognized Data Agencies and Data Response of Contacted Institutes/ Organizations

The availability of data with various recognized data agencies and data availability with responding institutions is compiled in Table 23 & Table 24, respectively. The recognized data agencies of the government such as Office of Registrar General and Census Commissioner of India, Directorate of Agriculture (Ministry of Agriculture GoI), Directorate of Agriculture Statistics of States, Directorate of Economics and Statistics of State Planning Division, Economic Statistical Division of state ministries of Rural Development have lots of data, which is available in digital and published report form at various levels i.e. village, block, district, state levels. This is very exhaustive data set and widely used in social science research. The website www.indiastat.com contains a very exhaustive compilation of such data sets. This data is always a very useful input for sector-wise general review of change.

Very few institutions responded to data availability requests; only 6 out of 94 institutions submitted their response to the questionnaire. The information available with them is very limited and scattered, mostly case study based, and does not cover the IHR states/ state fully or in stratified manner (in the forms of sample sets) that can be used for comparisons. Almost all institutes have reservations to data sharing and only the information in published form is shared. Therefore, there is need to evolve some credit system for protection of the intellectual efforts/ property of the institutes, to incentivize/ encourage data sharing. A policy for data disclosure, and a time limit for retaining unpublished data/ information can be decided.

Table 23: **Traditional/ Indigenous Knowledge (Data/ Information Requirements, Availability & Gaps)**

Issues/ Information Requirements	Data Requirements	Scale (Spatial/ Time) of Req. Data	Data Availability/ scale	Gaps	Data with Institutes
3. Traditional/ Indigenous Knowledge • Field of knowledge/ documentation • Validation for Efficacy • Utility in local/ state/ regional context • IPR accreditation • Accession to database/ digital database • Marketing	• Knowledge type database • Health Care knowledgebase • Natural resource conservation, use & management knowledge. base • Preservation/ storage of produce knowledge • Water resource conservation • Animal husbandry/ Plant variety, breeding • Traditional means of livelihood	• Village/ eco-cultural zone/ tribe/ community/ region wise/ 5 10 yearly	• Case study based in published form/ few cases might be existing, • Some documentation digital database	• No organized documentation/ data gap area	• Traditional means of • Livelihood, Livestock husbandry, and pastoralism for few cases reported

Table 24: **Data Available with Recognized Data Agencies**

S.No.	Data Agencies	Broad Data Type	Scale	Data Periods/ Frequency	Availability/ Sharing Mechanisms
1	Office of Registrar General and Census Commissioner	Demography	Village, Nyaya Panchayat, Block, Tehsil, Urban Area, District, State	Decadal	Published Reports, Soft Copies/ digital
2	Directorate of Agriculture/ Ministry of Agriculture GoI Directorate of Agri Statistics of States	Agriculture Statistics (Agr. area, area under crops, production, land-holding !, use of fertilizers, irrigation status, Means of irrigation, Livestock Population & Composition)	District level	5 yearly	Reports
3	Directorate of Agri Statistics of States/ Office of Registrar General and Census Commissioner	land-use (Reported Area)	Village level	5 yearly	Computerized Land records/ payment basis/ published reports, soft copy
4	Directorate of Economics and Statistics, State Planning Division/ Economic -statistical Division of state ministries of Rural Development	District Statistical Handbook	Block, Tehsil, District, Urban	Decadal	Published Reports
5	State Planning Commission (Economic Survey Reports - State)	State's Statistical Profile Demography- Population; Sex ratio Birth/Death rate • Literacy etc; Town/ villages Nos., • Economic Classification • Recorded Forest Area (state) • Sector-wise Plan Outlay	rural/urban/district, - state, district/ State Rural/Urban District/ State - State Level/ District	Yearly Financial Year-wise	Published Reports

	• Beneficiaries of various schemes (SGSY)/Rural Housing/ Financial Performance- Indicators of State economy • Food Security, Agri development (distict) • Health care/ human services, family welfare • Horticulture & cash Crop development, • HRD/ Industries/ Irrigation • State Economic Survey (Misc. Info - Agriculture/horticulture, Infrastructure, Industry/ trade/ commerce, environment etc)				
6	Directorate of Economics and Statistics, State Planning Division	Socio-economic Survey	Miscellaneous data, Block/District	5 yearly	Soft copy
7	NIC	Miscellaneous data	Village/block/ district/ state	Data-based	Soft copy
8	www.indiastat.com	Socio-economic & statistical Info	statewise	Not regular, on specified year basis	
9	Ministry of Statistics & Program Implementation	Statistical Year Book/ Abstracts (Miscellaneous - population, sectorwise data	Country/ statewise	Time series for the decade	Reports
10	Office of Registrar General & Census Commissioner, India	Census Data			Website

Table 25: **Data Response of Institutions contacted (Socio-ecological)**

S.No.	Data Agencies	Broad Data Type	Scale	Data Periods/ Time Frequency	Availability/ Sharing Mechanisms	Quality check/ Remarks
1	GBPNIHESD, NE Unit, Arunachal Pradesh	• Demography, • Means of Livelihood • Livestock • Traditional Knowledge	Village	2009-13 - 2004-05, 2016 yr survey	Digital	Yes Primary data, TK type/ spatial coverage/ numbers/ community not specified
2	IIT Mandi	• Demography, • Means of Livelihood • Livestock • -Infrastructural Facilities • Educational • Economic Background	District (Sample data of Mandi district)	Aug 2015 - Sept 2016	Digital/ Hard Copy	Yes/ Sample data of Mandi district
3	CSIR-IHBT, Palampur, Himachal Pradesh	• Demography, • Means of Livelihood • Livestock • Health • Infrastructural Facilities • -Landholding Size • Traditional Knowledge	Village Level (Bhawana Block, Kangra District)	2013 - 15	Digital/ Hard Copy	Yes (Bhawana Block of Kangra District only) - TK type not specified (Bhawana Block)
4	HFRI, Shimla, Himachal Pradesh (J&K Data, NRAA Project)	Means of Livelihood • Livestock • Traditional Knowledge	Village	Not Specified	on request basis (Basic Data)	

5	JNU	• Traditional Means of Livelihood • Traditional Knowledge • Traditional Health Care System • Traditional Livestock Husbandry Practices including Pastoralism	Eco-Cultural Zone basis Eco-cultural Zone/ 40 local Communities across Himalaya • Eco-Cultural Zone • Eco-cultural Zone (Selected few)	2015- 2017 2015-2017 - Not Specified - Not Specified	Report Form submitted to DST	No
6	SKUAST, J&K	• - Means of Livelihood • -Landholding Size • - Traditional Knowledge	Ladakh Region • Village Level • District Anantnag	2012-2014 2012-13 2009 & 2012	PDF Form PDF/ Geospatial	No

Conclusion & General Suggestions

- The decision making on conservation and development issues for sustainable development, is a subject of developmental research. Such research in IHR and the country is still in the incipient stage. Therefore, to enable scientific evidence-based decision making, there is a need to encourage such research, and extend patronage to institutions/ organizations mandated for such research.
- Decision making in conservation and development issues involves comparison of policy choices, developmental options/ alternatives, and appraisal of management options. The information and data required for such exercises require inputs from diverse disciplines or multidisciplinary team of experts, and such data is not generated in conventional university/ college/ institute level R&D. Therefore, this is an area of huge information or data gaps.
- To bridge this information gap there is a need to promote such research through interdepartmental and inter-institutional collaborations by making best use of the core expertise of the institutions/ individuals. The government should also sponsor such research by making allocations to state/ central government R&D funding programmes. International collaborations for funding such research/ projects should also be encouraged.
- To promote such R&D to support decision making, a culture of multidisciplinary research should be encouraged at university level, and a policy of awarding Ph.D. to research team members carrying out such researches of interdisciplinary nature, based on the evaluation of their individual assignments/ components should be evolved.
- All the conservation and development issues of IHR should be prioritized on area/ region basis, or pan-IHR scale, and research themes and areas should be designated to institutions/ universities, to generate data sets for decision making. A culture of collaborative practice/ research for best results should be adopted.
- With regard to addressing data gaps and data development for hydropower sector the Ministry of Water Resources or CWC could be the nodal agency, while BSI/ ZSI could be responsible for biodiversity, Wadia Institute of Himalayan Geology/ Geological Survey of India for Geological data/ mapping, CWC for river flow and siltation, NIDM/ IIT Roorkee/ IIT Guwahati for disaster/ extreme events and dam breach simulations, and IISSR/ GBPNIHESD/WII for post dam EIAs and learning.
- The data gaps of the Rural Development (agriculture sector) can be managed by Directorate of Agricultural Statistics and Directorate of Economics and Statistics of State Planning Division (state governments)/ Economic Statistical Division of ministries of Rural Development of the states as nodal and support agency at state level. While for data/ information development on efficacy of alternative agriculture options, community based market chain potential assessment and agriculture performance simulations under climate scenarios, the Ministry of Agriculture, GoI/ ICAR could be entrusted as nodal agency and state agriculture department can be a supporting/ partnering institution. The data/ information on human-wildlife conflict can be assigned to state forest departments and WII.
- The data on reasons for outmigration can be entrusted to NSSO or Directorate of Economics and Statistics of State Planning Division; the information on livelihood and enterprise potential, which is exploratory work, can be covered through sponsored research and should be shared by ICAR and

the State Agriculture Directorate/ departments. Inputs/ funding from sponsored research by ICIMOD and international organizations should also be used for strengthening of data base.

- The data on women health and reduction of drudgery for women, information/ data on women health, nutritional status, and time spent on different chores, can be entrusted to Directorate of Economics and Statistics of State Planning Division; Department of Health Statistics and NSSO can be the data generating/ supplementing agencies. The opportunity cost estimation, and information on appraisal of drudgery reduction measures can be generated through sponsored research by DST, NMHS, IERP and others. The international exposure of ICIMOD can be used and data through sampled study of representative villages/ pockets can be generated through involvement of institutions like IEG, IIFM, IIRM, GBPNIHESD, and State Forest Departments.
- The data on opportunity costs of fuel/fodder collection and information on appraisal of drudgery reduction measures needs analysis and can be developed through study of representative villages from all the Himalayan states. As indicated above the work can be assigned to IIFM, IIRM, and State Forest Departments, etc. The information from sampled representative villages can also be developed through sponsored research funded by DST, NMHS, IERP and others.
- For TIK database, DST can be the nodal agency. The other agencies that can be engaged for information/ data related to their respective fields are - Directorate of Unani, Ayurveda & Siddha for Health Care, and ICAR/ GBPNIHESD/ WII/ state ministries of rural development, State Forest Department and related Line Agencies, and Ministry of Tribal Development etc. for natural resource conservation and management. The crop protection/ storage/ and Integrated Pest Management based knowledge database development can be entrusted to ICAR and State Agriculture Departments.

Chapter 3
Data Management and Data Sharing

Background

This chapter is a compilation of responses received during the questionnaire survey and meetings from multiple research and development institutes of India regarding the existing trends and gaps in Himalayan data management and sharing. A concise outline of centralized Himalayan data management and sharing mechanism to facilitate decision making on conservation and developmental issues of Himalaya is also proposed. This chapter is, therefore, a response one objective in the terms of reference: *"to suggest Data Generation, Management, Sharing and End-user accessibility and use with a view to ensure quality (the data set on the Himalayas need to be developed to the level of fidelity), formats, access and sharing at different levels including local, state, National and regional"*

Existing Trend of Data/ Information Management and Sharing

In order to assess the existing trends management and sharing of key conservation and developmental data, responses of the Indian institutes and agencies working on Indian Himalaya were compiled for four sectors: (i) climate and cryosphere, (ii) disaster, (iii) biodiversity, and (iv) socio-ecological dimensions. It is noted that along with few dedicated/ nodal institutes for sectoral data collection, compilation and management, such as India Meteorological Department (IMD) and Indian Space Research Organization (ISRO) for climate and cryosphere, Geological Survey of India (GSI) and National Disaster Management Authority (NDMA) for disasters, Botanical Survey of India (BSI) for floral diversity, Zoological Survey of India (ZSI) for faunal diversity, Office of the Registrar General and Census Commissioner (MoHA, GOI) for demography and socio-economic data, a significant number of agencies are also involved in primary data generation for IHR. However, most of these individual institutes/ agencies produce primary data for research purposes and limited to small spatio-temporal scales.

Particular observation with respect to data management and sharing of dedicated/ nodal research institutes collecting sectoral data are:

- Irrespective of sectors, i.e. climate and cryosphere, disaster, biodiversity and socio-ecological dimensions, data management and sharing mechanisms are not uniform.
- Nodal institutes for climate and cryosphere data collection and dissemination have their portals for data dissemination. However, limited technological and monitoring mechanism exists for prohibiting repetition of data generation by other agencies from a single location.
- Nodal institutes for biodiversity conservation have hardcopy records mostly missing geocoding that needs digitization and technological interventions for easier and appropriate data sharing.
- It is noted that irrespective of data format and availability, little or no centralized Himalaya specific mechanism exists for smoother and faster furnishing of data to policy makers for improved decision making. A central agency may address this problem.

