Draft Report

SUSTAINABLE DEVELOPMENT IN MOUNTAINS OF INDIAN HIMALAYAN REGION

WORKING GROUP ON "DATA / INFORMATION AVAILABILITY FOR INFORMED DECISION MAKING BY MULTIPLE STAKEHOLDERS"

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PREFACE

NITI AYYOG (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 & Sustainable Development (GBPNIHESD) as a Lead Institution as Convener of the Working Group 5 "***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 need to be developed to the level of fidelity), formats, access and sharing at different levels including local, state, national and regional (Annexure-I).

To accomplish the task of this Working Group 5 a systematic approach of consultations were held through several mechanisms with a range of stakeholders both within and outside the IHR engaged in data generation and data utilization for policy prescription in the IHR. In general, it was found that several methods and approaches are followed for collection, collation and dissemination of data / information. No definite protocol is in place for data quality control and sharing except for a few organizations. There is a need to put user-friendly mechanism to access the data for policy and planning in place. There are also glaring gaps in data generation and also quality control of data needs to be addressed. In this report typology of data requirement, data availability, data gaps and proposed measures for quality control of data and mechanism for its access for end-users has been given to make it utilizable for development planning in the IHR. This assignment of dealing with a new domain of data management has been quite challenging and provided us the opportunity to venture in developmental issues of the IHR. Managing data is an evolving process and hence, there is an ample scope of suggestions and improvement in this document. 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 in consonance with environmental conservation of the IHR.

CHAPTER - 1

Himalayan Environment & Sustainable Development: Key Issues

To start with, it is prudent to understand the state of Himalayan environment and concerns of 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 in the 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. Encompassing more than 2,500 km in length and 80 to 300 km in width and rising from low-lying plains to over 8000 m asl the Himalaya produces a

[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 Science* 90 (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.

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, parts of Assam and hill district of 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 total population of the country. 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. Traditionally, indigenous communities in the region have been dependent on bioresources to meet basic sustenance needs, notably food, fodder, fuel, fertilizer, fibre, shelter, health care, etc. 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 Himalayan region is well recognized for diversity of medicinal plants, wild edibles and other non timber forest produce (NTFPs).

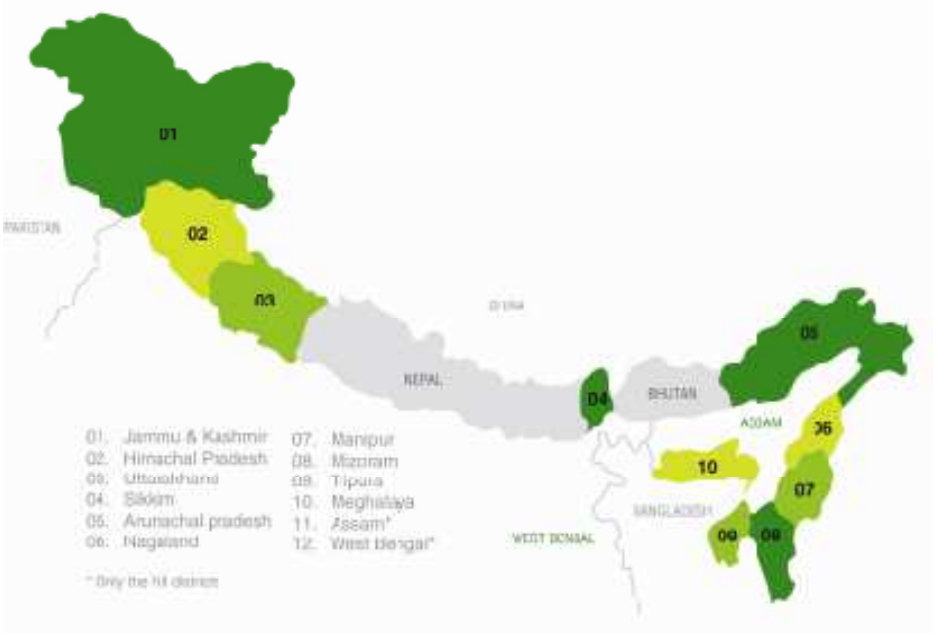

Fig. 1: Indian Himalayan region[4]

[4] Anonymous, 2009. Governance for Sustaining Himalayan Ecosystem (G-SHE): Guidelines & Best practices, GBPIHED, Almora.

The region constitutes the principal basis for the climate system that prevails over India. This region represents diverse biomes/ climate zones (e.g., tropical, sub-tropical, temperate, and sub-alpine and alpine) and recognized amongst 34 Global Biodiversity Hot Spots with 32% endemic flora. This region is a vast reservoir of water and referred to as the "Water Towers of the Earth". Approximately 10–20% of the area is covered by over 9,000 glaciers storing about 12,000 km^3 of freshwater[5] and makes the head waters of important north Indian rivers, and influences the well-being of 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, be they nature-lovers, tourists, or seekers of peace and truth. The Himalaya has historically 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 on the highly diverse and fragile Himalayan eco-system[6] .

In the 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

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

on Climate Change[7] has concluded that there is an unequivocal evidence of current trends of global warming of earth's atmosphere caused by anthropogenic emissions. The geologically young and geotectonically active Himalayan mountains make them 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 the warming rate increases 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. 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 action for environmental conservation and sustainable development".

This region is endowed with rich vegetation and dominated by forested landscape - an important reservoir 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 plethora of goods and services. The forests provide protection against soil erosion, regulate water flows in the rivers connecting the Indo-Gangetic plains and prevent flooding and provide sinks for atmospheric carbon. The Himalayan ecosystem is also vital to the ecological security of the Indian landmass and occupies the strategic position of entire northern boundary (North-West to North-East) of the country. Therefore, any developmental intervention at the cost of forests has a plethora of ecological repercussions. Not surprising, therefore, that the complexity of such issues continues to receive considerable attention at the global fora like the WSSD (World Summit on Sustainable

[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.

[11] Anonymous, 2015. India State of Forest Report - 2015. Forest Survey of India, Dehradun. pp. 1-73.

Development, Johannesburg, August 2002) and Bishkek Global Mountain Summit (October 2002) those emphasize 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, a renowned mountain socio-economist has identified inaccessibility, fragility and marginality as major constraints to sustainable mountain development and has proposed diversity, niche and human dimensions as key opportunities to uplift the livelihood 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 these remain within the carrying capacity of the mountain ecology.

The IHR, due to its undulating topography, difficult terrain, inclement weather conditions and natural hazards, sparse population, poor infrastructure, etc. has been facing various environment and developmental problems and challenges[14]. Also, due to poor infrastructural facilities there are limited opportunities for resource utilization for revenue generation and

[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

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 resources availability and opportunities for mainstreaming development initially, three states in the IHR (Jammu & Kashmir, Nagaland, and Assam) were accorded special category status and covered under special assistance programme of central government. In the Fifth Plan, this list was extended to include 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 has also become the part of this category of states. Thus, all the 12 states of IHR fall in the special category status, or state eligible for assistance under Hill Area Development Programme[1].

Past Efforts on Making 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 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]. Recognizing the importance of IHR and integrating the environment, climate change and development concerns during the last few decades, IHR has attracted the attention of policy makers and planners and as a consequence various task forces/workgroups were constituted by the Planning Commission for formulating the policies for development of Himalayan region. Among these some of the important ones are given in Box-I.

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

BOX-I

Various Task Force / Workgroup / 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 the 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)

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 yielding benefits for addressing climate change efficiently and effectively. The broad objectives of NMSHE include - understanding of the complex processes affecting the Himalayan Eco system and evolve suitable management and policy measures for sustaining and safeguarding the Himalayan eco-system, creating and building capacities in different domains, networking of knowledge institutions engaged in research and development of a coherent data base 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 inclusive of

farming and traditional health care 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 AYOG), 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 of 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 & Ecological Modelling for Himalayas' with an aim to assess the potentiality of various sectors of natural resources under which data base was generated for selected micro-watersheds in the states of Uttarakhand and Himachal Pradesh for application oriented scenarios for 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 the efforts to address the 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 "Governance for Sustaining Himalayan Ecosystems" were the two documents published by GBPIHED. In 2010, Planning Commission assigned this Institute to compile the Task Force report on "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 has exclusive focus on

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

creation of natural and human capital in IHR and finding science based solutions to burning problems of Indian Himalaya (Box-II).

BOX-II
National Mission on Himalayan Studies (NMHS)

The Twelfth Plan priorities include up to 13 monitorable targets towards environment, forests, wildlife, and climate change. The NMHS is expected to support these priorities specifically in the context of IHR and will help in developing understanding on effectiveness of laws and policies in the IHR. The twelfth 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 remove data deficit on glaciers, landslides, sustainable methods of building roads and tunnels, weather and other related issues. In 12th Plan an outlay of 2014-2015 provision of Rs 100 crore has been made 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 practioners (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. The GBHNIHESD, Kosi-Katarmal, Almora is the Nodal Agency to execute the NMHS. Presently under this mission 42 projects have been supported in the 12 Himalayan states on various priority issues of environmental conservation and sustainable development of IHR.

Undoubtedly the people of the IHR aspire for economic growth and development. As mentioned earlier, people of the region, like elsewhere in other mountain ecosystems, are heavily dependent for their livelihood on their immediate natural resources and production from primary sectors such as agriculture, forestry, livestock, etc[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 promoting poverty and degradation of natural resources[18]. Despite its rich biological and cultural resources, the region is under-developed. 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

[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 transboundary landscape, Eastern Himalayas. *Journal of Asia-Pacific Biodiversity* 9: 1-10.

of natural hazards. Large number of studies carried out in the region focusing on development interventions reflect the unscientific exploitation of resources leading to environmental degradation. It is well understood that the problems in the Himalaya are complex, having intricate linkages between social, economic and ecological concerns. The solutions, therefore, cannot be addressed in isolation. Apparently sectoral practices of development will not work, and therefore, 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 around 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, are rich in many aspects (physical, biological, chemical, social, anthropological and economic) and need to be deeply felt, thoroughly researched and properly documented. It has been 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 the Himalayan ecosystems remains rudimentary and poor data, hasty conclusions, and bad science plague Himalayan research. For example, the IPCC (2007) report erroneously predicted for widespread glacier recession exposed how little was known of 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 construction appears driven by passions rather than science.

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 IPCC in its Fourth Assessment Report has described the Himalaya 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 want more systematic information on the Himalayas and the basins of rivers that flow down.

[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.

Across the IHR, various researchers have pointed out towards data gaps and data requirement for conservation planning. Now, the NITI Aayog also recognizes the fact 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 doing fresh research for collecting data set. Unwillingness in data sharing is another major issue which is essential for integration of data for conservation and developmental planning. An international survey conducted to ascertain the attitudes, experiences, and expectations regarding biodiversity data sharing and archiving of researchers 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 want of technological and operational barriers and appropriate benefits 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 can be emphasized that to lessen the "Himalayan Dilemma" characterised with increasing population and poverty, degrading resource base and increasing pressure on marginal resources, prompt action should be taken to improve the livelihood of mountain communities. Harmony should be maintained between the national and international policies and their development priorities. 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.

Process / Approach of WG5

To begin this task a series of brainstorming meetings were held by Convener of the WG5 wherein the requirements of the NITI Aayog were contextualized. To handle this assignment an expert group consisting of six scientists of GBPNIHESD from different subject expertise was constituted to deal with multiple sectors of key conservation and development issues (Box. IV).

[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.

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 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 Technological (Man-made)
- ✓ Loss of Biodiversity and Uncontrolled Exploitation of Biodiversity
- ✓ Unplanned urbanization and hydropower development
- ✓ Destructive Tourism including pilgrimage
- ✓ Sustainable rural development

In the following course of action, this expert group meticulously followed a systematic approach and so far held about 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. I. 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 (Annex. I). Following this, a questionnaire was developed for each sectors separately pertaining to data requirement, data availability and data sharing, etc. (Annex. II). This questionnaire was circulated among the Member Institutes of the WG5 identified by NITI Aayog along with a few co-opted member Institutions to seek their inputs on this draft questionnaire. The final questionnaire after receiving inputs from the Member Institutes was sent to various Institutions/Organizations (listed in Annex. I) for getting their response. The response thus received was compiled and analyzed in terms of sector-wise data availability, source of procurement of data, difficulty in data accessibility, data gaps, quality check, data sharing policy etc. (Annex. III). Also, sector wise issues and data required to address those issues were identified (Annex. IV A-D). In this process a meeting was held by NITI Aayog (3 July 2017) in which progress of WG5 was presented and suggestions / inputs from officials of NITI Aayog /Conveners

of other Working Groups were received which were incorporated in this report. 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 shall be finalized after incorporating suggestions/recommendations of different stakeholders and also based on further analysis of data/information collected to make this document useful for policy makers and development planners.

Fig. 1: Approach adapted by GBPNIHESD for execution of WG-5

CHAPTER 2 A
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 corresponding temperature over regions in the other continents along similar latitudes. Therefore, it is often epitomized as *'climate regulator*' or '*weather maker*' or '*ecological buffer*' of South Asia. With reference to the 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 cms). In the current context of climate change, this highly fragile region is expected to response irregularly in almost all aspects of life. Rapid climate-induced changes in the region directly affect the water resources of more than 1.3 billion lives, as well as services such as electricity, and the food supplies of 3 billion. 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] have done a study related to precipitation fluctuations in the Nepal Himalaya and its vicinity and found a large inter-annual and decadal variability in the 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–

[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.

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 1.5ºC over pre-industrial average temperatures—similar to increases seen in the Arctic and Antarctic Peninsula[26]. Measurement of the impacts of this temperature rise on the Himalayan cryosphere has proved challenging because of the complicated topography that makes each glacier and region unique and difficult to study, even using satellite technology[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, 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 decade. The most extreme melting has occurred in the eastern Himalayas, where the mean glacial thickness of Chinese glaciers decreased by nearly 11 meters from 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 such as in Bhutan by implementing measures like siphoning off melt water, as occurred with 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-

[26] Shrestha et al. (2012): Widespread climate change in the Himalayas and associated changes in local ecosystem. Plos One 7(5):e36741

[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.

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 loss for that season.

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

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 issues of the region. Some major conservation and development issues of Himalaya related to climate and cryosphere are identified and briefly discussed here (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 response more severely than the water cycles of 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 limited opportunities for adaptation and mitigation. A significant number of Himalayan flash floods are generally caused by the cloud bursts and, until now, there is no detection tool for cloud bursts. Moreover, countries surrounding 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 shift in climate regime is now being considered as one of the catalytic forcing factors for dramatically impacting human and ecological regimes that extract 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 the contingency plans could be drawn before it is too late.

The changing climatic condition is expected to result frequent floods and droughts. As the Himalayas act as the source of fresh water for both rainfed and irrigated agriculture, the crop yield

over the Himalayan region as well as adjoining plains is expected to be affected severely. Better monitoring and prediction of these extreme events in all time scales starting from short to medium and extended (2 weeks) will be helpful to optimize the crop yield by properly scheduling farm level interventions by the farmers and the government w.r.t. different stages of the crops. For this purpose, there is a need for enhanced observational network, compilation of available data, availability of data in a common domain so as to be utilized by various stake holders, provide information on observations and forecasting with respect to agriculture.

