Octa Journal of Environmental Research
International Peer-Reviewed Journal
Oct. Jour. Env. Res. Vol. 5(4): 258-269
Available online http://www.sciencebeingjournal.com

Oct. – Dec., 2017
ISSN 2321 3655

Review Article

Octa Journal of Environmental Research
(Oct. Jour. Env. Res.) ISSN: 2321-3655
Journal Homepage: http://www.sciencebeingjournal.com

PRESENT TREND OF RESEARCH AND DEVELOPMENTAL ACTIVITIES TAKING OVER BY GLOBAL MOUNTAIN ORGANIZATIONS

Singh Ashok[a*], Vats S.K.[b] and Kumar Sanjay[b]

a. CSIR-IHBT-Centre for High Altitude Biology, Ribling, P.O.-Tandi, Lahaul and Spiti, Himachal Pradesh-175 132, India
b. CSIR- Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh-176 061, India
*Corresponding Author: **ashoksingh@ihbt.res.in**

Received: 6th Dec. 2017 **Revised**: 26th Dec. 2017 **Accepted**: 30th Dec. 2017

Abstract: Mountains regions of the world are most fragile and susceptive to climate change effect. Due to climate change, countless consequences have been felt by many investigators. Over-exploitation by human induced interferences and natural hazards has resulted rapid change in the climate of mountains. Today, with pace of globalization process, need to sustain fragile mountain ecosystem has been realized by many government and non-government organizations. A detailed study for collection of concrete data of all important subjects related to climate change and plant biodiversity sciences has been summarized by us to see the trend of research going in the global mountains and timely making strategy to protect mountainous regions of the World. It is a baseline study related to climate change effect and institutes / agencies working in all mountain regions of the World and further development for opportunities to lead in the mountains.

Keywords: Biodiversity; Climate; Collaborative research; Development; World Mountains.

Postal Address: IHBT-Centre for High Altitude Biology, Ribling, P.O.-Tandi, Lahaul and Spiti, Himachal Pradesh-175132, India Ph: 01894-233339

INTRODUCTION

Global mountain regions supposed to be most fragile ecosystem, containing varied bioresources, sustaining with different life forms and a source of livelihood to a large number of communities. Occupying approximately one-fifth of the world's land surface area and occurring over 75% in the global countries, mountain provides resources and services to more than half to the world's population (Viviroli *et al*., 2007; Immerzeel *et al*., 2010). It is most vulnerable by global climate change effect resulting into habitat degradation and overexploitation by human induced impacts (Walther *et al*., 2002; Parmesan, 2006). Mountain generally collects and store global water resources, providing up to 60% of downstream fresh water in humid regions and up to 95% in arid environments (Viviroli *et al*., 2007). In addition, it contains important unique natural resources, rich heritage of Biological communities with unique culture and custom, lifesaving glaciers, perennial source of water feeding into the river basins, attract tourists and sports enthusiasts and found to be hospitable site to live. Since emphasis for the present review opinion is mainly focused on climate change and biological science research and developmental activities undergoing over global mountain ecosystems. Further, information on global mountain research strength and trend of their working areas were first time compiled by us. Information is useful step towards more collaborative research among the global institutes.

Global Challenges and Opportunities in the Mountains

In mountain regions of world, effect of climate change on biotic and a-biotic environment has been felt and realized by many research and developmental organizations. It is a real threat to well establish civilizations in the low laying

altitudinal regions of world, is totally dependent on mountains for life saving resources. Some of the research and developmental issues needs to be give attention are as follow:

- Long-term monitoring and analysis of indicators of environmental change in mountain regions
- Integrated model-based studies of environmental change in different mountain regions
- Integrated watershed management system
- Sustainable land use and natural resources management
- In our planet out of total glaciers160,000 (indicate that most, but not all) glacier systems have been losing mass for at least last four decades, and that rate of loss has been accelerating since 1990s, which includes Andes loses 50% of ice in just 40 years and after 1970s Andean glaciers shrunk by an average of 30-50%, 70% of the Alps glaciers disappear by 2050, Himalaya glaciers (Nepal's glaciers by 21% and Bhutan's by 22%) have shrunk over last 30 years (www.thinkglobalgreen.org/glaciers.html). Perennial source of mountain glaciers are retreating very fast and is believed that 99% glaciers in Mount Everest (Robert Mcsweeney in Carbon Brief) will disappear up to end of the Centaury 2100 years, needs strengthening of R & D activities.
- Continuous monitoring of Native, Endemic, Economically and Ethno-botanically useful species found under varied habitats and communities are important to know their status for present and future (Samant *et al.*, 2002; Singh and Samant, 2010). Studies on invasion rate of non-native species and their migration from continent to another continent; country to country, zone to zone, within a bio-geographical zone from low altitude to high altitude and their proliferation by seeds, roots/suckers is of real concern for long term sustaining species diversity without damaging habitats and ecosystem (Samant *et al*., 2002).
- Morphological and Bio-chemical characterization of species under different distribution zones and their variation studies under climate change need to be assessed.