Particular observations with respect to data management and sharing of individual agencies or institutes collecting sectoral data are:

- Individual institutes collecting different sectorial data over Himalaya have mostly no or little institutional mechanism for proper data management and sharing. Occasionally, data is shared by these institutes on requirement basis and data procurement process may take time.
- Irrespective of sectors, i.e. climate and cryosphere, disaster, biodiversity and socio-ecological dimensions, heterogeneity in data format and occasional lack of geospatial attributes are major hindrances for proper data management.
- It is noted that often data formats that were designed decades ago are still being followed whereas the technology advancement and global development requires the primary generators to timely review these formats so as to cater the need of information generators.
- Irrespective of sectors, data collected over the Himalayan region by individual agencies are for small spatio-temporal scale and may not directly be used for improved decision making.

As indicated above, an important aspect of proper data management and sharing is the uniformity of data format, lack of which leads to duplication of work further leading to imprudent use of government funds for the same kind of work. Therefore, the existing formats of datasets need to be reviewed by the expert institutes in discussion with stakeholders and academia.

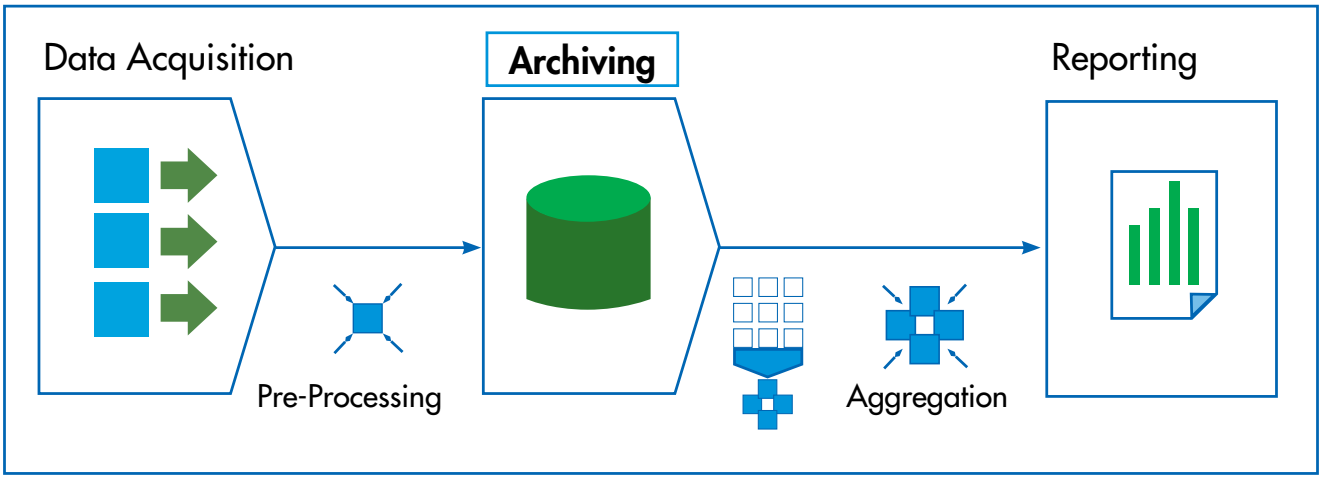
It has also been noted that digital gridded data, irrespective of sectors with consensual spatio-temporal resolution, is easy to check for quality and geotagging and are better manageable and easy to share. However, availability of such data are rare and needs to be produced through concerted research activities.

There are certain classified data or strategic data that are being generated by different institutes. Case and requirement based sharing of such data may also be considered as per the mandate of Government of India. It is further noted that there should be a timely review of such classified data which may be released to public domain for better utilization after review.

Suggestions and Recommendations for Data Management and Sharing

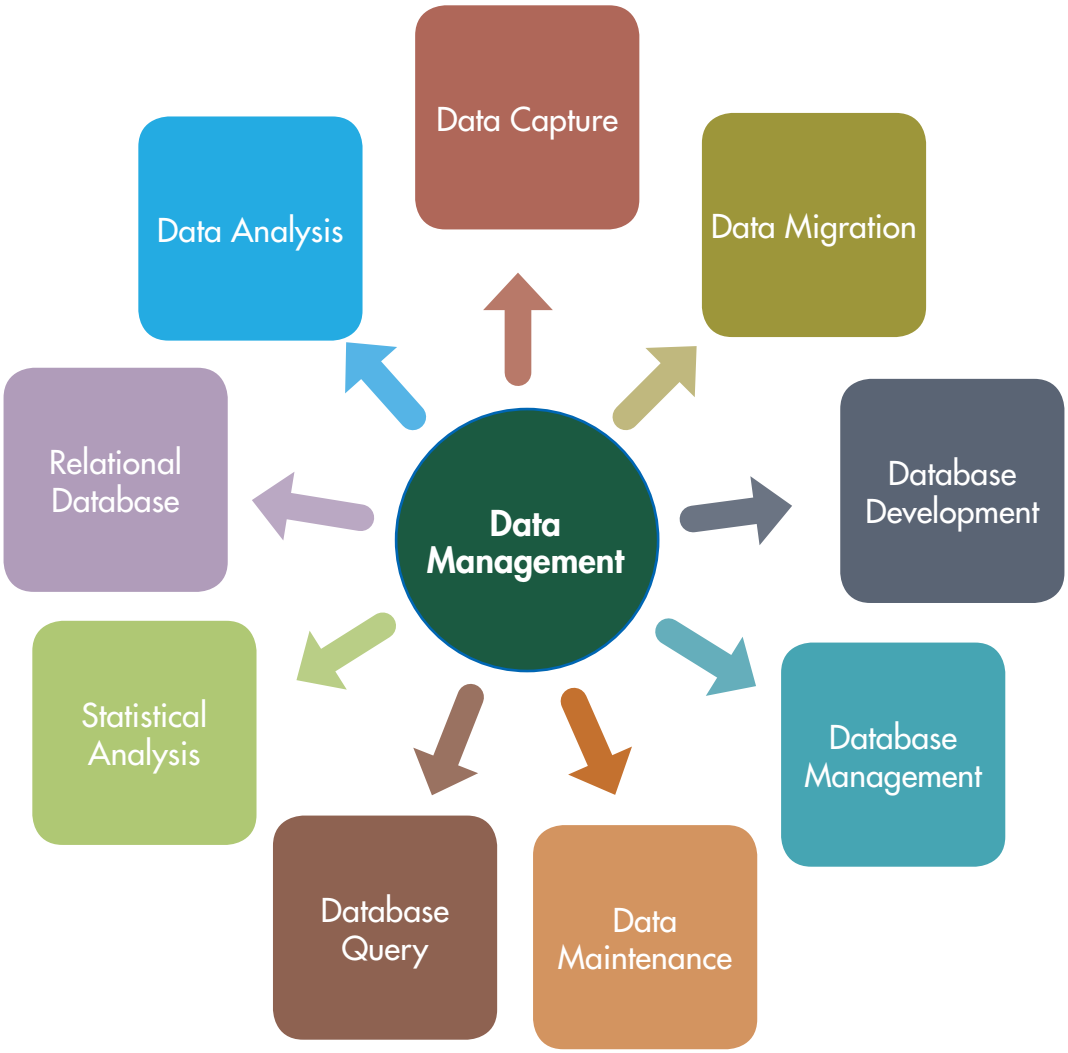
As mentioned earlier, a few nodal agencies associated with different sectors do maintain their data inventory for data dissemination and sharing through a defined procedure as shown in Fig 9. A similar framework may also be opted by other nodal agencies primarily responsible for high-value data generation over Himalaya. However, as of now there is no separate agency which is facilitating all possible kinds of data/ information hosting and sharing for Indian Himalayan region exclusively through a common platform such as through a single window by which complete set of conservation and development related data and its metadata can be viewed.

Figure. 9: **Framework for Data/ Metadata/ Information Hosting at a single platform for data sharing**



Moreover, while discussing the formats, levels of data dissemination and ensuring end user accessibility, there is a need for drawing up guidelines for data sharing. Department of Science and Technology, GOI has suggested allowing data sharing based on the existing National Data Sharing and Accessibility Policy (NDSAP) prepared by Department of Electronics and Information Technology (DeITy), Ministry of Communications and Information Technology, GOI. *The NDSAP policy is designed to promote data sharing and enable access to Government of India owned data for national planning, development and awareness.* The policy emphasizes on *"Different types of data sets generated both in geospatial and non-spatial form by different ministries/ departments are supposed to be classified as shareable data and non-shareable data. Data management encompasses the systems and processes that ensure data integrity, data storage and security, including metadata, data security and access registers. The principles on which data sharing and accessibility need to be based include: Openness, Flexibility, Transparency, Quality, Security and Machine readable."* (For details, refer to Annexure XIII). A schematic on data management following the recommendation of NDSAP is provided in Fig. 10. It is further highlighted in NDSAP that there should be a provision to establish a NDSAP cell in each department involved in data sharing. The NDSAP framework for data management and sharing with required modifications could be a suitable framework for Himalayan data archival, management and dissemination.

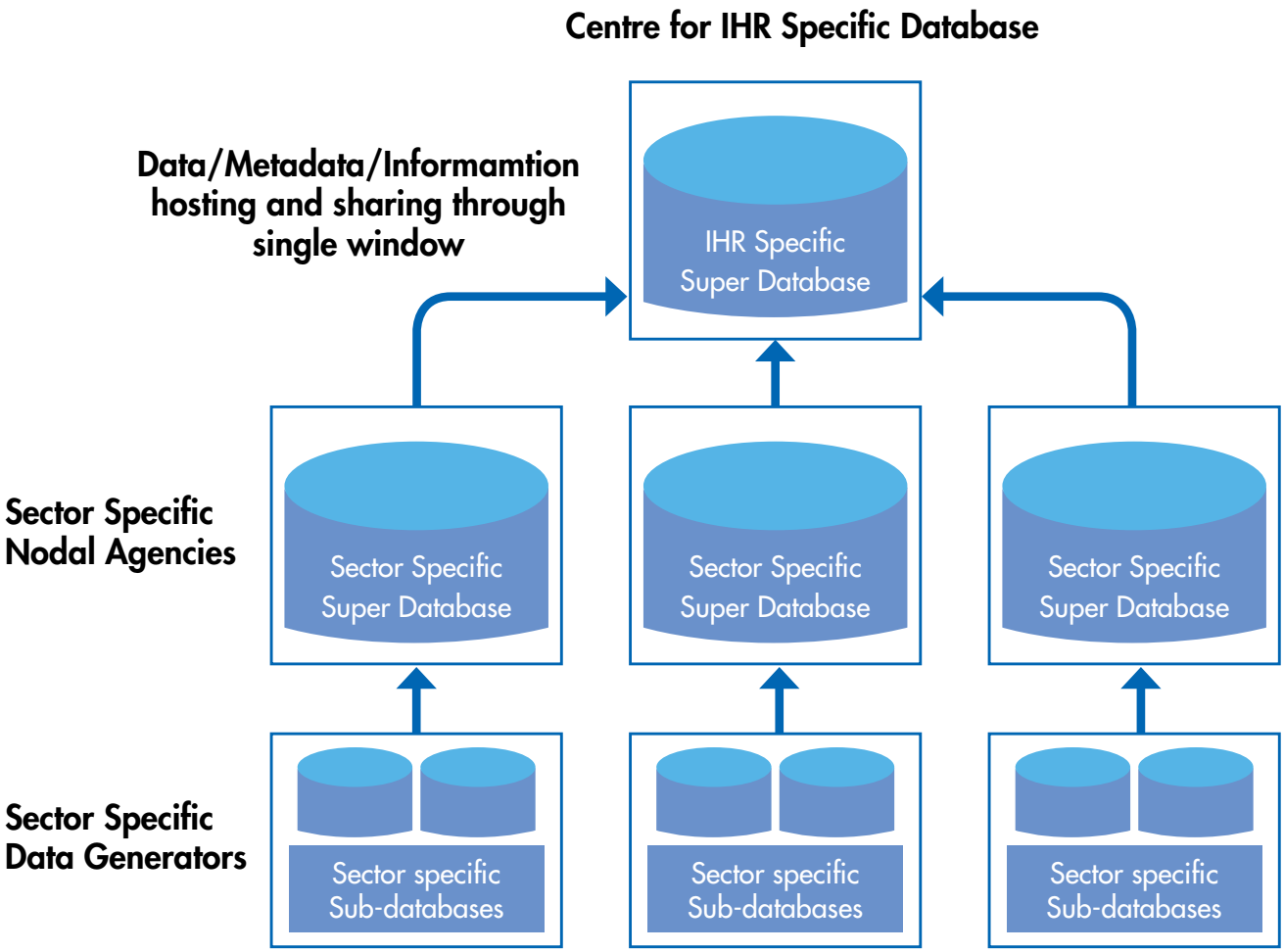
Figure. 10: **Components of data management**



It is also noted during the survey that NRSC, Hyderabad and ICIMOD, Nepal have an existing mechanism for data management and sharing on larger scale. However, ICIMOD, being an inter-governmental organization, may face difficulty in hosting Indian Himalayan region data at their end. ISRO-NRSC, Hyderabad being the body of Government of India, has well defined state-of-art data management and sharing portals like "Bhuvan" and "National Information system for Climate and Environment Studies (NICES)" for sharing geophysical data. However, in view of pan-India data management and sharing structure of Bhuvan portal, a dedicated Himalayan specific data sharing and management mechanism through Bhuvan needs to be customized with necessary administrative clearance. Therefore, the proposal for a Himalaya specific data centre for management and robust sharing is still open and requires to be

addressed. An accredited central government institution (such as ISRO, INCOIS, GBPNIHESD, etc.) may be given the responsibility for developing the Centre for Database Management to collect, manage, and disseminate data/ metadata across various sectors following the NDSAP guidelines with required modifications for the stakeholders and to ensure end-user accessibility for informed decision making as suggested in the earlier chapters. A schematic representation of data management at the Centre for database management is provided in Fig 11. The data quality classification can be made by the nodal agencies following Table 26

Figure 11: **Schematic representation of Centre for Database Management specifically for IHR as a whole**



After reviewing the responses to the questionnaire received from various institutes, it was evident that ISRO covers and collects the data mostly for all the sectors. Moreover, they also have well defined state-of-the-art facilities for data dissemination. ISRO's portals like Bhuvan and NICES covers thematic data archival and data sharing for different data/ information including their expertise of geospatial data for which ISRO is also the nodal agency.