Box – 1: Identified 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 retreating 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

3. Climate and cryosphere data requirement and availability:

A generic list of parameters associated to 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 is 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.

Table1: *Details of data requirement and availability associated to 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,B]	1. Geospatial data (rainfall and temp.) available through IMD, GOI and can be purchased.	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

		2. Geospatial data (snow cover; albedo, lakes and water bodies) available through NRSC, GOI; 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.	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		

Notes:

[A] These parameters are also available from few international sources as: (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 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 & development institutes in the region. It can be noted from Table 2 that these designated agencies in the country providing various observational and forecast data over 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 related data can be obtained for free of charge. However, such data is not found to be sufficient for decision making to conservation and developmental issues of Himalaya due to several reasons. A questionnaire survey amongst the various research and developmental institutes of India (Table 3) aimed at compilation and apprehension of climate and cryosphere data requirement and availability reveals the following:

- *Few basic gridded data of climate and cryosphere (i.e. temperature, rainfall, soil moisture etc.) are available from reputed Indian and international organizations for free. Such data is long-term, quality checked and but coarse in spatio-temporal resolution.*
- *Few climate and cryosphere data (typically for research purpose) 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 no/little 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 Himalayan region*

S. No.	Name of Agency	Type of Data	Parameters
1.	India Meteorological Department (IMD)	All meteorological & 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 available data with Indian institutes after receiving the 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	Meteorological: point source	Cryospheric published data	Digital	yes	Cryospheric data: free

	Geology	Cryospheric: point source/intermittent / campaign mode / research purpose	Geophysical data			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:	Meteorological	PDF	yes	Free

		point source	: on demand basis for academics			
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:

As described earlier, following the questionnaire survey amongst various research and developmental institutes of India working on climate and cryosphere of Himalaya data gaps in Himalayan climate and cryosphere data relevant to conservation and developmental issues are primarily 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 for proper decision making. Inadequate observational network and lack of data sharing with respect to climate, cryosphere extremes and related disaster management planning & preparedness are also identified as important gaps in the Himalayan region.

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 (region > 2500 m) is very sparse.
- No concerted scientific monitoring effort on 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.
- Very few glacier monitoring data are available for the entire Himalayas.
- Site specific basic supporting data for disaster assessment is not enough for inferences.

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:

1. *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.*

2. *There is no consensual uniform spatio-temporal scale for Himalaya that can support and aggravate the decision-making process.*

3. *There is no dedicated Himalaya specific center for data collection, compilation, dissemination and monitoring of climate and cryosphere which could cater data needs for policy makers.*

4. *Sufficient security of instrument and unavailability of proper site for standard station establishment and maintenance is an issue affecting continuous data collection.*

5. *Harsh terrain and tough climatic conditions are major constrains for regular sensor calibration and maintenance leading to substantial data loss on temporal scale.*

6. *Insufficient and irregular teleconnection is a constraint for real time data collection and early preparedness for disaster mitigation.*

It is also noted by India Meteorological Department, as member of working group on "Data / information for informed decision making by multiple stakeholders", that real time data are very useful in the operational analysis and numerical weather prediction process which greatly help in issuing timely warnings so that the climate and cryosphere related disaster management activities can be carried out by the concerned agencies more efficiently. Since data collection and issuing weather forecasts are IMD's prime responsibilities, it is acknowledged that extensive monitoring of weather parameters are 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 & warnings for the entire northeastern region. This will require enhancement of the existing data collection network, which will in turn, aid in the accurate analysis of weather situation leading to improved weather forecasts for the region.

Moreover, there is an urgent need of integrated approach for improving the meteorological services over the Himalayan region in a holistic manner. High resolution state of 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 required essentially to run a 3 km resolution weather model which requires the data from very dense network of observatories over the entire region with minimum 2-3 observatories at very high altitude. Entire observational networks need to be augmented to improve the weather & forecasting skills over the region by commissioning of state of art systems like Doppler Weather Radar, GPS sonde systems, Snow Gauges, and augmentation of Automatic Weather Stations, Automatic Rain Gauges etc.

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

Following the construction of a working group on "Data / information for informed decision making by multiple stakeholders" by NITI Aayog, GBPNIHESD Almora, as a nodal institute, has conducted a questionnaire survey and hosted meetings amongst several stakeholders to collect and compile information regarding climate and cryosphere data requirement, availability, gaps and bottlenecks of data sharing associated to conservation and developmental issues of Himalaya. Subsequently, it has been generically 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 govt. 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 for the climate and cryosphere related disasters can be further improved.

- Very little information on the cryosphere data is available throughout the entire Himalayas, and even the processed information as publications is not available for decision making. It is suggested that some pooling mechanism for data generated under different projects and that existing with different agencies/ institutions 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 is stressed.

- It is to mention that the isolated project based studies wouldn't be of much use 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 indentify institutions that can provide past data for data reconstruction and fill 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, particular nodal institutes may be solicited. Identified collaborating institute for individual gap areas may provide further information or data for better apprehension. Table 4 may be considered by NITI Aayog 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 for further solicitation.*

Data gaps in climate and cryosphere to be addressed	Addressing institutes
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	GBPNIHESD as nodal institute and Himalayan State Climate Change Cells, ICIMOD as collaborating institutes

- In view of complexity in the Himalayan terrain and paucity of sufficient climate and cryosphere data, further exercise is yet to be carried out towards collection of suitable data, identification & overcoming data gaps, and collation / compilation of data to appropriate decision formats.

- Improved data collection, forecasts and warnings especially in respect of heavy precipitation/cloud bursts will help many sectors like army operations, air operation,

agriculture, tourism, mountaineering, aviation, roads and communications, power generation, water management, environmental studies, Sports & Adventure, Transport, Government Authority, NGO and Public in general over the Western & Central Himalayan region.

- Considering the existing observational network, gap 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, as indicated in Annexure A, and other organisations assures augmentation of the meteorological network to a large extent, the gap in cryospheric observations is still challenging. There is a strong need to augment the cryospheric observations by a nodal agency.

- As it is difficult to record human based observations in the high altitude regions with sub-zero temperatures, attempt should be made to enhance the space based observations over the Himalayas.

- However, as there are still quality issues with respect to the 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 of historical period involving hydrosphere, biosphere and cryosphere of the region

- There are very limited paleo-climatic data available in the region to address the climate change issues as well as changing water cycle. Whatever data are available are also not accessible in common platform , thus limiting the activities and hence their applications in physical understanding of the processes in climate and cryosphere. Hence there is a need for intensive collection of the paleo-climatic samples to study the past changes and project the future scenario.

- As we know, the polar region as well as the the Himalayas, the third pole play dominant role and are the driving forces for climate and its variability. The role of the Himalayas is very crucial in the regional climate scenario and its changes. 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.

- The interdisciplinary working and intergovernmental experience on sustainable mountain development policies and observations on best practices needs to be implemented 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 all the countries in the Himalayan region through bilateral or multilateral arrangements. Hence, an institute working on the Himalayan region should be considered as nodal agency for detail 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. The mandate of IMD is to take meteorological observations and to provide current assessment & weather forecast information for optimum operation of weather based service activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc including the warnings for severe weather phenomena like tropical cyclones, norwesters, duststorms, heavy rains, snow, cold and heat waves, etc., 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 & 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, IAF etc.
- Spatial weather bulletins for Mountaineering Expeditions, Amarnath Yatra, Road Forecast etc.
- Development of Climatology on Himalayan Region.

The data availability in IMD is presented in Table 4 and 5 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 the Archived forms. The Real Time data can be accessed by anyone through IMD website, while the Archived data can be obtained through requests. 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.

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 days weather observation forecasts for the entire Himalaya with almost 75% of accuracy, under normal circumstances.

Table 4. *Data availability in IMD*

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 5. *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, Squal, Gale etc	Report(Hard Copy) Annual Disaster Events)	For the country	Annual	1981-2015	Yes

1.B. Indian Space Research Organisation:

NRSC Hyderabad maintains BHUVAN Portal to provide the 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 longterm database on climate variables.
- Establish and develop linkages with appropriate observational networks, calibration and validation sites
- Acquisition and processing of international satellite missions' data for other relevant parameters in addition to Indian EO data for generation of longterm 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 – 6.

[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).

Table – 6: *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
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 in consultation with the State Governments concerned, 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. The major activity with respect to precipitation, monitoring and hydrological forecasts are as follows.

- To collect, compile, publish and analyze the hydrological data relating to major rivers in the country, consisting of rainfall, run-off and temperature, etc. 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 basin-wise development of water resources
- To undertake necessary surveys and investigations as and when so required 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 of glacial lakes/water bodies was taken up by Central Water Commission (CWC) during XI plan period. As this work involved processing of satellite imageries and usage of Remote sensing and GIS techniques, CWC signed an MOU with National Remote Sensing Centre (NRSC), Hyderabad in 2009 for making an inventory and monitoring of Glacial Lakes / Water Bodies in the Himalayan region catchment which contributes to rivers flowing in India. The Satellite images of Advanced Wide Field Sensor (AWiFS) of Indian Remote Sensing Satellite Resourcesat-1 were collected during the month May-November, 2009 of Himalayan region. 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 has been prepared and published in June 2011. The information in inventory includes location of the lake (Latitude, Longitude and Elevation), name of lake (if available) and water spread area, Inventory and Monitoring of Glacial Lakes/Water Bodies in the Himalayan Region of Indian River Basins Report. The main conclusions of the study are as under:

- There are 2028 Glacial Lakes and Water Bodies having water spread area more than 10 Ha in the Himalayan region catchment which contributes to rivers flowing in India. Out of these 503 are glacial lakes and 1525 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 contributes to rivers flowing in India are presented in Table 5.

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 are listed 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 etc). 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 many 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 structure for controllong avalanches in formation, middle and run-out zone. Control structures e.g. Snow bridges, Snow nets, Wind baffles, Snow fence, Jet roof, terrain modification, terrace cutting, etc 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, Snow Characterization Model etc. 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 since 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 in ground as well as air borne mode for assessment of snow cover and glacier thicknesses. 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 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 has also state-of-the-art upper air observations

It has 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 & Chaturangi Glaciers, and 'Ice-thickness map indicating ice volume *vis-a-vis* retreat' for the Dokrani Galcier. 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 towards the 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. HIMANSH is a dedicated Research Station established at Sutri Dhaka, Chandra Basin, Lahaul-Spiti valley of Himachal Pradesh which has an altitude of 4080m amsl. The station was unveiled on Sunday 9th October 2016 and since then the station has been made functional round the year. However it was closed during winter (15th 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 "HIMANSH". Apart from above two Automatic Weather Stations (AWS) and five Water Level Recorders (WLRs) have been installed over glacier surface and along with a stretch of 120km of Chandra River respectively for energy and hydrological budget calculation. This all generated data will help to understand glacier behaviours in 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 partner universities cover most of the northwest, central and northeast part of the Indian Himalaya. The IUCCCC intends to bring in the field data for scientific explanation for 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 interest of research remained sediment transport and production, meteorological variation and runoff, degree-day factor for snow and ice and melt water chemistry of very few selected glaciers and river catchment 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 & Central Himalayas** and **Integrated Meteorological Services for Northeastern Region** with the consultation of several other government organizations/institutions working on weather, climate, hydrological, ecological and environmental aspects of the Himalayas region. It will be implemented in all Himalayan states including Jammu & Kashmir, Himachal Pradesh, Uttrakhand, West Bengal, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Mizoram, Tripura & 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 art surface and upper air observatories for real time observations with failsafe communication.
- ✓ Improving the understanding and prediction of weather & climate processes in complex terrain.
- ✓ Development of appropriate system of 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 cloud burst etc in mountain region and to build appropriate services.
- ✓ To develop improved Climatology for the region to cater the requirements of all users.

State-wise distribution of observational network to be implemented under Integrated Meteorological Services for northeastern region is presented in Table 7.

Table 7: *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: Dopplar Weather Radar, AWS: Automatic Weather Station, ARG: Automatic Rain Gauges, SG: Snow Guage, MR: Microwave Radiometer, WL: Wind Lidar, HAWOS: Heliport Automated Weather Observation Systems.

At present, DWRs are installed at Mohanbari & Agartala. 14 X-band DWRs will be installed to cover the entire region under the proposal is shown in Fig.12. Proposed AWS, ARG and snowgauge (SG) network for the region is also shown in Fig.1.

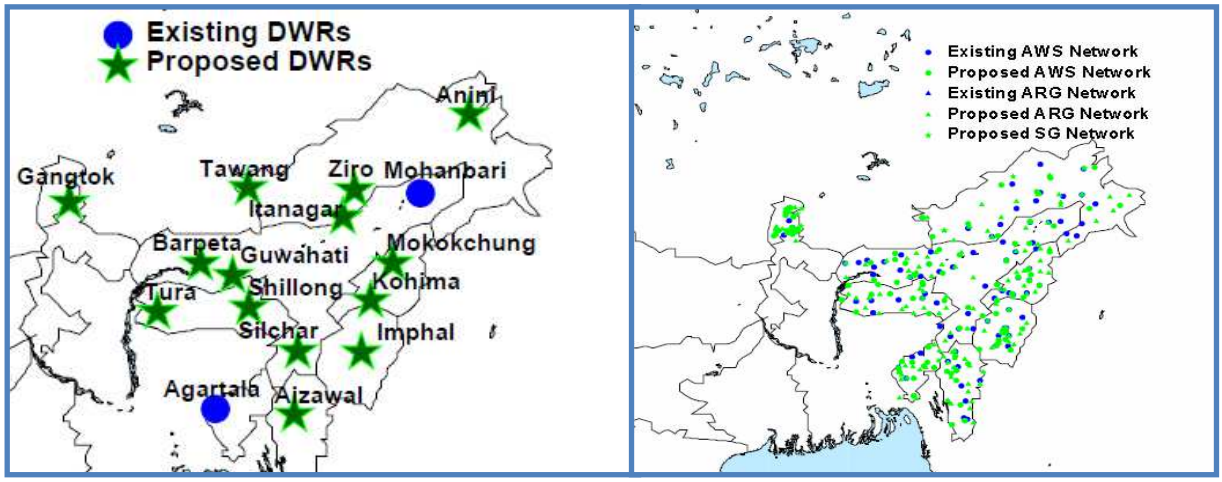

Fig. 1: *Existing and proposed (a) DWRs and (b) AWS, ARG, SG network over northeastern states*

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, hail, etc. Aviation and agriculture sector can also be benefitted by forecast of severe weather in and around or en-route of aircrafts and rain fall occurrence time and

quantum of rain may enable farmers to plan the agriculture activities which in turn may yield more production. 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 aloft 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 & atmospheric humidity, Column-integrated total amount of water vapour& liquid water, Vertical profiles of cloud liquid water, Atmospheric stability (now-casting of convection, thunderstorms & Measurement of fog. At present, Microwave Radiometers are not installed over the region; eight numbers of these systems will be introduced in the network as presented in Fig. 2:

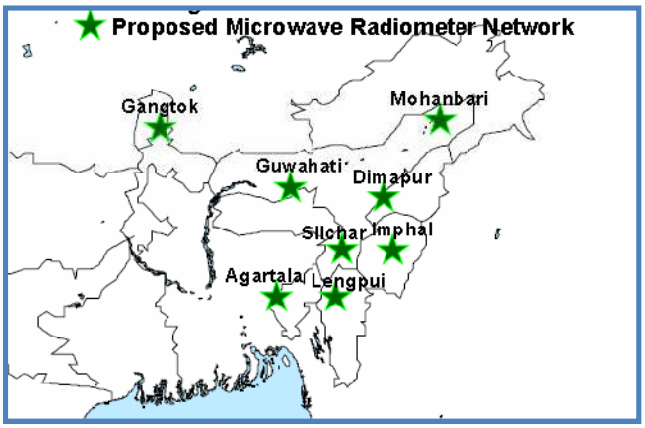

Fig. 2: *Proposed microwave radiometer network over northeastern states*

Winds are the most important variable 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, the wind velocity is one of the most important in many environmental areas such as 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 radiosoundings. **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 in the region. Proposed Wind Lidar and Heliport AWOS network over northeastern states ispresented in Fig. 3.

