Climate change – Science and Impacts

ICCCH 01

Temperature trends at Dehradun in Doon valley of Uttarakhand, India

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Interest in climate change has increased over the last three decades. Of all the climatic elements, temperature plays a major role in detecting climate change brought about by urbanization and industrialization. This study, therefore, attempts to evaluate temporal variation in temperature at Dehradun city in Doon valley of Uttarakhand, India during the period 1967-2007. The city has demonstrated phenomenal growth in population, industries, vehicles etc after becoming the capital of newly carved out state of Uttarakhand. Trends in annual, seasonal and monthly temperature series were analyzed using Mann-Kendall rank statistics and linear trend. Three variables related to temperature, viz, annual maximum, minimum and mean temperature were considered for analysis on annual, seasonal monthly basis. Each year was divided into four principal seasons, viz, winter, summer, monsoon and pre-monsoon. Temperature anomalies were plotted and it was observed that majority of the trends namely in annual maximum, minimum and mean temperature showed increasing tendency annually, seasonally and monthly during the reported period at Dehradun. The increase in magnitude of annual maximum, minimum and mean temperature was observed to be 1.08°C, 0.98°C and 1.18°C/100 year, respectively. This rise in annual maximum, minimum and mean temperature is presumably attributed to urbanization effect.

ICCCH 02

Combustion characteristics of Tertiary coals and their Biomass Blends from NER India

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The North Eastern region of India is endowed with a considerable deposit of tertiary coal and biomass resources. The coal deposits are unevenly distributed across the states

of Assam, Meghalaya, Arunachal Pradesh and Nagaland. The biomass resources such as wood, timber, agricultural residues etc., are mainly used for household energy needs. Apart from these, significant amounts of biomass materials were found used in the industries as a fuel source in the boilers as a primary or secondary fuel along with the coal. The tertiary coals found in the region used mostly in the cement, coke-making industries, ferrosilicon paper mills and thermal power plants. The physico-chemical characteristics of wood/timber which are mostly used for energy utilization contains lignin (14 – 21%) and holocellulose (63 – 82%). On the other hand, north eastern Indian coals exhibit the properties of high organic sulphur (75–90%), less oxygen, low ash, high volatile matter, mostly caking in nature with partly swelling propensities. It also exhibits low ash fusion temperature range, highly friable and perhydrous in nature generally with low slagging potential which are indifferent in comparison to other Indian coals. Hence, combustion of NER coals in any thermal system results significant amount of the release of SO_x to the environment.

In the present investigation, an attempt has been made to investigate the combustion behaviour of some north eastern coals, a biomass material and their blends. *Corresponding Author: Email: prasentu@gmail.com*

ICCCH 03

"Estimation of Snowmelt Runoff in Chenab Basin, Western Himalayas"

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The increased availability of remote sensing data with good spatial and temporal resolution, and global coverage allows for fast, semi-automated, and cost-effective estimates of changes in glacier parameters over large areas. Such methods are particularly useful in remote areas with limited field-based glaciological measurements. This paper is primarily focused on investigating the effects of the spatio-temporal variation of the various influencing parameters

on the snow-melt runoff scenario using Snowmelt Runoff Model (WinSRM). The study has been performed in the Chenab river basin of western Himalayas. Snowmelt runoff computation, preparation of NDSI images, snow cover area extraction, snow cover depletion curves were generated from April to October for each year during 2000 - 2011 using MODIS Terra data. Composites were derived from the MOD09A1 eight day surface reflectance product. The performance of the model was evaluated by calculating Nash and Sutcliffe efficiency criteria R^2 which revealed good performance. From the NDSI values snow cover area was estimated for each month that was found to be more in April and less in July and August ascertaining that snow starts melting just after the end of the winter season.
The simulated values of snowmelt runoff for the Chenab river basin showed good agreement with the observed values of discharge with the months of July and August showing the maximum amount of discharge as compared to the rest of the months in the observed time duration.

ICCCH 04

Cedrus deodara (Roxb.) G. Don a possible indicator of climate change in Sikkim Himalaya

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The Himalayan region is of prime importance in the context of global climate change. Palaeoclimatic studies are important for understanding the role of the Himalaya in global climate change. In this context, the rich conifer forests of the Himalaya offer excellent dendroclimatic tools to reliably reconstruct the past climatic variations, even going back to about 1000 years. *Cedrus deodara* (Roxb.) G. Don through its dendroclimatic potential and Phenological studies can be attributed to climate change in Sikkim Himalaya.

Cedrus deodara (Roxb.) G. Don, is ecologically and economically highly valuable taxa belonging to the unique and diverse Gymnosperms. According to the current conservation status it belongs to threatened species which is least concerned and at lower risk whose IUCN conservation status need updating. The future oriented, successful conservation strategies of threatened species are impossible without knowledge of its biology, taxonomy, morphological and genetic variability, distribution, conservation status and the necessary first step in this direction is identification of the organism. The categorization, description of species, their interdependence and distribution across the globe are essential components of biodiversity. Henceforth, systematists and systematic studies are significant to contribute to conservation and biodiversity assessment and to make taxonomic data more accessible to a larger audience.

Sikkim is endowed with a rich biodiversity of flora and fauna. Sikkim is at top with respect to the number of flowering plants (26 %), around 4500 species or number of endemic and threatened species (65 species). Conservation of these species and their habitat warrants special attention in the State, especially in

the context of climate change. Also climate change posing a threat to the production and productivity of the cash crops and livestock products in Sikkim, which are significant from the point of view of the livelihoods they provides to the people.

ICCCH 05

Decision Support System for Water Resource Management in Watershed of Mid-Elevation Central Himalaya

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Central Himalaya is facing a crucial water problem to supply for drinking and other household purpose. The increasing utilization of water and lack of its natural storage causes a decline in the availability of water, particularly in the rainfed areas. Water demand is increasing day by day due to population growth, rapid urbanization and climate change. Upper Kosi is a non-glacial river in mid-elevation of Central Himalaya. Water availability in its watershed is decreasing and water scarcity is experienced in summer months. In this condition, it is necessary to take better decision to better supply for all sectors (urban & rural population, livestock and agriculture). In this study a Decision Support System (DSS) is introduced as interactive tool that understand the problem and explore various courses about water demand and supply management to help decision makers for better water supply. The DSS is implemented in Upper Kosi watershed. Urban & rural water demand forecasting in different scenarios, water allocation and optimization are main prospects in DSS for each month in forthcoming years (2012 to 2030). Two months (April and May) of summer season is explored as more critical for assumed years, in constant supply condition, because of water scarcity. DSS is tested and found suitable for water allocation in this situation and for optimization in June and July month.

ICCCH 06

Impacts of Jhuming in Manipur

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Manipur a small landlocked, hilly and mountainous state of north eastern part of India covers a total area of 22,327 sq. km. Out of this; forest is 17,679 sq. km. Of which dense forest represents only 22.11% and the rest are shrubs or grassland. Jhuming *(locally pamlou)* is a traditional method of farming system adopted by tribal peoples in the region. More than 83 thousand families are reported to be engaged in this system. Churachandpur with 34% of the total area covered by jhum is highest among the hill districts followed by Chandel (25 %), Ukhrul (22%), Senapati (10%) and Tamenglong (9%). Reports reveal that forest area is declining rapidly and total forest area coverage is estimated to be 17,152 sq km. The reasons for fast reduction of the forest area are particularly due to burning of the forest (99%) for shifting cultivation (jhuming) and hunting of animals. Jhuming which is directly related to deforestation is one of the main causes for extreme weather changes in the state. Though the impact of jhuming is not felt by the masses for lack of awareness, it is evident that jhuming is leading to a number of ecological catastrophes. Effect of jhum cultivation can also be clearly seen from the quality and quantity of water from streams and rivulets. The water from streams in those areas where jhum cultivation took place, had dried up now. Besides, causing destruction to biodiversity as a whole other socio-economic and ecological impact of jhuming in the state is discussed in particular.

ICCCH 07

Trend in atmospheric CO_2 across the globe derived from AQUA (AIRS) satellite observations and the facts from Mauna Loa

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The international community is very much concerned with the atmospheric concentration of CO2 since its established connection with global warming and climate change. The ambiguity regarding the trend of this trace gas level in the earth's atmosphere is yet to be eliminated by the modern scientific knowledge and tools. The latest development in the satellite technology and remote sensing provided an efficient method based on infrared spectroscopy for the measurement of CO2 across the globe. Atmospheric Infra Red Sounder (AIRS) is an advanced spectrometer with a high spectral resolution in the thermal infrared region (3.7 - 15.4 μm) aboard on NASA's Aqua satellite, which retrieves mid tropospheric CO2 and contributes monthly global CO2 map from its inception year 2002 to present time. The time series analysis of these monthly CO2 data of global coverage (180W-180E, 90S-90W) for a period of 2002 (Sept) to 2011(Sept) showed a sharp increasing trend in the CO2 concentration across the globe. The area averaged concentration of CO2 increased from 372.6 ppm to 392.0 ppm with a monthly increment of 0.18 ppm an dannual increment of 2.15 ppm during this period. The AIRS measurements are compared with the data collected from Mauna Loa observatory for the same period and found the values are closely matching. The decadal increase of 2.07ppm/year from Mauna Loa measurements and that obtained from time series analysis of AIRS CO2 2.154 ppm/year have a negligible difference <0.1ppm. Moreover the annual averages calculated from Mauna Loa observations and the linear fit of AIRS retrieval found in good agreement. For e.g. the annual average of CO2 for the year 2010 from AIRS is 389.38ppm where as from Mauna Loa is 389.78ppm. The regional trend in mid tropospheric CO2 for developed, developing, least developed nations are also analysed and the observations showed that some of the least developed countries' upper atmosphere is also exhibiting the same or higher increasingtrend of CO2 level as that of the developed nations. Most surprisingly the region of Greenland showed the highest increasing trend value where the CO2 emission from surface is estimated as less. This establishes the existence of strong global midtropospheric circulation and intercontinental transport of CO2. These research findings manifest the capability of AIRS in monitoring the global and regional changes of CO2 in the mid troposphere, especially in well agreement with the ground observations at Mauna Loa owing to the well mixing nature of CO2 in the troposphere. It also revealed the CO2 level at mid troposphere depends more on the global atmospheric circulation than the surface emission. Future scope of this research may include the impact of warming of atmosphere due to the migrated CO2 on the snow cover of polar region.

ICCCH 08

The focal themes of the conference are exclusively related to "the Himalayas" Disaster, Mitigation and Adaptation Climate Change and Appropriate Actions Worldwide

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Climate change continues to be a subject of intense public and political debate. 2011 was the costliest year on record for disasters, with estimated global losses of £234billion (US$380 billion). Losses from extreme weather-related disasters are doubling every 12 years as more people and assets are in harm's way and the effects of climate change bite. A number of far-sighted countries are already integrating disaster risk management into economic and fiscal planning. Disaster risk assessments must be factored into national and provincial budgets, land-use plans, infrastructure investments, with

legislation and enforcement that limits the exposure of people, critical infrastructure and other assets. In 2007, scientists from the International Panel on Climate Change (IPCC) predicted that warming oceans and melting glaciers due to global warming and climate change could cause sea levels to rise 7-23 inches by the year 2100. And now the Australian Government is investing more than $5 billion in developing and commercialising clean energy technologies with belief that these technologies will be crucial for Australia's efforts to reduce its carbon pollution emissions besides other countries. These technologies will also be important to the rest of the world as they also need to reduce their carbon pollution. The plan to move to a Clean Energy Future will cut pollution by at least five per cent compared with 2000 levels by 2020—which will require cutting net expected pollution by at least 23 per cent in 2020—and 80 per cent below 2000 levels by 2050.The comprehensive plan also aims to introduce a carbon price and invest billions of dollars in renewable energy. It includes transforming the energy sector away from high polluting sources such as brown coal and storing carbon in the land through better land management strategies. Even though a warming trend is global, different areas around the world will experience different specific changes in their climates, which will have unique impacts on their local plants, animals and people. Overall, worldwide, people are paying serious attention to climate change.

ICCCH 09

Climate Change Impact Study on rainfall data analysis of Jabalpur area, using Statistical Techniques

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Today, Climate changes are a real fact and pose significant challenge to our surroundings. People and their environment are severely effecting. Noteworthy changes are going on earth surface, including increasing atmospheric temperature and irregular distribution of rainfall and increasing the incidences of drought. These real facts play crucial role in manifested impacts of climate change in Jabalpur area. Temperature and Rainfall are two most important metrological parameters which are responsible for the global climate change scenario in the world. The temperature and rainfall data of Jabalpur District, Madhya Pradesh for a period from 1901 to 2000 was collected from the Indian Meterological Department (IMD), New Delhi and the results of the statistical analysis of rainfall data pertaining to the twentieth century (1901 to 2000) have been presented in this paper. The statistical parameters such as Mean, Median, Mode Standard Deviation, Coefficient of Dispersion, Coefficient of Variation and Coefficient of Skewness have been computed and discussed for each individual year with the help of statistical techniques with a view to assess the future climate change impacts affecting this area.

ICCCH 10

ESTIMATING GLACIER CHANGES IN THE SPITI BASIN (1972-2006) THROUGH REMOTE SENSING TECHNIQUES

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The glaciers maintain a balance with the local climate and have a profound influence on human life and its sustainability. They have a highly decisive role in the hydrological cycle. A study of 60 glaciers in the Ravi basin reveals that the glaciers have receded by 12.86 km^2 during the period 1972-2006. The area loss has been 9.8 km^2 in the period of 1972-89, whereas it shows a loss of 5.65 km^2 and 3.08 km^2 between 1989-2001 and 1989-2006 respectively. Thus, the Ravi basin has witnessed a loss of about 13% in the last four decades and approximately about 9.78% in a span of about 17 years (1972-1989). However, the investigation reveals that the rate of retreat has been higher in the period 1972-89 as compared to that during 1989-2006, estimated to be about 3.08%. The Ravi basin shows a marked retreat of about 45% in the area range 2-5km^2 comprising the period 1972-2006. A loss of about 40% and about 27% has been noted in the period 1972-89 and 1989-2001 respectively. The area loss has been highest in the aforesaid category if we compare it with the other area classes. This reflects that glaciers in the area range of 2-5 km^2 are under a bigger threat. The number of glaciers have increased, in the time period, although not very significantly.

ICCCH 11

Methodology to derive land surface and energy balance parameters using satellite remote sensing

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Spatiotemporal dynamics of evaporative fraction (EF) that depends on the dynamics of landsurface and energy balance parameters plays a significant role in understanding regional and global climate, terrestrial ecosystem and energy transfer processes from the land to the atmosphere. The present research focuses on the methodology to generate these parameters as inputs in energy balance model over Indian region using exclusively MODIS data products like land surface temperature (LST), surface albedo and normalized difference vegetation indices (NDVI) during monsoon season (June-September, 2009). EF is computed using LST-albedo two-dimensional image space. These parameters show a symbiotic relationship. Dry pixels (bare soil with low moisture) corresponds to higher value of LST and soil heat flux (G) whereas wet pixels (dense moist vegetation) corresponds to higher value of LE, EF, NDVI revealing high evapotranspiration. However, the relationship varies widely over India due to the variability of vegetation cover, moisture status and meteorological conditions.

ICCCH 12

Glacier Mass Balance Estimation using Remote Sensing Data in the Himalayan Region and its Potential for Climate Change Studies

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Glaciers extent has shown oscillation in the geological past and continues to do so in the present time too. The most conspicuous reason to the current variations is attributed to climate change due to natural cycles and anthropogenic activities. Harsh climate and rugged terrain conditions restricts repetitive monitoring of glaciers at regular interval using conventional methods in the Himalayan region where remote sensing has played a key role in mapping and monitoring of these resources. One of the major applications is the estimation of mass balance using accumulation area ration (AAR) approach. Mass balance of a glacier usually referred as total loss or gain in glacier mass at the end of a hydrological year.

The basic premise of AAR approach is mapping of snow line on the glaciers from a series of satellite images. Annual upward and downward movement of the snow line governs the duration of the exposure of bare ice of glaciers to the environment. The snow line at the end of ablation season is identified and used to calculate the ratio of accumulation area (area of glacier above snow line) to the total area of the respective glacier. There is pertinent relationship between AAR and mass balance of glacier developed for the Himalayan glaciers. This study presents use of satellite images of AWiFS data (repetivity 5 days) of IRS to estimate AAR and mass balance of glaciers in parts of Chenab and Ganga basins, and its variability across the Himalayan region.

More than 700 glaciers have been monitored in the present analysis and it has been observed that overall all sub-basins have shown a positive mass balance for the year 2010. Approximately 80 percent of glaciers have shown positive mass balance whereas 20 percent glaciers have shown negative mass balance. Spatial distribution of mass balance have shown that Ganga basin has high number of glacier representing negative mass balance in comparison to Chenab basin. Maximum numbers of glaciers in Chandra, Bhaga and Bhagirathi basins have shown positive mass balance whereas maximum numbers of glaciers in Dholiganga and Goriganga basins have shown negative mass balance. This study demonstrates the use of technique and its application in assessing overall health providing improved understanding to the response of the Himalayan glaciers to climate change.

ICCCH 13

Diurnal variation in precipitable water vapour over Almora, Central Himalaya India

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Water vapour plays an important role in atmospheric radiation and hydrological cycle. The Rise in temperature due to global warming increases

the amount of water vapour content in atmosphere. Water vapour is potent greenhouse gas contributing about 60 % natural green house effect. It is also essential for cloud formation. Precipitable Water Vapour (PWV) in the atmosphere also acts as major error factor for space geodetic technique such as Global Positioning System (GPS). Knowledge of spatial and temporal variation in atmospheric water vapour over the Himalayan region is important in forecasting regional weather and for understanding the global climate system. Diurnal variations in precipitable water vapour at Almora, a mountainous area of Central Himalaya, India, are studied by analyzing the GPS-derived precipitable water vapour and surface meteorological observation data during winter and monsoon season.

A permanent GPS station at Almora has been selected for this study, which is situated in Central Himalayan Region. This GPS station was selected due to the availability of observed data from nearby meteorological station where automatic weather station of Cambell Scientific (Model CR10X) is installed.

The precipitable water vapour had minimum value in the morning, increases in the afternoon to evening and again decreases to the midnight in both the winter and monsoon seasons. Rate of increase of PWV is not same as the rate of increase of temperature at morning. These results suggest that diurnal variation of water vapour is caused by the transport of water vapour by thermally induced local circulation. Diurnal variation between rainfall and PWV shows that at hourly scale PWV increases before the rainfall and dropped after the rainfall events. Mean diurnal variations in precipitable water vapour is also analyzed for low and high solar radiation days in monsoon and winter season. Value of mean PWV is high in case of low solar radiation days on monsoon season with large diurnal variation.

ICCCH 14

Late Quaternary / Holocene evolution of Sub-Himalayan Dehra Dun: an interaction of climate with the active tectonic processes.

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The exhumation of Sub Himalaya along the Himalayan Frontal Thrust (HFT) often form Duns as piggyback longitudinal synclinal basin, which is bounded by Main Boundary Thrust (MBT) towards north. In the Trans Yamuna segment of Dehra Dun, a series of out-of-sequence structures are identified within the MBT-HFT wedge, which partition the intra-wedge deformation. These out-of-sequence structures are observed in form of structural, geomorphic and stratigraphic expressions in Siwaliks as well as post-Siwalik Late-Quaternary gravel deposits. Two landforms like piedmont fan and river terraces with distinct lithological characteristic are identified within gravel deposits that were deposited in distinct fluvio-dynamic conditions during 33.9 Ka to 4.9 Ka before present. These deposits of distinct gravel sediments in varying fluvial setting have definite climatic signature. These fluvial deposits also show distinct cross cutting relationship with the out-of-sequence active structures suggesting that the structures are active even during early Holocene.