Table 26: **Data quality metrics to be adopted by Nodal Agencies**

Accuracy threshold	Quality
90% and above	Excellent
80% - 90%	Very Good
70% - 80%	Good
60% - 70%	Average
Below 60%	Poor

Similar kind of mechanism for sharing, retrieval and end-user accessibility of data/ information with required modifications may be adopted by proposed CDMA for IHR as suggested in Appendix A. Improvements in the mechanism as desired necessary may be adopted by the proposed Central Data Management Agency (CDMA) as single data dissemination window for IHR. Therefore, NITI Aayog may suggest an Organization/ Institute to be the CDMA with the necessary provisions for required funding and manpower. A corpus to this effect may be granted by the concerned ministry of the organization/ institute to facilitate the establishment of the proposed single window CDMA for IHR.

During the Working Group review meeting held at NITI Aayog on 27 June 2018, it was decided and recommended that although ISRO has expertise in hosting and managing the data/ information, yet it would be desirous to host the CDMA at one of the existing Himalayan institutes. As NRSC-ISRO hosts the data/ information on a pan-India scale, the need for a Himalaya specific central data centre might not be met holistically. Therefore, it was agreed upon by the Working Group that GBPNHESD could be the CDMA for hosting, managing and disseminating the data/ metadata/ information for IHR as a single window. For details refer to Annexure IX.

Appendix: A

Sharing, retrieval and end-user accessibility of NRSC, Hyderabad.

Bhuvan GeoSpatial data infrastructure is established as a one stop solution to cater to geo-processing and dissemination of data & services. Bhuvan Web Portal of NRSC/ ISRO is accessible at http://bhuvan.nrsc.gov.in. NRSC is disseminating the data through Web Map Service (WMS) as per the Remote Sensing Data Policy. To build a long term database on climate variables, NRSC/ ISRO has established National Information system for Climate and Environment Studies (NICES). Its objective is to promote data dissemination and climate change impact assessment and mitigation. NICES data products are available through an online portal that is hosted on Bhuvan. The portal was operational since October 2013 with access to more than 50 products at national level. More than 45,000 instances of data download recorded so far. For more information, visit http://www.nrsc.gov.in/nices.

Similar to Bhuvan, NSDI can also provide a platform where agencies across the country are sharing their WMS after following OGC standards for data creation and sharing policy.

Additionally, NRSC has suggested to utilize their portal for data management and sharing and responded as follows:

The following institutions are involved in data generation and data sharing which can be connected with the proposed central server to facilitate all kind of data through a single window/ platform and avoiding any complexities in data accessibility.

- Dedicated weather forecast and data from historical archives to present day near real time data services is made available through Meteorological & Oceanographic Satellite Data Archival Centre (MOSDAC), Space Applications Centre (SAC), ISRO. Data acquired from missions is disseminated in near real time from SAC, Ahmedabad through the MOSDAC web site (http://www.mosdac.gov.in). The web site also hosts weather services including cloud burst and heavy rain alerts and a three hourly weather forecast for the next seventy two hours.
- IMD provides data on meteorology (http://www.imd.gov.in/).
- NRSC and NESAC primarily collects, acquire and generates Geospatial data
- Forest Survey of India (FSI) generates data for biennial monitoring of Forest cover (crown density) since 1987.
- FSI has forest type based in spatial form that could provide broad information of forest types at county level and for the Himalayan region.
- Forest fire alerts information from 2004 onwards are available as point information further carrying information of the forest fire outbreaks at forest administrative units can be used.
- Survey of India provides data on geological mapping
- Central Ground water board generates data for Ground Water potential
- National Institute of Hydrology generates the data on Hydrological aspects

- GBPNIHESD collects data on various themes including biodiversity, Climate data, Forest information, biotechnological applications and information of species of IHR, socio-economic/ socio-ecological issues, etc.

The institutes involved in data generation need to ensure quality so that such data may be useful to generate results with high certainty relying on the legitimacy of data. A threshold classification may be incorporated suggesting the quality of data collected or generated.

Chapter 4
Draft Recommendations/ Specific Action Points

Findings

- Our questionnaire survey/ consultations revealed a limited response ~25 % (out of 96 leading organizations). Additionally, information was also generated from web portals of various institutions. Considering the limited response, the status of data availability, data requirement and data gaps needs to be updated regularly.
- Although various organizations are engaged in R&D in the IHR, the data/ information available is fragmentary and has several data gaps.
- Data/ information seems to be incomplete with respect to location details, user-friendly format, spatio-temporal scale, dynamics of quantities, resource use patterns, and drivers of change required for conservation and sustainable mountain development and thus this remains incompatible for comparison and decision making.
- In R&D institutions/ Universities, data is often collected under a certain activity/ project mode for a specific location, duration, scale and replications without any long-term strategy and thus they lack conclusive datasets for development planning.
- There is no organized mechanism/ system for data collection, data management and data dissemination, leading to repetitions and overlaps in data collection.
- Keeping in view the emphasis of the Government on engaging citizens in governance reforms, placing of non-strategic data in public domain and the provisions of RTI Act 2005 for empowering the citizens to secure access to information under the control of public authority leading to the transparency and accountability in the working of every public authority, the National Data Sharing and Accessibility Policy (NDSAP) has been brought out and Department of Science & Technology is the Nodal Department for all matters connected with overall co-ordination, formulation, implementation and monitoring of the policy. The NDSAP envisages that large volumes and different types of data are generated and compiled by various arms of the Government of India and various State Governments for meeting their specific requirements. Ministries/ Departments of Government of India while releasing funds to State Governments and other Institutions including Central/ State Universities should impose some conditions so that the data generated using such funds would come under the purview of this Policy.

Recommendations:

- Ensuring implementation of NDSAP for collection, management and accessibility of data: There should be a coherent scheme for data collection, management and accessibility for end-users in the context of IHR. Presently, sector-specific data collected by several agencies of State/ Central Govt. can be pooled and synthesized as per the NDSAP recommendations and made user-friendly to improve its accessibility to various policy/ planning and decision making processes. A proposed plan indicating nodal agencies and partnering organisation for data pooling on IHR, which may be assigned the specific task as per

their expertise, is given in Table 1. Following the NDSAP policy, all the data generated using funds of government of India should be shared on the open data portal (http://data.gov.in) for free access of data. However, this mechanism still lacks proper implementation as only 2 out of 12 Himalayan states nominated their chief data officers. Moreover, there is no mechanism for regular follow up with the nodal person from the states and different departments under central government. For this purpose, a Nodal Point in the NITI Aayog may be considered to ensure implementation and follow up of NDSAP.

- Data centric architecture for better data archival and management: It is suggested that a "data centric architecture" may to be adopted for addressing data gaps, data quality control, data management and data access to end-users. Under this approach, GBPNIHESD may be identified as an accredited Central Govt. organization to act as Central Data Management Agency for IHR (CDMA-IHR) and given the responsibility to maintain dedicated Data Centre on IHR. A node by this CDMA may be hosted at each of the Govt. nodal organization/ institute mandated for data collection/ dissemination in the IHR. A schematic of workflow in the CDMA is provided in Appendix 1. Each of these nodal organizations may be given the responsibility to act as a sector-specific regional platform for data collection, data repository, data management, eradication of data overlaps and quality control through in-house subject experts and institutional collaborations (please refer Chapters 3 - 7 for details). And for this purpose adequate resources should be provided. The CDMA can host a devoted portal for data archival to end-users to promote informed decision making for sustainable development planning. In addition, State Line Depts. also need to be linked with the regional sector-specific nodal organizations network both for data hosting and data retrieval for development planning and decision making.
- Digitization of non-digital datasets (maps, specimens etc.).: In most of these sectors data/ information is available in the form of maps, specimens, published documents etc. that need to be digitized and may be a part of digital library of the nodal organizations/ partnering organizations. Efforts should also be made to convert the analogue data into digital within the set time frame. Some incentive based mechanism needs to be promoted for digitization/ reconstruction of past data existing in old reports, hard copies, etc. In the biodiversity and socio-ecological sectors ethno botanical and IKS relating to best management practices of conservation of natural resources for sustainable development available with the inhabitants need to be documented and popularized following Citizen Science approach.
- Harmonizing the Data Scales and Data Formats: There is also an issue of compatibility of temporal and spatial scale of data. For example, the NRSC has LULC data at 1:10,000 scale for the entire IHR/ country. Whereas, FSI generates data on 1:50,000 scale, which is less appropriate for planning for biodiversity conservation and management of forests. However, if it is not possible to generate data at 1:10,000 scale, the data need to be generated at 1:25,000 scale to minimize the mismatch. Another example is related to decision making in ESZ where long-term rainfall data is often required. However, for a specific location such data may not be available as most of the gridded data has a scale of 25 x 25 Km grid that is desirable on a 5 x 5 Km grid. Data/ information should thus be collected across different sectors following standard/ compatible formats and uniform spatio-temporal scale. There is also a need to integrate the data sets collected by various nodal organizations to address development planning concerns.

- A big challenge is to bring collected data in a compatible format to utilize it optimally in developmental planning. To achieve this compatible "Data Formats" need to be designed by the respective nodal organizations (Table 27). Also, the time consuming and complex procedure related to use of available data, authenticity, compatibility, validation, user charges, archival of paid data, non-availability of unpublished data from various organizations need to be minimized and made user-friendly.
- Data access mechanism: The data access mechanism and user charges (if any) may be decided by the respective nodal organizations keeping in view the cost involved in data collection and management. For this purpose, the parental Ministry/ organization should provide adequate support to the regional nodes for data collection and management. Data portal to be developed by Sector Specific Nodal Organizations for data sharing. There are certain Institutes that are already collecting sector-specific data/ information. These Institutions should be encouraged and the data generated by them should be taken into account by sector specific Nodal Organizations. Sector specific Nodal organizations need to manage the data/ metadata, perform quality check and establish payment mechanism. Incentives for IPR and copyright issues for such unpublished datasets need to be devised. This will promote the interlinking of the various R&D Institutes with the nodal organisation and enhance data use for making plans and informed decision making.
- Research and development projects for data generation: To generate data on various spatio-temporal scales and overcome the data gaps the National funding agencies (e.g., DST, CSIR, ICAR, MoEF&CC, ICSSR, UGC, MoRD etc.) may consider allocating some part of their grants given under R&D projects to various organizations across the IHR for data generation to fill data gaps in different sectors such as climate change, cryosphere, biodiversity, disasters, socio-economy etc. In this context, funding agencies may invite time bound specific short-term (< 5 yrs), medium-term (5-10 yrs) and long-term (> 10 yrs) projects for data collection in the heterogeneous, physical, biological and socio-economic settings of the IHR. Also, the in-house data collection activities of nodal agencies of Govt. of India should be time-bound. Thus, encouraging natural resource conservation and development research, and extending patronage to institutions mandated for such research is required. Monitoring of such funding for data generation on annual/ periodical basis can be performed by NITI Aayog, Govt. of India.
- Need of a multi-disciplinary approach for sustainable development: In the context of IHR, there is need for a multi-disciplinary approach for data generation and decision making for sustainable development planning. In most cases first-hand data/ information generation is required on specific developmental intervention. Therefore, the sector specific nodal agencies should provide baseline data. Also, improved IT infrastructure for real time data collection and dissemination for different users is required.
- Capacity building for awareness and utilization of data from CDMA: Training/ capacity building of planners/ decision makers for utilization of data/ information from the CDMA/ nodal organizations and members of NDSAP cell would be highly desirable for better planning in view of SDGs. Decision making involves comparison of policy choices, and appraisal of management options. Citizen and youth may be empowered to collect data and information as done under 'Citizen Science