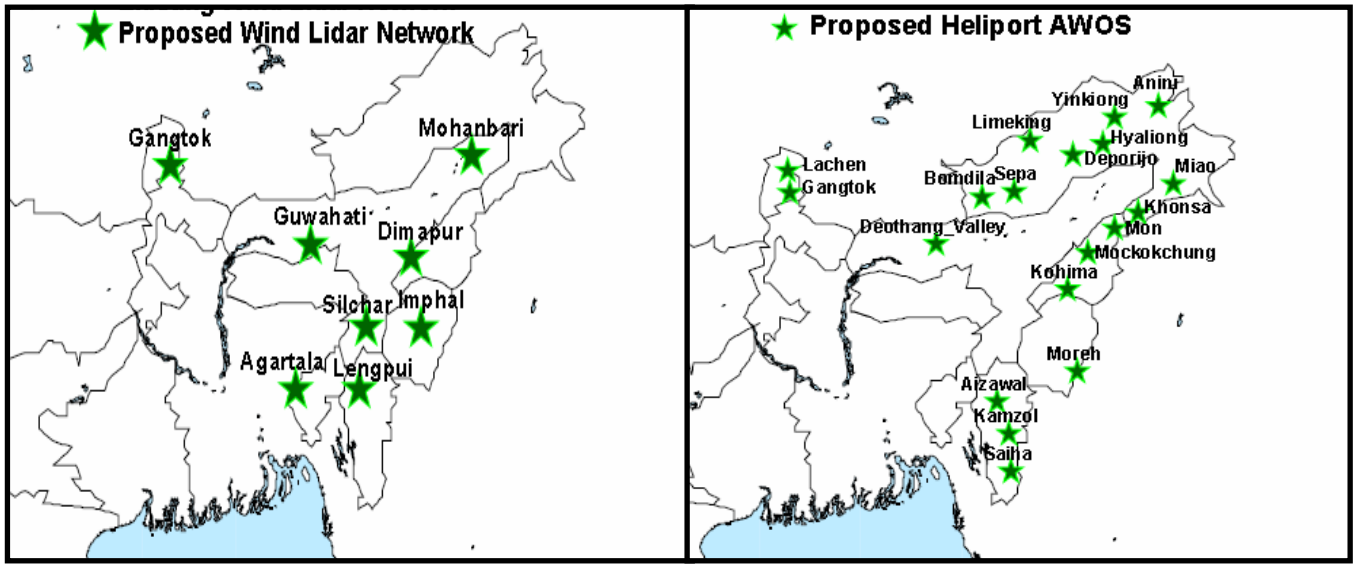

Fig. 3: *Proposed Wind Lidar and Heliport AWOS network over northeastern states*

Integrated Himalayan Meteorology Programme for Western & Central Himalayas covers four states namely Jammu & Kashmir, Himachal Pradesh, Uttarakhand and Sub Himalayan West Bengal (SHWB). Type and number of observational equipment was decided by taking into consideration of existing network of IMD, other organization and the future requirement in order to meet the minimum network for capturing the synoptic & 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. Centre (RMC) & 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. Finally, State-wise observational network planned is presented in Table 8.

Table 8: *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.

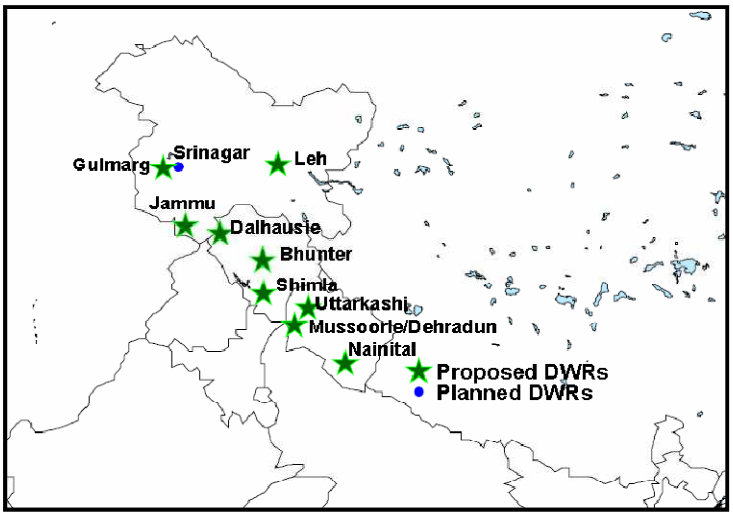

Fig. 4: *Proposed DWR network of IMD in western Himalayan region*

At present, one DWR has been installed at Srinagar in western Himalayan region. All the proposed DWRs are X-band, the proposed locations are shown in Fig.15.

Surface Observing equipment consisting of Automatic Weather Stations, Automatic Rain Gauges & Snow Gauges sensors will be commissioned in entire region to obtain surface observation data as displayed Fig. 5:

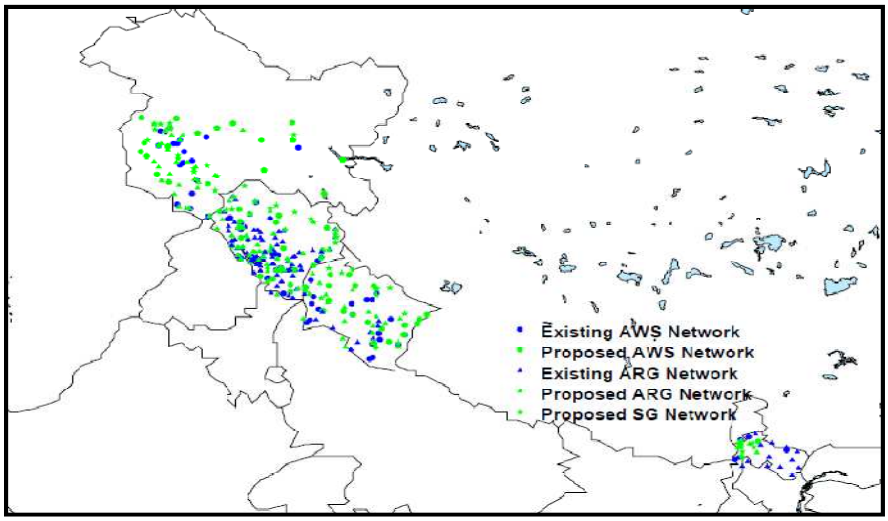

Fig. 5: *Existing and proposed Automatic Weather Station, Automatic Rain Gauge and Snow Gauge Network*

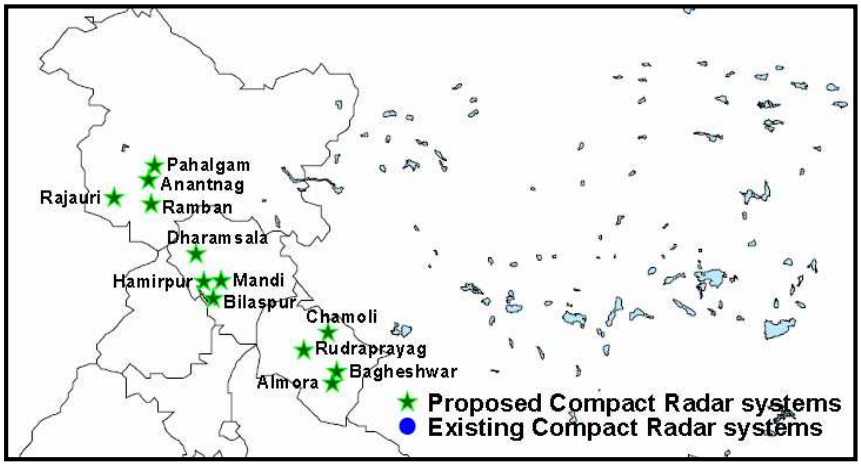

Fig. 6: *Proposed and existing network of compact Radar systems*

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 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. 6.

Four numbers each of these systems will be commissioned in the state of Jammu & Kashmir, Himachal Pradesh & Uttarakhand.

Helicopter operations in India have been a challenge ever since such operations commenced. The requirement of helicopter operations in the country particularly over the mountainous areas where roads, railways and runways are difficult and expensive to build, population density is low and journey time at the surface 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 of most flights being non scheduled, small size of aircraft, absence/limited weather observations in the remote locations, sudden development of adverse weather in mountainous region and narrowing valleys often make U turns and avoidance of adverse weather more often than not very difficult. This necessitates the need for meteorological support to helicopter services which is nonexistent hitherto. Therefore, it is proposed to install specialized Heliport Automated Weather Observation Systems (HAWOS) with aviation specific sensors at 7 heliport locations are shown in Fig. 7.

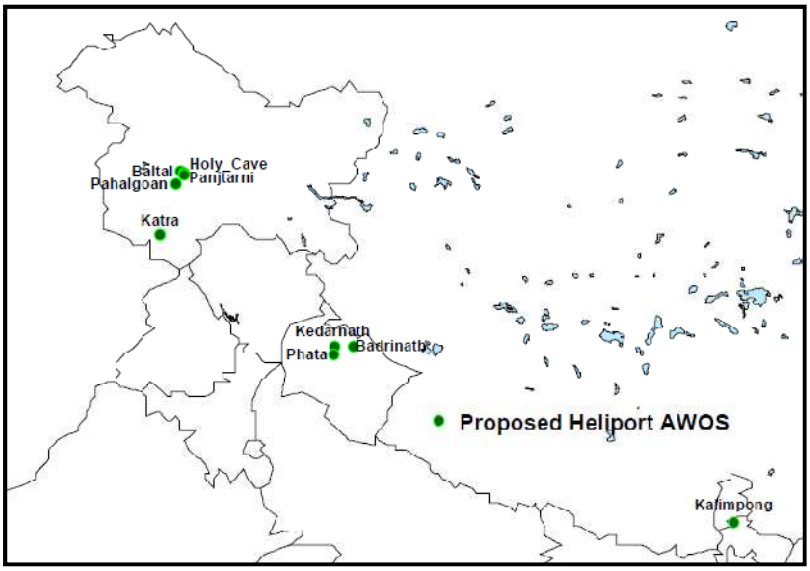

Fig. 7: *Proposed network of AWOS*

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 due 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^{o} 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 truth, 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 general public. These, also will help in disaster preparedness and mitigation.

Chapter 2 B

Disasters in IHR

1) Introduction/Background

The hazard assessment is prime concern for the 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 reduction of the effects of hazards. The elastic strain energy built due to the plate movement resulting the Himalaya from collision between India-Asia plates, is a continuous process, and has resulted in the occurrence of four great earthquakes in last one hundred twenty years in the Himalayan region. Adjustments of crustal blocks to the accumulating strain continuously also trigger micro-earthquakes in Himalaya, which can further stimulate other hazards like landslides. The earthquake seismic monitoring, source processes and the 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 & Technology (CSIR-NEIST) operates 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), Dehra Dun in the Himalaya.

There have been ever increasing developmental activities in the form of widening of existing roads, construction of new roads, development projects for township, tunnels, bridges and water resource etc. Often, these activities lead to destabilization of slope and sometime results into catastrophic landslides and related mass movement activities. In addition, climate change including the extreme rainfall also effects the slope stability resulting mass movement under gravitational force. Therefore, studies are required for landslides and slopes vulnerable to form landslides. In the Himalayan context, data so far available on these aspects are limited and site specific. In addition, cloud burst, flash flood and the forest fire are not uncommon in IHR. The cloud burst and the flash flood result from extreme amount of precipitation in short period of time, whereas the forest fire occurs in dry season mainly during pre-monsoon period, often because of human intervention.

Worst thing about Disasters is that they are impacted by huge number of parameters and therefore to predict the disaster has been nearly an impossible task. Though various institutes are already engaged in developing early warning system to assess the disaster scenarios in advance, much promising system could not been developed for the cause. So preparedness,

as of now, is the best redressal mechanism to mitigate the socio-economic loss resulting from the disasters. Government of India has taken initiatives and come out with different institutes specifically for disaster like National Institute of Disaster Management (NIDM), National Disaster Management Authority (NDMA), National Disaster Response Force (NDRF) and others. The primary goals of these institutes are to monitor the scenarios that might lead to disaster or drawing the action plans, respond to the after effects to minimize the loss in best possible way in case the disaster has already happened.

2) Disaster and associated Issues

Himalayan region has been highly prone to disasters. Different types of disasters are likely to happen due to presence of extreme climatic conditions, undulating topography and unstable mountain ranges. Possible list of potential disaster that generally takes place or might happen in near future has been categorized. Primarily two classes of disasters affect the IHR:

1) Natural Geological Disasters are again classified into **Geological Disasters** such as landslides, earthquake, avalanche, sinkholes, etc; **Hydrological Disasters** such as flash floods, etc. and **Meteorological Disasters** such as Cloud Burst, Forest Fire, Glacial Lake Outburst Flood (GLOF), etc. that are caused by Geological; Hydrological and Meteorological parameters.

2) Man made or technological disasters that are caused as the result of human interventions such as unplanned infrastructure development or augmentation, Urban Sprawl, etc. triggering one or more disasters.

Following section describes the potential disasters in brief which are common to IHR:

2.1. Natural Disasters

- **Earthquake/ Seismic Hazard**

The earthquakes are most vulnerable hazard for Himalaya, which are being studied by geophysical observatories spread in various areas of IHR. However, the density of the observatories is inadequate for precise seismic investigations. The number of multi-parametric Earthquake precursory research observatories need to be enhanced.