Idea for doing Research

In general, the atmospheric concentration of greenhouse gases (which include CO_2, Methane, Nitrous oxide) and other trace gases has showing increasing trend over the last Century and it is supposed that concentration of CO_2 will be double by the middle and latter part of next century (NAS 1979; Pearman 1980; Watson et al. 1998). During the past 100 years, global mean surface air temperature increased by 0.3 to 0.6°C (Jones et al. 1990) with average rise will be up to 0.2 to 0.5°C per decade (Houghten et al. 1990) and future rise will be 1.0 – 3.5^0C by 2100 observed (Watson et al. 1996). Past and future climate predictions model tried for fossils (Martínez-Meyer *et al*., 2004). Due to climate change accelerated erosion rate and sedimentation in the mountainous region of world has been observed (Peizhen *et al*., 2001). The rise in regional and global temperature is affecting many ecosystems over continents of the World (IPCC, 2007). Global change significantly affecting on biodiversity (Vitousek *et al*.. 1997; Dukes and Mooney, 1999; Sala *et al.,* 2000), shift in tree line zone (Friedrich and Gabriele, 2007), reduces species diversity from their actual distribution range and evolutionary responses to climate change studies (Grabharr *et al*., 1995; McCarty 2001; Theurillat and Guisan, 2001; Root *et al*., 2003; Parmesan, 2006; Kelly and Goulden, 2008), extinction of large number of species (Bloomgarden, 1995; Thomas *et al*., 2004) resulting into habitat loss, nitrogen deposition and biological invasions of non-natives (Millennium Ecosystem Assessment, 2005). At global level 10% of the vascular plants have been estimated under threat by the International Union for Conservation of Nature and Natural Resources. Prediction of future species level preparation of distribution models (Bloomgarden, 1995; Hijmans and Graham, 2006) and management of Biodiversity elements (Hannah *et al*., 2002) requires at most attention. Higher proliferation rate of the non-native species is drastically changing the ecosystem properties, also resulting into direct competition with the native

and endemic species (Vitousek, 1986; Samant *et al*., 2006), and affecting the pollination rate (Schweiger *et al*., 2010). Although Long term observation of pollination interaction studies (Hegland *et al*., 2009) is useful for future predicting of reproductive biology, which is time consuming and rarely practiced (Ghazoul, 2005), effect on phenological variations by climate change were observed at global level by Hegland *et al*., 2009; Miller-Rushing and Primack, 2008; Rosenzweig *et al*., 2008. The integrated studies by the different organization in the world mountain scenario are not attempted sofar. This study will give a path way for doing more research and cooperation by collaboration for achieving target.

Data Generation

Information on global institutes situated and working with special focused on climate change and Biodiversity Conservation related subjects in the mountain areas of world were compiled to study extended distribution range of R&D activities. All necessary available information collected from the published home websites of each organization by internet Google based data search. Trend of efforts made by different organization were also compiled based on their mandate, objectives and mission. Compilation of data for number of localized organizations may vary, however it shows general trend of research undergoing over global mountains regions of the world. Institutes / collaborative groups / or individual scientists situated in the low laying altitudes / flat plain areas working in high altitude areas are not includes for the present study.

Strength of High Altitude research at Global Mountains

A total of 21 research and development organizations (R&D) from Asian region (including 11 from India alone), 22 from European region, 14 from North American region, 8 from South American region and 1 from African region were recorded from mountain regions of the world (Table 1). Similarly 18 institutes working from Himalayan Region, 16 from Alps, 15 from Andes, 07 from Arctic/Polar, 07 from Rocky Mountains, 05 from general mountains, 01 from White mountains and 01 from Kalimanjaro mountain were recorded (Table 1; Figure 1). In addition 6 Institutes from European region (like Andes – 4, Arctic / Polar -2) and 8 Institutes from North American Region (Andes – 4, Arctic / Polar -4) are working in other mountains (Table 1).

Table 1. **Continent wise selected Research and Development organization Institutes located in the High Altitude Mountains of the World**

	Asian Region: (21)	**Working area in Mountain region**
	Institutes:	
1.	Institute of Mountain Science, Shinshu University, Japan	Mountains
2.	Institute of Mountain Hazards and Environment (IMHE), China	Himalaya
3.	The Mountain Institute, China	Himalaya
4.	The Mountain Forum, ICIMOD Nepal	Himalaya
5.	Himalayan Forest Research Institute (HFRI), Shimla, H.P., India	Himalaya
6.	G.B. Pant Institute of Himalayan Environment & Development, Almora, India	Himalaya
7.	Defence Institute of High Altitude Research, Leh, India	Himalaya
8.	Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, India	Himalaya
9.	CSIR-Institute of Himalayan Bioresource Technology - a Research Centre for High Altitude Biology, Ribling, Lahaul & Spiti (H.P.), India	Himalaya
10.	Institute of Polar Research, Kaga, Itabashi KU, Tokyo Japan	Polar
	Centre/ Research Station:	
11.	International Centre for Integrated Mountain Development (ICIMOD), Nepal	Himalaya
12.	Mountain Societies Research Centre, University of Central Asia, Bishkek, Kyrgyz Republic	Mountains
13.	Centre for Environment Education-Himalaya, India	Himalaya
14.	High Altitude Physiology Research Centre, Srinagar, Garhwal, India	Himalaya
15.	Regional Research Station at Stakna Leh, Shere Kashmir University, India	Himalaya
16.	High Altitude Regional Stations (4 Nos.) of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, H.P., India	Himalaya