To understand and characterize the effect of interaction of active structures on landscape morphology and drainage evolution in Trans Yamuna Dun valley, the geomorphic indices like *Valley width/height ration* (*Vf*) and *Mountain front sinuosity* (*Smf*) are

calculated. Prominent V-shaped valleys of the Giri and Markanda rivers flowing across the active thrusts have *Vf* values ranging from 0.4 to 0.9 and 0.6 to 1.3, respectively. This suggests a response of active to moderately active tectonic influence on the *Vf* indices. The *Smf* index along the HFT ranges from 1.0 to 1.3 suggests that HFT is active. These geomorphic indices fairly suggest the MBT-HFT system is tectonically active. Further, the growth of out-of-sequence thrust within MBT-HFT tectonic wedge in Trans Yamuna Dun segment is analyzed in light of critical wedge theory suggesting an under-critical wedge, which accommodates bulk shortening by internal thickening. The observed out-of-sequence structures in the MBT-HFT wedges are the reflection of the same and expressed in the form of geomorphic landform and deposits that develop by active interaction of climatic processes with the active tectonics.

ICCCH 15

Climate Change Impacts in Central Himalayan Agro-ecosystem and Adaptation Strategies: Integrating Local Perception and Traditional Knowledge

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Climate Change is one of the most important global environmental challenges facing humanity, has its implications on food production, retreat of glacier, natural eco-systems, fresh water supply and health in central Himalayan mountain region. It has already contributed to the increase in air temperature leading to rapid melting of glaciers and increment of glacial lakes. Exploitation of natural resources associated with growing population has led to increasing pollution, declining water quality, land degradation, etc. Extreme climate events including flooding, heavy rainfall, droughts, heat wave and cold stream etc. are also the consequences of climate change observed recently in central Himalayan region. Moreover, this region is largely dependent on climate-sensitive sectors, such as rain-fed agriculture, its fragile mountain ecosystems and undulant topography make the region prone to climate change sensitive zone. Due to such events, agricultural productivity is declining with increasing problem of food security in this mountainous region. In recent years, the signs of such changes are being observed and may become more prominent over next couple of decades. Until recently, economic, social and political changes such as globalization and out migration were considered to be the main drivers of change in mountains. Today it is increasingly acknowledged that climate change and its consequences are likely to have similar or even greater impacts. It has been observed very recently that many traditional rural communities inhabited in different agro-climatic zones of this region are struggling through different adaptation measures as an attempt to reduce the risk of climate change vulnerability. This paper describes the general information of agriculture and agrobiodiversity, agricultural vulnerability to climate change particularly impact of drought and shift of rainfall and insect/pest incidence on agriculture, farmer's perceptions on climate change impact and adaptation and coping strategies.

ICCCH 16

IMPACT OF TOURISM ON THE FLORA OF CHANDERTAL LAKE – AN ALPINE RAMSAR SITE OF THE HIMALAYA

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Himalayan wetlands are unique ecosystems that fulfil important functions in the overall water cycle of the large Himalayan river basins. They also provide habitat for many rare and endangered wildlife species including several migratory birds. The high altitude wetlands are of particular interest as a result of their remoteness, relatively pristine state, and provision of favourable habitat in otherwise harsh areas. Lakes have an aesthetic significance for attracting tourists. Due to their sheer beauty, religious and cultural significance, these high altitude wetlands attract millions of tourists every year. Since these wetlands are fragile, the pervasion of human presence and activity in the region brings on a set of challenges. These processes have altered ecosystem processes and resulted in several threats on lakes including loss of biodiversity, eutrophication, proliferation of invasive weeds, siltation, toxic contamination and over extraction of water.

Tourism as the fastest growing industry has touched every part of the globe, and the Himalaya is no exception. The Himalaya get visitors in such volume that in several places, roads and campsites have become part of the landscape, wildlife has been chased away into areas from their natural habitat and the food-chain and ecosystem have been seriously disrupted.

The Chandertal with its deep blue icy water constitute an important high altitude cold desert wetland of western Himalayas. Situated at an altitude of 4337 m in one of most fascinating environments, the place has been, aptly termed as heaven on the earth. The lake by virtue of its crescent moon like shape derives the name Chandertal or lake of moon. It is a tourist spot because of its beautiful location and attracts nature lovers especially during the summer season. The lake has been identified as a wetland of international importance-Ramsar Site in the year 2005, due to the presence of rare plants, variety of animal species and its role in the maintenance of eco-biodiversity of the region. The Chandertal Lake and its catchment area fall in the Alpine zone, characterized by the absence of trees. The herbaceous growth is remarkable for its variety of species like *Ranunculus trichophyllus, Gentiana marginata, Triglochin palustre, Geranium collinum, Potentilla multifida, Pedicularis pectinata, Limosella aquatica, Polygonum tubulosum, Juncus himalayensis, Polygonum alpinum, Leontopodium alpinum, Polygonum affine, Veronica beccabunga, Saxifraga flagellaris, Trifolium repens, Anaphalis nepalensis* etc. The common grasses frequently encountered are *Poa* and *Agropyron.* Aquatic and marshy plants found near the lake are *Juncus* sp*., Halerpestis tricuspis* and *Potamogeton* species. Plants growing on rocky slopes are sturdy with deep roots. They also develop hairs and spines to cope up with the harsh climatic conditions. The species growing on the slopes are *Astragalus emodi, Taraxacum officinale, Draba lanceolata, Arnebia euchroma, Ephedra intermedia, Eremopoa persica, Astragalus rhizanthus, Aster alticus, Cicer microphyllum, Thymus linearis, Saussurea jacea and Waldheimia glabra* etc.

One of the characteristic of mountain tourism is the high degree of seasonality. This enhances the adverse impact on environment, especially true for fragile high altitude alpine ecosystem and wetlands as well. These ecosystems represent oasis of productivity in otherwise arid environment and have high conservation value. Rapid increase of visitors tend to have a negative impact on the biodiversity. The anthropogenic interference with the wetland ecosystem is seasonal [summer] through visits by trekkers and tourists from Batal, Kunzam or Baralacha pass routes. During the tourist season, a large number of visitors pollute the water quality of the wetland by way of leaving garbage quantity after camping. As such, this adds toxicity to the wildlife as the camping spot on the alpine meadow at the northern end drains into the lake. In addition, the migratory grazers with huge flocks of sheep and goats, who pass through the Chandra valley, graze the meadows. The combined effect of the visitors and grazers does contribute to increased siltation and organic influx into the wetland.

There is an urgent need for management action that supports both conservation and wise use of the wetlands important for landscape productivity, and that supports risk reduction from natural disasters.

ICCCH 17

Hydrochemistry of meltwater emerging from Raktavaran glacier, central Himalaya, India

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Hydrochemical characterisation of Raktavaran glacier meltwater was studied for two years to identify its nature and sources of dissolved ions. The order abundance of cations and anions in the meltwater varied as follows: $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$ and $SO_4^{2-} > HCO_3^{-} > Cl^{-} > NO_3^{-} > PO_4^{3-}$, respectively. The high ratio of (Ca+Mg)/(Na+K) i.e 12.4, the relative high contribution of (Ca+Mg) to the total cations (TZ^{+}) i.e ($Ca+Mg/TZ^{+}$ = 0.93) and low average ratio of ($Na+K/TZ^{+}$ = 0.07) shows that their hydrochemistry (of Raktavaran glacier meltwater) is mostly controlled by carbonate weathering followed by silicate weathering. The observed high average equivalent ratios of Na/Cl = 8.3 and K/Cl = 8.4 as compared to sea water indicate that relatively negligible contribution from atmospheric precipitation to the observed dissolved ion budgets of stream draining from Raktavaran glacier. Trace amount of NO_3^{-} and PO_4^{3-} was also found from the study area, indicating palatability of water. The possible source of NO_3^{-} may be acidic NO_3^{-} aerosol contribution coupled with possible contribution from anthropogenic activity while for PO_4^{3-} it may be anthropogenic activity.

ICCCH 18

SUSTAINABLE ECOSYSTEM DEVELOPMENT PLANNING IN PHAKOT SUB-WATERSHED, TEHRI GARHWAL DISTRICT, UTTARAKHAND USING IKONOS DATA

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The State of Uttarakhand is facing diverse problems related to natural resources and land degradation due to deforestation, soil erosion, forest fire, hydrological imbalance, landslides, low agricultural production and a poor economy. The Uttarakhand state is also facing impact of global warming and climate changes which is evident from receding glaciers in Himalayan region. For sustainable development, it is imperative to know the available resources, major problems in the area and its remedial measures along with ecological consideration through integrated resource management. Remotely sensed data, which provide reliable and cost effective information, was used for the present study in Phakot sub-watershed of Tehri Garhwal district of Uttarakhand.

The study was carried out under a programme 'Bio-geo Database and Ecological Modeling in Himalayan Region', sponsored by Dept. of Science & Technology, Govt. of India with an objective of development of Himalayan Ecosystem. Besides natural resources, information on the infrastructure facilities, socio-economic and ecological aspects was generated. For this purpose, temporal high resolution IKONOS satellite data was used. The information thus generated was vectorised and put into a Geographical Information System (GIS) as different layers. Spatial distributions of natural resources as well as important plant and animal species have been given in the study area. The data was spatially integrated, based on certain decision rules, to generate site-specific management plan/action plan for water resource management and land resources management in order to achieve sustainable development. Information generated in this study would form a baseline data and in future, monitoring periodic changes in the parameters of natural resources analysed in the present study, would also help in understanding the changes in biodiversity as well as impact due to climate change.

ICCCH 19

CLIMATE CHANGES INFLUENCE THE PHYTOPLANKTON BLOOM *(Prymnesiophyceae: Phaeocystis* spp.*)* IN NORTH ANDAMAN COASTAL REGION

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Phytoplanktons were studied in Andaman waters (13° 17' 47.71" N - 093°03'27.80''E to 13° 17' 43.63" N - 093°03'13.70''E). The bloom occurred during the period of July 2011, first phase of monsoon and identified in four classes such as; Bacillariophyceae (Diatom), Dinophyceae (Dinoflagellate), Cyanophyceae (Cyanobacteria or Blue-green algae) and Phaeocystales consists of 25 genus with 43 species of phytoplankton were recorded during this study. Among these 16 genera was represented by 25 species of diatoms, six genera and 15 species of dinoflagellates, two genera and two species of cynophaceae, one genera and one species of Prymnesiophyceae. During this study, it was observed that *Phaeocystis* spp. bloom was occurred between 13° 17' 47.71" N - 093°03'27.80''E to 13° 17' 43.63" N - 093°03'13.70''E of North Andaman coast. *Phaeocystis* spp., were observed with the following seawater conditions based on the estimation carried out by HYDROLAB/Quanta (USA) probe. The environmental parameters such as temperature (26.56 to 28. 48°C), pH (8.50 – 8.68), salinity (32.23 – 32.74 PSU), dissolved oxygen (4.1 – 5.43 ml/L), ORP/Eh 277 – 281 mV and turbidity (55.35 – 57.90 NTU) were recorded from the study area. The species richness of *Phaeocystis* species ranged from 24, 500 to 26,000 cells/ml. Since these waters are oligotropic, the anthropogenic activities rooted through different sources such as mixing of land drainage and rain water discharge during monsoon in this region enriches nutrient concentration in this water column could have favoured the outbreak of this *Phaeocystis* spp. The physio-chemical parameters which are induced by sassonal changes may be the reasons for the phytoplankton blooms in the coastal waters of north Andaman regions. Moreover, the *Phaeocystis* spp., occurrences normally associated with high salinity and low temperature conditions in world wide. The present study also supports the same. Further, it may also causes damages to other aquatic organisms though release of biogenic gases or toxic substances into water and air.

ICCCH 20

Analysis of long term climate variability and changes in North-Western states of Indian Himalayan Region (IHR)

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In the recent past, erratic weather patterns have been experienced all across the globe. Climate Change is a major concern in the Himalayas; they are assumed to be the most sensitive to global warming as change in temperature has marked effect on many natural and human systems in the

region. In the present paper, analysis of long term climate variability for three North-Western Himalayan states (Jammu & Kashmir, Himachal Pradesh and Uttarakhand) of the IHR has been done for the twentieth century (1901-2001). The interpolated meteorological data (0.5°×0.5° lat-long) of Climate Research Unit (CRU TS2.1), Tyndall Centre for Climate Change Research, UK is used in the study. Long-term analysis of temperature (max, min), precipitation, and diurnal temperature range (DTR) on seasonal (Pre-monsoon: March-May, Monsoon: June-September, Winter: November-February) & annual basis is presented here. Cubic Spline method is used to remove inter-annual variability and statistical parametric/non-parametric (linear regression & Mann- Kendall) methods are used to identify the trend.

The analysis reveals significant increasing trends of temperature at different rates in different parts of NW Himalaya during the twentieth century. Maximum temperature during the winter season is found significantly increasing at the rate of 1.3°C/100 yr in J&K and Uttarakhand, where as it is declining in Himachal Pradesh. Significantly increasing trends of maximum temperature during monsoon season is observed in all three states. Increase in monsoon and winter DTR in all three states has been observed. Further, it is also observed that maximum temperature is rising at relatively higher rate than the minimum and rate of increase in temperature in NW Himalayan region is higher than Indian annual mean (0.51°C/100 yr) as well as global mean (0.74°C/100 yr). Precipitation is showing overall decrease in the region. Significantly declining trends of monsoon precipitation in all three states while increase in winter precipitation in UK & HP and decrease in J&K is observed. The Power Spectrum Density (PSD) analysis, carried out to investigate periodicity and explore cyclic pattern in the time series, confirm episodic variation in the data; results have been compared with past studies and are found in good agreement. Such irregular changes in climate can have profound impacts on ecology, environment, and economy of upstream-downstream areas in the Himalaya.

ICCCH 21

IMPACT OF CLIMATE CHANGE ON HIMALAYAN GLACIERS AND HIGH ALTITUDE WATER RESOURCES IN NW HIMALAYA (INDIA)

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The melting of glaciers in the Himalaya is one issue that has no conclusive answer so far. The document (Raina 2009) prepared by the Ministry of Environment and Forests, Government of India suggested that Himalayan glaciers are not responding to the global warming/climate change in the strictest sense negating the projection made by IPCC AR-IV that the glaciers in Himalaya shall vanish by AD 2035. In GRACE satellite mission it has been found that the glaciers in high-altitude Asia are losing ice one-tenth as fast as the previous estimates and the glaciers in Tibetan Plateau are actually growing on average (Qiu 2012). The fluctuation in glaciers shows no relation to the variation in the pattern of monsoon except for the period between AD 1900 and AD 1909 that coincided with the peak in monsoon (Owen 2009). Decrease in the snow accumulation of Qomolangma (Mt. Everest) between AD 1534 and 1880 coincides with the reduction in northward incursion of summer south Asian monsoon (Kaspari et al. 2008) whereas accumulation rate for the same period at Dasuopu (125 kms from Qomolagma) shows an opposite trend (Davis et al. 2005) making it very obvious that the variation in the higher Himalaya is

related to seasonal variation in monsoon systems versus westerly moisture system that gives rise to complex mountain meteorology (Kaspari et al. 2008). It is further projected (Immerzeel et al. 2010) that the supply of water from upstream of Upper Indus, Ganges, and Brahmaputra rivers is likely to decrease by -8.4%, -17.6% and -19.6%, respectively and simultaneously there is also likelihood of increase in the mean rainfall in the upstreams of Indus (+25%), Ganges (+8%) and Brahmaputra (+25%), implying that the rivers originating from Himalaya may not show any substantial decrease in their runoff. The distribution pattern of moisture in Himalaya, therefore, holds a key factor to the hydrological system that is still not been well understood (Wininger et al. 2005, Hewitt 2011).

ICCCH 22

NEED FOR A STRATEGY TO SAVE CULTURAL HERITAGE SITES

Y. Pandey (CBRI, Roorkee)

Indian Himalayan states are rich in cultural diversity and considered to be the sacred abode of God in strictly Hindu religious sense. Apart from pilgrimage, many cultural heritage sites are the nationally protected monuments under Archaeological Survey of India (ASI) and Archaeological departments of respective states. Almost all the protected sites of ASI Dehradun (42) and Simla (40) Circles may be designated as Himalayan heritage sites, in addition to approximately 150 protected sites from North Eastern states and Jammu & Kashmir. Out of five natural World Heritage sites, Nanda Devi & Valley of Flowers National Parks (514268ha, Uttarakhand), Manas Wildlife Sanctuary (39100ha,Assam) and Kaziranga National Park (42986ha,Assam) fall under the close influence of Himalayas. Under cultural heritage category, Darjeeling Himalayan Railway (88.5km, West Bengal) and Kalka Simla Railway(96km,Himachal Pradesh) are World Heritage sites.

Fast changing climatic parameters have been keenly observed and studied in India by various organizations on the basis of scarcely available records. Just to circumvent this serious handicap, few studies emerged out of the verbal sharing of perception/experience of the affected local people. Sustained failure of age old precipitation cycle, depleting river water flow, receding snowline, shifting areas of traditional crops like apple, increased extreme weather events etc. are counted as some of the pronounced indicators of climate change. Severe physical manifestations of impending such changes may damage heritage sites permanently.

Our visit to Leh just after Aug 2010 cloudburst exposed us to serious questions on our conventional understanding of cold desert architecture and the very existence of several centuries old Buddhist monasteries (Ladakh) and precious wooden structures (Lahaul Spiti) seem to be at stake. Scientific studies undertaken by CBRI on Katarmal Sun Temple and Jageshwar Temple in Kumaon (Uttarakhand) establish that repeated incidences of extreme rainfall events make them quite vulnerable. Lack of professional skill of the keepers of such monuments, without local participation, makes the thing worse.

This paper deals with the present day live problems and stresses upon a holistic scientific approach to tackle the serious problems posed by climate change.

ICCCH 23

Quaternary Geological Structures and Natural Hazards in Coastal Island of Mauritius using Remote Sensing & GIS Technology

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Mauritius Island has been formed by a succession of volcanic episodes that began in the middle of the Miocene. The island emerged approximately 10 million years ago following a volcanic phase, mainly explosive, whose most ancient witness is the breccias formation at the base. The chronology of the volcanic activity and of the formations, confirmed by several dating, recapitulates in time, the important stages of the geological history of the island. Two great magmatic and structural cycles gave rise to volcanic formations characterized by breccias and old lavas for the first cycle, intermediate and recent volcanic lava and explosive formations for the second cycle. Geological structures confirm the existence of this duality between intermediate and recent basalts. Recent basalt formations and intermediate basalts not weathered are globally strongly resistant when they are dry, and more conducting when they are aquifers and recent basalts rest on a conducting terrain that coincides almost always with the intermediate series, clayey and weathered. This conducting terrain of the intermediate series rests on alternating resistant and conducting strata that evoke very well the laminated structure of the intermediate formation. Mauritius is a small developing island located in relation to the intensity and frequency of natural and environmental disasters and their high economic, social and environmental consequences. The Island is exposed to various sustainable developmental challenges, which principally arise from their remoteness, small size, ecological fragility, topography, susceptibility to natural disasters, limited resources, limited local capital for productive investment, and excessive dependence on imports. Though there is significant progress made towards sustainable development in Mauritius particularly in the protection and management of land, environment, fresh water, coastal area, biodiversity, agriculture and waste, using GIS and remote sensing technologies. The Natural hazards of common occurrence in Mauritius include floods, landslides, cyclones, sea waves etc. The role of GIS and remote sensing in the geological structures and natural hazards in the marine Island of Mauritius has been explained in this research paper. This has been observed during geological field work in the coastal island of Mauritius. Some field photographs are also shown in this paper.