- **Landslides**

The data of the landslide and related phenomena are dynamic in nature as every year new landslides are developed and at times old landslides get stabilized. 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

with limitation to reference the data geospatially. Much of the data related to landslides and related phenomena that are not affecting the human habitation/ infrastructure, are not reported. Therefore, regular up-gradation of data is important, as very old data may not represent the present ground conditions.

- **Cloud Burst**

A cloudburst is an extreme amount of precipitation in a short period of time[31] which is accompanied by hail and thunderstorm. A cloudburst is capable of pouring heavy amount of Rainfall rate equal to or greater than 100 millimetres (3.9 inches) per hour is a cloudburst. In Indian a cloudburst usually occurs when the monsoon cloud drifts northwards, from the Bay of Bengal or Arabian Sea across the plains, then onto the Himalaya and bursts, bringing rainfall as high as 75 millimeters per hour[32]. Major impact of the cloud burst may be flash flood and mass movement on the slopes

- **Flash Floods**

IHR often faces extreme hydro-meteorological conditions that results into 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. 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 analyze the causes of event and extent of consequences.

- **Avalanches**

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

- **GLOF (Glacial Lake Outburst Flood)**

Kedarnath - Uttarakhand 2013 massive flood disaster was caused primarily due to 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

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

[32] *Weathernotebook.org*

Himalayas. These have led to catastrophic floods — so-called glacial lake outburst floods (GLOFs) — especially in Nepal and the Tibetan region.

- **Forest fire**

The Himalayan regions is ecologically sensitive areas and mostly affected by these fires. Forest fire in IHR is observed often in the month of May/pre-monsoon and till the precipitation starts generally in June. The cause of forest fire is primarily attributed to natural such as Lightening, friction between rolling stones/stems of falling trees, etc. And manmade such as shifting cultivation, tribal traditions, etc. Chir Pine area is generally effected maximum, followed by Oak and Oak mixed forests. The 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 effects of forest fires include – depletion of the ozone layer, soil erosion, and loss of forest cover, habitat and the livelihood of many tribal and rural people.

2.2 Technological or Manmade Disasters

Increased interference of humans in uncontrolled manner has resulted in devastating consequences in the form of so called manmade disasters due to anthropogenic activities. It is not limited to any area specific havoc, stimulus at one point source may trigger a disaster affecting the region at nearly the same or even at far locations. Combustion of fossil fuels result in high emission of carbon compounds and other particulate matter which are getting suspended in the atmosphere above the glaciers of IHR. The carbon compounds and aerosols are catalyzing the action of trapping the sun radiation within the earth's atmosphere which is one of the primary reasons for climate change and glacier retreat. This is substantially increasing the temperature of the region leading to higher degree of melt in the glaciers. Another example of manmade disaster prominently for IHR can be well understood by the example of unplanned expansion of urbanization and infrastructure including hydropower projects, construction of new roads, etc. where explosives are used to blow off the part of the mountain or unplanned cutting of the mountains are done. These activities results in introducing the crevices making the mountains to lose it stability which results in landslides or better can be termed as human induced landslides.

Unprecedented destruction by the rainfall witnessed in Uttarakhand state was also attributed, by environmentalists, to unscientific developmental activities undertaken in recent decades contributing to higher socio-economic loss. Roads constructed in unscientific and unplanned manner, newly constructed resorts and hotels along the fragile river banks and more than 70

hydroelectric projects in the watersheds of the state led to a "disaster waiting to happen" as termed by certain environmentalists[33].

IHR consists of various tourist spots due to its picturesque view and serenity which attracts lots of tourist per year from around the globe. Lots of solid wastes are dumped haphazardly by the tourists. Uncontrolled flux of tourists in IHR becomes a huge problem for the region that again triggers one or more category of Disaster ranging including the water crisis.

Unplanned expansion of urban areas or urban sprawl in the IHR is again a serious issue. This may not be directly linked to cause of disaster but surely has a huge role to play in consequence of disaster. Valleys are being disturbed, water channels are shifting, geology of the region is being altered, land use to land cover ratio is increasing, etc. All these human intervention has been preparing a platform to be impacted by disasters with unprecedented catastrophe and unimaginable loss.

3) Data availability constraints, if any - Sectoral, cross-sectoral, regional

- 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 being operated by various agencies (IMD, WIHG, IIT-Roorkee, NGRI, CSIR-NEIST etc) are available for different duration.

- Data on landslides and related phenomena like outburst flood, cloudbursts etc are collected as and when there is an event. There is no systematic data repository for these events by any of the organizations. The data is collected for the specific projects and are mainly published in the form of either research paper or report.

- Many events that do not affect the human habitation or any infrastructure, remain unnoticed and unreported. However, there is plenty of data available with various agencies along the roads/national highways.

- Data for cloud burst 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.

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4) Nodal Agencies for Disasters

Table 3: 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
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 requirement and the data gap

- In addition to the spatial distribution of seismic events, it is also pertinent to know the causes of such events. Therefore, it is important to collect comprehensive data about a particular seismic earthquake event.

- The seismic data is required whenever the epicentres of earthquakes is out of established seismic array. In order to record the lower magnitude earthquakes, an increase in the density of the network is prerequisite.

- Seismic zone maps at district level are not available.

- Large scale landslide zonation map in important river valleys, along the highways/roadways and vulnerable townships are required. Event specific data is useful for analysis, inferences and implications.

- Cloud burst, Flash flood data and their repository of records in Himalayan region.

- Avalanche and Glacial Lake Outburst Flood (GLOF) data and repository of records in Himalayan region. SASE is monitoring the Avalanches, however much of their data is strategic for security purpose.

- Forest fire data and forest fire maps, and the identification of forest fire prone zones.

Table 1 has been compiled to give the idea of different types of disasters that IHR is prone to and different data/information that are required for early warning or preparedness to minimize the after affect of disaster in form of socio-economic loss and for the informed decision making for sustainable development in IHR. Table also mentions against the required data/information what are the data that is already available and data gaps that are required to be addressed by data generators.

Table 2 emphasizes on the agencies/institutes that are involved in data/information generation or collection which is already available as mentioned in Table 1. Also the spatio-temporal scale, frequency of data collection, time period for which the data is available, format for the data dissemination and whether the data has been passed through quality checks or not has also been listed.

Table 1: *Disaster related issues and data requirement, availability and gaps 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 subsidence 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 / Meteoroloigcal *(Forest fire, Flash Floods, Cloud Burst)*	4. Forest fire map	Geospatial data with temporal scale of 4 alerts/day. District level data for Uttarakhand[3]	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 any particular 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	District level data for Uttarakhand	-	-

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 2: *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	Foramt – 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	i. Indian Meteorological Department	For Entire Country	Annual	1981-2015	Report/Hard Copy - Y
	ii. NRSC, Hyderabad	State/Grid – Event Specific	NA	NA	Geospatial - NA
	iii. 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
	iv. UCOST, Dehradun	District	NA	NA	PDF – Y
	v. IIT Mandi	Point Source	Hourly	Ongoing	PDF/reports/Geospatial – Y
	vi. JNU	NA	NA	NA	PDF – NA
Cloud Burst	i. Indian Meteorological Department	For Entire Country	Annual	1981-2015	Report/Hard Copy - Y
	ii. 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
	iii. JNU	NA	NA	NA	PDF – NA
Flash Flood data	i. Indian Meteorological Department	For Entire Country	Annual	1981-2015	Report/Hard Copy - Y
	ii. NRSC, Hyderabad	District	Opportunistic satellite data availability	NA	Geospatial - Y

	iii. 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
	iv. JNU	NA	NA	NA	PDF - NA
Forest Fire data	i. Forest Survey of India, Dehradun	District	Daily	20014 to 2017 (Jan – June)	Geospatial (Point) - Y
	ii. NRSC, Hyderabad	Point Source/Grid	Daily 4 Alerts	2006 to till date	Geospatial – Y
	iii. UCOST, Dehradun	District	Hourly	NA	PDF – Y
	iv. IHBT, Palampur	Kangra District	One time (forest fire prone areas)	2015	Geospatial – Y
	v. 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.

- A system can be evolved whereby the data can be shared without hampering the interest of the organization, after a defined period from the date of data generation/ acquisition.

- Data collected by various agencies are not in the same format and thus is not always possible to collate data from different sources. A standard module can be framed for the 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 at times 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 to collect data by a single institution in all the areas, involvement of more than one institution may be useful. It is also not easy to share data because (i) the career growth of the scientist is linked with the research output/publication based on the data collected by him/her and (ii) the policies of the institutions. Addressing these issues may be useful.

- A nodal agency may record and study forest fire and the preventive measures need to be strengthened. Since much of the forest fire is because of the human intervention, active awareness programs would be useful.

- The role of some agencies/organisations is to generate data, which can be shared. Some multi-organizational national programs may be initiated.

Table 4: *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*	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 generation of data and keeping repositories.
- There can be nodal agencies for various kind of data generation (Table 3) and keeping records.
- Sharing of the data for a disaster event may 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.
- Since much of the forest fire is related to human activity, awareness programs to educate the human settlement would be greatly useful.
- Incidence and casualties of disaster events from state and central govt. 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 for the climate and cryosphere related disasters can be further improved.
- Improved IT infrastructure for real time data collection and dissemination for early disaster preparedness.
- Disaster prone zone should be identified in advance with potential disasters that might affect the area and evacuation plan must be prepared and trained to locals.
- Sector specific single central data management agency for early warning against the disasters and real time information availability.
- Some data is categorized as classified or strategic and has not been reviewed since decades. A timely review mechanism should be there 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, few parameters are being collected as point locations. So 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 need to be a standard format for data collection / generation and the quality of the data should be checked regularly. A third party review for the quality of data may be useful at times. Nodal agencies must generalized the format and threshold of the quality of accepted data against various data/information being acquired nationally by different organizations, taking into consideration and consent of their requirements which is to be followed nationally. This will ensure availability of wide range of data throughout IHR with a uniform format and therefore will have less ambiguity in data compilation.

(iii) Sharing, retrieval and end-user accessibility

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

Chapter 2 C

Biodiversity Conservation

Background on Biodiversity of IHR:

Mountains are remarkably diverse and globally important as centers 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 specifically developed a programme of work on mountain biodiversity in 2004, which 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 brought mountains on the main agenda of 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 the 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

[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.

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 amphibia (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.

Table 1. *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-centers of plant origin, the region represents 3 sub-centres (viz., Western Himalaya, Eastern Himalaya and North Eastern Region). These sub-centers respectively contribute 125, 82, and 132 species of

[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.

[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.

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, yak, etc. (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 aquatic flagship species river dolphin also occurs. High altitude habitat nurtures some of the charismatic and unique faunal species (e.g., snow leopard, red panda, hangul, chiru, musk deer, serow, Himalayan tahr, etc.). (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*).

The wealth of biodiversity of this region supports peoples' livelihood 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 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 to them. The unique diversity of medicinal plants in the region is manifested by the presence of a number 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 they are 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 life saving drugs and accrue immense economic wealth. Apart from the human use, many plant species as its primary source of healthcare of livestock.

Traditional agriculture in the Himalayan mountains has been a rich repository of agro-biodiversity and resilient to crop diseases. 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 another best example of rich agri-diversity of 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 at the brink of extinction, such as *Glysine spp., Hibiscus sabdariffa, Panicum miliaceum, Perilla fruitescens, Setaria italica, Vigna* spp., to name a few. It is anticipated that the onslaughts of climate change will have a cascading impact on biodiversity, plant reproduction and growth, plant population hence on the 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 harvesting, deforestation, forest fire, livestock grazing and agricultural expansion into forest lands, land fragmentation, illegal trade of timber and MAPs, and above all the 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 ely to have certain impacts on ecosystems to species level those are not yet fully understood. Warming in the Himalayan region indicate moderateto large-scale shifts in vegetation types, with implications for forest dieback and biodiversity,change in the timing of phenological events

[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 Ecology* 4: 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.

BOX-I

Issues relating to Conservation of Biodiversity

- Deforestation and loss of biodiversity
- Invasion of alien species
- Forest fire
- Land fragmentation for developmental projects
- Over-exploitation of bioresources
- Pests and diseases
- Lack of connectivity of corridors for wildlife migration

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

During the past few decades, because of the increasing anthropogenic disturbances, tourism, air and water pollution, industrialization, urbanization and infrastructure development man has caused much harm to natural habitats and biodiversity. Forest loss and fragmentation negatively affect species diversity. Deforestation and land degradation / increasing waste land and extraction of fuelwood from forests is also causing tremendous pressure on forests. A survey of fuelwood 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 has become one of the major driver in causing colossal damage to the forest ecosystem. The loss to forest wealth accounting grossly underestimates the loss to biodiversity and micro-habitats. Related to the loss of habitats and food availability in wild human-wildlife conflict has emerged as another big issue. For example, in Uttarakhand, during the past ten years over 722 leopards, 81 tigers and 241 elephants died, many due to unnatural means. On the other hand, leopards, tigers and elephants collectively exterminated over 338 human lives and injured another 460 during the same period[41]. Similar situation prevails in many other states, making the management of human–wildlife conflict as the challenging issue. Poaching is a major threat to wildlife in IHR, especially endangered species like musk deer, snow leopard, tiger, and Himalayan black beer, 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 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.

[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.

Data requirement, availability and gaps:

To address various issues prevalent in biodiversity conservation and sustainable development specific data sets are required. In Table 2 we have presented data sets required to address identified issues related to biodiversity conservation based on responses from 23 Institutions (out of 96 Institutions to whom we circulated the questionnaire; Pl. see Annexure-..). Also, their data requirement and data gaps are listed in Table 2. There are limited datasets on IHR and that too is scattered among various Institutions. There is a need of Himalaya specific centralized institution responsible for biodiversity data collection, integration, storage and dissemination. A syntheses of response 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, Forest Research Institute, etc. 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 suiting to the R&D need of the Institutions. The frequency and temporal scale of data collection is also not strategic suiting 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.

Table 2: *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)	• Herbarium / museum data sets • List of threatened and endemic plants and animals • Plant / animal	• Location specific and geo-coded datasets on flora / fauna • Species / community wise data on forests • Location specific data on rate of deforestation / loss

	• 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	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)	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

In the IHR there are a host of Institutions those are engaged in biodiversity research and conservation. Table 3 provides syntheses of information provided by 23 Institutions (out of 96 Institutions to whom we circulated the questionnaire; Pl. see Annexure-..). 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 those who 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 its 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 view of plant checklist available with BSI, the States like Uttarakhand, Meghalaya, Nagaland, Tripura, Assam and Darjeeling (partially) and the entire Flora of Himalaya are not available. Also, as per the publication list of ZSI, checklist of State Fauna available but the complete list of Fauna of Indian Himalayan Region is not available. However, for the 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 arises in biodiversity conservation planning is the lack of data set on quantum of bioresource available in the nature 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 these R&D organizations is urgently required to find synergy and dovetailing their data base to find areas of strength and weakness to come up with an action plan for biodiversity conservation and development issues in the IHR.