17.	High Altitude Regional Stations (2 Nos.) of Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, H.P., India	Himalaya
18.	Station at High Altitude for Research on the Environment, Nepal	Himalaya
19.	Station at High Altitude for Research on the Environment, Pakistan	Himalaya
20.	Resources Himalaya, Kathmandu, Nepal	Himalaya
21.	HIMANSH High Altitude Station in Spiti, Himachal Pradesh, India, a National Centre for Antarctic and Ocean Research, Goa	Himalaya
European Region: (22)		
	Institutes:	
1.	Institute for Alpine Environment - Projects, Esperanto, Bolzano/Bozen, Italy	Alps
2.	Andean Research Institute, Germany	Andes
3.	Mountain Invasion Research network, Institute of Integrative Biology, Zurich, Switzerland	Alps
4.	Scott Polar Research Institute, University of Cambridge, England	Arctic/Polar
5.	Institute of High Mountain Biology, University of Zilina, Tatranska Javorina, Russia	Alps
	Universities / Centres/ Research Stations:	
6.	Alpine Research Centre Obergurgl, Austria	Alps
7.	Oeschger Center for Climate Change Research, Bern, Switzerland	Alps
8.	K1 Centre Alps -Centre for Climate Change Adaptation Technologies, Innsbruck, Austria	Alps
9.	International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat Switzerland	Alps
10.	The University of Innsbruck, Western Austria	Alps
11.	Station at High Altitude for Research on the Environment, Italy	Alps
12.	Interdisciplinary Mountain Research, Innsbruck, Austria	Alps
13.	Mountain Research Initiative, University of Bern, Switzerland	Alps
14.	Northern federal Arctic university, Russia	Arctic
15.	The Open university, UK	Andes
	Societies / Collaborative organizations:	
16.	GLORIA (Global Observation Research Initiative in Alpine Environments), Austria	Alps
17.	The Alpine Network of Protected Areas, Chambery, France	Alps
18.	Global Mountain Biodiversity Assessment – (GMBA), Switzerland	Alps
19.	CIPRA-International Commission for the Protection of the Alps Schaan, Liechtenstein	Alps
20.	ISCAR-The International Scientific Committee for Alpine Research, Berne, Switzerland	Alps
21.	Oxford Long-term Ecology Laboratory (OxLEL), UK	Andes
22.	European Geosciences Union, Laboratory for Glaciology and Environmental Geophysics Grenoble, France	Andes
North American Region: (14)		
	Institutes:	
1.	Andean Research Institute, USA	Andes
2.	Andean Research Institute, Canada	Andes
3.	Cooperative Institute for Alaska Research (CIFAR), Alaska	Rocky /Arctic
4.	Institute of Arctic and Alpine Research, University of Colorado Boulder	Arctic/mountain
5.	Mountain Research Station, Institute of Arctic and Alpine Research, University of Colorado	Mountains/Rocky
6.	Mountain Studies Institute, Colarado	Rocky
7.	The Mountain Institute, Washington DC, Virginia USA and Peru office	Rocky /Andes
8.	Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska,USA	Arctic
	Universities / Centres / Research stations under Universities:	
9.	White Mountain Research Center, Bishop, California, USA	White mountain
10.	Northern Rocky Mountain Science Center (NOROCK), Montana	Rocky
11.	Centre for Alpine studies, University of British Columbia	Rocky
12.	Byrd Polar Research Center, The Ohio State University Columbus, Ohio	Polar /Arctic/ Mountain
13.	U.S. Rocky Mountain Research Station Research Institute,860 N 1200 E, Logan, UT 84321, USA	Rocky
14.	School of International service, American University, Washington DC	Andes
South American Region: (8)		
	Institutes:	
1.	Andean Research Institute, Peru	Andes
2.	The Earth Institute, Columbia University, Columbia	Andes

3.	Environmental change institute, Oxford University Centre for the Environment, Oxford, UK (Working in Andes)	Andes
4.	French Institute of Andean study, Peru, Bolivia, Colombia and Ecuador	Andes
5.	Institute of Ecology, San Andres University (UMSA) in La Paz, Bolivia	Andes
Universities / Centres/ Research Stations:		
6.	The University of the Andes, Venezuela	Andes
Study programme / Collaborative research:		
7.	Andean Study program, Amazonas Quito, Ecuador	Andes
8.	UNEP- Andean Páramo Project, Venezuela, Colombia, Ecuador and Peru	Andes
African Region: (01)		
1.	Station at High Altitude for Research on the Environment, Uganda	Kalimanjaro mountain

Mountain Region wise Research Strength and Weakness

European Region: In the European region, research is mainly focused on Climate change/Environmental Sciences / Glaciology (20 Institutes); followed by Biodiversity Conservation and Management (18 Institutes); then Long term ecological/Socioeconomic research / Sustainable Issue (8 Institutes each) working. However new emerging attention more or less has been made on other subjects like Aerosol, Biochemistry, Trace gases, Greenhouse gases, Incidence of solar radiations, Radio-active substances, Agro-metrology studies, Biophysics, Alpine Engineering, Alpine sports, Astrophysics / particle physics, Paleoclimatology, Palaeoecology, Land scape ecology, Polar research, Geology, Socio-humanitarian issues, High altitude health practices *etc.* (Figure 2).