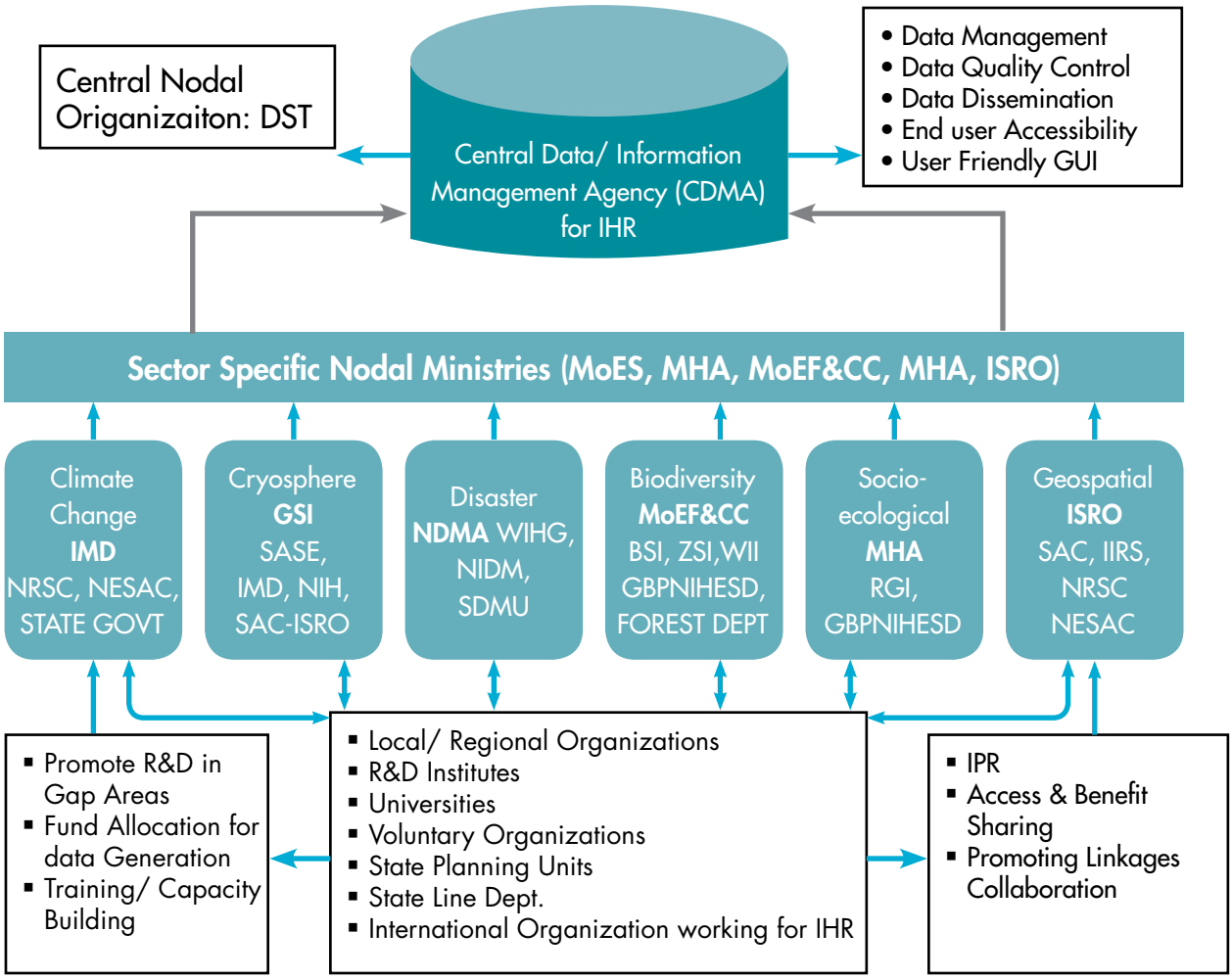
Programme' under the guidance of reputed R & D institutions and nodal agencies. This can also provide employment opportunity to youth to be trained for collection and transfer of data to respective nodal agencies. Linkages with Ministry of Skills and Entrepreneurship would be required for implementation of such training programmes. Working group 4 on "Strengthening Skill & Entrepreneurship (E&S) Landscape in Himalayas may take this as the input to address the issue.

Table 27: **List of suggested nodal organizations for data generation, management, quality control and end-user accessibility under different sectors for the IHR.**

S. No.	Sector for data repository	Name of the Nodal Organization	Partnering local/ regional organizations
1.	Climate change	MoES	IMD, NIH, DST, NRSC-ISRO
2.	Cryosphere	MoES	GSI, WIHG, NIH, SASE, NRSC-ISRO
3.	Disaster	MHA	NIDM, WIHG, NIH, SASE, NRSC-ISRO, GSI
4.	Biodiversity	MoEF & CC	BSI, ZSI, GBPNIHESD, ICFRE, WII, NBA, SBBs, ICAR, DST, DBT, NRSC-ISRO, State Forest Dept.
5.	Socio-ecology	State agencies in IHR/ NSSO	Planning Dept. of State Govt., Census of India
6.	Geospatial	Dept. of Space	ISRO, IIRS, NRSC, NESAC, State RS application Centres of IHR States

Appendix 1

Figure. 12: **Schematic representation of CDMA**



ANNEXURES

Annexure I

No. P. 12018/12/2016-RD
Government of India
NITI AAYOG
(Rural Development Division)

Sansad Marg, New Delhi
June 2, 2017

ORDER

Subject: Constitution of Working Groups on Sustainable Development in Mountains of Indian Himalaya Region

With the approval of competent authority, five Working Groups are hereby constituted along with Lead Institutions as Conveners of the Working Groups for Sustainable Development in Mountains of Indian Himalaya Region (IHR) to achieve the identified action points of each thematic area. The terms of Reference of Working Groups are as follows:

Sl. No.	Working Group (thematic area)	Terms of Reference	Lead Institutions and Members
1.	Inventory and Revival of Springs in Himalayas for Water Security	• To take stock of the magnitude of the problem (drying of spring, quality of water from springs). • To review related policies across IHR to ascertain its adequacy and gaps. • To review existing initiatives and best practices including inventorisation and spring revival by different agencies across IHR. Ascertain to what extent learning from best cases and 8 steps methodology is being integrated into spring work and ways to strengthen it. • To assess challenges faced by the existing initiatives. • To suggest policy and practice actions in short, medium and long term.	Lead Institution-Convener Department of Science and Technology (Dr. Akhilesh Gupta) **Members:** Representative form: Department of Land Resources, Government of India Ministry of Environment, Forest and Climate Change Central Ground Water Board Rural Management and Development Department (Government of Sikkim) Dr. Himanshu Kulkarni, ACWADAM, Pune (NGO) International Centre for Integrated Mountain Development (ICIMOD), Kathmandu

2.	Sustainable Tourism in Indian Himalayan Region(with emphasis on heritage tourism)	To review of tourism & related policies and practices of center & mountain states. To identify best initiatives (policy and practice). To identify policy and regulatory frameworks, financial and institutional incentives and capacity building focus areas that will support sustainable tourism development. To recommend short, medium and long term actions.	Lead Institution-Convener NITI Aayog (Shri Vikram Singh Gaur, Joint Secretary, State Coordination & Tourism) Members: Representatives from: Ministry of Tourism Ministry of Environment, Forest and Climate Change Ministry of Culture Department of Tourism of Himachal Pradesh, Uttarakhand and Sikkim Kanchenjunga Conservation Committee, Sikkim WWF India (Dr. Sejal Worah, Director Programs) UNESCO, India India Tourism Development Corporation Ltd. (ITDC) International Center for Integrated Mountain Development (ICIMOD), Kathmandu
3.	Shifting Cultivation: Towards transformation Approach	To consolidate the learning on magnitude of the problem To identify viable best practices having upscale potential To assess of Institutions (Formal and traditional one's) and needs for their transformation to adopt sustainable practices To ascertain to what extent and which "Co-Benefits" could be delivered (to Jhumias and State agencies) To suggest ways to promote transformative approach to shifting cultivation, which combines eco-restoration, food and cash incomes through participatory land-use planning taken up on a scale. Suggest actions in short, medium and long term.	Lead Institution- Convener National Institute of Rural Development and Panchayati Raj NIRDPR_NERC, Guwahati (Dr. R.M. Pant, Director) Members: Representatives from: North Eastern Region Community Resource Management Project (NERCORMP) Ministry of Environment, forest and Climate Change Ministry of Development of North Eastern Region (MDoNER) Ministry of Agriculture International Center for Integrated Mountain Development (ICIMOD), Kathmandu

4.	Strengthening Skill and Entrepreneurship (E&S) Landscape in Himalayas	To assess magnitude of the problem including youth unemployment and migration, with due consideration of gender. To review policy/best practices built around unique/niche mountain goods and services to build E&S landscape. Also assess new industrial policy to see how it address mountain specificity. To identify potential unconventional areas for skilling and entrepreneurship in Himalaya for scaling up to address issue of migration and unemployment. This may also include software/IT based options in addition to unique mountain goods and services. To suggest strategies/actions for development of Qualification packs and National Occupation Standards (NOS) in niche mountain goods and services. To identify ways of strengthening Public- Private Partnership and Networks of skill/entrepreneurship centers across Himalayas. To articulate comprehensive strategy/ actions building on institutional, policy, market, technology and financial resources (including leveraging of resources) in short, medium and long term to address the issue.	Lead Institution- Convener Ministry of Skill Development And Entrepreneurship (Dr. Jyotsna Sitling, Joint Secretary) Members: Representatives from: Ministry of Environment, Forest and Climate Change, Ministry of Rural Development Ministry of Development of North Eastern Region (MDoNER) North Eastern Region Community Resource Management Project (NERCORMP) Entrepreneurship Development Institute of India, Ahmedabad International Center for Integrated Mountain Development (ICIMOD), Kathmandu

5.	Data/Information for Informed Decision Making by Multiple Stakeholders	To assess data requirement & availability across multiple sectors/ institutions and gaps for monitoring of key conservation and development issues including climate change, cryosphere, disaster, biodiversity and socio-ecological dimensions, and ways to address the same through cross-sectorial and interdisciplinary institutional collaboration and data sharing.	Lead Institution-Convener G.B Pant National Institute of Himalayan Environment & Sustainable Development (GBPNIHESD) Members: Representatives from: Department of Science and Technology Forest survey of India, Dehradun Wildlife Institute of India, Dehradun India Meteorological Department Wadia Institute of Himalayan Geology, Dehradun National Remote Sensing Centre, Hyderbad International Center for Integrated Mountain Development (ICIMOD), Kathmandu

2. The working Groups may co-opt other members as deemed fit to best suit the overall objectives of the Sustainable Development of IHR. They may also utilize the existing data available with the government organizations/universities/research organizations/international organizations etc. as enough data is available rather than doing fresh research for collecting data sets.

3. The Working Groups will submit their report within a period of three months to NITI Aayog. It include one month time for inter-thematic consultations also.

(Neeraj Srivastava)
Director (RD)

(नीरज कुमार श्रीवास्तव)
(NEERAJ KUMAR SRIVASTAVA)
निदेशक/Director
नीति आयोग/National Institution for Transforming India (NITI)
भारत सरकार/Govt. of India
नई दिल्ली

To,

1. The Secretary, Ministry of Tourism, Government of India, Transport Bhawan, Connaught Place, Sansad Marg, New Delhi-11001.
2. The Secretary, Ministry of Environment, Forest and Climate Change, Government of India, Indira Paryavaran Bhavan, Jorbagh Road, New Delhi-11003
3. The Secretary, Ministry of Rural Development, Government of India, Krishi Bhavan, Dr. Rajendra Prasad Road, New Delhi-110001
4. The Secretary, Ministry of Development of North Eastern Region, Government of India, Vigyan Bhawan Annexe, Maulana Azad Road, New Delhi-110011.
5. The Secretary, Ministry of Skill Development and Entrepreneurship, Government of India, 2nd Floor, Annexxe Building, Shivaji Stadium, Shaheed Bhagat Singh Marg, Connaught Place, New Delhi-110001.
6. The Secretary, Department of Land Resources, Government of India, NBO Building, Nirman Bhawan, Moulana Azad Road, New delhi-110011.
7. The Secretary, Ministry of Culture, Government of India, Shastri Bhawan, New Delhi-110001
8. The Secretary, Department of Science & Technology, Government of India, Technology Bhavan, New Mehrauli Road, New Delhi-110016.
9. Shri Vikram Singh Gaur, Joint Secretary, State Coordination & Tourism, NITI Aayog.
10. Dr. Jyotsna Sitling, Joint Secretary, Ministry of Skill Development and Entrepreneurship, Government of India, New Delhi.
11. The Principal Secretary, Department of Tourism, Government of Himachal Pradesh, Shimla.
12. The Principal Secretary, Department of Tourism, Government of Uttarakhand, Dehradun.
13. The Principal Secretary, Department of Tourism, Government of Sikkim, Gangtok.
14. The Principal Secretary, Rural Management and Development Department, Government of Sikkim, Gangtok.
15. The Director General of Meteorology, India Meteorological Department, Mausam Bhawan, Lodhi Road, New Delhi-11003.
16. The Chairman, Central Ground Water Board, Bhujwal Bhawan, NH-IV, Faridabad-12100.
17. The Director General, Forestry Survey of India (Ministry of Environment, Forests and Climate Change) Kaulagarh Road, P.O. IPE Dehradun, Uttarakhand-248195.
18. Mr. Shigeru Aoyagi, Director, United Nations Educational, Scientific and Cultural Organisation, 1, San Martin Marg, Chanakyapuri, New Delhi-110021.
19. Dr. Sajal Worah, Director Programs, WWF India, 172 B, Lodhi Estate, New Delhi-11003.
20. Dr. R. M. Pant, Director, National Institute of Rural Development & Panchayati Raj, North Eastern Regional Centre, NIRD Lane , Jawaharnagar, Khanapara, Guwahati, Assam- 781022