Table 3: *Summary of data on biodiversity available on 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)
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	Datasets on Landuse /	Location specific data on forests	Digital data set	Yes	Free (followin

	Sensing Centre, Hyderabad	Landcover, vegetation type, Forest type, etc.				g 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	• Location-specific	Location specific data on flora/fauna	Herbarium specimen	Yes	Free (following

	Himalayan Environment & Sustainable Development, Kosi-Almora	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	Published information on important plants of IHR	data Digitized data on biodiversity		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	Location specific medicinal plant resources Regulation on traded	Reports and published informati	-	-

		Trade / utilization information of commercial medicinal plants Regulations on medicinal plant resources	plants	ons		
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	Herbariu m 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	Herbariu m 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 website based
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

Data sharing is indeed a major issue. 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 as willingness to share the data, quality of data, duplicity of data will need to overcome to utilize the intellectual, capital and material resources in the best interest of the region. In this context Citizen's Science approach holds paramount importance that ensures participation of a range of stakeholders in data collection, data compilation and drawing useful inferences as has been tested by GBPNIHESD in case of seeking participation of rural people in valuation of forest ecosystem services in community forests of Uttarakhand[43].

[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).

[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.

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

Our questionnaire survey/consultations across the 17 leading organizations and website 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 biodiversity. The data available so far is fragmentary and points out a number of data gaps (Box-I). Data/information base required for biodiversity conservation and management for sustainable development such as location details on habitat ecology, population dynamics of biodiversity elements, seasonality and frequency of data collection, documentation of ethanobotanical 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 is also grossly undermined. This may lead to overlaps in data collection leaving useful data collection for wider interest. Further there is a need to compile that data in a uniform format to make it user-friendly. There is no / poor mechanism for data sharing and quality control of data/information. All these issues need to be handled by establishing a centralized data repository for gainful utilization in biodiversity conservation and sustainable development.

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

Recommendations:

(i) 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, integration and use-friendly interface for access to data/information. An

integrated regional biodiversity information system housed at a nodal organization of MoEF&CC with distributive linkages for easy storage, retrieval and dissemination, also having linkages with the national database, is essentially required.

(ii) Biodiversity distribution data at spatial (grid) scales are prepared as input for integrative analysis along with related climate, topography, soil, socio-economic data etc. This data if available on a lower resolution can be effectively useful 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 long time frame.

(iii) 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.

(iv) In view of the long-standing wisdom of regional inhabitants there is a need to place special attention to document the traditional knowledge on best practices on biodiversity conservation and sustainable utilization both for *in situ* and *ex situ* conservation. There is ample avenues to harness the income generating potential of bioresources and value addition and seek participation of local communities in biodiversity conservation. This would also imply that the national policies have to 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).

(v) Biodiversity offers a variety of bioresources for human use and allied activities. However, the quantification of the bioresources (such as NTFPs) is limited to only a few species. There is a strong need to promote sustainable use concept which attempts to establish linkages between conservation and economic use, and recognizes that the bioresources represent a renewable source for sustainable income. Thus, there is a felt need for considering holistic or ecosystem

based approaches of management. This implies that management of biodiversity components in any ecosystem would require integration of research outputs and human dimensions.

(v) Globally there has been a growing concern to effectively attach monitory value to biodiversity, specifically to the ecosystem services and make provisions for transfer of payments (compensations) to the protectors. Often the spatial and temporal dynamics is overlooked in such ecosystem services valuation. There is, therefore, an urgent need to understand the intensity and direction of consequent on-going and potential impacts of changes on the structure and functioning of biodiversity elements, including humans, in the IHR.

(vi) The present investigation suggests that the response on our questionnaire was only indicative and does not provide the spectrum of whole range of answers to set of questions given by us in our format. However, it can be suggested that data on the following aspects /gap areas need to be generated by the suggested Institutions (Table 4). These Institutions are mandated for various aspects of data generation on biodiversity conservation and sustainable management (Table 5). All the above dataset/information can be stored with a centralized system (such as MoEF&CC or its nodal organizations in the IHR) for data management, quality control and accessibility to end users.

Table 4: *Data gaps that need to be addressed by Govt. 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)	BSI & ZSI
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 Deptts. 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, use pattern of bio-resources and sustainable use practices	State Forest Deptts. 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 5*: 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	a. Undertaking intensive floristic surveys and collecting accurate and detailed information on the occurrence, distribution, ecology and economic utility of plants in the country; b. Collecting, identifying and distributing materials that may be of use to educational and research institutions; and c. 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	a. Herbarium records of plants of IHR (digitalization is under progress) b. Document on medicinal, economic, threatened and endemic plants	a. Geo-coded datasets on plants b. Population of endemic, threatened, economically important and medicinal plants c. Datasets on lower group of plants d. Plant based resources and use pattern e. Habitat ecology and associated flora
2.	Zoological Survey of India, Kolkata, West Bengal	a. Exploration, Survey, Inventorying and Monitoring of faunal diversity in various States, Ecosystems and Protected areas of India b. Taxonomic studies of all	a. Information on faunal distribution b. Museum specimens c. Threatened	a. Geo-coded datasets on Faunal habitats b. Population of native, endemic and threatened and other fauna

		faunal components collected. c. Periodic review of the Status of Threatened and Endemic species and Preparation of Red Data Book, Fauna of India and Fauna of States. d. Bioecological studies on selected important communities/species. e. Preparation of databases for the recorded species of the country. f. Maintenance & Development of National Zoological Collections. g. Training, Capacity Building and Human Resource Development. h. Faunal identification, Advisory services and Library Services. i. Publication of results including Fauna of India and Fauna of States.	and endemic fauna d. Checklist of fauna found in selected states and PAs	c. Migratory pattern and areas of migration f. Habitat ecology
3.	Forest Survey of India, Dehradun, Uttarakhand	a. To prepare State of Forest Report biennially, providing assessment of latest forest cover in the country and monitoring changes in these. b. To conduct inventory in forest and non-forest areas and develop database on forest tree resources. c. To prepare thematic maps on 1:50,000 scale, using aerial photographs. d. To function as a nodal agency for collection, compilation, storage and dissemination of spatial database on forest resources e. To conduct training of forestry personnel in application of technologies related to resources survey, remote sensing, GIS, etc. f. To strengthen research & development infrastructure in FSI and to conduct research on applied forest survey techniques.	a. Biennial forest report and changes details b. Information on forest and non-forest areas c. Thematic maps of 1:50,000 scale, using aerial photographs d. Spatial database on forest resources e. Training information / details related to forest survey	a. Location specific datasets on forest resources in Indian Himalayan Region b. Ground based approaches on Forest resources documentation c. Population structure of major forest types and its changes in denoted time frame d. More precise thematic map (i.e. 1:10,000 scale). e. Precise / accurate forest loss in region wise, i.e. forest fire. f. Extended distribution of invasive trees in forest and forest disturbance indices.

		g. To support State/UT Forest Departments (SFD) in forest resources survey, mapping and inventory. h. To undertake forestry related special studies/consultancies and custom made training courses for SFD's and other organisations on project basis.		
4.	National Biodiversity Authority, Chennai, Tamil Nadu	a. 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. b. 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. c. 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. d. Advise the State Governments in the selection of areas of biodiversity importance to be notified as heritage sites and suggest measures for their management. e. NBA and SBB provide guidance and technical support to Biodiversity Management Committees for documenting People's Biodiversity Registers.	a. Information on Biodiversity Heritage site in selected States b. Notified threatened plants and animals on different States c. Document on People's Biodiversity Registers (PBRs). d. Regulations for Bioresources for commercial utilization e. Notification of Bioresources normally Traded as Commodities f. Guidelines on access to Biological Resources and Associated Knowledge and Benefit sharing regulations	a. Precise location and diversity specific details on 'Biodiversity Heritage Site' b. Quantifiable information and location specific availability of biodiversity on threatened elements and cause of threat, etc. c. Retrievable datasets on PBRs to common public d. Pictorial guidance on normally traded commodities for common people e. Quantifiable use of Bio-resources in different States

		f. Perform such other functions as may be necessary to carry out the provisions of BD Act.		
5.	G.B. Pant National Institute of Himalayan Environment and Sustainable Development, Almora, Uttarakhand	a. Undertake in-depth research and development studies on environmental problems of the Indian Himalayan Region (IHR). b. 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. c. Evolve and demonstrate suitable technological packages and delivery systems for sustainable development of the region in harmony with local perceptions	a. Location-specific information on plant / animal diversity in selected areas of IHR b. Selected information on forest cover / area under forest /biomass, NTFPs c. Checklist of invasive plants in IHR d. Agri-diversity conservation practices in Uttarakhand e. Propagation protocols of important plants	a. Ecological datasets on important biodiversity elements b. Location specific datasets on forest biomass / NTFPs and invasive biota c. 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)	a. To undertake, aid, promote and coordinate forestry education, research and their applications. b. To develop and maintain a national library and information centre for forestry and allied sciences. c. To act as a clearing-house for research and general information related to forests and wildlife. d. To develop forestry extension programmes and propagate the same through mass media, Audio-visual aids and extension machinery. e. To provide consultancy services in the field of forestry research, education and allied sciences. f. To undertake other jobs considered necessary to attain	a. Information on forest diversity of different forest types b. Information of forest records and maintaining museum, herbarium and life repository of valuable elements c. Datasets on forest resources in selected areas	a. Location specific datasets on forest resources (including NTFPs) in Indian Himalayan Region b. Datasets on best forest practices for conservation of forest resources c. Datasets on threat on forest resources (i.e. forest fire, pest / disease information, etc.) d. Datasets on Long-Term monitoring in Permanent Forest Plots established earlier. e. Datasets on inventory of forest

		these objectives.		resources f. 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.)	a. Providing platform for research and market interface b. Optimization of the resource base of the country and the industrial sector c. Developing required infrastructure d. Focus on technology of the future	a. Location specific data on Lichens, Bryophytes, Algae and Angiosperms of selected region. b. Herbarium and published datasets on plant distribution c. Propagation protocols for high value plants d. Biochemical composition of different plants e. Conservation of plants through Botanical Garden	a. Geo-coded datasets on plant diversity b. Openly available digitized datasets on herbarium / botanical garden c. Commercialized / tested / adopted protocols for high value plants specific to hilly region d. Information on marketing linkages in hilly regions for high value products
8.	Indian Council of Agricultural Research, New Delhi	a. To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, animal science, fisheries, agro-forestry and allied sciences. b. 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. c. To provide, undertake and promote consultancy services	Agri-biodiversity of different states of IHR	Datasets / information on location / environment specific quantitative agro-diversity in IHR

		in the field of research, education, training and dissemination of information in agriculture, animal science, fisheries, agroforestry, home science and other allied sciences; d. 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, Bhaba Atomic Research Centre, state Agricultural Universities etc.; e. To do other things considered necessary to attain the objectives of the society.		
9.	Wildlife Institute of India, Dehradun, Uttarakhand	a. Build up scientific knowledge on wildlife resources. b. Train personnel at various levels for conservation and management of wildlife. c. Carry out research relevant to management including the development of techniques appropriate to Indian conditions. d. Provide information and advice on specific wildlife management problems. e. 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	NRSC provides data for natural resource management, geospatial applications and	Datasets on Landuse / Landcover,	Location specific biodiversity maps on IHR

	Centre, Hyderabad, Telangana	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*'	vegetation type, Forest type, etc.	

Chapter 2 B

Socio-Ecological Sector

Introduction - Himalaya is important for wide range of eco-system services it provides to its inhabitant population & the areas outside its geographical extent. But, the Himalayan ecosystems are the most fragile areas both ecologically & geologically; the IHR is also relatively under/ less developed as compared to rest of the country. It is characterized by hill specificities, and development of the region and communities is a very genuine requirement. The developmental activities of fragile Himalayan ecosystems involve huge costs for environment, which also have negative bearings for 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 taming to its ecological capabilities with due considerations for environmental sensitivities and conservation. Hence, the developmental decision making needs a holistic visualization of - environmental impacts, conservation threats and priorities, and a balancing of conservation and development, for which comprehensive & 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 syndrome is also being considered as a major hurdle in use of the outcomes of scientific research for policy formulations and development planning & decision making.

In this context, for a better science, policy, and practice connect the 'NITI - Aayog' have constituted a work group on - 'Data and information for informed decision making on key conservation and development issues'. The group is required to assess the data/ information requirements & availability across sectors/institutions/ organizations, identification of the gap areas, and the data to be generated, and suggest institutional collaborations for data development, data access, and formats and the sharing/ management modalities.

Terms of Reference for Work-Group 5: The task of the Work Group on 'Data/ Information for Informed Decision Making' is described in terms of the following points of the TOR.

1. To assess data requirement & availability across multiple sectors/ Institutions and gaps, for monitoring of key Conservation & Development issues including climate change, cryosphere, disaster, biodiversity, and socio-ecological dimensions and ways to address them thru cross-sectoral and interdisciplinary institutional collaborations

2. To suggest data generation, management, sharing, and end-user accessibility and use with a view to ensure quality, formats, and sharing at different levels

Socio-Ecological Context/ 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 for the conservation and development in the area/ region. There are several socio-ecological issues/ themes that need consideration, some of them are covered under sections on climate change/ disaster/ bio-diversity. Those identified/ prioritized for socio-ecological section, during the 'meeting' held at 'NITI-Aayog' on Aug 18, 2017 are as under -

a) Development of Hydropower

b) Sustainable Rural Development (Components - Agricultural Development, Out migration, and Female Drudgery)

c) Indigenous Traditional Knowledge

Perspectives on Socio-ecological Issues for Informed Decision Making: The identified major issues in context of possible decision choices, related data requirements/ availability, gaps etc., for the desired action points, are discussed below. The suggestions regarding collaborations for data development, sharing mechanisms, policy and formats etc., are separately given with each theme.

1. *Development of Hydropower* : The IHR has tremendous potential and scope for hydropower development, 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 earn revenue to IHR states thru sale of hydropower to other states of the country. But, development of hydropower in the region, specially the large hydro-electric projects have also evoked controversies due to associated geological/ environmental fragility of the region, estimated benefits/ life-span of the dam due to underestimation of dam-sedimentation, displacement/ relocation of people, and the compensation issues, etc. As the issue is crucial for the development of the region, the 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, and therefore needs a thorough analyses of available decision choices in the sector in wider context of the social welfare and economic well-being of the people. Now 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 & resettlement history (learning from previous experiences), vulnerability to disasters/ extreme events, and economic & 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/subbasin-wise geological information, river flow & siltation information are the major data gaps areas, where data/ information needs to be generated.

Suggestions to address data gaps, Inter-institutional collaborations, data generation, formats - Some broad suggestions with respect to above points are stated as under -

- The conventional decision making on hydropower development is usually based on the EIA exercises 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 etc. Such exercises are need specific and once the proposal for hydropower development in an area has been approved, 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 researches 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/ researches 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. Therefore, there is a need to encourage a team based developmental researches in the area involving institutional collaborations, and a team based research culture. Also, the outputs of such endeavors 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 researches with inter-institutional, inter-departmental (intra-institutional), will help in generating a large set of 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 a firsthand experience to researchers for participation in developmental planning process 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 that of the subjects experts in the field can be used, for better guidance of researchers and quality of research outputs for use in decision making.