South American Region: Over global level, Andes Mountain showed new avenue as research hub for researcher coming outside the continent from North America and Europeans countries. Majority of work is focused on Climate change / Environmental Sciences/Glaciology studies (14 Institutes), followed by Biodiversity Conservation and Management (7 Institutes), Ethno-botany and Long Term Ecological Research (4 Institutes each), Astronomy, Environmental protection, Historical studies, Ice study (3 Institutes each) *etc*. observed. Usually frequent visits and exploration by various individual researchers from different Departments/Institutes situated at urban areas in the lower altitudinal zones are not included for the present study. Areas showing new emerging attention more or less are Astrophysics, Aerosol, Trace gases, Incidence of Solar radiations, Greenhouse gases, Health practices, Wood and Natural plant product chemistry, Disaster management, Distance education, Energy issue, Alpine Engineering, Bioresourse technology, Environmental protection, Permafrost, Alpine sports *etc* observed (Figure 2).

Asian Region: In Himalaya majority of organizations based on Socio-economic/Socio-humanitarian/Sustainability issues (20 Institutes); followed by Biodiversity Conservation and Management (11 Institutes); Distance Educational Programme (10 Institutes); Ethno botany (9 Institutes); Environmental Science/Climate Change/Glaciology; Environmental Impact Assessment and Land use practices (8 Institutes each); Hydrology, Remote sensing, Forestry/Agro forestry (6 Institutes each) are working. The studies on remaining subjects are fragmentary restricted within the main subjects like Biology, Life Sciences *etc*. The subjects of new attention more or less are Aerosol, Greenhouse gases, Radio-active substances, Permafrost deposition, Incidence of solar radiations, Trace gases, Long Term Ecological studies, Social research, High altitude health practices, Ice chemistry, Wood chemistry, Geology, Wild life management, Energy issues, Value addition, Food technology, Alpine Engineering, Alpine Sports, Astrophysics, *etc* (Figure 2).

North American Region: Most of the research organization is working on Biodiversity Conservation and Management (11 organization), Environmental Science/Climate Change/Glaciology (10 organization), Long Term Ecological Research (4 organization), Forestry (3 organization), Distance

education/Sustainability/Socio-economic /Natural hazards (2 each organization) has been working. Some more or less effort as emerging field are also been tried to subjects like Geography, physiology, Astrophysics, Archeology, Anthropology, Geochemistry, Palaeochemistry, Ocean dynamics *etc.* (Figure 2).

Focused lead research areas attempted by global mountain organizations

According to information collected from present focused study scenario over global trend on subjects are mainly focused on Climate change effect, Biodiversity Conservation and Management, Mountain hazards, Physics (like Solar radiation/UV rays/Aerosol/Ozone), Ecology (including Long Term Ecological Research), Remote Sensing and GIS, Forestry/Natural Resource Management, Ethnobotany, Biochemistry/Biogeochemistry and Agricultural sciences *etc*. However some studies is also going on subjects like Fossil & Historical studies, Oceonology, Socio-economic, Sustainability, Biomedical, Geology, Energy issue in the mountain institutes recorded. In addition, information for other subjects related to high altitudes like Physiology, Genetics, Bioinformatics, Biotechnology, Biomedicine, Biochemistry (Secondary metabolites), Molecular ecology, Molecular tracking, Microbiology *etc*. showed comparatively localized restricted study focused on some region or within broad subject areas like Biology, Agriculture and Basic Sciences. Subjects like radiation effects, Environmental impact assessment studies, Ice chemistry, Wood chemistry, Solar energy tapping, Mechanisms of biological invasions, Threats to mountain systems as natural heritage areas, Alpine Engineering, Sustainable land use practices, Environmental protection issues, Heavy metal studies on biota *etc*. are yet not been explored widely and a very few R&D organization located in the mountain, Arctic regions is working on these issues (Figure 3).

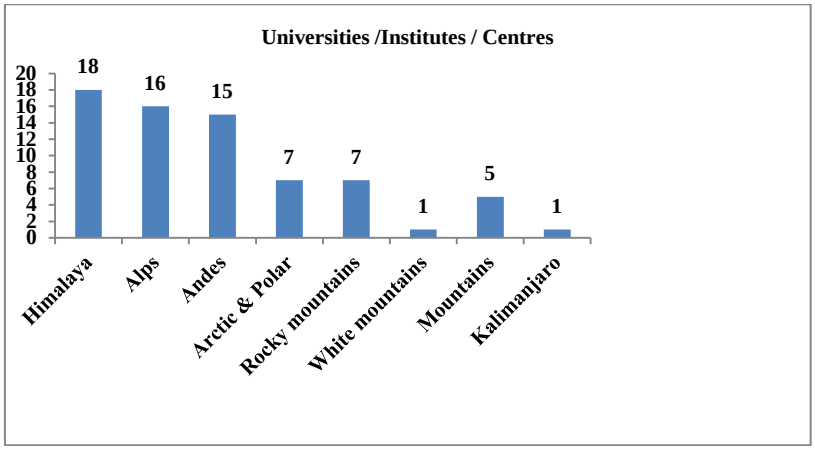

Figure 1. Climate change and Biodiversity Conservation related R&D organizations working in the Mountains and Arctic regions of the World