21. Dr. Akhilesh Gupta, Head, Department of Splice, Department of Science & Technology, Department of Science & Technology Bhavan, New Mehrauli Road, New Delhi-110016.
22. Dr. P. P. Dhyani, Director, G.B Pant National Institute of Himalayan Environment & sustainable Development, Kosi-Katarmal, Almora, Uttarakhand-263643
23. Dr. Kireet Kumar, G. B. Pant National Institute of Himalayan Environment & Sustainable Development, Kosi-Katarmal, Almora, Uttarakhand, India.
24. Dr. Himanshu Kulkarni, Executive Director, Advanced Center for Water Resourcces Development and Management, "Suvidya", 27, Lane no. 3, Kshipra Society, Karve Nagar, Pune, Maharashtra-411052.
25. Prof. Anil Kumar Gupta, Director, Wadia Institute of Himalayan Geology, 33 GMS Road, Dehradun, Uttarakhand-248001.
26. Dr. S. Chaudhari, Managing Director, North Eastern Region Community Resource Management Project, Sympli Building, First Floor, Malki-Dhankheti, Shillong, Meghalaya-793001.
27. Dr. V. B Mathur, Director, Wildlife Institute of India, Post Box 18, Chandrabani, Dehadun, uttrakhand-248001
28. Dr. Sunil Chandra, Assistant Director, Forest Survey of India, Akulgarh Road, PO-IPE, Dehradun,Uttrakhand-248195
29. Director, National Remote Sensing Centre, Main Road, Ashok Nagar, Balnagar, Hyderbad, Telangana-500042.

Copy to:

1. PS, Vice Chairman, NITI Aayog, New Delhi.
2. PPS to Member (VKS), NITI Aayog, New Delhi.
3. PPS, Chief Executive Officer, NITI Aayog, New Delhi.
4. Additional Secretary (AKJ)/Joint Secretary (DP&SP Cord)/Adviser (Agriculture)/Adviser (Skill Develpoment), NITI Aayog, New Delhi.
5. Shri Jitendra Kumar, Adviser (NP&E/SP/SD/Mines), NITI Aayog, New Delhi.

Copy also to:

Mr. David James Molden, Director General, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal.

Annexure II

List of Institutions & Universities in the IHR approached for survey on availability of data

State	No. of institutions	No. of universities
Arunachal Pradesh	2	
Assam	4	4
Himachal Pradesh	4	4
Jammu & Kashmir	2	6
Manipur	1	
Meghalaya	2	1
Mizoram	2	
Nagaland	2	1
Sikkim	2	1
Uttarakhand	15	5
West Bengal	4	

Annexure III

Survey questionnaire on availability of data/ information in the Himalayan Region

WORKING GROUP ON SUSTAINABLE DEVELOPMENT IN MOUNTAINS OF INDIAN HIMALAYAN REGION

Background

In the Himalayan Region, the knowledge gap created by the limited availability of quality data/ information is negatively impacting the decision making by different stakeholders. Comprehensive data set on the Himalaya needs to be made accessible to different user agencies in a systematic manner to ensure sustainable development in the Himalayan Region.

Considering this,the NITI AAYOG, Government of India has created 5 working groups on sustainable development in Mountains of Indian Himalayan Region vide letter No. P.12018/12/2016-RD dated June 2, 2017. In this regard, the Working Group 5 on "Data/ Information for Informed Decision Making by Multiple Stakeholders" has been coordinated by G. B. Pant National Institute of Himalayan Environment & Sustainable Development (GBPNIHESD), Kosi-Katarmal, Almora (Uttarakhand) with the following objectives:

- To assess data requirement & availability across multiple sectors/ institutions and gaps for monitoring of key conservation and development issues and ways to address the same through cross-sectoral and interdisciplinary institutional collaboration and data sharing.
- To suggest Data Generation, Management, Sharing and End-user accessibility and use.

In this context, you are requested to please provide your valuable inputs in the following format. These inputs will greatly help in the preparation of sector-wise comprehensive report to meet the above defined objectives for monitoring the key issues in Indian Himalayan Region.

1. Whether your Organization/ Institute has following data that can help in monitoring of key conservation and development issues in Himalayan Region (Please Tick)

Data Related to	Availability (Please Tick)
Climate Change	
Cryosphere	
Disaster	
Biodiversity	
Socio-ecological	
Any Other(Please Specify)	

2. Please provide the details with respect to above existing Primary data/ Information in following sectors that you generate or is readily available with your Institute

i. Climate Change related

Type of Data	Format (Digital/ Geospatial Report/PDF/ Hard Copy/ Any Other)	Level at which data is available (Village/ Block/ District/ State/ Watershed/ Sub-watershed/ Point Source/Grid)	Timescale of acquisition (Hourly/ Daily/ Weekly/ Monthly/ Annually/ Any Other	Period of data availability (DD/MM/YY To DD/MM/ YY, Years)	Quality Checks (Yes/No)
Temperature					
Humidity					
Rainfall					
Wind Speed					
Radiation					
Heat Flux					
Soil Temperature					
Soil Moisture					
Any Other					

ii Cryosphere

Type of Data	Format (Digital/ Geospatial Report/ PDF/ Hard Copy/ Any Other)	Level at which data is available (Village/ Block/ District/ State/ Watershed/ Sub-watershed/ Point Source/Grid)	Timescale of acquisition (Hourly/ Daily/ Weekly/ Monthly/ Annually/ Any Other	Period of data availability (DD/MM/YY To DD/MM/ YY, Years)	Quality Checks (Yes/ No)
Glacier Retreat Rate					
Discharge					
Sedimentation Rate					
Snow Density					
Snow Depth					
Mass Balance					
Any Other					

iii. Biodiversity

a. Flora/ Fauna checklist

Type of Data	Location details (State/ District/ Village/ Geo-coordinates/ Altitude, etc.)	Date/ Time period of data availability	Frequency of data (daily/ weekly /seasonal/ annual)	Data sheets/ Herbarium/ Museum/ live accessions/ Digital/ Hard copy	Native/ Endemic/ Exotic
Species/ taxa/ Community					

b. Population Status

Type of Data	Population size (individual/ unit area)	Location details (State/ District/ Village/ Geo-coordinates/ Altitude, etc.)	Date/ Time period	Frequency of data (daily/ weekly /seasonal/ annual)	Regeneration/ Growth rate
Species/ taxa/ Community					

c. Threat status

Type of Data	Threat status	Location details (State/ District/ Village/ Geo-coordinates/ Altitude, etc.)	Date/ Time period	Frequency of data (daily/ weekly / seasonal/ annual)	International/ National/ State level/ local Assessment
Species/ taxa/ Community					

d. Conservation approaches

Type of Data	In-situ/ ex-situ approaches	Location details (State/ District/ Village/ Geo-coordinates/ Altitude, etc.)	Date/ Time period	Frequency of data (daily/weekly / seasonal/ annual)	Problems of conservation (if any)
Species/ taxa/ Community					

e. Propagation/ breeding protocols

Type of Data	Source of Protocols	Number of individuals multiplied/ breeds	Time period	Frequency of data (daily/weekly /seasonal/annual)	Problems of propagation/ breeding (if any)
Species/ taxa/ Community					

f. Use pattern and economic value

Type of Data	Economic/ medicinal/ other	Use patterns	Market value	Frequency of data (daily/ weekly /seasonal/annual)	Trade (legal/ illegal)	Biomass/ productivity
Species/ taxa/ Community						

g. Please provide the details of typology of any other information (not covered above) related to Himalayan Biodiversity available with your organization/institution …….....

.....

iv. Disaster

Type of Data	Format (Digital/ Geospatial Report/PDF/ Hard Copy/ Any Other)	Level at which data is available (Village/ Block/ District/ State/ Watershed/ Sub-watershed/ Point Source/ Grid)	Timescale of acquisition (Hourly/ Daily/ Weekly/ Monthly/ Annually/ Any Other	Period of data availability (DD/MM/YY To DD/ MM/YY, Years)	Quality Checks (Yes/ No)
Forest Fire					
Seismic					
Flash Flood					
Land Slides					
Cloud Burst					
Any Other ……					

v. Socio-ecolgical

Type of Data	Format (Digital/ Geospatial Report/ PDF/ Hard Copy/ Any Other)	Level at which data is available (Village/ Block/ District/ State/ Any other)	Period of data availability (DD/MM/YY to DD/MM/YY, Years)	Quality Checks (Yes/ No)
Demography				
Means of Livelihood				
Traditional Knowledge				
Health				
Poverty				
Infrastructural Facilities				
Land Holding Size				
Livestock				
Any Other				

vi. Any Other

Type of Data	Format (Digital/ Geospatial Report/ PDF/ Hard Copy/ Any Other)	Level at which data is available (Village/ Block/ District/ State/ Watershed/ Sub-watershed/ Point Source/ Grid)	Timescale of acquisition (Hourly/ Daily/ Weekly/ Monthly/ Annually/ Any Other	Period of data availability (DD/MM/YY to DD/MM/YY, Years)	Quality Checks (Yes/No)
Geospatial data					
Point of Interest	Point Locations				
.....					

3. What type of data/ information your organization requires from other sources and what are the sources (Organizations) from where the data/ Information is collected?

Type of Data (Sector-wise)	Source (Name of the Organization)
Climate Change	Source/s
Cryosphere	Source/s
Disaster	Source/s
Biodiversity	Source/s
Socio-ecological	Source/s

4. What difficulty is faced by your Organization/ Institution while collecting the Data/ Information from other sources (mentioned in above and other potential sources as well)

Difficulty	Remarks
Accessibility	
Timely Availability	
Reliability/ Quality	
Complex Data Sharing Policy	
Heavy Cost of Data	
Any Other Information	

5. What is the sector wise Gaps in Data/ Information availability like data is not sufficient, quality issues, etc?

Sector	Gaps/ Bottlenecks in Data
Climate Change	
Cryosphere	
Disaster	
Biodiversity	
Socio-ecological	
Any Other(Please Specify)	

6. What is mechanism of data sharing/ Dissemination for available or generated data by your Organization at various levels?

Type of Data	Level at which data is Shared (Village/ Block/ District/ State/ Watershed/ Sub-watershed/ Point Source/ Grid)	Mechanism (Digitally/ Printed/ Website/ On Request/ Any Other	Availability (Paid/ Free)
Climate Change			
Cryosphere			
Disaster			
Biodiversity			
Socio-ecological			

7. Is there any classified data available that is not shared by the organization? If yes, please briefly mention the type of data and constraints in their sharing?

TYPE OF DATA/ INFORMATION .....

.....

CONSTRAINTS .....

.....

8. Does your Institute have any Centralized Data Management System? If Yes, will your Institute be agree to share or link the system with centralized server for Himalayan data for decision making?

.....

9. Any other suggestions/ remarks?

.....
.....
.....