- As evident from the Table 1, 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, river flow/ siltation information etc. 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 thru 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 oustees etc. These issues provide a cue for future decisions, and their documentation therefore is important.

- In the face of climate change, increased extreme events, and the built in disasters of Himalayan environment, the hydropower projects have become more vulnerable to threats of dam breach, therefore, future developments of hydropower should also incorporate disaster/ extreme event risks in hydro-power project 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, the accounting of extreme events and the disaster concerns i.e. risks, sensitivity, and vulnerability, etc. should be an integral component of the standard EIA/ SEA/ CBA formats/ exercises.

- The data available with recognized data agencies on demography, land-use, agriculture 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 & 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 work, and prioritize the potential hydropower sites across IHR, the geological data of those sites should be the responsibility GSI/WIHG, Biodiversity - BSI, ZSI supplemented by GBPNIHESD & 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.

Arrangement 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 1: *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 arge/small, & run-off the river projects for various places & sites	- Consolidated appraisal statements/ Reports	- Micro/ medium/ large etc. projects for all potential sites	- Limited, specific to commissioned/ proposed projects [A]	-Systematic data for all rivers/ potn. locations	- Not Reported
	- Biodiversity/ Forests (population, density, endemism, Index, RET details)	- Grid based, basin /sub-basin & Season wise	- **Limited context**[B] site specific	- Needs to be generated	- Study specific (Not relevant to context)
- Submerged area /Economic losses/Displacement/ Impacts	- Demographic structure	- Village wise for project affected area/10 yr	- Village level/ 10 yr	- No Gap -	-- do --
	- Geomorphic structure of the dam area/ probable sites	- Land use (village/ decadal)	- Land-use (village) /5 yr	- **Geological data/ Info.**	-- do --
	- River Flow	- Basin/ sub-basin level, &			
	- Siltation	near confluence points of tributaries	- Not known, Sparse (Limited [B])	- **Data Gap** -	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 -	- **No Gap** -	- do -
- Disaster/ Climate Risks Accounting	- Disaster History	- for available years	- available -	**I**	
	- Social vulnerability	- Influence/ affected zone / 5-10 yearly		**Data Gap**	
	- Physical vulnerability		- Needs to be developed - Vulnerability(few cases)	**I**	Not Reported
	- Risks accounting/ simulations				
- Learnings (political ecology, movements, long term monitoring)	- Issues of dam movements	- Agri production/ fish-catch		- **Fish (Data Gap)**	Not reported
	- Upstream/downstream impacts		- Agriculture/5 yearly		
	- Project performance (Periodic post EIAs)	- Specific to installed/ ongoing projects - 5 yearly EIAs)	- Fish (No data) - Published reports (Movement Issues) Post EIA - No data	- **Data Gap** -	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 are the typical representative of the peculiarities of the 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 & small land-holdings are some other important factors responsible for poor agricultural returns. The poor productivity of agriculture is a major cause of outmigration the male work-force for jobs from the rural areas to adjoining urban areas, and to areas outside the Himalayan mountains. The poor social & 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 building sentiments, and mindsets for jobs; later search for jobs became a coveted preference of educated mass, 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 shielded it from adoption of new technologies, and innovations; the over-engagement of women in agricultural work in addition to their daily chores & concomitant social commitments further compounded the quality of agriculture/ output, and adversely affected the educational progress of the women in the area, and thereupon the evolution/ development of progressive farmers/ farming in the region. The agriculture sector forms the backbone of rural development, therefore, bringing about rural development, needs reforms in the agriculture sector, which require considerations for type/ quality of land, the capacity of agricultural workforce, and the possibilities of technological applications. The agriculture in IHR is infested with the problems of topography, outmigration of male workforce, and female drudgery, therefore development decision making to reform agriculture or foster rural development need consideration of these aspects. off late, damage to crops by climate change, and depredation by wild animals, particularly, monkeys and wild pig has considerably increased, 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, information on requirements of data sets for decision choices, available data sets, and gaps are compiled in Table 2. The data gaps and response of institute contacted are shown in the relevant columns.

Suggestions to address data gaps, Inter-institutional collaborations, formats Some pertinent issues related to Rural Development, related data sets, and gap gaps with suggestions are commented below.

2a. Agricultural Development & Sustainability -

- In hill agriculture the crop choices, crop-combination and timings vary with altitude & aspects, therefore in cropping decisions the altitude factor is very important, and for micro level decisions information at village level is a must. The crop production/ productivity data at village/ block levels is a data gap, compilation of such data at village/ block/ and altitudinal zone-wise on 5yealy/10 yearly basis is required.

- The livestock and forests are important component of hill agriculture of IHR, presently livestock data at village level is 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, the 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, such data at village level on 5 yearly basis is available; now 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 adaptations to technologies, is an important statistics, 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 levels and zone basis. Similarly, information on seed availability of planting material at zone level is a gap area, and requires compilation.

- Similarly, the information for requirements/ availability of market chain for agricultural produce/ value added products of an area/ cluster of villages, crop damage by wild-life invasions and climate change at village level & zone basis, and status of traditional crops i.e. type, production, lost biodiversity etc. at village/ zone level is a gap area/ missing link, 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 thru 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 a 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-existing 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. The human-wildlife conflicts is a core research area of WII.

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, problem of cash are some other reasons behind this. The outmigration results in loss of affiliation to native environment & resources, also creates apathy and inferiority in the minds of those left out in the villages. This impact is weakening of traditional institutions devoted for conservation and management, resulting in resource degradation and the social & 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, gaps etc., are as under.

- The recognized data agencies do not collect data on causes of outmigration, therefore, there is a need to generate such data. Generation of this data can be achieved through researches carried out by universities, developmental research organizations, social science/ agricultural research institutes, and thru sponsored research for enterprise development or by incorporating these aspects in the survey schedules of the data agencies.

- Similarly information on other data gap area i.e. livelihood development scoping, SWOT, 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 livelihood& 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, and ICSSR, and GBPNIHESD.

2c. Status of Women (Minimizing Female Drudgery) : The female drudgery in Hills of IHR is an outcome of non-remunerative agriculture, and male outmigration, it is also an indicator of rural poverty and economic backwardness of the area. The female drudgery is evident in terms excessive workload, and time elapsed and efforts put in collecting and carrying heavy head-loads/ back-loads of fuelwood, fodder, etc., from distant forests. Besides, they also perform their routine family duties, and also contribute to household agricultural activities from the very early childhood. The female drudgery is a typical problem of IHR mountains, which has nutritional and health implications for the women folk, and inflicts huge cost in terms of missed out/ lost opportunities. The data set required for drudgery reduction is compiled in Table 2 (2c), the comments on data requirement, availability, gaps etc., are as under-

- The data on female literacy, occupation, rural electrification status, LPG connections village is available in census, state level survey reports, however data on women health, nutritional status, time spent in household chores, distance travelled for collection of water/ fuelwood/ fodder etc., and related opportunity cost is not available with data agencies, such information is limited to some case studies in few areas only. Therefore, this is a data gap area, 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, IIRD etc. can be sought in this respect.

- Similarly appraisal data on drudgery reduction measures is not collected by data agencies, such information on a very limited contexts confined to few case studies in report/ published form, may be available in public domain. But for decision context this is a big data gap area, 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 women health, nutritional status, and time spent in different chores, etc. can be entrusted to State's 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, etc. The information from sampled representatives villages can also be developed thru sponsored research funded by DST, NMHS, IERP etc. The ICIMOD's exposure and program can be used for this work.

Arrangements for Addressing Data Gaps/Data Development for Rural Development (** Yet to be finalized)

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	MoEFCC	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 2: *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 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/ 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. Stock- Dist/ 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 **I** **Data Gap** **I** **Data Gap** **I** **I** **Data Gap** **I** **- Data Gap -**	Case study based/few areas Not reported
2b. Out-migration/ depopulation	- Population statistics over a	- Village level/ 5 yr or 10yr	-Village/ 10 yr	- Available -	Case study

of villages - Time series data on outmigration - Growth data on social infrastructure - Livelihood opportunities - SWOT & livelihood/enterprise scoping	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/ 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	- Likely (Few cases; report form) Village (available-10yr) No Data No Data	- Data gap- - Available - Data Gap - Data Gap	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/ Vil.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/ 5-10yr	- 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 the 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 & subsistence. This knowledge in due course of time became refined and persisted through a system of traditions. The high spatial & climatic variability in Himalaya, helped in evolution of a large body of such knowledge base. Under the climate change scenario, such knowledge base 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 base relating to various fields such as traditional health care system, preservation and storage of agricultural produce, water resource conservation, plant breeding etc. though very useful, have mostly remained undocumented, and under the influence of modernization and globalization, and lack of patronage is gradually losing ground, and have become extinct. The documentation and revival of such knowledge systems is not only important from cultural perspective but also holds key to many of our modern day problems. This knowledge also needs to be validated for its efficacy and the scientific contents.

Suggestions to address data gaps, Inter-institutional collaborations, formats The data requirements, availability, and gap status based on information received is compiled in Table 3. 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, & its region-wise status documentation on 5-10 years cycle basis for village/ village clusters/ and eco-cultural zone basis should be carried out. This will also help in capturing its efficacy and importance of such knowledge base, and utility in face of new knowledge and changing cultural regimes.

- Some case study based information on different knowledge systems in published form is available, some information in digital database form has been attempted/ exists. But still, we don't 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 Yunani, Aayurveda & Siddha; natural resource conservation & 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 and lot of such knowledge can be developed through sponsored research. The DST and state level identified centres should provide a portal for registration/

documentation of such knowledge, wherein all such knowledge-base generated through various research agencies 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 of responding institutions is compiled in Table 4 & Table 5, 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 have responded to data availability request, only 6 out of 94 contacted institutions submitted their response. The information available with them is very limited and scattered, which is 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 in data sharing, it is remarked that only the information in published form, can be 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 3: *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 accredition - Accession to database/ digital database - Marketing	- Knowledge type database - Health Care knowledgebase - Natural resource conservation, use & management Knowl. 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	Tr means of Liv.hood, Lstock husbandry, and pastoralism for few cases reported

Table 4: *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	Decadenal	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*	Decadenal	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 - 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)	rural/urban/district, - state, district/ State Rural/Urban District/ State - *State Level/ District*	Yearly Financial Year-wise	Published Reports
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 5: *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	Village Level (Bhawana Block, Kangra District)	2013 - 15	Digital/ Hard Copy	Yes (Bhawana Block of Kangra District only)

		- Traditional Knowledge				- 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 - Major conclusions and suggestions are as under -

- 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 an area of huge information or data gap.

- To bridge this information gap there is a need to promote such researches 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 in state govt./ central government's R&D funding programs. International collaborations for funding such research/ projects should also be encouraged.

- To promote such R&D to support decision making, at university level, a culture of multidisciplinary research should be encouraged, 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 & 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 of data gaps and data development for Hydropower sector the Ministry of Water Resources or CWC could be the nodal agency, while the other 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 disaste/extreme events and dam breach simulations, and IISSR/ GBPNIHESD/WII for post dam EIAs & learnings.

- 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 conflicts can be assigned to state's forest department 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 livelihood & enterprise potential which is exploratory work can be covered through sponsored research and should be shared by ICAR and the State Agriculture Directorate/ departments, the inputs/ funding from sponsored research by ICIMOD etc. international organizations should also be used for strengthening of data base.
- For section on women health and reduction on female drudgery, for generation of information/ data on women health, nutritional status, and time spent in different chores, etc. can be entrusted to Directorate of Economics and Statistics of State Planning Division; State's 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 etc, the international exposure of ICIMOD can be used, the 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 which is needed for a policy decisions; the generation of 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 representatives villages can also be developed thru sponsored research funded by DST, NMHS, IERP etc.
- For TIK database the DST can be the nodal agency, the other agencies that can be engaged for information/ data related to their respective fields are - Directorate of Yunani, Aayurveda & Siddha for Health Care, and ICAR/ GBPNIHESD/ WII/ state ministries of rural development, State Forest Department & related Line Agencies, and Ministry of Tribal Development etc. for natural resource conservation & management. The Crop protection/ storage/ and Integrated Pest Management based knowledge database development can be entrusted to ICAR, & State Agriculture Department etc.

Chapter 3

Data Management and Data Sharing

Background

This chapter is 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. Moreover, a concise outline of centralized Himalayan data management and sharing mechanism to aggravate decision making on conservation and developmental issues of Himalaya is also proposed. This chapter is, therefore,a response to NITI Aayog's terms of reference objective:"*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 of key conservation and developmental data management and sharing, responses on the Indian institutes and agencies working on Indian Himalaya were compiled primarily forfour sectors: (i) climate and cryosphere, (ii) disaster, (iii) biodiversity,and (iii) socio-ecological dimensions. It is noted that along with few dedicated / nodal institutes for sectorial 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 & Census Commissioner (MoHA, GOI) for socio-population data etc., a significant number of agencies arealso involved in primary data generation for IHR. However, most of these individual institutes / agencies are noted to produce primary data for research purpose and limited to small spatio-temporal scale.

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

(i) Irrespective of sectors, i.e. climate and cryosphere, disaster, biodiversity andsocio-ecological dimensions, data management and sharing mechanisms are not uniform.

(ii) Nodal institutes for climate and cryospheredata 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.

(iii) Nodal institutes for biodiversity conservation have hardcopy records mostly missing geocoding that needs digitization and technological interventions for easier and appropriate data sharing.

(iv) 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 observation with respect to data management and sharing of individual agencies or institutes collecting sectorial data are:

(i) 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.

(ii) 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.

(iii) 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.

(iv) 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 lacking of which involves duplication of work further leading to utilization of the government funds for the same kind of work. Therefore, the existing formats of datasets are immensely required to be reviewed by the expert institutes in discussion with stakeholders, academia, etc.

It has also been noted that digital gridded data, irrespective of sectors having a 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 basis 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, few nodal agencies associated to different sectors do maintain their data inventory for their data dissemination and sharing through a defined procedure as shown in Fig 1. 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 kind 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.