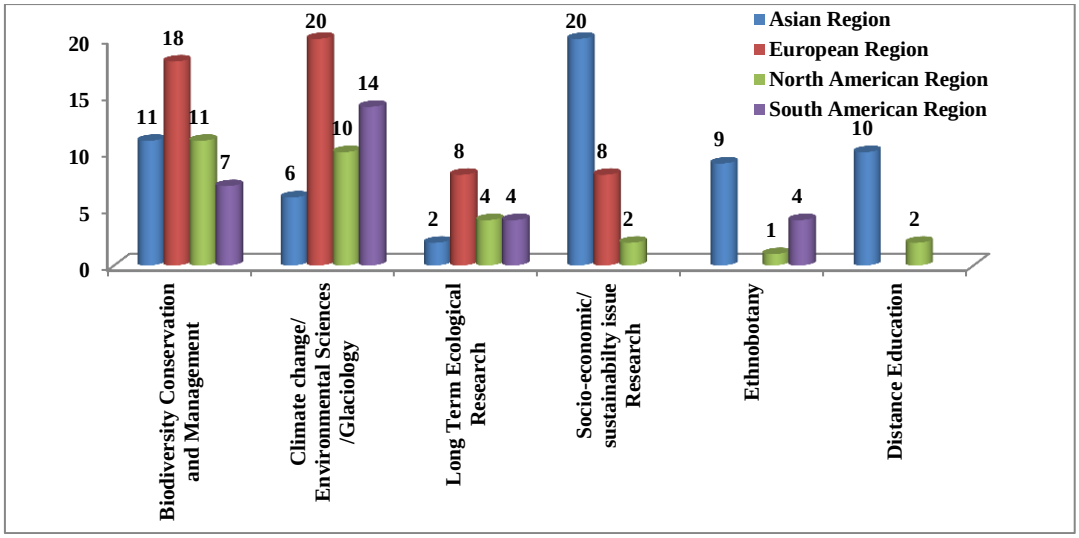

Figure 2. A trend of research subjects of interest to major regions of the World from available information

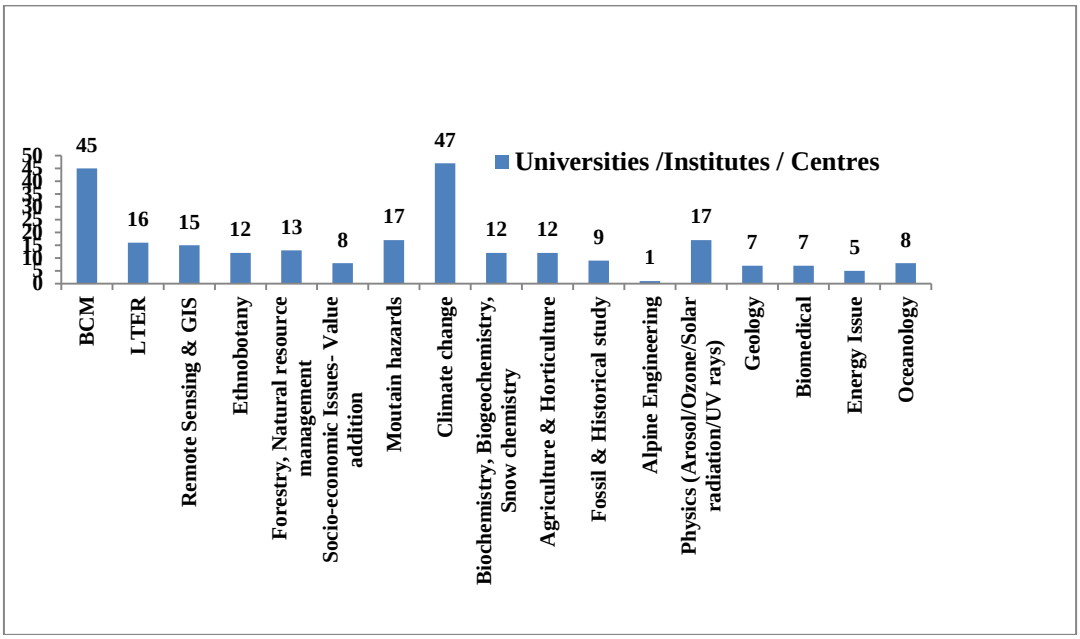

Figure 3. Top most focused subjects studied by the Climate change and Biodiversity Conservation related R&D organization working in the Major Mountains of the World

Collaborative Research Program Undergoing

With the pace of developmental activities undergoing in the mountain regions, impact of climate change is resulting into various threats on life saving snow towers in the mountain, decreasing ground water table, increase in rarity of bioresources, various health related problems, reduce in productivity / quality production of agricultural crops and frequent occurring of disasters *etc*. In various global forum discussions regarding mitigation strategy has obviously been discussed. But most of the guidelines regarding R&D challenges are not been properly overcame yet, because of working attitude in isolation. Today, emphasis on collaborative research and developmental studies has been realized and initiated by some of the organization working in the mountains, but there is lot of gap and scope to work together for effective implementation of various programs and very less collaborative work is undergoing worldwide. For present study some of the selected organization who started working collaborative in global mountains is documented. Study from the available data

shows that almost 46.67% collaborative organization based from European region; 23.23% from Asian region; 23.33% from American region; 6.67% from African region with headquarters started working in the mountain regions (Table 2).