Sign with Seal

Designation:

Date

Name of Institute/ Organization

Note: Kindly download the questionnaire and please send back duly filled scanned copy to following addresses by July 10 2017, positively; we shall be very grateful to you for your cooperation:

kireet@gbpihed.nic.in
ashus_rhythm@yahoo.co

Annexure IV

Data availability at different institutions and universities in the IHR

Sl. No.	Name of Institution/ Universities	Primary Data	Data source/ Required	Issues	Gaps in data	Data format/ availability
1.	CSIR-IHBT, Himachal Pradesh	Climate change, Disaster, Biodiversity,Socio-ecological	Meteorological data from IMD, ISRO, DRDO, IPH CWC etc. State Forest department GBPNIHESD Almora, Anthropological Survey of India, Census of India etc.	Accessibility, time Response, data sharing	Limitation/ Recorded data. Lack of data availability. Security issues in installing field sensors. Lack of data about plants. Lack of forest fire data.	On request (PAID)
2.	JNU, Delhi	Climate change, Cryosphere, Disaster, Biodiversity, Socio-ecological and Extra Terrestrial influence on Himalayan Environment for Sustainable Development	Requiring weather data from IMD, ISRO etc.	Focus on effective data sharing policy. Time taking process to visit Himalayan borders.	River Discharge data Lack of data on crucial themes like Climate Change adaptation and mitigation, disaster management and gender though large number of publications-Scattered data	Soft copies quarterly/ annual reports (2015-2017) Research Papers/ Digital (FREE)
3.	IIT-Mandi, Himachal Pradesh	Climate change, Cryosphere, Disaster, Biodiversity,Socio-ecological	DU, JNU, Field visit, satellite data, ISRO, SAC, DRDO,GSI, WIHG, ICIMOD	Accessibility, Time response, Quality check, Format of Data, data Sharing	Data insufficient/ Lack, Quality compromised, limited Accessibility	On request/ Digital/ Hard copy (FREE)
4.	University of Jammu, Jammu	Climate change, Cryosphere, Palaeoclimatic Changes	GBPNIHESD, SAC, WIHG	Poor road and telecommunications Data sharing security issue, focus on admire young scientist in their respected fields.	Non availability of geochronological/ centralised data centre and labs for sharing poor accessibility and communication facilities to glaciated valleys	Reports/ Hard copy/ PDF/ Printed (FREE)

5.	UCOST, Dehradun	Disaster, Socio-ecological District wise secondary data collection is under process from several state departments	IMD, Uttarakhand Disaster Mitigation and Management Centre (DDMC), Uttarakhand Biodiversity Board ,Survey methods, Directorate of agriculture, Directorate of Livestock, Directorate of Census operation Uttarakhand	Data discrepancy b/ w institutional information Insufficient Data. No Centralized database	-	Hard copy/ PDF/ Excel Sheet/ Digital (FREE)
6.	NIT, Sikkim	No data available	-	-	-	-
7.	SKUAST, Kashmir	Climate Change, Biodiversity, Soil status, Socio-ecological	NRSC-Hyderabad (Satellite data), IMD, MoEF&CC, Research institutes and Universities across India. Department of Statistics (J&K Govt.), Department of Ecology, Environment and Remote Sensing (State and Centre), MoEF&CC, Rural Development Department (State and Centre).	State level information not easily accessible/ updated timely, Need to Quality checks, Heavy cost of data	Insufficient data available. Data not available for all districts of J&K (Forestry related)	PDF/ Geospatial/ Digital/ On request (FREE)
8.	NIH, Roorkee	Climate change, Cryosphere, Water Quality	IMD, GSI, Central Warehousing Corporation (CWC) Bhakra Beas Management Board (BBMB), Centre for Snow and Avalanche Study Establishment (SASE)	Time consuming, Heavy cost, focus on data sharing policy	Non-existence of snow thickness data/ mapping. Permafrost monitoring is non-existence. Climate data of higher altitude region>2500 is very sparse. No scientific monitoring on climate events such as cloud burst at national level, All glaciers are monitored for glacier mass balance	Digital/ On request

9.	NCAOR, Goa	Climate change, Cryosphere, Discharge (Hydrological balance)	-	Harsh climate and difficult excess, Quality check, high cost, high risk of life, small time frame for collecting data	Poor quality/ lack in continuity/ sparse data/ maintenance problem. Patchy data, rare annual hydrograph of high Himalayan basin	Digital/ printed in publications(FREE)
10.	ICAR-NRCY, Arunachal Pradesh	Climate change	State government	-	No detailed information available on the climate change data in the yak rearing region of Arunachal Pradesh (West Kameng and Tawang)	Digital/ on request (FREE)
11.	CSIR-NBRI, Uttar Pradesh	Climate Change, Cryosphere, Biodiversity(Point level microclimate data generated in two geographical regions of Himalayas)	-	-	-	Excel data sheet
12.	Kumaun university, Nainital, UK	Biodiversity, Socio-ecological	-	-	-	Published research paper hard copy
13.	I.C.A.R.-Directorate of Mushroom Research, HP	Biodiversity	-	-	-	-
14.	HFRI	Climate Change, Biodiversity, Socio ecological, EIA, Pest Disease, IPM Strategy, Medicinal Plants, Cold Desert Afforestation and Pasture management	ICGRE, GBPIHED, DBT, ICAR, Jaypee University, UHF Nauni, SKUAST Jammu	Do not have any issue	Site Specific data not available, Biodiversity assessment, its status, prioritization etc. In different wildlife sanctuaries and other area of significance is essentially required to be worked out/ can be shared with other organization	Free/ Sponsored under projects

15.	BSI	Biodiversity	No Information	No Information	No Information	Publications
16	Nagaland State Science and technology	Climate, Disaster, Socio-ecological	NESAC, Soil and Water Conservation Dept., Economic Census	Data from other sources often lacks proper documentation	Poor quality; Often needs prior permission.	Digital and Hard copy (FREE)
17.	FSI, Dehradun	Disaster(forest fire Monitoring)	State forest department	Accessibility (Satellite data)	-	Digital/ website (FREE)
18.	Wadia institute of Himalayan Geology, Dehradun	Climate Change, Cryosphere, Disaster	IMD, State government departments such as Disaster Management cell, Forest department, Irrigation department, Hydropower projects, etc.	At times it is difficult to obtain data from other sources because of the administrative procedures involved	Very few glaciers are being monitored in field because of accessibility issues and lack of trained manpower. Site specific basic supporting data for disaster assessment is not enough for inferences.	Reports/ Published work/ Research paper/ PDF/ Digital
19.	National Remote Sensing centre, Hyderabad	Climate Change, Cryosphere, Disaster, Biodiversity, Socio-ecological, Any other(Land cover/ land use)	GSI, Space Application Centre IMD, INCOIS, NASA, USGS, NOAA, European Space Agency U.S. Environmental Protection Agency, WMO	Delay in timely availability of Rainfall data in IMD website.	Steep slopes/ terrain and cloud free optical satellite data availability; SAR data has limitations in hilly terrain. Gaps in information related to Community/ Species level vegetation maps	Geospatial/ FREE
20.	WII, Dehradun	Biodiversity	IMD, IITM, FSI, NRSC, CWC, SOI, GSI, NBSSLU, FSI, ZSI, BSI, Forest Dept., GB Pant, Universities, Museums, CZA, NTCA, Census of India, NSSO	Accessibility, Timely availability, Reliability, etc.	Heavy cost, Digitized legacy rate, development data another issue	On Request(FREE)

21.	IMD	Climate and Cryosphere	Few State authorities and other organizations having observational Network, disaster events from state and central govt. authorities	Accessibility	Inadequate observational network and lack of data sharing with respect to climate change and disaster management (planning & preparedness)	Paid/ Free
22	ICIMOD	Climate, Cryosphere, Biodiversity and socio-ecological	National Meteorological Organizations, Satellite data for cryosphere, Relevant Disaster Management Agency, Relevant protected area/ State forest Department	Accessibility, Reliability/ Quality, Complex data sharing policy	Reference and projected climate data for high all IHR states, Glacier retreat & Mass balance for glaciers, Database on disaster, Biodiversity data is available but not for PAN IHR	Website (Free)
23	GBPNIHESD, Kosi-Katarmal	Climate, Cryosphere, Biodiversity and socio-ecological	IMD, ISRO, IITM, BSI, State Forest Department, Economic Census, FSI, DBT	Accessibility, Reliability/ Quality, Complex data sharing policy	Lack of continuous temporally continuous climate and cryosphere data. Location specific and geo-coded datasets on flora/ fauna	On Request; Digital/ Hardcopy

Annexure V

Gaps identified in the data availability on different parameters

Climate and cryosphere related issues	Parameters	Available spatio-temporal scales	Data availability	Gaps Based on Survey responses	Remarks
1. Accelerated soil erosion, landslides and floods 2. Rainfed farming and decline of crop yield 3. Water scarcity for household use 4. Deforestation and land degradation Forest Degradation 5. GLOF	1. Precipitation[A,B] 2. Temperature[A,B] 3. Radiation[A,C] 4. Soil temperature[A] 5. Soil moisture[D] 6. River/ spring/ stream discharge 7. Sedimentation rate 8. Snow density 9. Snow cover [E] 10. Snow albedo[E] 11. Geospatial distribution of glacial lakes and water bodies Forest Cover	1. Gridded: at 0.25 x 0.25 deg. or above on daily temporal scale duration 1901-2015 for precipitation and temperature. 2. Gridded 3 x 3min snow cover data since 2014 to present. 3. Gridded 5 x 5km albedo data since 2015 to present. 4. Selected catchment specific river/ spring/ stream discharge and sedimentation rate data. 5. Scatter point source data predominantly over north western Himalaya of research grade climatic parameters.	1. Geospatial data (rainfall and temp.) available through IMD, GOI; Purchase. 2. Geospatial data (snow cover; albedo, lakes and water bodies) available through NRSC, GOI; Free. 3. Point source data available from R&D institutes through request and after publication. User charges may be applicable. 4. Few gridded climate and cryosphere data are available from International resources as mentioned in ANNEX A; Free.	1. Lack of continuous (Spatio-temporal) climate and cryosphere data over NE/ whole Himalayan region 2. Very few reliable climate and cryosphere data above 2500 m elevation. 3. Geospatial data resolution (spatio-temporal) is coarse for Himalayan terrain. 4. Non-existence of snow thickness data/ mapping	Poor quality/ lack in continuity/ sparse data/ Instrument maintenance problem Geospatial data need verification with point source data No uniform data format for point source data collection by R&D institutes

Issues	Parameters for data requirement	Data availability	Data gaps
Deforestation and loss of biodiversity Invasion of alien Species Forest Fire Over-exploitation of bio-resources Pest & Disease outbreaks Connectivity of corridors Outmigration Loss of carbon sink	Grid based quantitative information on biodiversity/ species richness (flora/ fauna/ agro-diversity) Location specific information on forest cover/ area under forest/ biomass stock of timber, NTFPs, etc. Rate of loss of species/ population change Information/ data on biodiversity of PAs network Invasive species/ pests; area of spread and loss to biodiversity/ forest wealth Area damaged/ loss of biodiversity/ forest wealth due to forest fire Causes of forest fire Quantitative information/ data on bio-resource use/ pattern	Checklist of Flora/ Fauna in selected states/ protected areas Forest types/ forest cover/ forest growing stock at State Level List on economic and threatened taxa Biodiversity present in Garden/ Park/ Zoo/ Herbaria/ Museums/ Arboreta, etc. Conservation protocols/ approaches on selected species Project based dataset on species/ population dynamics Checklist of selected high-value species of conservation importance	Location specific and geo-coded datasets on flora/ fauna Species/ community wise data on forests Location specific data on rate of deforestation/ loss of plant/ animal species. Long-term changes in population status of biodiversity (flora/ fauna) for conservation priority. Geo-coded specimens/ live repository in Herbaria/ Parks/ Arboreta, etc. Best practices of conservation of biodiversity Availability of bio-resource of priority species Gaps on peat land.

Disaster Related Issues in IHR	Parameters/ Data required	Data Availability	Scale of Data	Data Gaps as per survey responses	Remarks
Natural Hazards Geological (Earthquake and Land/ Mountain slides, Avalanches)	Seismic Zone map	Event specific geospatial data*, Local and regional grid wise in the Himalayan region for site specific events#	Seismic data is available at State level and at coarse scale. Local and regional gridwise#	Fine resolution seismic zone map at district level	
	Land/ Hill slide prone areas/ Land Subsistence	Event specific geospatial data. For Uttarakhand District level data^	Landslide data is available at State and grid level	Potential hill slide location data along Roads and highways	-
	Avalanche data	-	-	Event specific data with attributes	No response on Avalanche data.
Climatological (Forest fire, Flash Floods, Cloud Burst)	Forest fire map	Geospatial data with temporal scale of 4 alerts/ day. District level data for Uttarakhand^	Forest Fire data is collected at point source and Grid level	Zone of influence and loss analysis Damage assessment to biodiversity.	Traditional coping mechanism may be collected
	Flash flood data/ GLOF/ Floods	Opportunistic satellite data availability site specific studies*, may include large area along the rivers.	Temporal distribution map of rainfall data	-	-
	Cloud burst : Rainfall related data	Data is collected after the disaster for any particular area			Continuous data for prone area to be generated
	Road accident data	District level data for Uttarakhand	Site specific data	Cloud burst data for Himalayan and especially North eastern region	-
Technological or Man made (Road Accidents and Urban Sprawl)			Event Specific data		

	Data Requirements	Scale (Time/ Spatial) Of Req. Data	Data Availability/ scale	Gaps	Response of Institutes
Socio-ecological Issues					
1. Hydropower development A. Info needed for informed decision making - EIA/ CBA/ SIA etc. Appraisal statements for large/ small, & run-off the river projects for various places & sites - Submerged area/ Economic Losses - Disaster/ Climate Risks Accounting	- Demographic structure - Biodiversity - Geomorphic structure of the dam area/ probable sites - River Flow - Siltation - Area of submergence/ simulations (Agri, habitation, forests, other resources), HH/ villages affected/ Agri land - Disaster History - Social vulnerability - Physical vulnerability - Risks accounting/ simulations	- Village wise for dam affected/ influence area/ probable dam sites - Grid based (1: .....) Season wise - Near Confluence points of tributaries - Land use/ village/ decadal Demography/- - for available years - Influence/ affected zone/ 5-10 yearly	Village level/ yearly - Not available - Not known (Project specific) Agri- Not Available No Data	- Biodiversity Data needs to be generated I Data Gap I I Data Gap I	-Area specific case study based info Not reported Not reported Not Reported