ICCCH 24

Does the Himalayan Glacier Study mean for Climate Change?

Manohar Arora, Rakesh Kumar and R D Singh

It is now known and accepted that the climate is changing. Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). As per the IPCC Fourth Assessment Report the updated 100-year linear trend (1906 to 2005) of 0.74°C [0.56°C to 0.92°C] is larger than the corresponding trend for 1901 to 2000 given in the TAR of 0.6°C [0.4°C to 0.8°C]. The linear warming trend over the last

50 years (0.13°C [0.10°C to 0.16°C] per decade) is nearly twice that for the last 100 years. The total temperature increase from 1850–1899 to 2001–2005 is 0.76°C [0.57°C to 0.95°C]. Glaciers are the most visible indicators of global change. Climate controls the glacier behavior and any change in climate is reflected in the glacier. Glaciers in the Himalayas feed many important rivers of Asia including Ganga, Amu Darya, Indus, Brahmaputra, Irrawaddy, Salween, Mekong, Yangtze, Yellow, and Tarim. Apart from feeding the rivers, the Himalayas also play a significant role on the meteorological condition of India.

The glacier study is important in the sense that it has a direct relation with climate change. Glaciers respond to change in climate in terms of glacier length, mass balance and runoff. The climate and glaciers are interrelated. Thereby, the glacier length change, the advance or retreat, is the indirect, delayed, filtered but also enhanced signal to a change in climate, whereas the glacier mass balance, or the change in thickness or volume, is the direct and undelayed response to annual atmospheric conditions In this paper various issues related to the impact of climate change on Himalayan glaciers and melt are highlighted. A brief detail of the methodologies being used for the impact analysis are presented. There is a need to take up studies at individual glacier in order to explore the impact of global climate change on glaciers.

ICCCH 25

Climate Variability And Urbanization-Impacts, Risk And Solutions For Narmada River Basin

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Climate Change and Urbanization are one of the most pressing problems of this century and the centuries to come. The issue related to climate change and variability and that of urbanization is important to India. Trends in urbanization for the last 50 years show that the numbers of urban centres have nearly doubled from 1961 to 2001.According to Census 2001, percentage of urban population in India is 27.8 and it has 4378 urban centres that house 285million urban citizens and 35 cities having population more than 1 million. As per predictions made by UNHABITAT (2003) this number will rise even further, and by 2020, about 50 % of India's population will be living in cities. This is going to put further pressure on the already strained centralised water supply system of urban areas. The urban water supply and sanitation sector in the country is already suffering form inadequate levels of service, an increasing demand-supply gap, poor sanitary conditions and deteriorating financial and technical performance.

In most cities centralised water supply systems depend on surface water sources like rivers and lakes. Where surface water sources fail to meet the rising demand, ground water reserves are being tapped, often to unsustainable levels. Thus the natural water resources, both surface and ground are effected due to water demands from various sectors including cities. Climate change which is likely to aggravate climate variability in the long run, would further aggravate the impasse for India. Climate plays a very decisive role in water resource availability in our country. India has a climate dependent economy .The preliminary assessment of the IPCC (IPCC 2001) have revealed that under the GHG scenario, the severity of droughts and intensity of floods in various parts of India is projected to increase. Also a general reduction in the quantity of available runoff has been predicted from these studies. Thus considering the dual pressure on the water resources in India, addressing water resource scarcity and various threats to water resources at global, national and river basin level will help in addressing the more localised issues like sufficient and adequate water supply in present and growing cities.

The piece of research presented in this paper explores this dual threat to the water resources taking an example of Narmada River which is a lifeline for a number of settlements in two states in India, both rural and urban. The aim is to assess risk to the river as an outcome of climate variability and increasing urbanization within the river basin. Narmada river system is the major river system of the State of Madhya Pradesh and the 7th largest river system of India. It has tremendous capacity to provide irrigation and generate power and has great potential for providing water to ever increasing urban centres of Madhya Pradesh .In addition to Madhya Pradesh, Gujarat, Maharashtra and Rajasthan are also the beneficiary of the river. The river depends on monsoon rainfall and is a perennial river with unique geo –hydro morphology. A total of 71 towns of Madhya Pradesh and 8 towns of Gujarat fall in the Narmada River Basin, and its water is supplied to city like Indore with a plan of taking water to Bhopal also.

The research uses the modified version of Risk Assessment Framework for wetlands given by Van Dem et al (1999). A GIS inventory of the case fabric under study which includes the area containing 3 cities namely; Jabalpur, Narsimpur and Hoshangabad has been prepared to understand the geo-morphology of the area in question and to draw the indicators(components) for further risk analysis.The next steps involves a study of climatic data for last 10 years at 8 stations located along the stretch of the river Narmada.On the basis of the above two , the risk assessment exercise has been performed which is basically done making use of qualitative assessment and quantitative analysis. A structured approach has been adopted beginning with qualitative understanding of the conditions of vulnerability and progress towards development of quantitative indicators. Two cross impacts analysis were carried out where the key climate and climate related variables were listed and linked to selected activities or exposure units. The cross impact sensitivity analysis has been used to map the relationships between drivers and dependent variables in a system. This is followed by quantitative risk analysis of the chosen risk indicators and forecasting of future trends.

The results and findings of the exercise are interpreted in the form of defined relationship between the variables in question and definite risk to water resource in question.The solution is presented in the form of a generic risk management framework and a more detailed Management Action Plan for Narmada River Basin.

ICCCH 26

Impact of climate change on agriculture in sub-Sahara Africa

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Climate change is projected to impinge on sustainable development of most developing countries of sub-Sahara Africa as it compounds the pressures on natural resources and the environment associated with rapid urbanization, industrialization, and economic development. The impact of climate change on agriculture is now real and without adequate adaptation and mitigation strategies to climate change, food insecurity and loss of livelihood are likely to be exacerbated in sub-Sahara Africa.

The Inter-Governmental Panel on Climate Change (IPCC), released in 2007, has clearly revealed that increases in the emission of green house gases (GHGs) have resulted in warming of the climate system by 0.74°C between 1906 and 2005. Such climatic changes are affecting agriculture through their direct and indirect effects on crops, soils, livestock and pests, and hence the global food security.
It was also recognized that a reliable and timely early warning system of impending climatic risks could help determination of the potential food insecure areas and communities. Such a system could be based on using modern tools of information and space technologies and is especially critical for monitoring cyclones, floods, drought and the movements of insects and pathogens.

This paper declared that a concerted effort, backed by policy makers at the national level would be the key to enhance food security as well as ensuring agricultural sustainability. New genotypes tolerant to multiple stresses: drought, floods, heat, salinity, pests and diseases, will help further increase food production. This would requiresubstantial breeding and biotechnology (including genetically modified varieties) related efforts based on collection, characterization, conservation and utilization of new genetic resources that have not been studied and used.

ICCCH 27

Application of Isotopes of Water Vapour in Climate Studies – A World Perspective

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With changing climate, the changing distribution of water in the atmosphere has obvious and significant implications for water resources. The atmospheric water vapour content is expected to increase due to climate change due to the effect on surface warming and is the primary factor for increase in precipitation. The accurate evaluation and predicted changes in climate are affected due to limitations in our knowledge of the movement of water vapour and cloud formation which can be overcome by using the isotopic composition of water vapour.

Measurement of isotopic composition of water vapour provides insights into the hydrologic cycle and paleo-climate. These isotopic measurements are important tools to calibrate atmospheric models of the water cycle by providing new information on the mechanisms of the atmospheric transport process of water vapour and the subsequent phase changes in the atmosphere at the global and regional scales.

Analysis of stable isotope ratios of hydrogen ($^{2}H/^{1}H$) and oxygen ($^{18}O/^{16}O$) play a crucial role in integrating regional-to-continental water cycles. These isotope ratios are affected primarily by the fractionation occurring at phase changes—principally in the transition during surface evaporation or cloud condensation. Therefore, stable water isotope ratio measurements can be used as a diagnostic tracer to investigate hydrological cycles over many scales. An improved understanding of vapour isotope fractionation, both in the process of surface moisture exchange and cloud formation, is necessary if we are to fully exploit the power of stable isotopes in the water cycle.

Thus, it can be inferred that the knowledge of the isotopic composition of water vapour can build understanding of factors controlling the water and energy balance of the atmosphere, development of improved climate models, and guide new studies of clouds and the atmospheric hydrology. This paper presents the various studies on the role of water vapour isotopes in climate studies.

ICCCH 28

Impact of Pareto group of heavy-tailed distributions in probabilistic assessment of Himalayan earthquakes

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One of the beautiful and visible creations of plate tectonics is almighty Himalaya, stretching over 2,400 km along Indo-Nepal border. It has experienced a number of devastating earthquakes in recent past: Kangra-1905 (Mw 7.8), Bihar-1934 (Mw 8.1), upper Assam-1950 (Mw 8.4) and Kashmir-2005 (Mw 7.6) causing extensive loss of life and property damage.

In this paper, Pareto group of heavy-tailed probability models namely, Pareto, tapered Pareto and generalized Pareto are applied to a set of major-earthquake events ($Mw \geq 7.0$) from the Himalayan subcontinent mainly to appraise the recurrence interval in this region. The longer tails of these distributions play important role yielding wide variation in field decisions. The model parameters are estimated from a number of estimation strategies namely, Maximum Likelihood Estimator (MLE), Method of Moment Estimator (MOME), L – Estimators and Trimmed L – Estimators (TM). No geological or geophysical evidences are considered in this calculation.

The conditional probability curves of these distributions for an elapsed time years reveal that the probability of occurrence of an earthquake is very high (≥0.9) in next 20 years. Moreover, it has been observed that MLE is more effective than the other estimators for the above set of data points.

ICCCH 29

Hydrochemistry of meltwater emerging from Raktavaran glacier, central Himalaya, India

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Hydrochemical characterisation of Raktavaran glacier meltwater helps in identifying the nature and different sources of dissolved ions in the meltwater. The order of cations and anions in the meltwater varied as $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$ and $SO_4^{2-} > HCO_3^{-} > Cl^{-} > NO_3^{-} > PO_4^{3-}$, respectively. The high ratio of (Ca+Mg)/(Na+K) i.e 12.4, the relative high contribution of (Ca+Mg) to the total cations (TZ^{+}) i.e ($Ca+Mg/TZ^{+} = 0.93$) and low average ratio of ($Na+K/TZ^{+} = 0.07$) also shows that the hydrochemistry of Raktavaran glacier meltwater is mostly controlled by carbonate weathering followed by silicate weathering. The observed high average equivalent ratios of Na/Cl = 8.3 and K/Cl = 8.4 as compared to sea water indicate that relatively negligible contribution from atmospheric precipitation to the observed dissolved ion budgets of stream draining from Raktavaran glacier. Trace amount of NO_3^{-} and PO_4^{3-} was also reported from the study area, indicating palatability of water. The possible source of NO_3^{-} may be acidic NO_3^{-} aerosol coupled with possible contribution from anthropogenic activity while the possible source of PO_4^{3-} may be anthropogenic activity.

ICCCH 30

"Climate Change, Agriculture and Wetlands in Bihar: Vulnerability, Adaptation and Policy

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Wetlands are one of the crucial natural resources. Wetlands are areas of land that are either temporarily or permanently covered by water. This means that a wetland is neither truly aquatic nor terrestrial; it is possible that wetlands can be both at the same time depending on seasonal variability. Thus, wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant plants and soil or sediment characteristics. Because of their transitional nature, the boundaries of wetlands are often difficult to define. Wetlands do, however, share a few attributes common to all forms. Of these, hydrological structure (the dynamics of water supply, throughput, storage and loss) is most fundamental to the nature of a wetland system. It is the presence of water for a significant period of time which is principally responsible for the development of a wetland. Naturally-occurring wetlands perform such functions as flood control, pollution filtration, nutrient recycling, sediment accretion, groundwater recharge and water supply, erosion control, and plant and wildlife preservation. A large concentration of wetlands is located in Bihar. A significant amount of Bihar wetlands has been converted to agricultural use in the past, and remaining wetlands are subject to agricultural drainage. Drained wetlands are used as prime agriculture lands for a variety of food crops. Other agricultural uses of wetlands range from growing Phragmites australis (common reed) for thatch and livestock feed, to collecting peat for heating and cooking fuel. Altered hydrologic regimes due to global climate change could further exacerbate encroachment of agricultural land use into wetlands. The vulnerability and adaptation studies of the Country Studies Program are used to analyze where climate change impacts to agriculture may likewise impact wetland areas. Scenarios indicate higher temperatures and greater evapotranspiration altering the hydrologic regime such that freshwater wetlands are potentially vulnerable in Begusarai, Katihar and Saharsa have the highest extent of wetlands about 10 per cent of the geographical area of the respective districts. Runoff is identified as a key hydrological parameter affecting wetland function. Since wetland losses may increase as a result of climate-change-induced impacts to agriculture, precautionary management options are reviewed, such as establishing buffer areas, promoting sustainable uses of wetlands, and restoration of farmed or mined wetland areas. These options may reduce the extent of negative agricultural impacts on wetlands due to global climate change.

ICCCH 31

Modelling Energy and Mass Balance of Chhota Shigri Glacier

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The Himalayas have the highest concentration of glaciers outside the polar region and thus holds one of the most important natural resources of water in frozen form. It is important from the point of view of water and energy security of India and many other countries in the region. In addition it also regulates the regional climate and the environment. Himalayan glaciers also act as sensitive indicators of climate change. In view of the above one needs to study and monitor the status of the glaciers. One of the important aspects which is needed to be studied is the energy balance over the glaciers as melting and thawing of the glaciers depends largely on it. The energy balance study describes the physical connection between ice/snow ablation and climate forcing and so it can be used as one of the approaches in estimating the mass balance of glaciers. In the recent years there has been increasing interest in predictive tools for spatially distributed estimates of mass balance further promoted by increased availability of remote sensing data. We have developed a physically based, surface energy balance model to simulate ablation and mass balance on Chhota Shigri glacier of Chandra basin. The glacier covering an area of 15.7 km2, is located at a distance of about 36km SE of Rohtang Pass. It lies on the Chandra River basin on the northern poles of the Pir Panjal range in the Lahaul and Spiti valley of Himachal Pradesh, in the western Himalaya bound by latitudes 32.19-32.280N and longitudes 77.49-77.550E. Its reported maximum elevation is 6263 m a.s.l, snout position is nearly 4050 m a.s.l., glacier length is ~ 9 km. The surface energy balance is the balance between all positive and negative energy flows to the surface and is controlled by meteorological conditions and physical properties of the surface. The energy balance model employed incorporates radiative fluxes, turbulent heat fluxes and the energy flux in the subsurface. Assuming that the horizontal heat fluxes are absent and taking the energy fluxes directed towards the glacier surface as positive while those directed away as negative, the energy balance equation over the glacier surface can be written as:

$$Q = R + H + LE + G + P$$

Where Q is the energy available for melting of the snowpack; R is the net radiations; H is the turbulent sensible heat; LE is the turbulent latent heat of evaporation, condensation or sublimation, G is the conductive energy flux or subsurface energy flux in the snow/ice and P is the heat supplied by precipitation. Since precipitation is always snow in the vicinity of the equilibrium line and since snowfall intensities are usually weak, P remains insignificant and negligible as compared to the other terms. Here the radiative flux is calculated using satellite data (surface reflectance and land surface temperature) as well as Automatic Weather Station (installed at Chhota Shigri). Turbulent fluxes are calculated using the bulk aerodynamic approach which incorporates satellite data (land surface temperature), AWS data and in-situ measurements using surface profilometer. Assimilating all these fluxes we calculated the amount of energy being used in melting of glaciers. Melting and sublimation are computed over the glacier surface for the month of September, October, November and December, 2011. During the period under consideration (November, 2011) the net shortwave radiations (89.67 W/m2) and the sensible turbulent heat flux (14.72 W/m2) are energy sources at the glacier surface, whereas the net longwave radiations (-42.34 W/m2) and the latent turbulent heat flux (-5.489 W/m2) represent heat sinks. The sum of net shortwave and net longwave is the net radiation (50.045 W/m2). For the month of November, 2011, the amount of energy available for the melting of glaciers is 59.28 W/m2; mean melting rate from the glacier surface is 15.33 mm water equivalent/d; mean sublimation rate over the glacier surface is 0.1675 mm water equivalent/d and thus mean ablation rate is computed as 15.50 mm water equivalent/d. In this way the result of this study facilitate a better understanding of the glacier's dynamics and the response of

glaciers to change in temperature.

ICCCH 32

Biochemical Response of plants to induced drought stress under *in vitro* conditions

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Drought is a major environmental stress factor that affects the growth and development of plants. The effects of drought are expected to increase with climate change and growing water scarcity. Thus, an understanding of drought stress and water use in relation to plant growth is of importance. Certain metabolic processes are triggered in response to stress, which increase the net solute concentration in the cell, thereby helping the movement of water into the leaf resulting in increase in leaf turgor. Large numbers of compounds are synthesized, which play a key role in maintaining the osmotic equilibrium and in the protection of membranes as well as macromolecules. The accumulation of proline along with other biomolecular parameters viz. total chlorophyll, chlorophyll a, chlorophyll b and soluble sugar was studied in *in-vitro* raised cultures of *Swertia chirata* and *in vitro* germinated seeds *Salvi*a *sclarea* in response to drought stress caused by different concentrations of Polyethylene glycol (PEG), Mannitol, sorbitol and sucrose. *Swertia chirata* stressed cultures, accumulated increased levels of proline and Mannitol, however, the former osmotic agent was more effective. Pigment accumulation exhibited differential pattern with two different osmotic agents. Sugars melizitose and mannitol were found in high concentration under PEG and mannitol stressed conditions respectively. In stressed *in vitro* germinating seedlings of *Salvi*a *sclarea* increased concentration of all three osmotic agents led to the increased accumulation of proline whereas pigment accumulation showed a parabolic pattern i.e. the content increased first with the increase in concentrations followed by its decrease with further increase in concentration of all the three osmolytes. Sugar analysis of *Salvi*a *sclarea* stressed seedlings revealed that fucose was principal sugar found under sucrose and sorbitol stressed conditions while as mannitol occurred dominantly under mannitol stressed condition. These compounds help the cells to maintain their hydrated state and therefore function to provide resistance against drought and cellular dehydration. The species, which synthesize

large quantities of solutes, are known as osmotic adjusters.

ICCCH 33

Consequences of Climate Change – Risks to the Globe

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Background: The Earth is warming rapidly due to the emission of greenhouse gases (GHGs), mainly from industrialization, deforestation and increased use of fossil fuels for transport. The GHGs from human activities are among the major causes for global warming and climate change which have contributed to the variations in rainfall patterns (high, low and intensive rainfall) and seasons. These have direct and indirect impacts on environment, water resources, agriculture, forests and biodiversity, health, infrastructure development, tourism and livelihoods. Glaciers are receding in the Himalayan region, Africa, South Pacific, Arctic, North America, South America, Europe and Antarctica. Glacial retreat is the most visually convincing evidence of climate change.