Table 2. Some of the important collaborative institutions/agencies in the mountain regions of World working on Climate change and Biodiversity

S.No.	Collaborative Group name	R&D organizations	Partnership Involved
1.	Innsbruck working group, Austria, Europe	37	**Europe**:In Austria: (16 agencies); **Outside Austria:** (21 agencies) Scotland, Italy, Garmisch-Partenkirchen, France, Germany, Switzerland, Québec; **Himalaya (**Nepal); **Latin America (**Columbia, Chile *etc.*)
2.	Vienna working group-Global Observation Research Initiative in Alpine Environments, Europe	100	**Europe** (44 agencies): Austria, Switzerland, Czech Republic, Germany, Denmark, Spain, France, Faroe Islands, Georgia, Greece, Greenland, Iceland, Italy, Liechtenstein, Norway, Poland, Romania, Slovakia, Sweden, Scotland, UK; **South America** (17 agencies): Argentina, Bolivia, Chile, Colombia, Ecuador, Peru, Venezuela; **North America** (22 agencies): British Columbia, Massachusetts, California, Nevada, Missouri, Montana, Colorado, Alaska, Iowa, New York; **Asia** (12 agencies): Armenia, Bhutan, Sichuan, Yunnan, Iran, Japan, Nepal, Russia, Taiwan; **Pacific Rim and Africa** (5 agencies): Australia, New Zealand, Morocco, Uganda *etc*.
3.	Station at High Altitude for Research on the Environment, Working Group, (Working in Europe/ Himalaya)	15	Italy (4 stations); Nepal (8 stations); Pakistan (2 stations); Uganda (1 station)
4.	ALTER-Net, a Long-Term Biodiversity, Ecosystem and Awareness Research Network, Europe	26	United Kingdom (2 institutes); France (2 institutes); Netherlands (4 institutes); Germany (3 institutes); Austria (2 institutes); Italy; Romania; Slovakia; Finland; Poland; Sweden; Spain; Hungary; Belgium; Norway; Czech Republic; Denmark; Estonia
5.	C3-Alps: Smart Knowledge on Climate Change Adaptation, Europe	17	Alpine countries
6.	High ARCS Consortium , (Working in Europe/Asia)	10	United Kingdom (6 institutes); India (3 institutes); Vietnam; Denmark; Philippines; Germany; China
7.	Climate Himalaya Network, Asia	12	Asia; Asia pacific region; South Asia; Nairobi
8.	FluVAlps - Research Group-Fluvial Variability, Climate and Land Use Interactions in Alpine Environments, Europe	9	Spain (5 institutes); Switzerland; Austria and Germany
9.	Himalayan Climate Change Adaptation Programme, Asia	3	CICERO; ICIMOD; UNEP and GRID-Arendal
10.	Indian Himalayas Climate Adaptation Programme, Asia	>10	HPCCC; GBPIHED India; University of Geneva; Swiss Universities; Swiss Embassy; DST; MoE&F; IHR States; NGO's and Policy groups
11.	Alpine Network of Protected Areas, Europe	9	CIPRA; ISCAR; WWF; Reema; CIPRA France; Swiss academy of Sciences; CREA; EUROPARC FEDERATION
12.	The Palaeobiology and Biodiversity Research Group Bristol , Working in Europe / Asia / South America / North America	all continents (except Antarctica)	Canada; Chile; China; Finland; Germany; Japan; Netherlands; Russia; Spain; United States; Australia; Belgium; Brazil; Denmark; Finland; France; Greece; India; Ireland; Italy; Mexico; Norway; Romania; Sweden; Tunisia; Venezuela

13.	The Climate Change Collaboration London, Europe	9	College London; Local Energy Efficiency Partnership Birmingham; National Energy Foundation; Zopa Finance and Marches Energy Agency; Severn Wye Energy Agency; Green Deal Network WWF; Bio Regional, Institute for Sustainability; Centre for Sustainable Energy
14.	International Foundation High Altitude Research Stations, Jungfraujoch and Gornergrat, Switzerland, Europe	~70	Belgium (3 institutes); France (2 institutes); Germany (17 institutes); Switzerland (35 institutes); The Netherlands (4 institutes); UK (3 institutes); USA; Greece; Italy; Norway
15.	Consortium for Integrated Climate Research in Western Mountains, Working in (America, Europe / North America)	14 (institutes) and 7 (working groups)	Albeny CA; Boulder CO; La Jolla CA; MT; Seatle WA; Swizerland; AZ; Sandiego CA; Reno NV; Tueson AZ
16.	Mountain Forum ,Asia / Europe / North America / South America	663 organizations	All Mountain regions of the World
17.	Global Mountain Biodiversity Assessment, Workin in (Asia / Europe / North America / South America)	400 Mountain researchers/ policymakers	All Mountain regions of the World
18.	Mountain Invasion Research Network Switzerland, Working in (Asia / Europe / North America / South America)	30 Researchers, 11 regions (all continents)	African Mountains; Transecto Cordilerra Americana; Euroupe; Carpathians; SE Euroupe; CH-AT Alliance
19.	The Long Term Ecological Research Network United states, Working in (North America)	26 sites, 2000 Scientists	United States; Alaska; Antarctica; Islands in the Caribbean and Pacific
20.	Andes Biodiversity and Ecosystem Research group, Working in (South America / North America)	61 Senior Biologists	Oxford; Edinburgh; St. Andrews; Wake Forest University; Florida International University; Florida Institute of Technology; James Cook University; UCLA/JPL; Duke
21.	Indo-Swiss Collaborative Research on Climate Change Impacts & Adaptation working in the Himalayan Region, Indian Himalayan region	Department of Science & Technology India and the Swiss Agency for Development and Cooperation	India, Switzerland