2. Sustainability of Rural Ecosystems 2a. Agricultural Sustainability (Non-remunerative agriculture/ poor Agricultural returns) - Crop productivity under different farming practices	- Crop productivity under different farming practices - Per HH Landholding and livestock holdings - Soil Quality - Irrigation Status (Irrigated/ un-irrigated agri area ratio) - Agricultural workforce/ labour - Vicinity forest type (uphill)/ Forest to Agril land ratio - Technological options zonewise - Wildlife conflicts (Crop damage, invasion statistics) - Seed/ planting material availability - Market chain options/ Linkages - Status of traditional crops Type/ production - Climate conditions (Precipitation, Temp, Humidity	- village level/block level/ 5yr/ 10yrs - Village level/ 5 village/ 5 yr - village basis/ 5 yr Village/ zone/ 10 yr Village/ Zone /Sub-watershed; 5-10 yrs village & crop wise/ 5 yrs - Alt Zone-wise/ 5 yr Zone-wise/ 5 or 10 yr - Village/ cluster/ 5yrs Zone wise/ village	- District/ yearly - Dist. (LStock)/ 5yr No database Village/ 5yr Village/ decadal Village/ 10 yr - NA - No data/ case specific - Case study based - No data - No data - No data - No data	- Village level compilations to be brought out I Data Gap I Data Gap I I Data Gap I	Case study based/few areas Not reported

2b. Out-migration/ depopulation of villages	- Population statistics over a time scale - Reasons for outmigration - Health facilities PHCs - PDS - Schools/ Colleges/ Education -Alternative Livelihood/ Income Options - On farm - Off Farm - Industrial - Eco-tourism - SWOT/ Livelihood Developmental Scope Appraisals	Village level - Village/ sub-watershed - Village Level - village level/ 10yrs - Village/ 5 yr Village/ cluster/ eco-cultural zone/ sub-watershed/ 5-10 yr	-Village Few cases (CS based) - village No Data	- Data gap - Data Gap	Case study based Not Reported
2c. Status of Rural Women &minimizing drudgery of female workforce	-Female Literacy/Levels - Woman health - Nutritional status - Time spent in Daily chores - Distances travelled for collection of fuelwood/ fodder etc. (Opportunity costs/ impacts) - No. of LPG Connections - Electrification status - Appraisals of drudgery reduction choices/ measures	Village/ Village/ Village cluster/ distance remoteness basis/ 5 yearly	Village/ yearly -Case study based only few cases (Po)	- Data Gap	Not Reported

3. Traditional/ Indigenous Knowledge	- Knowledge type/ database - Health Care (knowledge base) - Preservation/ storage of agri produce - Water resource conservation - Plant varieties/ breeding -Traditional means of livelihood	Village/ eco-cultural zone/ tribe/ community/ region wise - 10 yearly	-Case study based in published form/ few cases might be existing, - Some documentation digital database	No organized documentation/ Still some data gaps	Traditional means of Livelihood, Livestock husbandry, and pastoralism for few cases reported

Annexure VI

Minutes of the Meeting of 'NITI-Aayog Working Group on Data/ Information for Informed Decision Making' held at NITI Aayog, New Delhi, on Aug 18, 2017

A meeting of NITI-Aayog Working Group 5 constituted for assessment of data requirements and availability and data gaps across various sectors/ Institutions for informed decision making on key conservation and development issues for sustainable development of mountains of Himalaya was organized at NITI-Aayog, New Delhi on Aug 18, 2017. The meeting was convened to deliberate on the key conservation and development issues under the specified themes, and to share the data availability response received from various institutions/ universities/ organizations, and data availability with recognized data agencies, the data requirements & gaps, the sharing of the responsibilities of the task amongst the member institutions of the working group.

The meeting was chaired by Dr A K Jain (Advisor RD, NITI-Aayog). The representatives of - 'NITI-Aayog', the member institutions of 'Working Group-5', and that of the lead institution (G B Pant National Institute of Himalayan Environment & Sustainable Development) participated in the meeting.

The list of participants is given in the list below.

- At the outset the Chairperson welcomed the participants, and briefed them about the genesis of the Working-Groups, the rationale behind the team constitution and identification of lead and member institutions for Group-5 tasks.
- Alluding to remarks of ICIMOD in a previous meeting of June 2016 on 'Sustainable development of mountains of Himalaya' stating Himalaya as a data deficient region, he said in Himalaya a lot of work is yet to be done towards collection of suitable data sets, identification & overcoming data gaps, and collation/ compilation of data to appropriate decision formats.
- It was emphasized that the interdisciplinary working and intergovernmental experience of ICIMOD on sustainable mountain development policies and observations on best practices implemented across Himalaya and other countries will be very crucial as a partner member of the group and preparing roadmap for sustainable development of mountains of Himalaya.
- He also spelled out the task of the working group which included description of magnitude of the problem, gaps, existing policies /plans/ practices, measures/ institutions/ capacities required to address the problem, and the short term and long term actions required for the redressal.
- Er K Kumar, Scientist-G and nodal person from the lead institute (GBPNIHESD), provided an orientation of the task, the state of the progress, flagged key conservation and development issues, and highlighted issues like data requirement needs, optimal temporal/ spatial scales, data digitalization/ digitization and retrievability/ extractability etc. The relevance of data on regional levels/ scales on issues such as climate change, ecosystems, agro-ecosystems, and sector specific data from the perspective of decision making was also underlined.
- The constraints related to use of available data, its authenticity, compatibility, validation, user charges,

archival of paid data, non-availability of unpublished data, and policy regarding time-frame for bringing unpublished data to public domain, etc., issues were also raised as discussion points on data management and sharing mechanisms.

- It was emphasized that there should be suitable policy arrangements for easy access of data, organized compilation of data, institutional responsibilities for data sharing, and credit mechanisms for confidence building to encourage data sharing. It was suggested that web linkages for data obtained/ available at various sources should also be provided with envisaged data management/ hosting platforms.
- Dr Nisha Mendiratta, Advisor CCP, DST, New Delhi mentioned that DST with the involvement of several national and State level research Institute has evolved and supported R&D projects with the aim to generate comprehensive data across five sectors i.e. Land, Water, Geology, Socio-economy and Biodiversity for lower, middle and higher hills of Himalayan region to support the requirements of local level decision makers and further the dissemination of generated information for sustainable development. It was also mentioned that these data were further integrated for generating suitable action plan by the decision makers. The data standards for watershed level experiments/ studies (up to 1:12,500 scale) were also attempted under this programme. DST has developed a database framework for Bio-Geo Database creation and Sustainable Watershed Development Planning in Himalayas which has also been Published.
- Dr Nisha further briefed on National Mission on Sustainable Himalayan Ecosystem (NMSHE), being coordinated by DST and other institutions having the objective to assess scientifically the vulnerability of the Himalayan region to climate change and to collate, generate data required to address the various technical thematic issues in the Himalayas aiming to build and support capacities at the central and state levels and formulate adequate response measures to the challenges in the Himalayan region.
- In response to IHR data sharing policy to be adopted by institutes, Dr Nisha highlighted on the National Data Sharing and Accessibility Policy (NDSAP) which has been designed to share non-sharable data generated by various Ministries/ Departments/ Subordinate Offices/ Organizations/ agencies of Government of India with user's community. The NDSAP policy is designed to promote data sharing and enable access to data for national planning and development.
- Dr Rajesh Sharma, Scientist, WIHG made his presentation on Cryosphere data available with the Wadia Institute. He apprised the group that the Wadia Institute has a continuous seismic and GPS data for selected sites in Himalaya from July 1, 2007, which is collected on real-time basis and can be shared. It was also informed that the Institute is also collecting data through its Multi Parameter Geo-physical Observatories (MPGO) (Gutu, Uttarakhand) the information from which is used as a precursor for prediction of earth-quake.
- It was also apprised that the Wadia Institute is monitoring 4 -Himalayan Glaciers for retreat, mass-balance, ice-volume, hydro-meteorological observations, and glacial lake inventory, and the institute has meteorological data for Dokrani & Chaturangi Glaciers, and 'Ice-thickness map indicating ice volume vis-a-vis retreat' for the Dokrani Glacier. It was suggested that the data/ information on landslides/ flash floods/ cloud bursts is event specific , and not on continuous scale; such data/ information is available in published form in PDF format.

- In view of the increased incidence of extreme events a suggestion was made wherein the need for 'sensitive area demarcation with respect to rainfall' was underlined. It was informed that in Sutlej valley a positive relation of rainfall with landslide was observed, and under NMSHE such data-base for west Himalaya is being developed.
- With regard to data sharing it was argued that a) the Himalaya is a sensitive area/ region, the sharing of data/ information therefore is difficult/ involves risks, b) credential/ credit of research accrue only after the publications, c) further interpretation of such information requires detailed knowledge of the phenomenon/ subject, and might lead to miscued deductions. The incentivizing data publication/ web dissemination was also suggested.
- It was remarked that very little information on the Cryosphere data is available, and even the processed information of publications is not available for decision processes; it was suggested that some pooling mechanism for data generated under different projects and that existing with different agencies/ institutions there should be put in place and such information be made available at some central archival/ platform for future use and planning. The need for identification of institutions that can be made responsible for collection/ collation of data was also stressed.
- It was remarked that the isolated project based studies wouldn't be of much use for decision making and instead area-wise/ region-wise/ macro level data sets would be required. The need to explore possibilities as to how this project based data can be merged with regular data collected by NRSC and other data agencies, was expressed.
- Dr Mohapatra from IMD informed that IMD collects some selected data on climate, cryosphere, disaster, and paleo-climate for the Indian Himalaya Region; the climate data is available on Real Time basis and the Archived forms. The Real Time data can be accessed by anyone through IMD website, while the Archived data can be obtained through requests. He added that the data required by government institutions for research purposes is available free of costs while the data for commercial uses is charged as per the department policy. The cryosphere data of IMD is available for snow depth only, and IMD also needs data on climate change.
- He informed the group that the IMD is planning new installations for climate monitoring in Western and Eastern Himalaya, and need to identify institutions that can provide past data for data reconstruction and to fill data gaps. It was pointed out that for climate and cryosphere information we have limited observational network, and whatever available is largely inaccessible; further data sets obtained from different agencies are mostly incompatible, and often lead to contradictory results/ interpretations.
- It was informed that IMD thru its Mountain Meteorological Division collects Real Time data for 7 regions of 3 states i.e. J&K, Himachal, and Uttarakhand of the Himalaya. This real time data is used to make 5 to 7 days weather observation forecasts for the entire Himalaya with almost 75% of accuracy, under normal circumstances.
- Dr Sudhakar Reddy from NRSC Hyderabad made a presentation on data sets available with NRSC in different fields/ sectors for the IHR in their BHUVAN Portal. A reference to NICES (National Information System for Climate and Environment Studies), a separate portal of NRSC, which contains data/ information on climate and environmental studies was also made for check of types of data set availability. The presentation covered description of data on climate change, cryosphere, disaster, biodiversity, socio-ecology, and land use/ land cover, their spatial and temporal scales/ formats, and

data sharing etc. The data for flora-fauna was derived through regular monitoring of 16000 locations and for the forest fire, disaster, landslide, and seismic data is locale/ event specific.

- The presentation from Dr Sunil Chandra, FSI covered the data collected by the from FSI Institute, which mainly confines to forest inventory, field data, and the maps; the classification of forest cover is done biannually, and forest type maps for all Himalayan states are available at 1:50,000 scale. It was told that the FSI has been carrying out the Real Time monitoring of forest fire at district level throughout Himalaya since 2004, and the data for the period 2004-2017 is available. The data is also used for burnt area assessment and pre-warning alert for forest fire. It was also informed that 'Data content standard on forest' have also been developed by FSI.
- Mr Ashutosh Tiwari from GBPNIHESD, presented the update on the progress of the work carried out so far; the presentation covered the requirements of data on the designated issues/ themes and identified sub-themes, and the data availability with recognized data agencies and the organizations/ institutes contacted in this context, the scale of data, etc., for discussions/ suggestions on new sub-issues/ themes to be included, clues on data sources, new data to be generated, and data sharing mechanisms/ possibilities.
- The data deficiency in climate and cryosphere section was discussed, and to overcome the gaps, the need to explore possibilities of suitable interpolation/ extrapolation was suggested.
- Dr Vishwas Chitale, ICIMOD suggested to refer the regional database system of ICIMOD http://rds.icimod.org/ to look for IHR data across different sectors which might be available and could be used for decision making.
- In disaster section, incorporation of land-subsidence as an issue was suggested; for snow depth 'GLIMS Database' was referred for data availability checks, and remote sensing data was also suggested for use/ modelling applications. The inclusion of data on snow cover fraction (fraction of snow cover) was also suggested and need for development of database on climatic extremes/ extreme events was also underlined.
- In bio-diversity section few new themes i.e. Corridor Connectivity, Trans-boundary Conservation, Pest & Diseases, Loss of Carbon Sink, Payment for Ecosystem Services and Outmigration was included in the list of issues, and 'Peat Land' included as a data gap area.
- The summary of responses of various institutions/ organizations revealed that the socio-ecological section is a data gap area. During the discussions the question as to what data is required for decision making on conservation and development issues was raised. It was agreed that the data available in census reports, livestock/ agricultural census, economic survey/ socio-economic survey reports, land-use etc. could be a good input for synthesis of information for any decision making exercise, but the decision making needs a different type of data-set/ information involving a comparative analyses of decision choices in the form of appraisal statements, EIA, CBA etc.; a need for generation of such data was expressed.
- It was suggested that in the summary of statement of 'Data availability and gap area' the web-links of the secondary data sources should also be given; for information on water availability at village level a check on 'mdws.gov.in' under National Rural Drinking Water Programme (NRDWP) was suggested.
- At the end the sharing of the responsibilities for the group task was discussed; based on the expertise of

the various member institutions, the following arrangement for information compilation and report on specified themes was agreed.