The Problems: Scientific evidence, as cited by the Inter-governmental Panel on Climate Change (IPCC), clearly indicates the wide scale of climate change. Average global temperatures are expected to raise 1.4-5.8ºC by the end of the 21st century. Warming in the Himalayan region has been higher than global average. Weather patterns are becoming more unpredictable and extreme – dry seasons become dryer and wet seasons wetter. This phenomenon is causing threat in the water supply – affecting lives and livelihoods of the people and food security.

Conclusions: The issues of climate change can be addressed by formulating and implementing relevant policies and programmes. Policy makers must ease the transition to a carbon-free energy industry by passing legislation that creates favorable market conditions, shaping new frameworks for change and ensuring that the Kyoto Protocol enters into force. In addition, the effective implementation of the United Nations Framework Convention on Climate Change (UNFCCC) provisions can help to minimize the current effects.

ICCCH 34

Comparative developmental study of two species of a homosporous climbing fern of *Lygodium*

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Lygodium japonicum and *Lygodium flexuosum* are the terrestrial climbing ferns belong to family Lygodiaceae. *L.japonicum* is used as an expectorant and in the snakebites while *L.flexuosum* is used in jaundice, rheumatic pain, sprains, scabies, ulcers, eczema and cut wound expectorant, Skin diseases etc. The events of spore germination, gametophyte growth and differentiation, sex ontogeny and development of sporophytes through intra-and intergametophytic mating have been studied. The spore germination was found to be of *Anemia*-type and prothallial development was of *Adiantum* – type. The result indicated that the species could moderately be a good colonizer as considerable number of sporophytes were produced through intra and intergametophytic selfing and crossing. Sporophyte production efficiency was observed to be 58% in composite gametophyte population, while 30% in isolate population in *L. japonicum* while 12% sporophytes production were observed in the composite population of *L.flexuosum* and no sporophytes were produced in isolate population. The main cause of threat could be due to and over exploitation for economic purposes. Need to conserve this taxon in the nature is urgently required.

ICCCH 35

Identification and Hazard Assessment of Potentially Dangerous Glacial Lakes in Himachal Pradesh

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Mountain glaciers interact sensitively with climate and therefore they are considered as climate indicators. The climate change of the 20th century has had a pronounced effect on glacier environments of the Himalayas. Warmer climates of the past 100 to 150 years have resulted in widespread glacial retreat and the formation of glacial lakes in many mountain ranges.The formation of moraine dammed glacial lakes at the snout of the glacier and outburst floods from such lakes are a major concern in countries such as Bhutan, Tibet (China), India, Nepal and Pakistan. These glacial lake outburst floods (GLOF,) can cause extremely high

water discharges as well as large mudflow events. Triggering events for an outburst can be moraine failures induced by an earthquake, by the degradation of permafrost and increased water pressure, or falling of a rock, snow, or ice avalanche into the lake causing a flood wave with a subsequent outburst. The instantaneous discharge of water from such lakes can cause flash floods, enough to create enormous damage in the downstream areas. The hazardous lakes, however, are situated in remote areas and are very difficult to monitor through ground surveys due to the rugged terrain and extreme climatic conditions. Therefore, remote sensing data and GIS are ideal tools for studying and monitoring glacial lakes and assessing their hazard potential. GIS is capable of integrating and aggregating the data acquired from different sources i.e. topographic maps, satellite data, published reports etc. Glacial lakes are identified and mapped from the satellite data using image processing tools. The glacial lakes and surrounding characteristics such as slope, geology, geomorphology, etc are used to identify the potentially dangerous glacial lakes. A comprehensive approach by coupling of remote sensing, geomorphometric analyses aided with GIS modelling for the identification of potentially dangerous and hazard assessment is used for the present study of glacial lakes in Himachal Pradesh.

ICCCH 36

Climate Change Impacts in Central Himalayan Agro-ecosystem and Adaptation Strategies: Integrating Local Perception and Traditional Knowledge

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Climate Change is one of the most important global environmental challenges facing humanity, has its implications on food production, retreat of glacier, natural eco-systems, fresh water supply and health in central Himalayan mountain region. It has already contributed to the increase in air temperature leading to rapid melting of glaciers and increment of glacial lakes. Exploitation of natural resources associated with growing population has led to increasing pollution, declining water quality, land degradation, etc. Extreme climate events including flooding, heavy rainfall, droughts, heat wave and cold stream etc. are also the consequences of climate change observed recently in central Himalayan region. Moreover, this region is largely dependent on climate-sensitive sectors, such as rain-fed agriculture, its fragile mountain ecosystems and undulant topography make the region prone to climate change sensitive zone. Due to such events, agricultural productivity is declining with increasing problem of food security in this mountainous region. In recent years, the signs of such changes are being observed and may become more prominent over next couple of decades. Until recently, economic, social and political changes such as globalization and out migration were considered to be the main drivers of change in mountains. Today it is increasingly acknowledged that climate change and its consequences are likely to have similar or

even greater impacts. It has been observed very recently that many traditional rural communities inhabited in different agro-climatic zones of this region are struggling through different adaptation measures as an attempt to reduce the risk of climate change vulnerability. This paper describes the general information of agriculture and agrobiodiversity, agricultural vulnerability to climate change particularly impact of drought and shift of rainfall and insect/pest incidence on agriculture, farmer's perceptions on climate change impact and adaptation and coping strategies.

ICCCH 37

Chronology of Glaciation and Late Quaternary climatic changes recorded from the Pindari glacier area, Kumaun Himalaya

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The timing and the palaeoglacial extent of various episodes of Late Quaternary period is not very well documented in the central Indian Himalayan region. Systematic field investigations in the upper reaches of Pindar glacial valley has helped in identifying a number of glacially sculptured landforms. The present work has been carried out in the Pindari glacier region in the Kumaun Himalaya. Periglacial geomorphic features have been systematically studied, recorded and mapped to reconstruct the pattern of Late Quaternary glaciation. After carefully examining and dating some of glacial deposits, an attempt has been made to build up moraine stratigraphy along the Pindar valley.

Remnants of the recessional moraines near Khati (2925 m asl), about 22 km downstream of the present day snout, suggests that the Pindari trunk glacier during **Stage I** had probably extended up to Khati (Khati Stage), sometimes during the Middle to Late Quaternary. The LGM in the area seems to have occurred during the early part of last glacial cycle i.e. MIS-3 (23-58 Ka BP). The valley cross section upstream of Khati suggests the presence of a broad U- shaped valley which has subsequently been modified into a narrow one, along the valley floor. During the **Stage II** (25 ka BP, Phurkia Stage), the glacier again advanced up to about 7kms downstream of the present snout. The extent of Stage II advance is marked by the well developed and preserved terminal moraine observed along the right valley wall before Phurkia.

A 435 cm deep Glacio-lacustrine sedimentary deposit from Jeha Gaer, in the vicinity of Pindari Glacier has been analysed using multi proxy data. The palynological and mineral magnetic data aided with ^{14}C and Optically Stimulated Luminescence (OSL) dates suggests that the region has witnessed variability in climatic conditions. The study reveals that the climate of the Pindar valley was cold and dry during 7 ka BP followed by five different vegetational shifts (Bali et al., 2012). The vegetation complex as marked by high conifers associated with broad leaved as well as herbaceous taxa and high magnetic susceptibility suggests the amelioration of climate during 7 ka to 4.9 ka BP. Thereafter, during 4.9 ka to 1.75 ka BP, the climate once again shows cold and drier condition as evidenced by acceleration of alpine herbaceous taxa with gradual decrement of conifers and broad leaved taxa. The geomorphic evidences also suggest that due to sudden advance and presence of rock knob, the **Stage III** advance did not cover the entire width of the valley. The left lateral moraine of the Stage III advance of trunk glacier is found well preserved as a morainic ridge in almost centre of the trunk valley. However, during 1.75 ka to 0.9 ka BP, the climate seems to have become relatively warm and moist (~Medieval Warm Period) as evidenced by the presence of both conifers and broad leaved taxa along with fair amount of Rhododendron. During

0.9 ka to 0.2 ka BP, a drastic climatic change has been witnessed (~Little Ice Age) as evidenced by the relative decline in conifers and broad leaved taxa except Quercus and Rhododendron. A number of crescent shaped recessional moraines disposed along the present day valley floor represent the **Stage IV** glacial advancement, coinciding with the global Little Ice age The sediments of this zone also show lower values of the magnetic susceptibility. Since the last 300 yr BP onwards, the vegetation complex including conifers, broad leaved taxa along with herbaceous elements along with high magnetic susceptibility indicates warm and moist climatic regime. The presence of culture pollen like Cerealia, Tubulifloreae, Acanthaceae, Caryophyllaceae and Polygonaceae also support the high pastoral activity during this phase. Further, the steady presence of both monolete and trilete fern spores suggest an overall warm and moist climatic condition as prevailing presently in and around the study area.

ICCCH 38

Institutional Governance for Sustenance of Himalayan Ecology

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Natural geological wealth, forestry, wild life, flora, fauna and biodiversity, snow, ice and water bodies, traditional knowledge and mountain agriculture which characterize the region are special. It is now widely recognized that the rich and diverse Himalayan ecosystem is fragile. Un-sustainable changes in the ecosystem should be carefully avoided. The perennial rivers of north India depend heavily upon the sustainability of glaciers and the ecosystem of the Himalayan region.

Sustainability of an ecosystem demands a balance and equilibrium among various forms of life and their surroundings established over long periods of time. The Himalayan ecosystem is fragile and diverse. It includes over 51 million people who practice hill agriculture and remains vulnerable The Himalayan ecosystem is vital to the ecological security of the Indian landmass, through providing forest cover, feeding perennial rivers that are the source of drinking water, irrigation, and hydropower, conserving biodiversity, providing a rich base for high value agriculture, and spectacular landscapes for sustainable tourism. The Himalayan eco system is vulnerable and susceptible to the impacts and consequences of

- Changes on account of natural causes,
- Climate change resulting from anthropogenic emissions and developmental paradigms of the modern society.

National Mission for Sustaining the Himalaya Ecosystem (NMSHE) by Government of India under NAPCC proposes to device a mechanism for understanding of the complex processes affecting the Himalayan Ecosystem 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 neighboring countries, to generate a strong data base through monitoring and analysis, to eventually create a knowledge base for policy interventions.

The NMSHE attempts to address some important issues concerning

- Himalayan Glaciers and the associated hydrological consequences,
- Biodiversity conservation and protection,
- Wild life conservation and protection,
- Traditional knowledge societies and their livelihood and
- Planning for sustaining of the Himalayan Ecosystem.

Some of the key deliverables of the NMSHE include;

- Building Human and knowledge capacities,
- Enhancing Institutional capacities,
- Building Capacities for evidence based policy formulation and implementation,
- Empowering people by awareness on continuous self learning for balancing between forces of Nature and actions of mankind.
- Mapping and network knowledge institutions engaged in research on Himalayan Ecosystem and develop a coherent data base on the geological, hydrological, biological and socio cultural dimensions including traditional knowledge systems on preservation and conservation of the ecosystem

The paper provides description of various coordinated efforts needed from various Central Ministries, Governments of 12 Himalayan states, R&D Institutions, NGOs and Civil Society Organizations, in implementation of broad objective of the mission of sustaining the Himalayan ecosystem.

ICCCH 39

Impact of climate change on the water resources of Himalayan Mountains

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The Himalayas is considered among the youngest mountain ranges of the world. It passes through five nations: India, Pakistan, Bhutan, China and Nepal. The Himalayas are a range of mountains and not just a geographical feature.
The Himalayas is the birthplace of many important rivers. Some of the famous rivers of the world including the Indus, Ganges, Yangtze, Brahmaputra, Salween, Mekong, Xunjiang Red River (Asia), Irrawaddy River, Chao Phraya, Syr Darya, Amu Darya, Tarim River and Yellow River have their sources in the Himalayas. The Mekong, Salween, Huang He (Yellow River) and Yangtze, all have their sources in various areas of the Tibetan highland that are geographically separate from the Himalayan mountains, and are consequently not regarded as genuine rivers of the Himalayas. A number of geologists denote all the rivers jointly as the circum-Himalayan Rivers.

The collective catchment area of the Himalayan Rivers houses around 3 billion people (nearly 50% of the population of the world) in Bangladesh, Afghanistan, People's Republic of China, Bhutan, Nepal, India, Cambodia, Burma, Uzbekistan, Tajikistan, Kazakhstan, Turkmenistan, Thailand, Kyrgyzstan, Vietnam, Laos, Pakistan, and Malaysia.

The mountain range covers approximately 15,000 glaciers, which function as the storehouse of approximately 12,000 km^3 of freshwater. The Siachen Glacier located at the border of India and Pakistan is the second longest glacier in the world away from the glacial region of South Pole and North Pole. The length of Siachen glacier is 70 km. Some of the other well-known glaciers include the Yamunotri and Gangotri (Uttarakhand), Baltoro and Biafo (Karakoram region), Nubra, Khumbu (Mount Everest region), and Zemu (Sikkim) glaciers.

The Himalayan region is not only tectonically active and ecologically fragile but it is also one of the most economically underdeveloped and most densely populated mountain ecosystems on the planet. These natural as well as human characteristics render the Himalayan region highly vulnerable to the impacts of climate change, in particular to those of melting of glaciers and changes in the patterns of precipitation.

The major Himalayan rivers are the Indus, Jhelum, Chenab, Beas, Ravi, Saraswati, Sutlej, Ganga (or the Ganges), Yamuna, and Brahmaputra. All these rivers collectively cover an area of 2,250 km. These rivers are the sources of water for domestic, agricultural, industry and fish culture purposes in India. Approximately 500 million people depend upon water from these three major river basins in India alone (Indus, Ganges and Brahmaputra) to support agricultural and economic activities. Some river flows are also used for hydro-electric power generation.

According to the Indian Institute of Tropical Meteorology (IITM), the rates of warming in the Hindu Kush-Himalayan region (HKH) are significantly higher than the global average. Within the region, the rates in the western Himalayas, eastern Himalayas, and the plains of the Ganges basin over the last 25 years are lower (0.01-0.03°C per year), and those for the central Himalayas (Nepal) and the Tibetan Plateau (based on limited station data), appear to be considerably higher (0.04 to 0.09°C per year and 0.03-0.07°C per year, respectively). The measurements in Nepal and Tibet also indicate that warming is occurring at much higher rates in the high altitude regions than in the low altitude areas; the vast low elevation areas of India do not show any significant signs of warming. All areas of South Asia are projected to warm by at least 1°C by the end of the century; in the Punjab area, a large part of Afghanistan, Badakshan, the western Nepal Himalayas, Himachal Pradesh, and the northern Tibetan Plateau, warming could be as high as 3.5-4°C. The rate of warming is likely to increase with increasing altitude, at least in Bhutan, Nepal, and Himachal Pradesh.

Six countries in the Hindu Kush-Himalayan region have prepared greenhouse gas inventories (Bangladesh, Bhutan, China, India, Nepal, and Pakistan). Together these countries emit approximately 17% of the total global greenhouse gas emissions, which is low compared with their area and population. China is emitting 12% of the global total, India 4%, and Bhutan acting as a net sink. The emissions from these countries are expected to increase further with future economic growth as per The United Nations Framework Convention on Climate Change (UNFCC).

Due to increasing temperatures, in the past two decades the ice mass in the Hindu Kush region has retreated at a rate of 0.3 to 1.0 meter per year, faster than the world average (Barnett, Adam, and Lettenmaier 2005). The few analytical studies that exist suggest that climate change could alter the timing and rate of snow melt, with an increase in annual runoff in the initial years, followed by a steep decrease in annual river flows. The uncertainty in water supplies could be exacerbated by increased incidence of extreme events, such as glacial lake outburst floods. With melting glaciers in the near term, flood risks could increase, particularly in Bangladesh and northeast India, if peak flows from the Ganges, Brahmaputra, and Meghna coincide more frequently. In the long

term, there can be no replacement for the water provided by glaciers, and their increasing retreat could result in water shortages of an unprecedented scale.

Though there are two schools of thoughts on the Himalayan glacier retreat, no study so far has clearly demonstrated that there will be no retreat in the future. Glacier lakes are the standing evidence that the glaciers of Himalaya is retreating. The present accumulation of glacier is likely to slow down the retreat in Gangotri region and prolong the retreat. But as long there is greenhouse gases emission and temperature rise there will be retreat in all the snow clad regions of the Earth.

The Himalayan glacier retreat is going to affect the water, food, energy and livelihood securities of the people of this region. This scenario will also affect the existing environmental security of the entire region. The available 12,000 km^3 of fresh water in this region equals 9.17 per cent of the annual global renewable fresh water resource according to the Ecological Society of America. If this water is lost, this region is going to lose 9,323 million tonnes of food grain; the farm work force will lose 6.25 lakh million man days and the wage loss to them will be Rs.938 lakh millon ($ 18.76 lakh million). The total loss of water in terms of food grain will be Rs.21.19 million crores ($42.38 lakh crore). This region's water can supply domestic water to the global present population for about 35 years or, to India for 201 years or, to Tamil Nadu for 3,376 years or, to Chennai City for 5,271 years as per the domestic water supply norms of the WHO. Therefore, it is the duty of the people of Himalayan region to control the green house gases emission to arrest climate change and protect the water resources.

The main objective of this paper is to explain about the impact of climate change on the water resources of Himalayan Mountains.

ICCCH 40

Climatic phases and its effect in the derivation and deposition of Himalayan foreland basin

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Major change in the climatic records is also observed from the derivatives of Himalayan foreland basin in response to the monsoonal circulation. 11 to 5 Ma is considered as an important time phase in deposition of the HFB. We here concentrate on the

detritals of the Ramganga sub-basin of HFB to understand the role of climate at the time of their deposition. During this time the sandstone deposited was coarse to fine grained with well to poor sorting. The derivatives of the RSB are classed as the sub-lithic ($Q_{86}F_4R_{F10}M_{X10}$) sandstone. The immature lithic dominant sandstone in the sink is evidenced for the uniformity of climate, high relief and near source. Temporally viewing the sequence shows sudden increase in grain size at 10.3 Ma and 5.5 Ma along with the anomalies in petrographic data. The survival of the malleable rock fragments indicates a humid to arid climate and small transport. Fluvial architecture further suggests increase in river size and its discharge as a result of increased precipitation hinting a humid climate.

Detrital clay minerals also reflect the effect of climate. Chlorite, illite, kaolinite and smectite are commonly present. Chlorite preservation indicates a cold or arid climate. At places the dominancy of illite over chlorite suggests a humid climate. The phases of arid and humid climate are recorded in the sink during 11 to 5 Ma. 11 to 7.9 Ma, RSB derivatives are evidenced to be deposited by frequent flooding in response to Himalayan uplift causing seasonal precipitation and are climatically controlled phase of sedimentation. The source was proximal and high in relief with similar climatic conditions all over. However, the climate was not the only factor for the derivation of the detritals from the source but was also tectonically controlled.