Overall highest focused studies on Biological Sciences is undergoing on effect of Climate Change in Alps mountains followed by the Himalayan region, the Andes, Rocky and very less research is undergoing at the Kilimanjaro African mountains. Although studies on mountains like Alps, Rockies and White Mountains are undergoing at advance stage. In Polar and Arctic regions, most of the studies is focused on Glaciology, Ice structure, Ocean life forms especially fishes diversity / wild life adaptive physiology to tundra and taiga region. In Himalayan region, a lot of study related to plants and socio-economic issues are available and effect of climate change is a new growing field of interest (since last two decades) to the researcher. However in Alps, Andes and Rocky mountains climate change issue (with R&D activities like long term ecological research, Socio-economic, Glaciology and Humanitarian monitoring groups) is of common interest to most Institutes working collaboratively. Research institutes situated from European region and North American region are showing more interest for extension of work to other regions (including South American mountain

Andes, Asian mountain Himalaya) and simultaneously expending more collaborative work to other regions of the world reported from the present survey. On the basis of present investigation following guidelines should be implemented strongly for future strategy:

- Long term continuous monitoring system on Collaborating research work,
- Need of more collaborative research and developmental mountain issues with exchange of knowledge,
- More involvement and establishment of Institutes, Agencies, Organizations in the high mountain regions of the World. Need of more priority and unexplored research in the high altitude mountain region,

CONCLUSION

The present study showed a very few organizations situated in the high altitude mountain regions of the world is working on the research and developmental issues. Although we found a lot of famous organizations situated in the low laying urban areas, cities, frequently do research and developmental work for their project activities, different schemes in isolation. Unlike that of developed regions (like low laying urban areas, cities) the in-depth focused research studies on the mountain bio-resources is still lacking, because of the remoteness and difficult climatic conditions. Moreover, research connectivity of data with sharing is still lacking for most of the mountain region organizations (especially Himalayan mountain region and Endes Mountains etc.) and many times the work shows repetition by much organization working in isolation. Today the need is felt to work in collaboration mode by some listed organization and requires further strengthening of collaboration to achieve the progressive vertical trend.

Acknowledgement: Authors would like to thank Dr. P.S. Ahuja, Former Director and staff of High Altitude Biology Division of CSIR-IHBT Palampur for providing us necessary help and support.

REFERENCES

Bloomgarden C.A. (1995). Protecting endangered species under future climate change: from single-species preservation to an anticipatory policy approach. *Environmental Management*, 19(5): 641-648.

Dukes, J.S., Mooney, H.A. (1999). Does global change increase the success of biological invaders? *Trends in Ecology and Evolution,* 14:135 - 139.

Friedrich-Karl Holtmeier and Gabriele Broll (2007). Tree advances-driving processes and adverse factors. Landscape online 1:1-33.

Ghazoul J. (2005). Buzziness as usual? Questioning the global pollination crisis. *Trends Ecol. Evol.,* 20:367–373.

Grabherr G., Gottfried, M. and Graber A. (1995). Patterns and current changes in alpine plant diversity. In: Chapin, F.S., Korner, C., Arctic and Alpine Biodiversity: Patterns, causes and ecosystem consequences. Ecological studies, Sringer Berlin, 113:167-181.

Immerzeel W.W., Beek, L.P.H.V. and Bierkens, M.F.P. (2010). Climate Change will affect the Asian water towers. *Science*, 328(5984): 1382-1385.

Jones P.D., Groisman, P. Ya., Coughlan, M., Plummer, N., Wang, W.C. and Karl, T,R. (1990). Assessment of urbanization effect in time series of surface air temperature over land. *Nature*, 347: 169 - 172.

Hannah L., Midgley, G.F. and Millar D. (2002). Climate change-integrated conservation strategies. *Global Ecology and Biogeography*, 11: 485 - 495.

Hegland S.J., Nielsen, A., Lazaro, A., Bjerknes, A.L., Totland, O. (2009). How does climate warming affect plant-pollinator interactions? *Ecology Letters*, 12(2): 184-195.

Hijmans R.J., Graham, C.H. (2006). The ability of climate envelope models to predict the effect of climate change on species distributions. *Global Change Biology*, 12(12): 2272-2281.

Houghten J.T., Jenkins, G.J. and Ephraums, J.J. (1990) Climate change — The IPCC Scientific Assessment. Cambridge University Press: Cambridge, UK.

IPCC (2007). Intergovernmental Panel on Climate Change, Fourth Assessment Report, Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability. Syntheses Report. UNEP, Genèva.