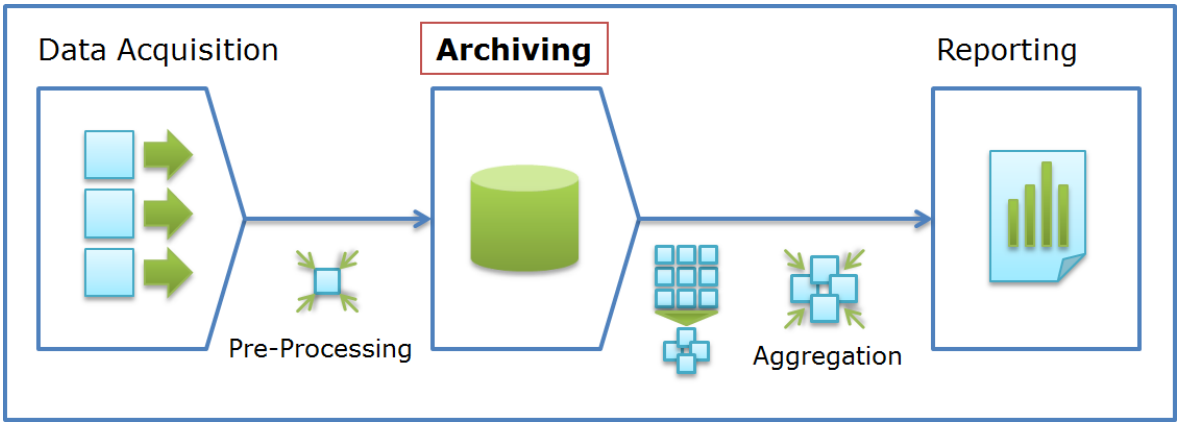

Fig. 1: *Framework for Data/Met data/Information Hosting at a single platform for data sharing*

Moreover, while discussing the formats, levels of data dissemination and ensuring end user accessibility, there is unprecedented need of drawing the 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*." A schematic on data management following the recommendation of NDSAP is provided in Fig. 2. 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 could be suitable a provision for Himalayan data archiving and management.

Fig. 2: *Components of data management*

It is also noted during the survey that NRSC, Hyderabad and ICIMOD, Nepal are having existing mechanism for data management and sharing on larger scale. However, ICIMOD, being a non indigenous 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, Himalayan specific data sharing and management mechanism through *Bhuvan* may not be suitable. Therefore, proposition of a Himalaya specific data centre for management and robust sharing is still open and is required to be addressed. **ISRO may be given the responsibility for developing the Centre for Database Management to collect, manage, and disseminate data/metadata across various sectors for the stakeholders and to ensure end-user accessibility for informed decision making as suggested in earlier chapters.** A schematic representation of data management at the Centre for database management is provided in Fig 3. The data quality classification can be made by the nodal agencies following Table 1.

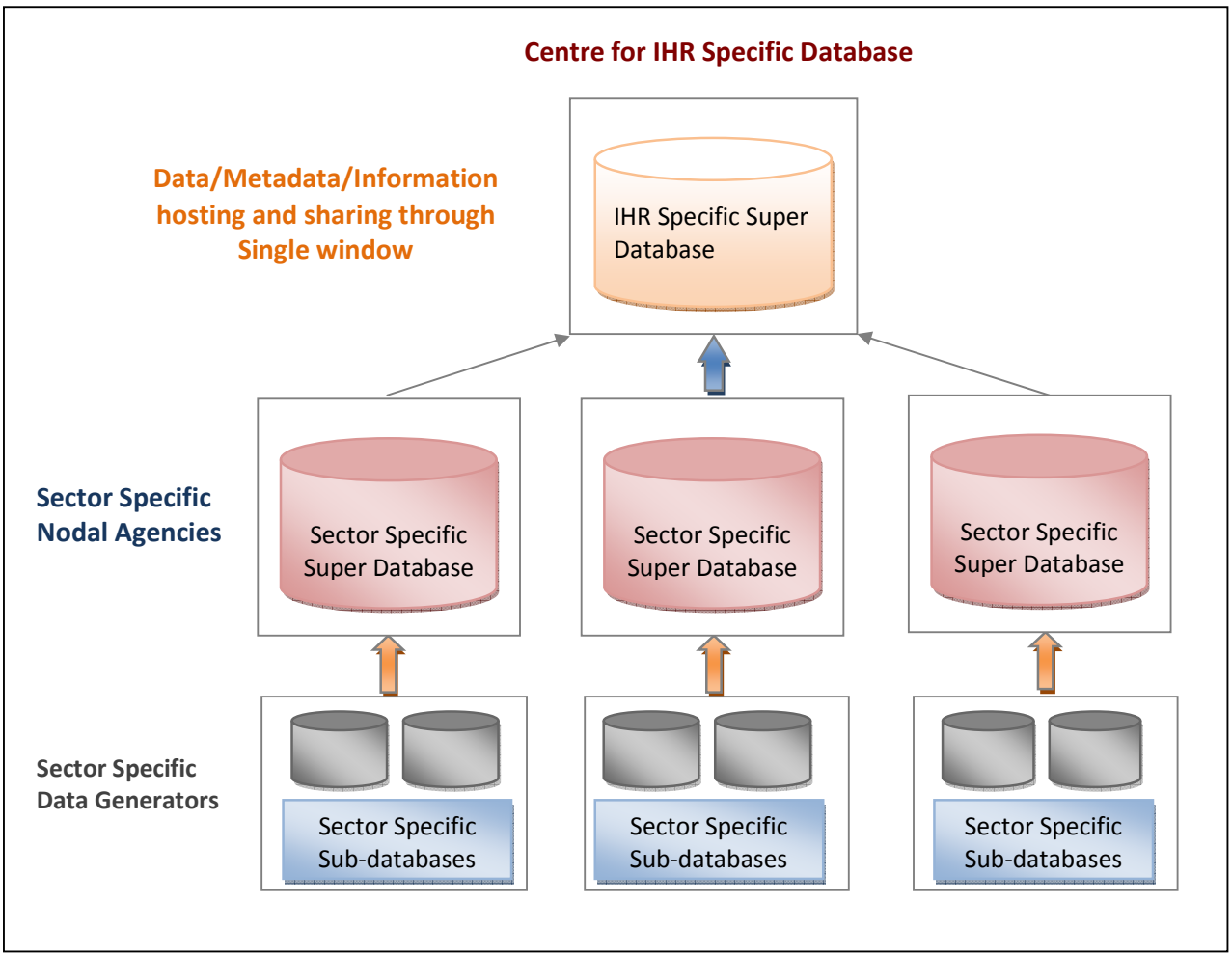

Fig 3: Schematic representation of Centre for Database Management specifically for IHR as a whole

Table 1: *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

After reviewing the responses to the questionnaire received from various institute, it was evident that ISRO covers and collects the data against mostly all the sectors. Moreover, they have well defined state-of-art data dissemination policy and system. 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 the nodal agency as well. Therefore, ISRO should be advised to develop a region specific Data Centre based on the model suggested in fig. 3 and a portal specifically for IHR which would be housed in any institute located in IHR.

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 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 portals for data management and sharing and responded as follows:

There are primarily following bodies involved in data generation and data sharing which can be thought of to have handshake with proposed central server to facilitate all kind of data through a single window/platform avoiding any complexities for data accessibility.

i. 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.
ii. IMD provides data on meteorology (http://www.imd.gov.in/).
iii. NRSC and NESAC primarily collects, acquire and generates Geospatial data
iv. Forest Survey of India (FSI) generates data for biennial monitoring of Forest cover (crown density) since 1987.
v. FSI has forest type based in spatial form that could provide broad information of forest types at county level and for the Himalayan region.
vi. Forest fire alerts from 2004 t ill data are available as point information further carrying information of the forest fire outbreaks at forest administrative units can be used.

vii. Survey of India provides data on geological mapping

viii. Central Ground water board generates data for Ground Water potential

ix. National Institute of Hydrology generates the data on Hydrological aspects

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

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

Chapter 4

Draft Recommendations / Specific Action Points

Findings:

- Our questionnaire survey/consultations revealed a limited response ~25 % (out of 92 leading organizations). Additionally, information was also generated form web portals of various institutions. Considering the limited response, 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 with them so far is fragmentary and points out to a number of data gaps.

- Data/information seems to be incomplete with respect to location details, user-friendly format, spatio-temporal scale, dynamics of quantities, resource use pattern of data collection, drivers of change, etc. Required for conservation and sustainable mountain development. Thus making the data incompatible for comparison and decision making.

- In R&D institutions/Universities, often data is collected under a certain activity / project mode for a specific location, duration, scale and replications without any long term strategy lacking conclusive datasets for development planning.

- There is no organized mechanism / system for data collection, data management and data dissemination. This may lead to 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 NPDSA **envisage that l**arge

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 put down a condition, the data generated using such funds would come under the purview of this Policy.

Recommendations:

1. In the IHR, there is no existing policy for data collection, management and accessibility for end-users so far. Presently, sector-specific data collected by several agencies of State/Central Govt. can be pooled and synthesized and made user-friendly to improve its accessibility to various policy/planning and decision making. A proposed plan is given in Table 1.

2. In the context of IHR, there need of 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.

3. 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 to allocate some part of their grants given under R&D projects to various organizations across the IHR for data generation on specified gap areas 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 heterogenous physical, biological and socio-economic settings of the IHR. Also, the in-house data collection activities of nodal agencies of Govt. of India need to be time-bound. Thus encouraging natural resource conservation & development research, and extend 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.

4. It is suggested that an "*Umbrella Policy*" to generate data, address data gaps, data quality control, data management and data access to end-users need to be created. Under this policy an accredited Central Govt. organization (such as ISRO) may by identified to act as Central Data Management Agency for IHR (CDMA) 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 Deptts. 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.

5. 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.

6. 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. Since such data are not generated under any standardized format, inter-operability of data poses a serious challenge. Hence a devoted portal for uploading the data generated by research Institutions, Universities and other voluntary organizations (List is given in Annexure 1) need to be created by the sector specific Nodal Organizations for hosting the data/metadata to promote data sharing. This will in turn increase the overall data collection and data availability. 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 dataset 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.

6. A big challenge is to bring data collected in a compatible format utilizable for developmental planning. To achieve this compatible "Data Formats" need to be designed by the respective nodal organizations (Table 1). 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.

7. 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. Thus, data on 1:25,000 scalemay be generated 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.

8. 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 also be made to convert the analogue data into digital domain 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 these two sectors enthnobotanical and IKS relating to best management practices of conservation of natural resources for sustainable development available with the inhabitants following Citizen’s Science approach need to be documented and popularized.

10. Training/capacity building of planners/decision makers for utilization of data/information from the CDMA / nodal organizations would be highly desirable for better planning in view of environmental conservation and sustainable development of the IHR. Decision making involves comparison of policy choices, developmental & appraisal of management options. There is a paucity of such approach in data generation that need to be addressed through training/capacity building programmes.

Table 1: 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	IMD	NIH, DST, NRSC-ISRO
2.	Cryosphere	GSI	WIHG, NIH, SASE, NRSC-ISRO
3.	Disaster	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 Deptt.
5.	Socio-ecology	State agencies in IHR/NSSO	Planning Deptt. of State Govt.

APPENDIX 1

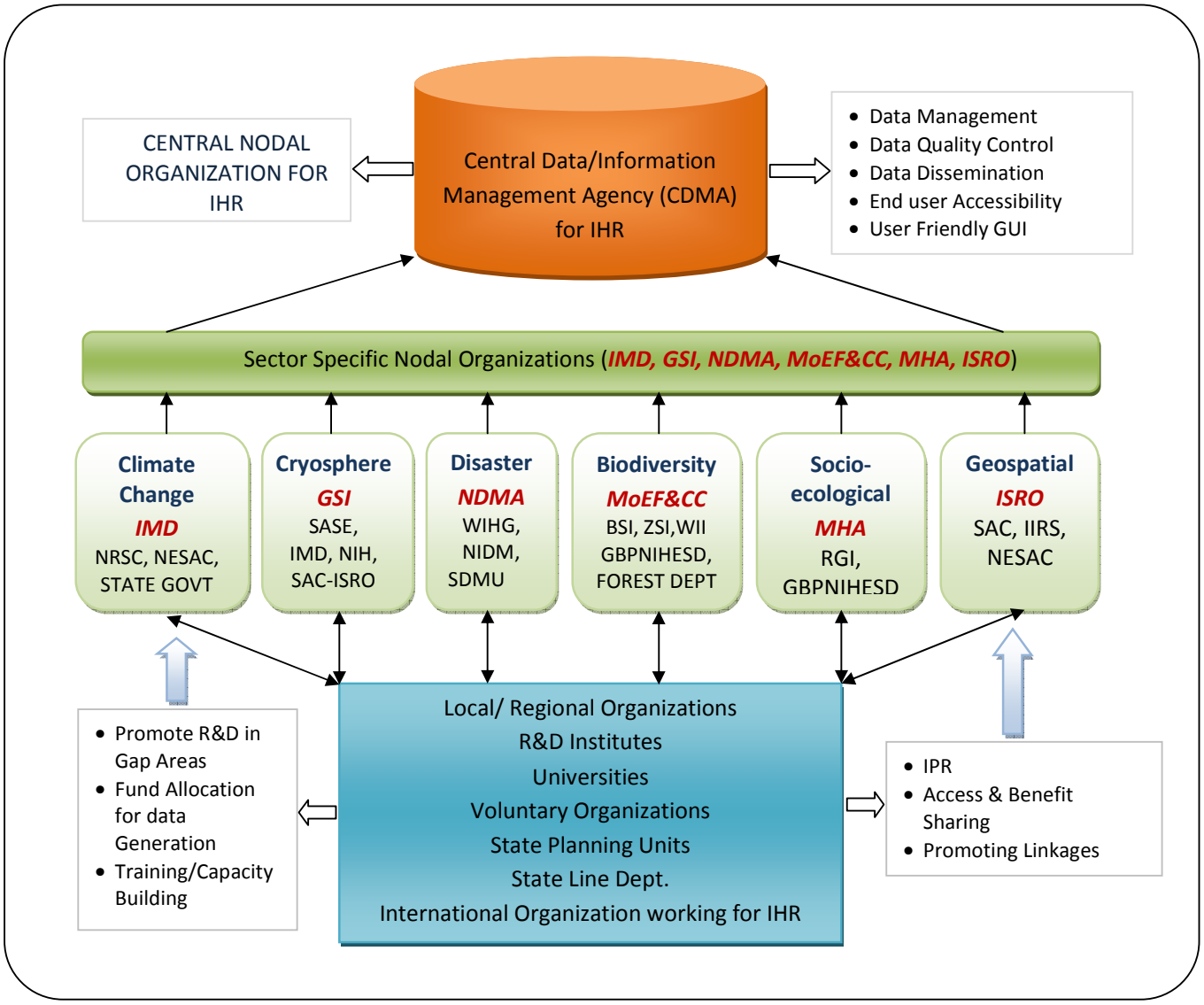

Fig. 1: Shematic representation of CDMA

Annexure I

List of Institutions in the IHR

S.No.	Name of Institution	Name & Designation
Uttarakhand		
1	Forest Research Institute (FRI), Dehradun	Vice Chancellor & Director Forest Research Institute (Deemed) University, Dehradun-248001,Uttarakhand Ph.: +91-135-2224439, +91-135-2751826 Email:dir_fri@icfre.org
2	Central Soil & Water Conservation Research & Training Institute (CSWCRTI), Dehradun	Director Central Soil & Water Conservation Research & Training Institute, 218, Kaulagarh Road, Dehradun-248 195, Uttarakhand Ph.: +91-135-2758564 Mob.No.:+91-9412053251 Email: director@cswcrtiddn.org pkmbellary@rediffmail.com
3	Forest Survey of India (FSI), Dehradun	Director General Kaulagarh Road, IPE Dehradun - 248195 Uttarakhand Ph.: (+91) 0135 – 2756139 Email:dgfsi@fsi.nic.in,jdtfi@fsi.nic.in, jdnfdmc@fsi.nic.in
4	G.B. Pant National Institute of Himalayan Environment & Sustainable Development, (GBPNIHESD), Almora	Director G. B. Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD) Kosi-Katarmal, Almora-263 643, Uttarakhand Ph: +91-5962) 241015 Email:psdir@gbpihed.nic.in
5	Wildlife Institute of India (WII), Dehradun	Director Wildlife Institute of India (WII) Chandrabani, Dehradun-248001,Uttarakhand Ph.: +91-135-2640910 Mob: +91-94120-54648 Email:vbm@wii.gov.in
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7	National Research Centre on Coldwater Fisheries (NRCCWF), Bhimtal	Director Anusandhan Bhawan,Industrial Area, Bhimtal-263136,Nainital,Uttarakhand Ph.:+91-5942-247280,247279 Email: director.dcfr@icar.gov.in,dcfrin@rediffmail.com, dcfrin@gmail.com
8.	Wadia Institute of Himalayan Geology (WIHG), Dehradun	Director Wadia Institute of Himalayan Geology (WIHG), 33 GMS Road, Dehradun – 248001,Uttarakhand. Ph.: +91-135-2525103 Email: director@wihg.res.in
9.	High Altitude Plant Physiology Research Centre, (HAPPRC), Srinagar (Garhwal)	Director High Altitude Plant Physiology Research Centre (HAPPRC), H.N.B. Garhwal University, Srinagar Garhwal, 246174 ,Uttarakhand Ph.: +91-1346-252143 Mobile No.: +91-9411154648