ICCCH 41

Climate Change and Hill Agriculture

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Despite their importance, mountains have received little attention in global discussions of environmental and development debate. Present scenario changed in 1992 with the adoption of Agenda 21 at the United Nations Conference promotes the sustainable development of mountain regions, points out the need for better understanding of the ecology of mountain ecosystems, and clearly acknowledges mountains' importance for humankind (UNCED, 1992). Although mountains are provider of key environmental services such as freshwater, biodiversity conservation and hydropower to more than half of humanity, mountain ecosystems play a critical role in world development and mountain systems are essential building blocks for long-term sustainable global development, but due to poor governance mountain people are being suffered by poverty food security and livelihood opportunity. In the recent time these vulnerabilities are getting serious gradually due to impacts of climate change.

A rich diversity of traditional crops occurs generally in the Himalaya and more particularly in Central Himalaya. Over forty species of food grains are grown in traditional agroecosystems of Central Himalaya, which have been managed by the local farming communities since time immemorial (Maikhuri, 1996). As regards to climate change impact on crop diversity, productivity and food security in mountain areas is concern, result of many international studies shows that climate change leads to unnecessary fluctuation in crop cycle, crop rotation, crop diversity and

agricultural output (Brodnig & Prasad, 2010, USCCSP, 2009 & Messerli, 2009).

Although hill agriculture has never been very productive in Uttarakhand, and migration has been an integral feature of the hill economy, it is felt that in the last decade the further decline in agricultural productivity – for which change in climatic conditions appears to be one of the causes – has been quite detrimental to the interests of the hill farmers and has contributed to migration (Jain, 2010). In light of above debate it is established that climate change is contributing to a decline in traditional crop diversity, agricultural productivity and food security in the mountain areas of Uttarakhand.

ICCCH 42

Climate Change and Social Media: Facebook as an effective climate messenger

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Awareness of climate change is widespread, but hardly any relationship exists between meaningful action and perceptions of climate change amongst people. Climate change by itself is too wide and too remote a subject for the general population without a link to immediate issues. People are not very clear about causes of climate change and its mitigation. Individuals and communities have been using these social networking sites particularly Facebook as it is the most accessed social networking site by people around the world to warn others of unsafe areas or situations, inform friends and family, and raise funds for disaster relief. Facebook supports numerous emergency-related organizations, including Information Systems for Crisis Response and Management (ISCRAM), The Humanitarian Free and Open Source Software (FOSS) Project, as well as numerous universities with disaster-related programs.

The present study would focus on the use of Facebook as an awareness tool for enhancing the level of awareness about climate change by using the medium to disseminate information and receive user feedback via incoming messages, wall posts, and polls. The study will provide the knowledge and skills of social networking site Facebook and its uses, as well as the current tools, methods, and models to properly make use of social media for raising awareness level as it is the need of the hour to significantly raise the level of awareness of the community of the opportunities and threats brought about by climate change, and to accept their responsibilities to adapt to, and mitigate against its impacts. It would be easily possible to enhancing networking and cooperation for action on climate change education among all stakeholders, in particular through actively engaging communities and youth; Enhancing action-research in social and human sciences, ethics and adaptable teaching materials to suit specific situations.

ICCCH 43

Euphorbiaceous macrofossils from the Himalayan foreland basin of Champawat district, Uttarakhand, India and their palaeoclimatic significance

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The Himalayan foreland basin has been resulted from the tectonic processes that have been taking place in the Himalayan orogeny since the Caenozoic era. The molassic (Siwalik) sediments deposited in the basin containing a variety of plant fossils, which have long been recognized as an important tool for reconstruction of phytogeography and palaeoclimate of the whole Himalayan foothills. The plant fossils entombed in the foreland basin itself indicate the climatic changes in the region during the upliftment of Himalayan.

A lot of plant mega fossil including leaf and fruit impressions were collected from lower and Middle Siwalik sediments exposed in a road section fom Thuligad to Purniyagiri temple in the Himalayan foothill of Champawat district of Uttarakhand.These leaf impression are well preserved on bluish grey coloured mudstone and are mostly devoid of cuticle. The morphotaxonomical study of some of the complete and well preserved leaf impression revealed the occurrence of four taxa viz., *Mallotus japonica*, *M. phillipinensis*, *Baccaurea tetrandra* and *Bridelia ovata* of the family Euphorbiaceae. The present habit and habitat of recorded taxa shows that they occur in the tropical evergreen forest of north-east and south India, Bangladesh, Myanmar, Malaya and adjoining area which receive higher rainfall. Thus, it may be concluded that a tropical evergreen forest was flourishing under warm humid climate in the vicinity of Tanakpur area in contrast to mixed deciduous forest there under reduced precipitation. All the modern comparable taxa except *Mallotus phillipinensis* do not found to grow in the vicinity of fosil locality as well as in the whole Uttarkhand region but they are migrated towards the North-east India and South east Asia region. Thus, it indicates that the climatic changes have been taken place after Mio-Pliocene times due to which such moist loving taxa could not survive there.

ICCCH 44

Impacts of Climate Change and Coping Strategies by Mountain Communities of Uttarakhand Himalaya, India

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Climate change is a globally accepted fact today. While the opinions differ on the rate of global warming, the fact remains that it is happening and even when the questions have been raised on IPCC projected scenario, there is some consensus that the warming of 21st century will be more than 1ºCelcius. The impact of climate change is considered more intense in mountain areas. The climatic variability with in short horizontal distance due to altitudinal variation resulting in high degree of variation in vegetation and hydrological characteristics make mountain more vulnerable to any climate change phenomena. The Himalayas not only play important role in global climate but are themselves subject to climate change impact and warming here is predicted to be well above the global average.

Uttarakhand Himalayan, located in the central Himalayan region of India, is home to a vulnerable community as it faces variety of challenges. While the region lacks in long-term widely representative climate data, the evidences are available of change in temperature, rainfall, glacier melt and other parameters for few locations. In this fragile ecological zone of Uttarakhand, apart from decreased water discharge in springs, rising average temperature and long dry spells during monsoons, the farming communities have perceived a definite change in climate by way of rainfall reduction, delay in monsoon, reduction in amount and delay in winter rainfall and snowfall, extension in duration of dry season, decline in frost and hailstorm and increase in crop disease and pests in last couple of decades. Increased frequency of forest fires and biodiversity loss are also being perceived as the results of warmer temperatures and drier climates. Though the communities may not always relate the changes to global warming and climate changes yet their responses and coping strategies are instant as they have to depend on agriculture and animal husbandry for their livelihood on almost daily basis.

The farming community is responding to these changes by adjusting their agricultural calendar on a yearly basis by delaying or advancing the sowing of rice and other crops. Winter crops such as potatoes and wheat are also planted earlier or later in some places depending on the arrival of the winter rains. Another coping strategy is the revival of traditional irrigation system with water sharing rules and regulations and protection of catchment areas by planting oak trees around spring catchments near villages. Some other strategies like increased dependence on external support through remittances or seeking alternative employment or even migrating to other locations, are also being tried.

This paper focuses on the above impacts and coping strategies by communities in Uttarakhand in detail.

ICCCH 45

Assessment of soil and aboveground biomass carbon stock in two Himalayan foot hills areas of Assam and their carbon sequestration potential

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The foot hills of Himalayan region in the Trans border state of Assam and Arunachal Pradesh and Assam-Bhutan are changing enormously due to myriad human activities. Therefore, the change of standing biomass carbon and soil carbon is inevitable and continuous. But, soil carbon and aboveground biomass carbon (AGB) plays important role in maintaining the carbon cycle and in mitigating global climate change. Therefore, quantification of carbon in soil and soil is a basic step for evaluating the carbon stocks and to compare its sequestration potential of an ecosystem. In this

study, we have assessed the soil and aboveground carbon stocks for three forests of Assam- Jiadhal and Damra to determine its nature of carbon sink and sequestration potential. Soil samples from varying depths 0-30, 30-60 and 60-100 cm were collected. Biomass of standing trees were estimated indirectly from diameter at breast height (dbh) and total height by using allometric relationships, while the biomass of herbaceous and litter were calculated directly from field measurements. We found that soil of Jiadhal was sandy type while Damra was clay type. The average soil carbon stock in the three layers of soil was 583.14 t ha^{-1}, 448. 51 t ha^{-1} and 372.54 t ha^{-1} for Damra; and 592.59 t ha^{-1}, 481.48 t ha^{-1} and 366.1 t ha^{-1} for Jiadhal. Both Damra and Jiadhal forest are deciduous forest with highest AGB (60.68 and 133.57 t ha^{-1}) and AGB carbon (30.34 and 66.78 t ha^{-1}) in the tree dbh class 50-70 cm and 70-90 cm, respectively. For higher carbon allocation and tree biomass replanting of broad leaved tree and other plants species are essential.

ICCCH 46

Industrial emissions from coal utilization and its effect on climate change

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The north Eastern region of India endowed with considerable deposit of tertiary coals estimated to be about 900 million tons. These coals exhibit the properties of high sulphur, low ash and high volatile matter content. In consequence to the large deposits of coals, a significant numbers of coke industries have been established in the region. Coal combustion processes have inherent characteristics that lead to the release of both gaseous and particulate matter in the atmosphere that have primary and secondary impact on air quality, human health and the climate. In the present investigation, particulate matter ($PM_{2.5}$ and PM_{10}) and gaseous (SO_2, NO_2 and NH_3) samples were collected from coke oven industries during the winter season of January, 2011. The investigation includes some significant heavy metals found in the particulate matters. From the current observation, NH_3 concentration was found predominant over SO_2 and NO_2 concentration, which was not only found due to the coal to coke conversion process but also have an effect from nearby cattle farms, agricultural lands etc. The concentration of NH_3, SO_2 and NO_2 were found in the range between 1.60- 4.199 $\mu g/m^3$, 0.136-0.563 $\mu g/m^3$ and 0.075-0.254 $\mu g/m^3$ respectively. The study also reflected that Fe (0.20-56 mg/l), Mn (0.01-1.6 mg/l) and Zn (0.53-7.12 mg/l) were irreversibly retained in the particulates which was also observed for other metals in decreasing order in case of Cu (0.02-0.08 mg/l), Cr (0.03-0.08 mg/l), Cd (0.02-0.04 mg/l) etc. It is worth mentioning that inorganic species like Fe, Mn etc. catalyze the process of SO_2 to SO_4^{2-} conversion in the atmosphere leading to acid rain. Similarly, concentrations of ions like SO_4^{2-}, NH_4^2 were also estimated.

ICCCH 47

Differential melting and distribution of debris cover on the Chhota Shigri glacier, central Himalaya, Himachal Pradesh, India.

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Not much is known about the status of the Himalayan glaciers and it's response to climate change. The dynamics of these glaciers must be understood. Dynamics of glacier requires the understanding of flow field of the glacier, mass distribution, energy and temperature distribution, entrainment of debris, character of moraine, crevasse formation, etc. Snout of the most Indian glaciers is covered by debris which retards the rate of melting of the snout. The decadal cumulative mass balance of the Chhota Shigri glacier is negative but it is not reflected by the snout position. During the studied period it was found that, at the lower part of the ablation zone near the snout the debris cover varies from 5 cm to 15 cm in thickness which reduce the melting rate upto 2m we to 4m we with respect to debris free area. It was also found that the percentage of debris cover is increasing. The western tributary of the glacier which was once connected to the main trunk is now totally cut off and is fully covered by debris at the lower part. Thus the snout position is not the true representative of the glacier, the health of the glacier must be monitored in terms of its mass balance. This paper deals with the decadal change in debris cover pattern and its effect on differential melting rate throughout the Chhota Shigri glacier and its relationship to mass balance.

ICCCH 48

Factors influencing glacier meltwater discharge in the Western Himalaya

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Himalayan glaciers are reportedly receding in response to increasing air temperatures. Glaciers in the Western Himalayas are no exception to this phenomenon. Melt water discharges from Gangotri Glacier Garhwal Himalaya and Chhota Shigri Glacier, Himachal Himalaya are seen to have fluctuated over the years. This study aims to quantify the interannual, seasonal and diurnal variabilities of glacier meltwater discharge and to understand the factors influencing glacier. In Gangotri glacier meltwaters which falls in the rain shadow zone, influence of monsoon precipitation is found to be minimal, while Westerlies contribute a significant amount of solid precipitation on Chhota Shigri Glacier. While tributary glacier meltwaters appear to influence the bulk meltwater character of the Gangotri Glacier, solar radiation and air temperature plays a major role in controlling the meltwater discharge from Chhota Shigri Glacier. Diurnal variabilities are highly influenced by meltwater storage characteristics, especially in Gangotri Glacier, while to a lesser extent in Chhota Shigri Glacier. In Gangotri Glacier, generally suspended sediment concentrations follow the discharge peaks with a lag time of a few days. However suspended sediment concentration peaks precede the discharge peak, where there is flushing out of sediments.

ICCCH 49

Benthic faunal assemblage - Diversity and Time Scale Changes in the ice cold Kongsfjorden Arctic Ecosystem

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Kongsfjorden is a glacial fjord in the Arctic (Svalbard) influenced by both Atlantic and Arctic water masses (glacial) and harbours a mixture of boreal and Arctic flora and fauna. Inputs from large tidal glaciers create steep environmental gradients in sedimentation and salinity along the length of the fjord. Sediment samples were collected from seven locations in the Kongsfjorden glacial system (78°54.299 N', 12º13.665 S') during the summer months of Indian Arctic expedition (NCAOR, India), during July-August, 2011. The sediment diagenetic carbon variations and benthic

sediment-inhabiting organisms (size range from meiofauna 60µ to macrofauna 500µ) from the Kongsfjorden system were investigated on board the research vessel *Teisten*, of Kings Bay, Svalbard.

The average depth of the system was 179 m, that varied from 40 m in station 3 to 244 m in station7. The average pH of sediment in the study stations was 7.12, whereas the highest value was in station 4 (7.34) and lowest in station 1 (6.66); that of Eh (mv) ranged from -141 in station 5 to -325 in station 1.

The sediment organic carbon content of the system showed the highest value of 2.37g.kg^{-1} in station 5 to 1.00 g.kg^{-1} in station1. The maximum abundance of macrofauna was observed in the outer fjord (station 7), whereas that of meiofauna was in the inner fjord (station 1).

Studies conducted in 2002, reported bryozoans, polychaetes and crustaceans, however during the present study three groups were present Viz polychaetes, molluscs and crustaceans. The meiofaunal community of Kongsfjorden system comprised of Foramanifera, Bivalvia, Harpacticoid copepoda, Gastrotricha and Nematoda. The nematodes formed on an average nearly 84% of the meiobenthic biomass in the seven stations of the study area. Therefore, the study could be considered a pioneering work on the benthic macro and meiofaunal assemblages of the Kongsfjorden system.

The study also establishes the fact that, due to the influence of glacial inputs and Atlantic water masses in the Kongsfjord system, the diversity and abundance of macrofauna showed wide variations and unpredictability.

ICCCH 50

Climatic signals and global events in the last 5 ka from a sub-tropical lake in Garhwal Himalaya (India)

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Garhwal Himalaya is mainly influenced by the Indian Summer Monsoon and partially by the Westerlies and it is likely that the climatic signals are preserved in the sediments of the modern lakes. Considering this, we studied a 3.55m long lake core from Badanital (30° 29'50"N:78° 55'26"E, tal=lake) which we think was created by the neotectonic activity on the top of a mountain (altitude 2,083m). The core has almost homogeneous sediments. The lower part is composed of finely laminated carbonaceous mud with occasional small rock fragments and woody material, whereas the upper part is dominated by sticky and micro-laminated cohesive mud. The micro-laminations are expected to represent the annual accumulation. To understand the possible extreme events and centennial scale climatic changes, we used AMS dating (of five layers), carbon isotopes, mineral magnetism, geochemical analysis (including Chemical Index of Weathering and Chemical Index of Alteration), clay mineralogy and palaeo-vegetation. A number of geomorphological features indicate landscape rejuvenation as a result of neotectonic activity which was responsible for formation of lake that remained a closed basin until very recent human interference. The AMS dates were calibrated using online Cal Pal program

and the approximate sedimentation rate of the core was calculated on the basis of calibrated ages. The topmost negative date (due to excess amount of carbon) is considered as zero for calibration. The accumulation rate is approximated as 1cm/~28.5 yrs for the period from 4,220 to 2,540 yr BP, 1cm/~11.7 yrs BP between 2,540 and 620 yr BP, 1cm/~2.75yr from 620-530 yr BP, and 1cm/~7.9 yr for duration from 530 yr BP onwards. By using the accumulation rate between various dates, we extrapolated the ages for boundaries of the important changes in the climate. We have found clear evidences of 4.2 ka arid event, MWP (Medieval Warm Period), Little Ice Age (LIA) and modern warming. The multi-proxy data indicate a semi-arid phase from ca. 5.1 to 2.9 ka BP with an event of peak aridity at 4.3-4.0 ka BP, corresponding to the global event of 4.2 ka BP. This was followed by wet/moist conditions from ca. 2.9 to 1.7 ka BP which in turn was followed by a longer arid phase between ca. 1.7 ka BP and 750 yr BP. A gradual shift to wetter conditions is observed between ca. 750 and 450 yr BP. This event perhaps corresponds to MWP (Medieval Warm Period). A further culmination of aridity from ca. 450-230 yr BP may correspond to the LIA.

The post LIA period from ca 230 yr BP (1770 AD onwards) indicate that the area was under the influence of the ISM due to modern warming. Our data are consistent with the earlier studies in the sub-tropical sectors of the India Himalaya and similar latitudes in Tibet and China.

ICCCH 51

Decadal scale fluctuations in the intensity of Indian Summer Monsoon (ISM) and Westerlies in the Central Himalaya (India) for the last ca. 4,500 years- evidence from cave stalagmite record

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The first U/Th dates and climatic events on two stalagmites (SA-1 and PH-1), spanning between 3.8-0.4 ka BP and 4.5- 2.0 ka BP respectively from the Indian Himalaya. In addition to specific inception and duration of multi-annual to decadal events, the data also provide information on the intensity of Indian Summer Monsoon (ISM) and Westerlies in north India during the Late Holocene. We suggest that the lighter $\delta^{18}O$ stalagmite values are associated with stronger Westerlies under wetter conditions. A large part of both the speleothems is made up of aragonite and the drip pattern in both the samples is found very similar. The $\delta^{18}O$ values range between -2 to -9‰ in SA-1 and -5.3 to -10‰ in DH-1 stalagmite. This variation of about 3‰ in both the samples can be attributed to the elevation difference in both the sites which is of the order of 700m. Three abrupt and prominent decadal scale events at ca. 3.7 ka, 2.4 ka and 0.45 ka BP are evident of elevated precipitation, the last of which coincides with a part of the wet Little Ice Age (LIA) in the north India as has also been recognized by earlier Himalayan speleothem studies. At 3.5 ka BP, a prominent aridity was culminated, signifying the lowest intensity of precipitation.

We suggest that the Westerlies played an important role in the Late Holocene climate of the Himalaya. Since the source of the Westerlies is subtropical Atlantic, the North Atlantic Oscillations (NAO) which were responsible for comparatively stronger Westerlies in the southern Europe, may have brought higher precipitation to the north India.

Our study of two U/Th dated stalagmites is the first record of the Central Himalayan climate for the last 4,500 years. The $\delta^{18}O$ variations reveal six major stages, (i) A wet phase from 4.5 to 3.7 Ka BP with the highest precipitation at 3.7 ka BP, (2) A sudden rise in $\delta^{18}O$ values from 3.7 to 3.5 ka BP with extremely dry event at 3.5 ka BP, (3) fluctuations within the humid regime between 3.5 and 2.7 ka BP, (4) a drop in $\delta^{18}O$ from 2.7 onwards with very wet conditions at 2.4 ka BP, (5) a long phase from 2.4 0.5 ka BP of comparatively less humid state than that in stage 3, and (6) a remarkably wet phase after 0.5 ka BP.