Kelly A.E. and Goulden, M.L. (2008). Rapid shifts in plant distribution with recent climate

change. Proc. *Natl Acad. Sci. USA*, 105: 11823 - 11826.

Martínez-Meyer E., Peterson, A.T. and Hargrove, W.W. (2004). Ecological niches as stable distributional constraints on mammal species, with implications for pleistocene extinctions and climate change projections for biodiversity. *Global Ecology and Biogeography,* 13: 305 - 314.

McCarty J.P. (2001). Ecological consequences of recent climate change, *Conservation Biology*, 15:320-331.

Millennium Ecosystem Assessment (2005). Ecosystems and human well-being: Scenarios, Washington, DC: Island Press.

Miller-Rushing A.J. and Primack, R.B. (2008). Global warming and flowering times in Thoreau's concord: a community perspective. *Ecology*, 89: 332 - 341.

NAS (1979). Carbon Dioxide and Climate: A Scientific Assessment. National Academy of Sciences, National Academic Press, Washington, DC, USA.

Peizhen Z., Molnar, P. and Downs, W.R. (2001). Increased sedimentation rates and grain sizes 2-4 Myr ago due to the influence of climate change on erosion rates. *Nature*, 410: 891-897.

Pearman, G.I. (1980). The global carbon cycle and increased levels of atmospheric carbon dioxide. In: Pearman, G.I. editor, Carbon Dioxide and Climate: Australian Research. Australian Academy of Science, Canberra, ACT, pp 11- 20.

Parmesan, C. (2006). Ecological and evolutionary responses to recent climate change. *Annu. Rev. Ecol. Evol. Syst.* 37: 637- 669.

Rosenzweig, C., Karoly, D., Vicarelli, M., Neofotis, P., Wu Q., Casassa, G. (2008). Attributing physical and biological impacts to anthropogenic climate change. *Nature*, 453: 353 - 357.

Root, T.L., Price, J.T., Hall, K.R. (2003). 'Fingerprints' of global warming on animals and plants. *Nature*, 421: 57 -60.

Sala, O.E., Chapin, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oesterheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M. and Wall, D.H. (2000). Biodiversity - global biodiversity scenarios for the year 2100. Science, 287:1770 - 1774.

Samant, S.S., Rawal, R.S. and Dhar, U. (2006). Diversity, extraction and status of fodder species in Ascot Wildlife Sanctuary, west Himalaya, India. *International Journal of Biodiversity Science & Management*, 2: 29-42.

Samant, S.S., Joshi, H.C., Arya, S.C. and Pant, S. (2002). Studies on the structure, composition and changes of the vegetation in Nanda Devi Biosphere Reserve of west Himalaya. Final Technical Report submitted to Ministry of Environment and Forests, New Delhi.

Schweiger, O., Biesmeijer, J.C., Bommarco, R., Hickler, T., Hulme, P.E., Klotz, S., Kuhn, I., Moora, M., Nielsen, A., Ohlemuller, R., Petanidou, T., Potts, S.G., Pysek, P., Stout, J.C., Sykes, M.T., Tscheulin, T., Vila, M., Walther, G.R., Westphal, C., Winter, M., Zobel, M., Settele, J. (2010). Multiple stressors on biotic interactions: how climate change and alien species interact to affect pollination. *Biological Reviews*, 85(4): 777 - 795.

Singh A, Samant SS (2010) Conservation prioritization of habitats and forest communities in the Lahaul valley of proposed cold desert biosphere reserve, north western Himalaya, India. Applied Ecology and Environmental Research, 8(2): 101-117.

Theurillat, J.P. and Guisan, A. (2001). Potential impact of climate change on vegetation in the European Alps: a review. *Climatic Change*, 50: 77 -109, 2001.

Thomas, C.D., Cameron, A., Green, R.E. (2004). Extinction risk from climate change. *Nature*, 472, 145–148.

Vitousek, P.M. (1986). Biological invasions and ecological properties: can species make a difference? In: Mooney, H.A., Drake, J.A., Ed: Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag, NewYork. pp 163-178.

Vitousek, P.M., Mooney, H.A., Lubchenco, J. and Melillo, J.M. (1997). Human domination of Earth's ecosystems. *Science*, 277: 494 - 499.

Viviroli, D., Duerr, H.H., Messerli, B., Meybeck, M. and Weingartner, R. (2007). Mountains of the world, water towers for humanity: Typology, mapping and global significance, *Water Resour. Res*., 43: W07447.

Walther, G.R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T.J.C., Fromentin, J.M., Hoegh-Guldberg, O., Bairlein, F. (2002). Ecological responses to recent climate change. *Nature*, 416: 389-395.

Watson, R.T., Zinyowera, M.C., Moss, R.H., Dokken, D.J. (1996). Climate change 1995; Impacts, Adaptations and mitigation of climate change; Scientific technical analysis. Contribution of working group II to the second assessment report on the IPCC, Cambridge, Cambridge University Press.

Watson, R.T., Zinyowara, M.C., Moss, R.H. (1998). The regional impacts of climate change. An assessment of vulnerability. A special report of IPCC working group II. Cambridge, Cambridge University Press.

Source of Support: None
Conflict of Interest: None, Declared.