- Climate and Cryosphere: IMD to take lead, to be assisted by WIHG and GBPNIHESD
- Disaster: Wadia Institute of Himalayan Geology
- Retrieval Mechanisms, Data Coasting and Sharing: NRSC, Hyderabad
- Biodiversity: WII (Lead), FSI, and GBPNIHESD to assist
- Socio-ecological: GBPNIHESD (Lead) and DST (Guidance)

- The meeting ended with a vote of thanks to Chair and other member

List of participants

1. Dr Ashok Kumar Jain, Advisor (RD), NITI-Aayog, New Delhi
2. Mr Neeraj Srivastava, Director (RD), NITI-Aayog, New Delhi
3. Dr Padma Kant Jha, Dy Advisor (RD), NITI-Aayog, New Delhi
4. Dr Vandana Sharma, Dy Advisor (RD), NITI-Aayog, New Delhi
5. Dr Nisha Mendiratta, Advisor CCP, DST, New Delhi
6. Er Kireet Kumar, GBPNIHESD, Kosi-Katarmal, Almora
7. Dr M Mohapatra, India Meteorological Department, Lodi Road, New Delhi
8. Dr Rajesh Sharma, Wadia Institute of Himalayan Geology, Dehradun
9. Dr Sunil Chandra, Forest Survey of India, Dehradun
10. Dr Sudhakar Reddy, NRSC, Hyderabad
11. Dr Gautam Talukdar, WII Dehradun
12. Dr Vishwas Chitale, ICIMOD Kathmandu, Nepal
13. Mr Ranjan Joshi, GBPNIHESD, Kosi-Katarmal, Almora
14. Mr Ashutosh Tiwari, GBPNIHESD, Kosi-Katarmal, Almora
15. Mrs Monika Singh, Senior Research Officer, NITI-Aayog, New Delhi
16. Ms Kritika Mittal, NITI-Aayog, New Delhi
17. Mr Yogesh Kumar Singh, NITI- Aayog, New Delhi

Annexure VII

Minutes of the Meeting held on 27.06.2018 under the chairmanship of Dr. V. K. Saraswat, Member, NITI Aayog in Room No. 122, NITI Aayog to discuss Draft Working Group Reports on Sustainable Development in mountains of Indian Himalayan Region

At the outset, Dr. Ashok Kumar Jain, Adviser (RD/ SDGs), NITI Aayog welcomed Dr. V.K. Saraswat, Member, NITI Aayog, all the participants from Central Ministries/ Departments , Institutions, officials from Himalayan State Governments, conveners of all 5 Working Groups and representatives from ICIMOD, Kathmandu. He appreciated all Working Groups for their Draft Reports and recalled that the Working Groups for Sustainable Development in mountains of Indian Himalayan Region were constituted about one year back. Now, the WG Reports are at the stage of finalization. He briefed about the programme details of the meeting that the conveners of Five Working groups will do presentations followed by discussion and finalization of further course of action. After that, he requested the Member, NITI Aayog for his Opening Remarks.

Dr. V. K. Saraswat, Member, NITI Aayog again welcomed all the participants and recalled the conference held in Kathmandu where the thought of 'Himalaya calls a New Development Narrative' had come up to take care of the all areas like Spring Revival, Tourism, Skill Development and Shifting Cultivation etc. for which the Working Groups were constituted. He further expressed a concern over contradictory demands. Demand for economic growth ultimately affects environmental and social aspects at a large scale which is not acceptable. He cited the example of Shimla which is facing large influx of tourists and eco-system related problems. This is generating economic growth but at the cost of environmental issues. It has to be sustainable in all the ways. He requested the States to prepare Implementation Strategy for recommendations of the Working Group Reports. In this context, three steps should be followed; Implementation of the strategy, Monitoring of the schemes and Impact Analysis.

Adviser (RD/SDGs), NITI Aayog commenced the session with a brief presentation. He narrated the journey so far, emphasized on the tasks for WGs, tools and platform, and best examples for inclusiveness and ownership. He threw a light on the objective of the meeting and gave the example as the best practice on springs in Sikkim where Government of Sikkim is doing a very good work in rejuvenating the springs.

Presentation by Working Group 5 on Data/ Information for Informed Decision Making by Multiple Stakeholders: Er. Kireet Kumar, Scientist G, GBPNIHESD and the convener of the Working Group 5 on "Data/ Information for Informed decision making by multiple stakeholders" made the presentation containing the details of objectives, approach adopted for the task of Working Group, key issues of IHR and the compilation of data requirement, availability and data gaps across the sectors, sector-wise key suggestions and recommendations, need for Centre Data Management agency (CDMA) for hosting, managing and disseminating data for IHR.

Suggestion/ discussion on the draft report of Working Group no. 5:

Dr. Vishwas Chitale, ICIMOD mentioned that maintaining of the Database for IHR data has been the critical issue which is to be addressed on urgent basis. It was also highlighted that there is a need of enhanced implementation of existing data sharing policy with required modifications after which the suitable data can be made public for informed decision making. Dr. V.K. Saraswat, Member, NITI emphasized the concern for hosting the data/ information at a centralized server for informed decision making. It was suggested by Member, NITI Aayog that GBPNIHESD can be the Central Agency for data collation and management for the whole IHR. GBPNIHESD should collaborate with ISRO, ICIMOD and other data disseminating agencies for larger volume of data hosting. Dr. Rajan Kotru, ICIMOD put certain important aspects which mainly focused on Network of Permanent Sample Plots to know about what is happening in the landscape, emphasis on data with communities and maintenance of consistent data. Dr. Akhilesh Gupta, Adviser, DST mentioned that NDSAP data sharing policy was framed mainly keeping in view the metadata, which is to be slightly modified, based on the Data/ Information available in public domain. He also added that lot of data is available with community which may also be augmented in the proposed new database. He highlighted that few Institutions such as ISRO and DST have their own hub for hosting and disseminating the data but the data available are generic and not specifically pertain to IHR. Therefore, the requirement of dedicated institute like GBPNIHESD for maintaining IHR specific database is a must. He suggested that state level initiative will be required so that all the data lying with State may be pushed to the proposed data server. It was suggested by Shri B.M.S Rathore, Chief Policy Advisor-NRM, ICIMOD that GBPNIHESD is a national institute for sustainable development of Himalayas and for managing this data for decision making, it should be linked to the ICIMOD as it has a regional database.

The Deputy Resident Commissioner, Manipur strongly suggested to make an access to credit for tribal people. There is no collateral to support land ownership, so proper access to credit must be incorporated for the tribal people of Manipur. A detailed study of land ownership and land system must be done as tribals have very strong emotions attached to land. A proper land ownership should go hand in hand in policy implementation. He mainly pointed out to look deeply into the matters of the skill development and entrepreneurship. People get vocational training to establish their business. Proper assistance after training must be built in. The representative from Sikkim put forward her views by saying that recently the State Government of Sikkim has submitted the proposal for supporting sustainable tourism. She strongly stressed upon to make a platform for sharing the revenue of tourism with local communities so that sustainable tourism becomes successful. She illustrated her views through an example of Changu Lake. This lake is frequented by tourists because the state govt. has set up a Tsomgo Pokhri Sanrakshan Samiti, which attracts tourists to visit and collects revenue from them to share between the Forest department and Tourism department. The maintenance of whole area is regulated out of revenues collected from the tourists. The representative from Nagaland put forward his views on importance of springs for tribals which accelerates their livelihood. Maintenance of spring and rejuvenation of spring water must be highly encouraged. There must be focus on improving Jhum cultivation by enhancing the Jhum cycle. By summing all the concepts regarding the Jhum cultivation, he put forth his words by saying deforestation is not due to Jhum cultivation but due to settled cultivation. The representative from West Bengal appreciated the concepts discussed regarding the tourism, springs and shifting cultivation. Shri Uma Kant, OSD, Govt. of Mizoram said that State Wise Implementation Plan must be formulated. As the capacity is limited in North Eastern States especially in Mizoram, there must be a full fledge focus on pilot at district level first and then

replicate it to remote areas. A representative from Nagaland put certain actionable views by highlighting the concept of Shifting Cultivation. In order to have remuneration for the farmers, increase Jhum tenure from 2 to 3 years which in turn automatically increase the Jhum cycle. She illustrated with one an example of Dimapur where certain interventions are put in place for improving and transforming the upland agriculture.

Smt. Jyotsna Sitling, Joint Secretary, M/ o SD&E emphasized on the main fact that key information need to be integrated in the Skill Development and Entrepreneurship. She suggested NITI Aayog to share the presentation to cross integrate those issues which are cross cutting. She requested the States of Assam and West Bengal to look into these aspects deeply. Mr. B.M.S. Rathore thanked NITI Aayog for building sustainable development among five themes. He pointed out some issues of springs to be at alarming stage. There is a need to transform shifting cultivation to access ecological security. As Jhum is the way of life that we should take up the key challenges and address these challenges. Looking at the data, if not 50%, at least 1/3 of the springs are dying which is a very the serious issue. All groups' recommendations can be categories into 4-5 categories. We should think for convergence and leveraging of resources and new capacity building across the sectors. Modern technology along with traditional science may be introduced. Mapping of each and every plot of IHR through technology needs to be done. Research should be done in Niche mountain products. On the finance part, it was suggested that Green Climate Fund, Cess and payment of eco-system services, along with sharing revenue with the community can be the areas to work. Water policies need to be implemented properly. The Central Govt. scheme running in the IHR i.e. MGNREGA may be used to improve the existing resources. Dr. V. K. Saraswat, Member, NITI Aayog opined that Jhum Cultivation is creating damage to afforestation. He recommended that like North-Eastern Region Development Authority, Himalayan Development Authority may be formed in which Chief Secretaries of all Himalayan States become the members. Entire development of Himalayan States may be coordinated through this authority. Majority of problems can be solved immediately at that level. He emphasized that actionable recommendations should be placed, not the statement of the problem.

Advisor (RD), NITI Aayog reiterated the main points of all Working Groups' presentations and mentioned to put some Dos and Don'ts for the tourists at prominent places including the public transport in the IHR States. Improving and strengthening the public transport for the local visit as well as promotion of the usage of eco-friendly vehicles in IHR States is also important. He also suggested that G.B. Pant National Institute of Himalayan Environment & Sustainable Development may become the Center for Data Management for IHR States. He has suggested the following timeline for the completion and release of the final reports:

Sl. No.	Date	Task to be performed
1.	9th July, 2018	Final Report of the Working Groups to be submitted by conveners of Working Groups
2.	16th July, 2018	Summary of the Summaries by ICIMOD
3.	31st July, 2018	Sending of Summary of the Summaries to the concerned Central Ministries and the State Governments in IHR for their feedback and comments by NITI Aayog
4.	7th August, 2018	Finalization of Report and Layout of the design by ICIMOD & NITI Aayog
5.	15th-20th August, 2018	Printing of the Working Group Reports
6.	20th August, 2018	Final Workshop (Release of the Working Group Reports)

14. The meeting is ended with vote of thanks to the chair by Director, RD, NITI Aayog.

Annexure VIII

Brief Survey on Problems prevalent in the State

Sectors	Problems	Data requirement of the State	Source for data procurement	Difficulties in Procurement
Water	e.g. Water Scarcity, etc.	e.g. Water body maps, spring location, etc.	e.g. NRSC, Hyderabad	e.g. time consuming, complex mechanism,etc.
Agriculture	e.g. Low production, etc.			
Forest	e.g. Deforestation, etc.			
Tourism	e.g. Destructive tourism, etc.			
Disaster	e.g. Landslide, flash floods, etc.			
Livelihood	e.g. Unemployment, poverty, etc.			
Any Other	.....			

1. What mechanism you suggest for making the various sectors data available to the state for planning and informed decision making?

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2. Are there any suggestions or recommendations you would like to make for any specific data requirement which can help to address or deal with the issues prevalent in your state?

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Date

Sign with Seal:

Name:

Designation:

Name of State:

Note: Kindly download the questionnaire and please send back duly filled scanned copy through email on: nitihimalaya@gmail.com and/ or through speed post on following address at your earliest convenience on or before September 15th, 2017 :

Er. Kireet Kumar

Scientist 'G', Group Head (WPM, EAM, EGP)

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