ICCCH 52

Role of redox homeostasis and glucosinolate production in determining adaptability of perennial pepperweed

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Perennial pepperweed *(Lepidium latifolium* L.) is an ecologically important plant of family brassicaceae, the members of which are known to produce glucosinolates. It tolerates a wide range of habitats ranging from cold deserts of Ladakh to marshy lands of western America. In this back drop, we tried to study the role of redox homeostasis and glucosinolates in determining such a great ecological plasticity in pepperweed. It was observed that plants have developed efficient antioxidative machinery in Ladakh to evade the extreme environment and is complemented by increased production of glucosinolates. The cellular conditions are maintained reducing in Leh despite the stressful environment, and the lower ratio of $NADP^+$/NADPH prevents plants from photo-oxidative damage under high light intensities. The plants showed over-production of glutathione and ascorbate at Leh than in Jammu. Apart from their increased expression, newer anti-oxidative isozymes with higher thiol content were also produced at Leh. Concomitantly, increased glucosinolate production was observed at Leh (3505 m) than in Jammu (305 m). However, higher expression of the indolic glucosinolates genes (like *CYP79b2*, *CYP83b1* and *SOT16*) was observed in Jammu. Since, higher production of indole glucosionlates are known to attract the specialist insect herbivores for oviposition of eggs, this could explain the restricted distribution of perennial pepperweed in Jammu. Our results suggest that responsive redox status in this plant play a crucial role in adaptation in harsh environments of Leh, but glucosinolate pattern play a limiting factor in Jammu.

ICCCH 53

Understanding the role of redox homeostasis in physiological and biochemical acclimation in *Salvia sclarea* L.

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Salvia sclarea L. (*Clary sage*) is a biennial herb that produces high value essential oil used in aromatherapy and food industry. It is native to mediterranean region, but is naturally growing in diverse habitats. To understand the biochemical basis of this plasticity, studies were conducted on Clary sage plants grown at three different locations viz., Jammu, Srinagar and Leh (subtropical, temperate and cold desert with altitudes 350, 1500 and 3200 m, respectively) of Kashmir Himalayas. The activities of antioxidative enzymes such as SOD, APX and GR as well as content of redox metabolites like GSH and NADP were investigated to understand redox status of plants at different environments. Results show that at higher altitudes, the redox homeostasis is maintained either by incresasing the total concentration of the metabolite or by changing its redox form. These results are also supported by the activities of GR that changes GSSG to GSH. H_2O_2 and other antioxidant enzymes however, show high specific activities at lower altitudes suggesting subtropical environement is not optimal for growth of *Salvia sclarea*. Similar observations were also made physiologically, using light curves measuring the photosynthetic efficiency of these plants. The photosynthetic efficiency was highest in Srinagar, followed by Leh and Jammu. Light saturation point was much lower in the plants growing at Jammu, thereby producing higher ROS. Percentage of essential oil and bioactive compound 'sclareol' was also found higher at temperate and cold deserts, suggesting metabolic reconfiguration at higher altitudes. The study suggested that *Salvia sclarea* has the potential to grow in diverse habitats and can be taken up for commercial cultivation in vast wastelands including cold deserts.

ICCCH 54

Vegetation and taxonomic profile of the flora of Indian cold desert: a highly fragile and vulnerable mountain ecosystem in the country

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Fragility of mountain ecosystems and their vulnerability to adverse effects of climate are well established. Increase in human pressure and activities pose serious threat to the survival of the floristic diversity and ecosystem as well. This human pressure and over exploitation of natural resources have made the trans-Himalayan cold desert, one of the world's most fragile and threatened ecosystems. Indian cold deserts cover an area of *ca* 98,980 km^2 come under the Trans-Himalayan zone comprising to Ladakh in Jammu & Kashmir (82,655 sq km), Lahaul-Spiti and Kinnaur in Himachal Pradesh (15000 sq km)

and Nelang valley, Mana, Niti valley in Uttarakhand (1000 sq km). Extending over the north of Himalayan ranges, Trans-Himalayan zone lies in rain shadow of main Himalayan range. The cold deserts are characterized by extremely low temperature -45°C, low rainfall ranging from 500-600 mm annually, forms a plateau extends from 4500-6000 m altitude in western Himalayas dominated by annual and perennial herbs, few stunted shrubs and bushes. The tree species of *Populus* and *Salix* are introduced in this region. The vegetative growth starts at the commencement of summer after the melting of snow which provides abundant moisture leads flora in full bloom in July-August. The mountain slopes, meadows and alpine pasturelands give a spectacular display of flowers of cold desert barren mountains. The vegetation of the cold desert in trans-Himalayas represents highly specialized group of plants with adaptive and reproductive strategies suited for maximizing their activity in harsh climatic conditions. The plants exhibit a number of ecological, morphological and physiological adaptations which help them to counteract the impact of harsh climate prevailing in this zone. The characteristic features of this ecosystem are sparse vegetation cover (<15 %), low primary productivity and extreme aridity. Major vegetation formations in this area are scrub steppe dominated by *Artemisia -Caragana, Ephedra - Juniperus, Salix - Myricaria,* and *Lonicera - Rosa* communities. A few patches close to the valley bottoms with moist clayey soil support herbaceous communities such as *Potentilla - Geranium* type, *Festuca - Stipa* grass communities and sedge meadows. A considerable area falls under typical desertic formation with less than 5 % vegetation cover characterized by scree slopes, very high altitude (>4800 m) pioneer environments and other rocky slopes dotted with mosses, lichens and a few hardy plants such as species of *Stipa, Melica*, *Christolea, Sedum*, *Draba*, and *Saussurea*.

Vegetation of the cold deserts of Himalaya represents alpine mesophytes, oasitic and desert vegetation types. An intensive and extensive survey of the area and critical study of the plants have resulted in the documentation of 1405 species, distributed under 490 genera and 98 families of flowering plants. Of these, *ca* 1050 species, 383 genera under 80 families belong to dicots and the remaining 347 species, 103 genera under 16 families to monocots. The analysis of data indicated that the family Poaceae is the most diverse and is represented by 198 species, followed by Asteraceae (172 spp.), Caryophyllaceae (122 spp.), Brassicaceae (102 spp.), Fabaceae (90 spp.), etc. A large number of species growing in this area are of medicinal and economic value which is used by local inhabitants. A brief account of area, vegetation types, floristic composition, affinities, medicinal and economic plants, threatened species, analysis of flora, threat to the flora and its conservation are discussed.

ICCCH 55

A Threat to Agro biodiversity and its Conservation in Uttarakhand Himalaya due to Commercialization of Agriculture

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The farmers in Uttarakhand have been cultivating traditional cultivars of a number of cereals, pulses and vegetables. These farmers have also conserved their forest reserve, the plant genetic resources and the methods of cultivation in the face of massive erosion of crop diversity all over India. The genepool of traditional crops has also been continuously enriched by geneflow across the Himalayan states and countries through trading of grain and exchange of seeds. Despite the urgent need of farming families to grow cash crops in order to survive in the market economy, women in Uttarakhand have emphasized the role played by the traditional crops in ensuring household food security and maintaining the cultural heritage of their tradition. But now due to increased market integration and commercialization of traditional agriculture to improve the productivity, per capita income and standard of living, this genepool diversity and traditional knowledge systems associated with conservation is deeply threatened.

ICCCH 56

Climate change and attendant landslide hazards in the northwest Himalayas

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Climate change manifested by an increase in intense rainstorms and cloudbursts is becoming more evident in many parts of the Himalayas. The increasing impact of climate change has enhanced our vulnerability to hydro-meteorological disasters, and has resulted in enormous human and economic losses. Synergy between climate change and mass wasting processes are crucially important in planning a proactive approach to mitigate the hazards and devising adaptation strategies in mountainous environment. A broad consensus also prevails in the scientific community that global warming will have profound effects on the hydrologic cycle (IPCC, 2007).

Continued collision tectonics, high seismicity, high relief expressions and high-energy regime of Northwest Himalayas possesses geo-environmental conditions conducive to major mass wasting phenomenon. Though, there are case studies of catastrophic landslides in historical and pre-historical past from the Northwest Himalayas, those occurred in,1880 and 1889 in Nainital basin and a natural rock fall in 1893 that blocked the Birahiganga in Garhwal Himalayas near village Gohna, have special significance due to rain induced failures. Several incidences of river blockades are known from Garhwal Himalaya such as Dhauliganga (1956), Rishiganga (1967), Patalganga (1970) and Bhagirithi blockade (1978, 1992). However, in last decade or so, the numbers of landslides of catastrophic dimensions have increased in the Northwest Himalayas as recorded from Malpa, Okhimath, Pithoragarh in the Garhwal Region; the debris flows around Nathpa Jhakri project and Parechu in Sutlej River catchments in Himachal Pradesh and; recent mud flows/ debris flows in Trans Himalayan region of Ladakh were conspicuous examples of landslide disaster in high altitude terrain inflicting a colossal losses of life and property.

Such spatial and temporal distribution of landslides in the NW Himalayas is of significance as the relationships have been influenced by the occurrence of intense rainfall events/ cloudbursts. The frequency of mass wasting activities have increased and transgressed into areas hitherto unknown for such cataclysmic events. It was possible to identify landslides of various dimensions and types and in many cases a concentration of events was detected during the recorded history of landslides in Himalayas; this led to the hypothesis of correlations between temporal distribution of slope movements and climatic changes in the region. Complexity arises on account of the problem owing to both the variability in time and space of climatic changes scenario in the Northwest Himalayas and the quantity and quality of data available on mass wasting phenomenon in the terrain.

Olea ferruginea Royle: a potential tree crop for sustainable development of North West Himalaya

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The Indian Himalaya is the youngest and loftiest mountain chain on the planet earth and is believed to be still rising, and thus has not stabilized from geological and geomorphological perspectives. The region occupies nearly 16% of the geographical area and directly supports 3.86% of the total population of the country. Because of diverse ecological and climatic conditions existing in the region, it harbours several ecologically and economically important plant species, including medicinal plant species, wild edibles and fodder tree species. Many species are endemic to the Indian Himalaya. However, continuously increasing human and live stock population and unscientific way of their exploitation are posing a great threat to these natural resources. The problem is further being exacerbated by global climate change. It has been projected that the greenhouse gas-induced climate change will severely affect the natural resources in mountain regions of the world. Thus, there is a need for conservation and sustainable utilization of natural resources.

O. ferruginea, Indian olive, is a multipurpose, zero waste, evergreen tree species as its different parts (leaf, bark, wood, timber, fruit, seed and root) are used for different purposes. This species is closely related to *O. europaea* and is believed to be one of its subspecies. Besides India, it is also found in Afghanistan, Nepal and Pakistan. The leaves and bark of *O. ferruginea* are used as antiperiodic in fever and debility. The leaves are also used in toothache, astringent medicines, mouth ulcer, demulcents, gonorrhoea, sore throat, hoarse voice, and as a tea beverage, mild digestive aid, antiseptic and anthelmintic. The timber is used for making agricultural implements. The fruits are edible, pickled, and used as appetizers, emmenagogues, antidiabetics and a source of olive oil rich in oleic acid, and they are used in typhoid, jaundice, biliousness, scabies, burning of the eyes, toothache and caries of the teeth. The oil is useful in cooking, rheumatism, joint pains, malaria, gonorrhoea, skin diseases and cosmetics. The root is used in asthma, scorpion sting, rheumatism and headache. The olive fruits and leaves contain a very high amount of polyphenols and antioxidants which are credited with many health benefits. *O. ferruginea* also contains oleanolic acid, a biologically very important compound, involved in various activities such as antitumour, antioxidant, anti-inflammatory, antipruritic, antiallergic, antiviral, and immunomodulatory.

In India, *O. ferruginea* is found in western Himalaya from Kashmir to Kumaun up to an altitude of 2400 m. It is locally known as Kahu (Kao) in Himachal Pradesh and Jammu & Kashmir, and Bairbanj in Garhwal. This species is being used mainly as fodder and fuelwood, and as rootstock in the grafting of *O. europaea* in Himachal Pradesh. However, it is facing uncontrolled and over exploitation due to increased population pressure. Due to this the occurrence of pure stands of this species in nature has become rare. It is also rare to find the healthy seed bearing trees in the region. Data obtained from the studies carried out on *O. ferruginea* at the Himachal Unit of this institute show that the fruits of *O. ferruginea* may be a potential source of olive oil. It was also found that olive oil content was

considerably higher in the fruits than in the seeds. The olive oil content in the fruits, depending on populations, varied from approximately 21% to 27%. The olive oil content of O. *ferruginea* in the fruits of Thalaut population was on par with that of the world's most prominent olive oil cultivars. In all the populations, monounsaturated oleic acid was predominant. Further, the levels of saturated fatty acids in the fruit oils varied from 13 to 21%, whereas unsaturated fatty acid varied from 79 to 87%. Further, this species showed different mechanisms to survive and grow under drought conditions prevailing in the rainfed areas and thus is a potential tree for afforestation of degraded lands, and can solve the problem of land degradation in the region. Thus, sustainable use of this potential of the tree could
be useful in the socio-economic development and environmental conservation of the area where it grows.

ICCCH 58

Biodiversity Hotspots of the Himalayan Region and Climate Change

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The Himalayas are sometimes called the world's "third pole" because they are covered with thousands of glaciers. Water from those glaciers helps feed some of the world's most important rivers, including the Ganges and the Indus. Glacial melting has a cascading effect on water, biodiversity and livelihoods. As the glaciers of the Himalayas are not uniform in their size, shape, age and proximity due to various local evapotranspiration effects, the life cycles of glaciers are different. During this period of time of confirmed global climate change, some glacier areas of the Himalayan region are actually growing while others are shifting and still others are melting. These effects of change of the glaciers affects local climatic conditions as well as impacts floods, landslides, rock flows and mud flows. Concomitant effects from these changes directly affect endemism as well as the potential for extinction. Specific glacial melt and river flow percentages and potential effects by siltation, flow rates and other physical river effects on breeding and species populations will be discussed. Actions at every level of society are necessary to this end, but these actions must include economic benefits as well as education to encourage citizens to treasure, protect and preserve the biodiversity of flora and fauna found within each region.

ICCCH 59

Effect of MSW leachate on the Deepar beel ecosystem, a ramsar site in Assam, India.

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The solid waste disposal sites are the primary sources of environmental degradation in any city. It increases the pollution level of the surrounding environment due to the percolation of the leachate from the landfill surface.
The dumping site of MSW of the Guwahati Municipal Corporation is in the fringe area of Deepar beel, a Ramsar site known for migratory birds and aquatic biodiversity. The Deepor beel provides livelihood to its neighbouring villages primarily in terms of fishing activities and water use for various purposes.

The water quality at a point near the dumping ground was monitored for a period of one year. Seven selected parameters (Temperature, pH, Total dissolved solids, Dissolved oxygen, Free CO_2, Alkalinity, Hardness) were analysed. Four trace elements viz. Zinc, Manganese, Copper and Lead were recorded in higher range in water samples as well as in fish (*Anabus testudineus*) samples collected from the site. Trace metal analysis was done using Atomic Absorption Spectrophotometer (iCE 3000 series). The range of the trace metal concentrations recorded in water samples are as follows: Zinc (0.17-0.95ppm), Manganese (0.51-6.53ppm), Copper (0.01-0.312ppm) and Lead (0.01-0.42ppm). This has been found to be within the range of water quality standards for surface water as given by CPCB (1986) but much higher than the WHO limit for drinking water. The analytical data shows a high range of free CO_2 (10.3-14.1mg/l), electrical conductivity (405-1601.1µS), hardness (120-324mg/l) and extremely low values of dissolved oxygen (0.9-2.4mg/l). In fish muscle samples, the metal concentration ranged from (2.10-3.95ppm)for Zn, (2.66-4.85ppm) for Mn, (0.048-0.41ppm) for Cu and (0.19-0.24ppm)for Pb. The results showed that Zinc and Manganese in fish accumulated in significantly higher concentrations compared to copper and lead. The study shows that there is biomagnifications
of trace elements in the fish muscle and may be detrimental for human health as these fishes are sold in the market for consumption.

ICCCH 60

Climate Change in Himalayas and Responses of Trees and Vegetation: Some analyses and Speculations

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The Himalayan region is of global significance because of its extraordinarily wide range of ecosystem types, from tropical rain forests to steppes, high endemism (eg 39% in plants of Kashmir), and about 61,000 km^2 area under glaciers (referred to as the third pole) to which are connected ten river basins where live some 1.3 billions. Himalayas are the maker of climate of much of the south-east Asia, the establishment of monsoon coinciding with the rise of these mountain ranges. Whatever data are available they indicate that the Himalayan region is warming at higher rates than anticipated and the rate of rise increases with altitude. In general, glaciers are shrinking rapidly, partly because of Black Carbon factor. Other anthropogenic factors include forest degradation because of the day to day dependence of poor people on forest biomass, frequent man made fires, spread of invasive alien species, and trophic downgrading. More frequent winter fires and widespread drying of springs due to increased temperatures without increased precipitation are being observed in at least in western Himalayas. In this article I have made an attempt to collect some evidences and hints indicating responses of Himalayan trees and communities to climate change, and have speculated likely changes in them based on researches carried out on similar systems elsewhere. Some evidences are there to suggest that several unexpected responses of trees and ecosystems to climate change are in store. They include : asynchrony between seed germination of several important forest species like ,*Shorea robusta* and *Quercus semecarpifolia* and arrival of monsoon, delay in leaf unfolding because of carbon drain due to a rapid seed maturation under the influence of a spell of drought *in Q. leucotrichophora*, and revelation that a stand *of Q. floribunda* has more than one population, one being able to maintain its water potential in the face of prolonged droughts and thus is able to produce leaves on time, while the other unable to do so delays it. Impact of climate change on biotic interactions which could be very sensitive to the phenology, behaviour, physiology and population dynamics of interacting species can also include unexpected consequences to ecosystems. The Himalayan alpine ecosystems are particularly vulnerable to climate change because of relatively more warming and changes in hydrology and albedo due to the rapid glaciers melt. How species differ in their dispersal capacities and its effect on their upward march, possibilities of formation of novel communities, and human assistance required to migrating species are other important areas of investigations, particularly from management stand point. Modellers, generally do not consider these complexities, and remain focussed on predicting range shifts on the basis distribution of species in relation to temperature and precipitation.

ICCCH 61

An assessment of NDVI on Himalayan Plateau by using Geospatial Technology

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Temporal and spatial changes of NDVI (Normalized Difference Vegetation Index) on the Himalayan Plateau were discussed in this paper, by using multi-temporal NOAA AVHRR-NDVI data from 1990 to 2000. Monthly maximum NDVI were used to analyze the seasonal changes, and annual maximum NDVI, were used to discuss the interannual changes. The difference between the average NDVI for a particular month of a given year and the average NDVI for the same month over the last 10 years is calculated as the NDVI anomaly. In most climates, vegetation growth is limited by water so the relative density of vegetation is a good indicator of agricultural drought. The main aim of this study is to determine the status of land and forest degradation in Himalaya using remote sensing technology. Large NDVI values correspond to greener areas whereas snow and ice have low, or even negative, NDVI. By analyzing the changes in the NDVI over a period of several years, an attempt is made to assess the changes caused by climate or socioeconomic aspects. Present study will also ascribe the multicriteria decision analysis to establish climate change induced natural hazards.