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11	Indian Institute of Remote Sensing (IIRS), Dehradun	Director Indian Institute of Remote Sensing ISRO , Govt. of India 4, Kalidas Road, Dehradun- 248001, Uttarakhand Ph.:+91-135- 2524101 Email: director@iirs.gov.in
12	National Institute Of Technology - [Nit], Srinagar Garhwal	Director National Institute of Technology, Uttarakhand Temporary Campus, Government Polytechnic, Srinagar (Garhwal)-246174, Uttarakhand Ph.:+91-346-257400 & Permanent Campus (Under Construction) National Institute of Technology, Uttarakhand Village: Sumari ,Post Office: Sumari Pauri Garhwal-246174, Uttarakhand Email:nituttarakhand@gmail.com
13	Uttarakhand Space Application Centre,Dehradun	Director 31/2, VasantVihar.Dehradun-248001,Uttarakhand Ph.:-+91-135-2763393, 2762098 Email:
14	UCOST(State Council for Science and Technology),Dehradun	Director General, Uttarakhand State Council for Science and Technology, VIGYAN DHAM, Vigyan Sadan Block, Dehradun - 248007 , Uttarakhand Ph.: +91-9412051556 / 57 Email: dg@ucost.in
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West Bengal		
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Jammu & Kashmir		
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9.	IUCN, New Delhi	Manager (Programme, Constituency & Administration) IUCN (International Union for Conservation of Nature) C4/25, SDA, New Delhi -110016 Ph: +91-11- 2652-7742 Email: js.rawat@iucn.org
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2.	Govind Ballabh Pant University of agriculture and Technology, Pantnagar	Vice-Chancellor, Govind Ballabh Pant University of Agriculture & Technology Pantvarsity, Pantnagar-263145 Distt. Udham Singh Nagar,Uttarakhand Phone: +91-5944-233333,233500 Email: vc@gbpuat.ac.in, vcgbpuat@gmail.com
3.	Doon University,Dehradun	Vice-Chancellor Doon University,Room No.105 (First Floor), Administrative Block, Doon University, Mothrowala Road, Kedarpur,

		P.O. Ajabpur, Dehradun-248001, Uttarakhand Ph.: +91-135-2533102, 2533114 Email:doonvc@gmail.com
4.	Kumaun University, Nainital	Vice-Chancellor Kumaun University Sleepy Hollow, Nainital-263001,Uttarakhand Ph: +91-5942-235068 Email: vc@kunainital.ac.in coeku.2013@gmail.com
5.	Uttarakhand University Of Horticulture & Forestry(UUHF), Dehradun	Vice-Chancellor Uttarakhand University Of Horticulture & Forestry(UUHF), Bharsar- 246123 ,Uttarakhand Ph.:+91-1348-226071 Email: vc27uuhfm@gmail.com , matthewprasad27@gmail.com
Himachal Pradesh		
1	Central University of Himachal Pradesh	Vice- Chancellor Central University of Himachal Pradesh, Dharamshala, Dist. Kangra, Himachal Pradesh - 176215 Ph.+91-1892-229330, +91-1892-229331 Email: vc@cuhimachal.ac.in
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3	Himachal Pradesh University	Vice-Chancellor Himachal Pradesh University, Gyan-Path, Summer-Hill, Shimla-171 005 Himachal Pradesh Ph:+91-177-2830912 Email: vc_hpu@hotmail.com
4.	Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya,Palampur	Vice-Chancellor Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya,Palampur – 176062,Distt. Kangra , Himachal Pradesh Ph. +91 1894 230521 Email: vc@hillagric.ac.in
Assam		
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3.	Gauhati University,Guwahati	Vice-Chancellor Gauhati University,Gopinath Bardoloi Nagar,Guwahati-781014 Assam Ph:+91-361-2570412 Email: vc@gauhati.ac.in

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2.	Central University of Kashmir, Kashmir	Vice Chancellor Administrative Block,Nowgam Campus-II, (Near Puhroo Chowk, Nowgam ByePass), Srinagar-190015, Jammu & Kashmir. Ph:+91 9419000976, 0194-2315271 2315296,0194-2315290 Email: vc@cukashmir.ac.in mirmehraj999@gmail.com
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4	University of Kashmir, Kashmir	Vice Chancellor Administrative Block,University of Kashmir, Hazratbal,Srinagar-190006,Kashmir Ph.+91-194 227 2003 Email: vcoffice@kashmiruniversity.ac.in
5.	University of Jammu,Jammu	Vice Chancellor University of Jammu,Baba Saheb Ambedkar Road, Jammu Tawi (J&K)-180006 Ph.:+91-191- 2450014 Email:
6.	Shri Mata Vaishno Devi University,J&K	Vice Chancellor Shri Mata Vaishno Devi University Campus, Sub-Post Office, Katra-182320,Jammu and Kashmir Ph: +91-1991-285686 Ph.: +91-1991-285535/285524/285634 /285699, 01991-285694 Email: vc@smvdu.ac.in
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Meghalaya		
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2.	Aligarh Muslim University , Aligarh (C)	Vice-Chancellor Aligarh Muslim University, Aligarh-202002, Uttar Pradesh Ph.:+91 (571) 2700994/2702167 Email: vcamu@amu.ac.in
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5.	University of Lucknow, Lucknow	Vice-chancellor University of Lucknow,V.C. Residence, Badshah Bagh, Lucknow University Campus, Lucknow-226025,Uttar Pradesh Ph:+91-522 - 2740467 Email: vc@lkouniv.ac.in

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4.	North Eastern Space Applications Centre(NESAC),Shilong	Director North Eastern Space Applications Centre (NESAC) Department of Space, Government of India Umiam -793103 (Meghalaya) Ph: +91 364 2570140/141 Email**:** director@nesac.gov.in
5.	National Centre For Antarctic And Ocean Research(NCAOR),Goa	Director National Centre for Antarctic and Ocean Research(NCAOR) Ministry of Earth Sciences, Government of India Headland Sada, Vasco-da-Gama, Goa 403 804,Goa Ph. +91-832-2520876 /2525511/2525600 /2525601 Email: mravi@ncaor.gov.in
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Annexure II

WORKING GROUP ON SUSTAINABLE DEVELOPMENT IN MOUNTAINS OF INDIAN HIMALAYAN REGION

Brief Survey on Availability of data/ information in the 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:

i) 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.

ii) 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/	Date / Time period	Frequency of data (daily/weekly /seasonal/annua	Problems of conservation (if any)

		Altitude, etc.)		l)	
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/**	**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)**

	Any Other)			
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)
Geospatila 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
Date **Designation:**
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:*

i) kireet@gbpihed.nic.in

ii) ashus_rhythm@yahoo.com

Annexure III

S.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, Research institutes and Universities across India. Department of Statistics (J&K Govt.), Department of Ecology, Environment and Remote Sensing (State and Centre), MOEF, 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
	NCAOR, Goa	Climate change,	-	Harsh climate and	Poor quality/lack in	Digital/printed in

9.		Cryosphere, Discharge (Hydrological balance)		difficult excess, Quality check ,high cost ,high risk of life, small time frame for collecting data	continuity/sparse data/maintenance problem. Patchy data, rare annual hydrograph of high Himalayan basin	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,	ICGRE, GBPIHED,	Do not have any	Site Specific data not	Free/ Sponsored

		Biodiversity, Socio ecological, EIA, Pest Disease, IPM Strategy, Medicinal Plants, Cold Desert Afforestation and Pasture management	DBT, ICAR, Jaypee University, UHF Nauni, SKUAST Jammu	issue	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	under projects
15.	BSI	Biodiversity	No Information	No Information	No Information	Publications()
16.	FSI, Dehradun	Disaster(forest fire Monitoring)	State forest department	Accessibility (Satellite data)	-	Digital/website (FREE)
17.	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
18.	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	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	Geospatial/FREE

			Protection Agency, WMO		maps	
19.	WII, Dehradun	Biodiversity	IMD, IITM, FSI, NRSC,CWC, SOl, 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)
20.	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
21	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	Climare data for high altitude area, Glacier retreat & Mass balance for glaciers, Database on disaster, Biodiversity data is available but not for PAN IHR	Website (Free)

Anexure IV A

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 3 min 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 dischargeand sedimentation rate data. 5. Scatter point source data predominantly over north western Himalayaof research grade climatic parameters.	1. Geospatial data (rainfall and temp.) available through IMD, GOI; Purchase. Which region?? 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

Annexure IV B

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.

Annexure IV C

Disaster Related Issues in IHR	Parameters/ Data required	Data Availability	Scale of Data	Data Gaps as per survey responses	Remarks
Natural Hazards **1) Geological** *(Earthquake and Land/ Mountain slides, Avalanches)*	7. 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	
	8. 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 Event specific data with attributes	- No response on Avalanche data.
2) Climatological *(Forest fire, Flash Floods, Cloud Burst)*	9. Avalanche data 10. 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
	11. Flash flood data/GLOF/Floods	Opportunistic satellite data availability site specific studies*, may include large area along the rivers. Data is collected after the disaster for any particular area	Temporal distribution map of rainfall data Site specific data	-	- Continuous data for prone area to be generated
Technological or Man made (*Road Accidents and Urban Sprawl)*	12. Cloud burst : Rainfall related data 13. Road accident data	District level data for Uttarakhand	Event Specific data	Cloud burst data for Himalayan and especially North eastern region -	-

Annexure IV D

	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 - D 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- N 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 production/ ity under different farming practices - Per HH Landholding and livestock holdings - Soil Quality - Irrigation Status (**Irrigated/ un-irrigated**	- village level/block level/ 5yr/10yrs - Village level/ 5 village/ 5 yr - village basis/ 5 yr	- District/ yearly - Dist. (LStock)/ 5yr No database Village/ 5yr Village/ decadal	- Village level compilations to be brought out	Case study based/few areas Not reported

	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/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	 Village/ 10 yr - NA - No data/ case specific - Case study based - No data - No data - No data - No data	 **I** **Data Gap** **I** **Data Gap** **I** **I** **Data Gap** **I**	
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 Few cases (CS based) - village No Data	- Data gap - Data Gap	Case study based Not Reported

		Village/ cluster/ eco-cultural zone/ sub-watershed/ 5-10 yr			
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 (knowledgebase) - 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	Tr means of Livhood, Lstock husbandry, and pastoralism for few cases reported

Annexure V

Minutes of the Meeting of 'NITI-Aayog Working Group on Data/Information for Informed Decision Making'
(Yojana Bhavan, New Delhi, 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 Cryospheric 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 thru 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 Galcier. 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 thru 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 indentify 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 thru 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.

a) Climate and Cryosphere : IMD to take lead, to be assisted by WIHG and GBPNIHESD

b) Disaster : Wadia Institute of Himalayan Geology

c) Retrieval Mechanisms, Data Coasting and Sharing: NRSC, Hyderabad

d) Biodiversity : WII (Lead), FSI, and GBPNIHESD to assist

e) Socio-ecological : GBPNIHESD (Lead) and DST(Guidance)

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

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 VI

Format for the Sector-wise report for Working Group -5 "Data/Information for Informed Decision Making" for sustainable development of mountains of Himalaya

Tentative outline of the sector-wise report are given as under:

1) Introduction/Background
(Regarding *the sector and the data, ongoing researches in the sector, data quality/accuracy and standards, existing data sharing and generation policies and initiatives from the Government*)

2) Sector-wise Issues
(*Tentative list of issues is attached which may be appended*)

3) Data availability Status and availability constraints, if any - Sectoral, cross-sectoral, regional (*The survey report is attached for reference which may be modified*)

4) Data requirement and the data gap
(*The survey report is attached for reference which may be modified*)

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

6) 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
ii) Formats and quality checks
iii) Sharing, retrieval and end-user accessibility

Note: *Existing issues identified by GBPNIHESD and sector wise report on data availability, requirement, scales of available data, gaps, sharing mechanism, formats, remarks etc. (copy enclosed) is not exhaustive and may be modified as per the discretion of expert institutes.*

Format for the report for Working Group -5 "Data/Information for Informed Decision Making" for sustainable development of mountains of Himalaya

For NRSC

Tentative outline of the sector-wise report are given as under:

1) Data requirement and the data gap
   (The survey report is attached for reference which may be modified)

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

3) 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
   ii) Formats and quality checks
   iii) Sharing, retrieval and end-user accessibility

Note: *i) There are existing portals with NRSC like **Bhuvan**, etc. for data sharing and dissemination. Can it be configured for data management and sharing the data specifically for Indian Himalaya Region (IHR) as appropriate*

ii) Existing issues identified by GBPNIHESD and sector wise report on data availability, requirement, scales of available data, gaps, sharing mechanism, formats, remarks etc. (copy enclosed) is not exhaustive and may be modified as per the discretion of expert institutes.

Annexure VII

Brief Survey on Problems prevalent in the State

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

   _____
   _____
   _____
   _____
   _____
   _____

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?**

   _____
   _____
   _____
   _____
   _____
   _____

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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LIST OF ABBREVIATIONS

GBPNIHESD

CSIR

UGC

DST

MOEF&CC