ICCCH 62

Climate Change and Multiple hazards in mountain region

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Himalaya Mountain is the youngest and is still evolving, active and rising. Recent earthquakes and landslide activities are the evidence of its tectonic activities. Rocks exposed in the area are folded, faulted, sheared and highly jointed. These rocks are further weak and vulnerable to erosion and weathering due to the rainfall, steep slope and of fragile lithology. This zone is highly prone to natural hazards viz earthquakes due to neo tectonic activities. Glaciations in the Himalaya mountain chain has been developed about two million years ago from the late ice age in Pleistocene Period. Himalayan region has the largest ice cover in terms of numbers of glaciers. Present inter-glaciers warm period is a period of glaciers retreat in the Himalaya. It is reported that glacier located in the Central Himalaya has recorded an annual retreat in 8-10 m/y. The global warming due to climate change will have extreme effect on the Himalayan ecosystem due to tectonic activities and melting during the glacial retreat period of Himalayan glaciers. Multicriteria decision analysis had been utilised to identify the regions of climate induced multiple hazards in Indian Himalayan region. The region of medium drainage density, higher fracture density, high degree of slope and higher relative relief will be

vulnerable and is adroit to landslide. The study observed that spatial distribution of drainage and its characteristics are crucial factors and have a vital function, since it carries an enormous amount of water, debris in case of melting of glaciers. The present study elucidates that Himalayan region will be highly vulnerable due to overlapping threads from landslides and other natural hazards.

ICCCH 63

CFCs, HCFCs and HFCs: Linkages to climate change and strategies for mitigation

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Several CFCs (and HCFCs) were extensively used as refrigerants, as blowing agents in the production of foamed or extruded polymers like PUF, as propellants or solvents for aerosols, as fire extinguishants, and as solvents or as cleaning agents. These CFCs (this term is broadly used here for compounds including HCFCs) seemed to have many desirable characteristics for the aforementioned applications, such as thermophysical and thermodynamic suitability, non-toxicity, non-flammability, material compatibility, thermal and chemical stability, low cost etc. but were considered to have damaging effect on the stratospheric ozone layer. Therefore, these compounds are also known as ozone depleting substances (ODSs).

As per the Montreal Protocol (MP) on substances that deplete the ozone layer, CFCs were phased out globally by 2010, and some countries including India, phased them out much earlier. While doing so, HCFCs or HFCs were used as substitutes. Now HCFCs are also mandated under MP to be passed out by 2030. In some cases, HCFCs are being phased out by using HFCs. HFCs are one of the controlled gases under the Kyoto Protocol. There is a also proposal pending under MP to consider phasing down of HFCs in the near future.

The focus of this paper is on refrigeration and air-conditioning sector. The refrigeration and air conditioning industry is currently facing two environmental concerns, namely, ozone layer depletion and global warming. Therefore it has to replace HCFC refrigerants by long-term substitutes (with zero ODP and preferably with low GWP). Some HFCs, introduced as the ozone friendly refrigerants, have much higher GWP. In Europe, according to the F-gas regulations, some HFCs have been substituted by natural refrigerants e.g. HCs, CO2, Ammonia, with negligible GWP, although Kyoto Protocol does not demand such replacements.

The paper will cover some of the criteria for the selection of appropriate fluids and the choices made. The first part of the paper deals with the conversion of refrigerators using CFCs to HC blends (HC-600a/290) as the refrigerant as well as cyclopentane as the blowing agent. The second part of the paper deals with the conversion of air-conditioners using HCFC-22 to HC-290. By these, any uncertainty associated with these two industries has been totally removed. Additional there are significant climate benefit.

ICCCH 64

Climate change and the Recession pattern of the Glaciers in the Himalayas

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Geological studies have revealed that the Himalayan mountain chain attained the present expanse around15 million years back- mid-Miocene, and the earth had the best climate around that time resulting in profuse development of plant life and vertebrates. There were no glaciers in the Himalayas then. In fact during the next 10 million years-16-6 million years resulted in the development of the Outer Himalayas-better known as Siwalik Ranges that garland the Himalayas from north-west to north-east with a width of around 10km and ranging in altitudes upto about 1000masl. Lithology of this range exhibits the typical characters of river borne material created by the rivers that were the flowing down the Himalayan slopes and flowing from across the main range. Obviously with enormous quantities of water that had the energy to erode such large material. Rivers that were fed by monsoon rains and or winter precipitation for there were no glaciers in the Himalayas then.

Glaciers in the Himalayas are the consequence of the last *Ice Age* -Pleistocene Epoch of the Quaternary Period around 1.7 million years back. In fact going by the available evidences, till date, development of the glaciers in the Himalayas may have been much later-around 400,000 years- very recently taking into view that the Himalayan uplift began around 67million years back. And during this period of 400k impact of four major cold epochs-glaciations intervened by warm epoch have been identified. While during the early phases of glaciations, glaciers may have come down to 600masl, during the Last phase of the glaciation-LGM-based on CRN date from Bhagirathi valley-have indicated that the glacier(Gangotri) may have come down to 2400masl almost 50kl-linear stretch-from the present position. Substantive dating data (CRN and OSL) has revealed that the glaciers, in the Himalayas by the end of the LGM-12k to 15k- had receded to around 5km or even less from the current position. Current glacier recession-historical-is the continuation of this natural phenomenon and likewise has been episodic with short periods of rapid degeneration alternating with relatively slow retreat; in response to what is referred as decadal climatic changes. Impact of the micro level human activity in the vicinity of the glaciers or glacier bearing areas on enhancing the glacier recession is debatable and is often quoted out of context. Possibility of the rivers in the Himalayas drying up as a consequence of rapid degeneration of the glaciers is not borne out by the past history.

ICCCH 65

Climate Change in Uttarakhand and its Impact on Flora and Fauna

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Climate change has become a matter of grave concern after Rio Declaration-1992 due to its potential impacts on earth's ecosystem. Mountainous regions are more vulnerable to climate change and have shown "above average warming" in the 20th century. In this paper Uttarakhand is selected as a study area to demonstrate the change in forest cover, biodiversity loss and overall climate change.The state of Uttarakhand is a region of outstanding beauty, with tremendous potential for sustainable growth and development. Being a hill state, Uttarakhand is more sensitive to and probably more affected by climate change. Owing to its largely mountainous regions, the state is endowed with a unique ecosystem that is home to large number of flora and fauna. Uttarakhand has experienced environmental changes, forest cover loss and biodiversity loss in the recent years. This paper makes an attempt to map the changes in forest cover from 2009 to 2012 in the study area by using remote sensing techniques. The forest area analysis of 2009 is done from LISS III and 2012 forest area analysis is done from the map obtained from Google Earth. After comparing and analysing the results of the change detection process, it was observed that during the period of 2009-2012, the forest cover has declined considerably. Uttarakhand is the home of several species which are considered globally threatened. The present paper also deals with wildlife of Uttarakhand which has also undergone substantial changes in recent years. Climate of Uttarakhand has changed over the years. There is an increase in the frequency of flooding and droughts. The paper also investigates the change in the rainfall pattern over the years in Uttarakhand. Climate change brings forth weather extremes, longer droughts, frequent floods, erratic rainfall, high temperatures and milder winter which affect the availability of natural resources and impact on agricultural systems. The study highlights the importance of geospatial tools in change detection studies. The present study addresses the above problems and elaborates the effects of climate change on biodiversity and brings out the possible solution for conserving the biodiversity and ecosystem.

ICCCH 66

A study on Amphibia - Bio indicators of global climatic change. Focal theme Biodiversity and Biodiversity Hot Spots

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Amphibia is the group of vertebrate which occupy an important position in the food chain and are extremely useful as indicators of the state of our environment. They have naked sensitive skin that readily absorbs toxins from their environment. Studies have already shown that areas that suffer from significant amphibian loss have also lost birds, reptiles, mammals and fish. Climate change, emerging diseases (chytridiomycosis) and increased exposure to UV-B radiation (due to ozone depletion) are some of the factors identified for global decline in amphibian population. Currently there are 7000 (amphibiaweb.org, 2012) amphibians occurring in all continents except Antarctica. About one third (41%) of all amphibian species are considered globally threatened.

Anurans are ecologically diverse and they inhabit aquatic, arboreal and terrestrial niches. Aquatic habitat is recognized by the breeding adults and the adult female lays eggs so that after hatching the emerging tadpole is assured of food and clean environment for completion of their life cycle. Early life history stages cannot complete their life cycle in polluted habitats and thus contribute to decline

of the species. The study gives an insight to the problem of deterioration of habitat in the areas surveyed.

The present work is based on exploratory surveys carried out by our team since 1997 in four states (Assam, Arunachal Pradesh, Nagaland and Manipur) of Eastern Himalayan biodiversity hot spot. Aim of the survey was to identify amphibian habitats and document distributional record of amphibian species from fresh surveys. 54 species (Chanda, 1994) of amphibians were reported from North Eastern India. Along with documentation, physic-chemical analysis of water of breeding habitat and ecobiological study of species of conservational importance was taken up.

So far fresh recording has been done for 55 species from Arunachal Pradesh, 40 species from Nagaland, 25 species from Manipur and 30 species from Assam. Detailed eco biological study of 12 species of conservational importance has been completed. Study by our team in the last decade gave us an opportunity to ascertain the present distributional status of a number of rare species, publication of a new species and recording new genera from India.

ICCCH 67

Altitudinal Shiftness of Butterflies Due To Increase of Air Temperature – A Case Study in West Kumang District of Arunachal Pradesh

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In high altitude, insect are evolved to reduce their body size their conspecific in plain. Specialized ecosystem in high altitude induce insect to reduce body size for their adaptive advantage. There are many respect reports about vertical and horizontal migration of insect from lower to higher altitudes due to impact of global warming. However, to document such phenomenon, past records of insect species in high altitudes are necessary for comparison. In this paper, we have developed a hypothesis to examine vertical migration of butterflies towards high altitude where no past records of documentation exist.

We surveyed butterfly species in three water-shed i.e. Pinjali Watershed (200m - 1400m), Tenga Watershed (1360m - 2100m) and Shergaon Watershed (1995m - 2677m) of different altitudes of West Kameng district in Arunachal Pradesh. We measured the wing span of each of the butterfly species in all the watersheds of different altitude and found that along with the altitudinal gradient wing span of 11 number of butterfly species vary, i.e., the wing span of butterflies located in high altitude watershed is less than their conspecific in middle and lower altitudes, which indicate that the species are evolved locally in respective altitude. However, we encountered 4 species of butterflies in high altitudes in which wing span is likely to similar their conspecific in plains. These may indicate the recent migration of butterflies from plain to high altitude i.e., cooler region to escape the rising of temperature of plain. To examine our hypothesis, we further analyzed the fluctuation of temperature of plain for last few decade and found that the temperature increase significantly from past to present. The raise of temperature in plain i.e., Assam, leads butterflies to migrate to high altitude i.e., Shergaon (1995m - 2377m), comparatively cooler area to escape the extreme heat. This study is useful to examine the impact of global warming

on vertical and horizontal shifting of species in an area where there are no any pass records of species documentation exist.

ICCCH 68

Evolving climate resilient livelihoods through integration of climate change adaptation and disaster risk mitigation

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The Hindu Kush-Himalayan (HKH) region is one of the most ecologically sensitive and tectonically fragile areas in the world with over 200 million people live in the mountains, valleys, and hills of the HKH region and over 1 billion people live in the basins downstream. An estimated 3 billion people benefit from the water and other goods and services that originate in these mountains (Singh *et. al*., 2011). The HKH mountain ranges are the regional storehouse of fresh water, and are an integral part of the regional monsoon system which is a lifeline to agriculture, the primary source of livelihood and sustenance to many in the region. The impacts of growing climatic variability and change in the region are becoming increasingly evident. The physiographic and climatic characteristics of the region make it prone to a high incidence of both geological and hydro-meteorological hazards (SAARC 2008). The predicted consequences of climate change and its impacts, frequency and intensity of natural hazards and disasters due to extreme weather events are likely to make the region even more vulnerable. On the other hand, CSDRM is an integrated social development and disaster risk management approach that aims simultaneously to tackle changing disaster risks, enhance adaptive capacity, address poverty, exposure, vulnerability and their structural causes and promote environmentally sustainable development in a changing climate (Mitchel *et al* 2010). Keeping these conditions central, this paper will use the Climate Smart Disaster Risk Management (CSDRM) Approach to better integrate disaster risk reduction and climate change adaptation into development efforts. This is envisaged to enhance the ability of policy makers and civil-society organisations in developing countries to build resilience of communities to disasters and climate change as part of their development work. CSDRM incorporates climate change resilience into the planning and response to natural disasters impacting vulnerable communities in developing countries. The authors will identify vulnerabilities of downstream populations and propose "climate smart" livelihood based adaptations options derived through integration of climate change adaptation and disaster risk reduction that enables the most vulnerable communities in this fragile region to effectively cope with the impacts of climate change.

ICCCH 69

Impacts of Climate Change on Groundwater Resource Management And National Policy

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Climate is highly complex dynamic system dealing with atmosphere, hydrosphere, cryosphere, land surface (lithosphere), and biosphere, but more importantly with interactions among them. Climate evolves due to its own internal dynamics but also because of external forcings of changes in atmospheric gas components (long term climate change) and of land use (short term global change). Climate system transmits heat over Earth`s surface, both in horizontal and vertical directions, to maintain heat balance.

Climate system is now alarmingly stressed, much above the natural carrying capacity of earth processes, due to anthropogenic causes such as global warming due to ever-increasing energy consumption (fossil fuel use, luxurious and wasteful lifestyles), rapid degradation of ecology/environment due to deforestation (increased food productions and urban settlements), and the present unsustainable management practices regarding utlization of water resources (including groundwater resources).

Optimal control of water cycle would lead to optimal management of critically depleted groundwater resources (and also of surface water) in arid and semi-arid regions of India, which is essential for sustainable social and economic developments with continued habitable and healthy ecology and environment. Therefore, an accurate and precise scientific climate model using time series and simulation methods is urgently needed which can forecast long term(50-100 years) and short term (5 – 20 years) climatic parameters (atmospheric temperatures, concentrations of greenhouse gases, daily and monthly rainfalls, extreme climatic events, impacts on ecosystems and groundwater, etc.) under different future forcings. Therefore, control of future climate change would be feasible with reductions of adverse impacts on groundwater systems (and other ecosystems).

A National Policy (in congruence with accepted global policy) on groundwater management should be developed using expertise of scientists, technologists, society leaders, administrators, policy makers etc., which must be implemented immediately. Suggestions regarding National Water and Groundwater Policy are as follows:

(i) Groundwater must not be used for irrigation and industrial purposes but reserved for drinking and domestic use only. Micro-dams on as many tributaries should be built to augment irrigation waters and groundwater resources.
(ii) Optimal mix of surface water and groundwater utilization must be drawn for each watershed of the entire country to avoid shortages of water for drinking, irrigation and industry, etc.
(iii) Severe penalties are to be enforced on polluters and those violating laws for water- use.
(iv) Afforestation, artificial recharge of groundwater, rain water harvesting etc. should beimplemented immediately to avoid predicted aridity and desertification of 80% land area.

ICCCH 70

Himalayan Biodiversity Conservation: a Challenge in Climate Change Scenario

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The Himalayan ecosystems are influenced by the climate. Ecosystem services provided by the

Hindukush region make this landscape most influential ecosystem in the world. The livelihood of about three billion people of the world is influenced by this unique landscape. The Himalayas also is one of the biodiversity hotspots in the country acting as a store house of innumerable economic, medicinal as well as repository of the wild genotype of numerous food crops. It is of utmost importance that the region is properly conserved for the sustenance of the region. Non-availability of adequate and authentic spatially linked database on plant population structure, population dynamics, and abiotic driving and driven variables and other limiting factors make it difficult for characterization, monitoring and required conservation measures for the species. With the current technological capability, it is very certain that the present species extinction rate will overtake the biodiversity inventorization and characterization. As a response to the dearth of scientific spatial information of the distribution of the biological rich regions, National Biodiversity Characterization at Landscape Level, a project jointly sponsored by Department of Biotechnology and Department of Space, has being implemented to identify and map the potential biodiversity rich regions in the Himalayas. The database thus provides baseline information on the status of the natural areas with respect to the fragmentation, disturbance and the biological richness in the Himalayas region of India. This database will provide inputs to various studies on impact of climate change on the various habitats and species in the region.

ICCCH 71

Biodiversity Conservation in the Alpine Areas of Hindu Kush Himalaya under Changing Climate: Need for Participatory Action Research

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A significant proportion of the Hindu Kush Himalaya (HKH) lies in the alpine zone that is characterized by unique bioclimatic conditions, treeless vegetation, and specialized floral and faunal communities adapted to extremely harsh and highly seasonal environments. The alpine habitats include species rich herbaceous meadows of Greater Himalaya, relatively pauper cold arid pastures of Trans-Himalaya, high altitude marsh meadows, peatlands and pioneer habitats in sub-nival and morainic environments. Long term studies on the effects of global warming on the alpine vegetation in European alps have indicated that many species have moved towards higher slopes affecting the species diversity at the summits. However, in the absence of long term climatic data and corresponding information on species abundance, many predictions on the species response to climate change in the Himalayan region are speculative and at the stage of untested hypotheses. Questions related to ecosystem and species response to changing (and fluctuating climate) can be addressed using experimental studies as well as empirical evidences. In order to answer several landscape level questions in the alpine region of HKH, there is a need to initiate participatory action research involving young field biologists, parataxonomists, volunteers and community based organizations. This would require a coordinated effort within identified transboundary landscapes. This presentation deals with broad patterns of alpine biodiversity in the HKH region, scientific data gaps and ways to bridge such gaps at different spatio-temporal scales in the light of reduction in cryosphere, changes in upstream hydrology, primary productivity and land use practices.

ICCCH 72

IMPACT OF CLIMATE CHANGE ON HETEROTROPHIC BACTERIAL COMMUNITIES IN THE WATER AND SEDIMENT OF KONGSFJORD IN NORWEGIAN ARCTIC

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Microbes are key to the maintenance of life on earth as they are major pillars of the biosphere. While autotrophic microbes such as cyanobacteria are important in primary production in the oceans, heterotrophic microbes also play an equally unique role via biogeochemical cycles, conversion of dissolved organic matter (DOM) to particulate organic matter (POM) and microbial loop. In the present study, diversity of heterotrophic bacterial communities in the water and sediment of Kongsfjord in Norwegian Arctic and their role in the release of sediment bound phosphorus has been analysed. Retreivable bacterial counts from water samples on full strength Zobell Marine Agar media ranged from 1.2 to 1.7 x 10^3 cfu/ml while that from sediment ranged from 1.4 x 10^5 to 8.4 x 10^6 cfu/g. A total of 298 bacterial strains were characterised from the samples and based on the biochemical tests and protein profiling, categorised into 33 groups. Representative bacterial isolates were selected from each group and nearest phylogenetic neighbor of these strains were identified following 16S rRNA gene sequencing and grouped in to 15 genera under 3 phyla viz. Actinobacteria, Firmicutes and Gammaproteobacteria. Gammaproteobacteria were dominant in the water samples while Firmicutes were abundant in sediments. Results revealed consistent recovery of *Stenotrophomonas maltophila*, a mesophilic organism of emerging clinical significance, from the water and sediment samples. Three sp. of *Pseudomonas* (*P. fragi, P. koreensis* and *P. sabulinigri*) and two species of *Bacillus* (*B. thuringiensis* and *B. flexus)* identified from Kongsfjord were not reported earlier. Consistent isolation of mesophilic bacteria from this high arctic fjord may be an indication of increased melting of arctic ice cover and resultant warm water incursion from the tropics. Speciation of phosphorus has been carried to determine the various forms of phosphorus available in the sediment and the microbial phsophatase activity such as alkaline, neutral and acid phosphatase has been studied. Retreating ice cover, warm water incursion, stratospheric ozone depletion over the arctic and enhanced UV input in this region can considerably impact bacterial communities. Perturbation in the metabolic activities could lead to serious impact on primary productivity in the Arctic Ocean.

ICCCH 73

Non-food oilseed plant as an alternative resource for biofuel production

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Jatropha curcas, a multipurpose shrub, is originated in Central America, is now present

worldwide throughout tropical and subtropical regions. In India, J. curcas had recently promoted interest as one of potential source to reduce dependence on crude oil. However, knowledge concerning genotype, phenotype and environmental interaction are limited. In the present study the magnitude of phenotype growth, oil yield and quality of promising jatropha sources from India growing belt has been evaluated at Jorhat in Assam. After 36 months of field planting, significant differences were noticed among all accession tested in agronomical and physiological parameters. All those data let to reduce the number of jatropha accessions to continue the evaluation of genotypes suitable for local climate and environment. The yield and oil quality of accessions selected on the phenotype and agronomic performance have been evaluated. Free fatty acids (FFAs), triglyceride acid composition as well as the presence of phorbol esters and tocopherols are basic components indicating the oil quality. The oil yield varied between 22-35% of seed weight and, in general, the heaviest seeds have higher oil content. Oils are also characterized by different color, from light yellow to dark orange, probably reflecting different oxidative process or presence of different pigments. Indeed hexane extracted oil fraction shows a wide range, from 2 to 38%, of FFAs content and a low content of tocopherols. As expected also the phorbols are present in all oil samples in the range reported for jatropha. In triglyceride the polyunsaturated fraction is relatively modest and in general the FAs composition doesn't show wide changes between the jatropha accessions tested. The triglyceride composition doesn't seem to be the main factor that influence the oil value. Free FAs and phorbols seem to be more important factors for selection of better accessions. Furthermore a first integration of biochemical with physiological and agronomical data shows that, under Jorhat environment, the accessions expressing the best performance in the field are also the best in oil yield and quality.

ICCCH 74

Tilting of the vegetation in the ablation zone may be potential indicators of climatic and glacial deviation: A case study

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We observed one of the most sensitive glacier of the Himalaya i.e. Tipra glacier which evidenced by rapid disturbances on mass, volume area and length further amplify longitudinal and transverse crevasses along with development of supra glacial lakes, ice cave and fluctuation of snout. More recently, it has been documented that whenever glacial mass, volume, area and length reduced sub-alpine (timberline) plants shifted towards permanent snowline. Some specialized plant species resides over glacial surface particularly high energetic and extreme cold resistant. The diversity and distribution of the plants vary and tilting behaviors observed around shrinkage areas due to intersect summit. Field data shown that due to the movement and melting of ice core within supra glacial material vegetational tilting (bend) activities over the surface. Habit and habitat inclined right and left angle from an erect appearances and finally obtain subsided.

ICCCH 75

EPIPHYTIC LICHENS AS INDICATOR OF CLIMATE CHANGE IN FOOTHILL OF KUMAUN HIMALAYA, UTTARAKHAND

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Lichens, the mutual composites of fungi (mycobiont) and green (phycobiont) or blue green (cyanobiont) algae. Lichens have certain ecological and physiological requirements that make them very sensitive to atmospheric changes and are thus excellent indicators of climate change. Many lichen species are heavily dependent on climate, often influenced by minor fluctuations. Climate change has a profound influence on the distributions of these sensitive organisms. A recent study in the foothill of Kumaun region was surveyed all districts comes on this region. The Udham Singh Nagar district and some part of the Nainital and Champawat districts falls under the foothills. The diversity of epiphytic lichens in subtropical shows occurrence of 30 species of lichens belonging to 17 genera and 13 families. The study area exhibits luxuriant growth of crustose lichens together with toxitolerant members of the lichen family Physciaceae which indicates the high anthropogenic activities in the area. The *Pyxine* and *Dirinaria* were found growing luxuriantly over different trees even in the close vicinity of the industries. In the subtropical area no records of saxicolous, terricolous, fruticose and dimorphic lichens are available from the region, because of these lichens grows on non pollution area like temperate and alpine zones. In the foothill area, due to the fast pace of urbanization most of the localities of the district are highly disturbed with anthropogenic activities including destruction of forests, agriculture, and industrialization. The heavy outflow of the debris and smoke released from industries create the atmosphere unsuitable for the lichens to grow. The present study provides baseline information which can be utilized for biomonitoring and other environmental studies in the area in future.

ICCCH 76

Diversity of Cold shock proteins in Psychrophiles from Leh: Himalayan Treasure

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Three quarters of the Earth is covered by sea and >90% of its surface experiences yearly temperatures <15°C asking for a remarkable adaptation of life to cold conditions. Temperature is a major environmental condition that affects microbial physiology and growth. Psychrophilic and psychrotrophic microorganisms are of particular importance in global ecology. Earth's permafrost is characterized by low carbon availability, low water availability and continuous exposure to gamma radiation (0.03rad/year) originating from the soil minerals.

The Himalayan and Sub Himalayan regions are yet to be explored for microbial diversity to discover the phylogenetic and ecological relationships. Leh (34°08′43.43″N

77°34′03.41″E) is situated in the northern part of India in state of Jammu and Kashmir and is known as cold deserts because of its very low temperature and very low vegetation. The present study is focused on microbial diversity mapping of Leh from the sampling sites: Khardong La, Chang La, Pangong Tso, Janskaar Sangam, Sindhu Valley, Nubra, and Hunder. A total of 7 samples were collected from psychrophilic conditions. Isolation of bacterium results in to 95 different isolates psychrophilic nature having temperature tolerance from 28^0C to 2^0C which were identified as different species of Bacillus, Exiguobacterium, Sphingomonas, Stenotrophomonas, Pseudomonas, Acinetobacter, Microbacterium and Micrococcus. 16SrRNA, *gyrB, rpoB, recA* and *dnaK* genes were used for setup the phylogenetic relationship. *Csp* genes were screened with known as well as designed degenerate primers for novel alleles, which shown a great outcome of few unknown *csp* alleles. These species have similarity to species those are present in Arctic and Antarctic Glaciers. The places are very special for microbial diversity having wealth of pathways and molecules.

ICCCH 77

Pattern of Rainfall distribution in Jammu and Kashmir

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The amount and intensity of rainfall received in an area determines the fresh water availability condition. A low to moderate intensity rainfall well distributed over space and time leads to good water availability conditions. However, India being under the influence of monsoon regime experiences high spatial and temporal variation in rainfall both in amount and intensity of rainfall. These variations in rainfall primarily affect the fresh water availability conditions in the rivers and water bodies. This has profound influence on the agriculture productivity and in turn the economy of the country. The Himalaya controls the climate of the sub-continent, specifically the distribution of moisture and in turn the hydrologic regime of the rivers that are originating there. The orography controls the amount and type of precipitation received by the Himalaya. There is a need to have better understanding of the rainfall distribution and its trend in the Himalayan region for management of water resources and to ensure better agriculture production so as to acheive food security for the country. The present study analyses the distribution pattern and trend of precipitation in Jammu and Kashmir.

The analysis has been carried out for Jammu (1951-2004), Srinagar (1951-2004) and Banihal (1961-2004), stations using various statistical methods. Mean, standard deviation and coefficient of variation were found for the 30 year periods since 1951 with decadal moving window (that is 1951-80, 1961-90, etc). Non-parametric Man-Kandell test was carried to analyse the trend in rainfall distribution in these stations. This method calculates the relative magnitude of the trend rather than the absolute values. The analysis of annual precipitation indicates absence of any specific trend during the study period. The annual precipitation showed moderate variation ranging from 24 per cent at Srinagar to about 30 per cent in other two stations. The annual precipitation variation is more prominent in recent years. The monthly and seasonal amount of precipitation showed high fluctuations. Some of the months during southwest monsoon showed an increasing trend while October, during retreating monsoon season, showed a declining trend. The increasing trend in rainfall, even though less in magnitude, is relatively high during latter part of the monsoon season in comparison with earlier monsoon months.

ICCCH 78

Palimpsest of Local Ecological Knowledge in Adaptation to

Climate Change

Andrea Déri

The international scientific community has been showing growing interest in local inhabitants' knowledge in adaptation to climate change over the last decade. Comparative studies of local and scientific assessments of trends of climate variables demonstrate consistent convergence. While there is increasing evidence of the importance of considering local inhabitants' knowledge in adaptation to climate change, there is relatively less effort dedicated to how to do it, what theories and analytical frameworks can be applied to account for possible mechanisms of integration. This paper explores some of the issues related to the process of how local and scientific inquiries can connect for better understanding of climate change. Inspired by the 'landscape as palimpsest' approach in cultural landscape studies, this paper introduces the 'local ecological knowledge as palimpsest' metaphor and examines its relevance in knowledge creation and adaptive response. Based on studies in the Arctic, the Alps and the Himalayas, it is suggested that the metaphor of 'knowledge palimpsest' can provide useful insight into the process of local knowledge creation and inform the design of databases intended to facilitate climate change adaptation.

ICCCH 79

God give me the courage to change the things I can (pollution and technology),accept the things I cannot change(climate change) ,serenity and wisdom to know the difference

Arya's C cycles
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Present paper is based on discovery of paleoclimatic signatures made by Indus glacier/river on the granites of Ladakh batholiths on the banks of river Indus since 11714 years by the author while exploring, drilling and developing groundwater on the borders of China(Changthang) and Pakistan(Siachen,Kargil)in NW Himalaya for the last 12 years.

These signatures resembles alphabet C, hence named Aryas C cycles. Cyclicity of cooling, warming and again cooling can be very well understood by writing alphabet C. The starting point of alphabet C represents the cooling phase (ICE age) and as we continue to draw the curve there is gradual curvilinear transformation from cooling to warming phase. Half of the C curve represents the warming maxima (an event marked by flooding, cyclones, sea level rise) and completion of alphabet C represents the culmination of the gradual curvilinear transformation from warming to cooling coinciding with ICE age. Transferring this sentence geologically means that since there is less water in the system during ICE age so there is less erosion hence we get starting and end of C curve but as the temperature increases the rate of erosion increases hence the curvilinear depressions are created making the upper half of the warming cycling center of alphabet C is marked by warming maxima. Then there is again gradual transformation from warming to cooling and as the water in the system decreases there is less erosion therefore we get a geomorphological feature which resembles the lower half of alphabet C finally ending into the ICE age. So paleoclimatic signatures in Ladakh Himalaya which resembles alphabet C , for the first time geologically and scientifically explains cooling, warming and again cooling phase in nature to be a natural climate cyclic process.

Granites played important role in the preservation of these climatic signatures because they are very hard and compact as compared to other rocks found in the Himalayas which are fragile and susceptible

to faster rate of weathering and erosion making preservation of the samples a tedious task. Taphonomical analysis of these C curves in massive Granites show great role of lithology and geomorphology in preservation and understanding the cyclicity of these climate signatures which have been beautifully preserved in the Ladakh Batholith in NW Himalaya. Author observed 10 such cycles in the site,8 complete and 2 half cycle. Geomathematical modeling of these paleoclimatic signatures show that after every 4 cycles there is a half cycle. According to this model Each complete cycle is of **1338.**6 years and half cycle is **669.**3 years.

Based on this model author has been trying to correlate the paleo climatic and geological events in the past and found that lot of events can be explained by Aryas C cycles. Important question now is which part of the C cycle are we now. Seeing the paleoclimatic signature in the Batholiths of Ladakh we are presently in the warming maxima times and are curvilinearly moving into the cooling phase finally culminating into ICE age in 2341 years, represented by the lower part of alphabet C. So enjoy global warming by building sustainable habitats in geologically favorable locations because the next warming maxima will be in 3014.

ICCCH 80

Probabilistic Assessment of Earthquake Recurrence in Northeast India: An Appraisal from Inverse Gaussian Distribution

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In this article, we provide an elaborate discussion on several physical properties of inverse Gaussian distribution and subsequently examine the suitability of this model in earthquake recurrence interval estimation. We consider a real, homogeneous, and complete earthquake catalog of 20 major events $(M \geq 7.0)$ from north-east India and its surrounding region (20^0-32^0 N and 87^0-100^0 E). The sample mean interval of occurrence, as calculated from this catalog, is 7.82 years. However, this region has not experienced any large magnitude earthquakes in last 17 years (during 1996-2012). This fact encourages scientists to re-appraise the recurrence interval modeling for this region.

We have used maximum likelihood estimation (MLE) and method of moment (MoM) techniques to estimate the model parameters. In addition, a number of statistical goodness-of-fitting tests are performed to validate these results. We observe that the estimated cumulative probability of earthquake occurrence by 2013 is very high (> 0.90) in the study area. Finally, a number of conditional probability curves (hazard curves) are drawn to vet the seismic vulnerability of the study area.

ICCCH 81

Phenotypic Plasticity leading to Sympatric speciation in populations of Ephedra in Lahaul and Spiti (India)

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Phenotypic plasticity is supposed to play a significant role in speciation. The structural and developmental bases of evolution of *Ephedra*, phenotypic plasticity for transitions in vegetative and sexual systems and adaptive strategies leading to Speciation are not investigated. Present work highlights the contribution of phenotypic plasticity to the phenotypic variation and cause of speciation in *Ephedra* populations. Phenotypic plasticity of qualitative and quantitative traits (morphology of stem, scale leaf, male and female strobilus) have been investigated in ten populations of the *Ephedra* (Ephedraceae), in the Lahaul and Spiti region (altitude up to 3800 m). We used a combination of field and laboratory measurements including Principal Coordinates Analysis (PCoA) for ordination. All data analysis was carried out in the software Past, version 1.98. An altitudinal morphocline (Spearman's rank order correlation $r_s = 0.95$, $p < 0.001$) and phenotypic plasticity is evident. The samples from each locality form tight, clearly separated groups in this morphospace. Distinct Conservative and stable, reproductive characters also brought out three new species (*E. sumlingensis* sp. nov., *E. kardangensis* sp. nov. and *E. khurikensis* sp. nov.). First report of Phenotypic plasticity as a major evolutionary force in populations of *Ephedra* via habitat adaptation through the variability of various morphological characters causing sympatric speciation is revealed. Efficient conservation of the populations can only be based on habitat management, to favour the maintenance of microenvironmental variation and the resulting strong phenotypic plasticity.

ICCCH 82

Climatic Change and Increasing Geo-hydrological Hazards

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The great mountain range of Himalaya, where twelve states of the country are located, has been wreaked by variety of disasters. The weather related hazards including cloudburst, phenomena of sudden copious rainfall, has proved to be one of the major disasters which rock the Himalaya now and then. The severity of this localized hydrological/climatic disaster can be understood by the consequences of it's by products like flood and landslides. The multi-hazard dimension of cloudburst is particularly disastrous when it is experienced in areas near population settlements like villages, towns and cities. The associated infrastructure like highways and roads which are one of the important communication routes in the Himalaya and cater to the need of emergency post disaster management including evacuation, emergency food and medical supply etc are generally found severely affected. As a result the toll of death as well as property damage increases by multiple folds. The weather related hazards like cloudburst, which were rarely reported, have increased in their frequency, spread as well as magnitude over the years, possibly because of the global climatic change. However, the multifold increase in death as well as the property damage should not be seen in isolation. The unmindful exploitation of natural resources for the development purposes should also be viewed very

seriously. Because of nonsystematic development with least consideration of natural environmental setup makes these phenomena to act against the humans and their infrastructures more belligerently.

ICCCH 83

Landslides and its impact on society – A case study of Narayanbagar Landslide

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Landslide is one of the most frequent Natural Disasters in the Himalayan terrain of India. These landslides are mainly responsible for creating frequent disturbance to the traffic on hill roads and consequent increase of Socio-economic problems. Landslides results in loss of life, property and disruption to traffic, which requires efforts for relief measures, restoration works and also necessitates alternate routes for traffic. This may give rise to scarcity conditions in the area, increase in cost of essential commodities and delay in movement of people and goods bringing in hard-ship to the people. The incidence of landslides and its destructive efforts can be controlled to a great extent by preventive and protective works at the time of initiation of the landslide. It is better to build a culture of living in landslide prone areas whilst reducing economically oriented pressure on these lands. Population could be made more aware of the limitations and potentialities of their environment could live more in harmony with the vicissitude. While the adverse natural conditions that trigger off slides so complex, total success in correction or prevention of slides cannot be dependent upon. Hence while examining cases of slides both technical and human problems should be borne in mind in providing relief and protection measures. An attempt has been made in this paper to study the effect of Narayanbagar landslide on road communication and its social and economical impacts on Inhabitants living in the surrounding region.

ICCCH 84

A Statistical Analysis to Study the Effect of Solar Activity on Gangotri Glacier

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Changes in glacial activity over a long period of time, is an indicator of changes in the regional climate. Climate change is not solely because of anthropogenic factors or natural factors, but is a combination of both. One of the factor involved is variations in solar activity and the present study attempts to analyze its effect on glacier variation. In this paper, different data of Sunspot Numbers, Cosmic Ray Intensity and rate of retreat of Gangotri glacier were compiled and analyzed. Different statistical correlations were developed between these parameters. It is observed that there exists a negative correlation between Sunspot Numbers and Cosmic Ray Intensity and in turn between Cosmic Ray Intensity and Gangotri glacier retreat. However, when the case of a direct impact of Sunspot Number and Gangotri glacier retreat is taken the coefficient of correlation was found to be fairly low. The study provides sufficient evidence to suggest that a deeper investigation on the effect of cosmic rays on clouds offers a real possibility of generation of new fundamental knowledge on the Sun-Climate problem.

ICCCH 85

Landslides and cloudburst in Indian Himalayan Region (IHR) during June 2013- Historical perspectives and remedial measures

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Abstract

Increasing trends of cloudburst and landslides in Indian Himalaya is a subject of serious concern. These hazards cause serious socio-economical problems in the Indian Himalayan states. These states, which are bordering with neighboring

countries, are also under serious threat for strategic point of view. The road network and other infrastructure may damage badly due to the natural calamities such as cloudburst, debris flow, flash flood and landslides etc. Recently in June 2013, Uttarakhand, and its neighbour state Himachal Pradesh is rocked by a chain of landslides occurred due to cloudburst, excessive rains, and followed by the flash flood in different parts of the Garhwal and adjoining areas of Himachal Pradesh. Thousands of lives and enormous property were lost and infrastructure is collapsed in this series of natural disaster. Rescue operation and supply of food could be possible through by helicopter. Collapse infrastructure was one of the main reasons for such a large number of deaths. Changed pattern of rainfall due to climate change, human encroachment, over and unsystematic exploitation of natural resources, lack of knowledge-where and how to built safe shelters are the main reasons for such a massive loss of life, property and infrastructure in the natural calamities of Uttrakhand. Present study is an attempt to discuss the increasing trends of cloudburst and landslide, causes and measures for better preparedness to minimise the losses in future.