A report on brain-storming session on climate change, organized by NASI-Jammu Chapter in collaboration with the Indian Institute of Integrative Medicine (IIIM), Jammu on May 19-20, 2015

Background

In the recent past, India has witnessed an abnormal amount of disastrous untimely rainfalls in Uttarakhand in 2013, which resulted in the death of more than 10,000 people. More recently, Jammu and Kashmir also witnessed the harbinger of the climate change with two floods, devastating several regions of the state within a year, leading to loss of life and livelihood as well as causing immense economic burden on the exchequer. Consequences include unpredictable, harsh and unplanned alterations in environment and climate across India. In a recent report of the United Nations Intergovernmental Panel on climate change, it is clearly mentioned that Himalayan region will witness an increase of 5-10 rainy days by the 2030s and the intensity of the rainfall is also expected to rise. We have also witnessed a series of earthquakes in the Himalayan range in the recent past with damaging effects in Nepal as well as some parts of our country.

In the light of the above grim realities, the Academy (NASI) took an initiative for promoting awareness on Climate Change and its effects. The Immediate Past President of NASI, Dr. K. Kasturirangan, former Chairman, Space Commission, Govt. of India, endorsed the idea of a brain storming session on Climate Change, last year, which must be urgently organised so as to assess the ground realities in Indian context; and to prepare strategic policies on mitigation. The brain storming session was planned to provide (a) guidelines for spreading awareness and (b) to prepare a strategic vision document. NASI also aims to produce information packets in the form of CDs, pamphlets, documentaries, articles, lectures, workshops, TV programs and conference proceedings for general dissemination of information to the public. These efforts will greatly aid in increasing public awareness on Climate Change across India, and especially so in Jammu and Kashmir. At its core, the NASI session covered the following topics in regards to Climate Change: 1) Impact on public health and infectious disease burden 2) Impact on agriculture and animal health 3) Impact on regions that will be affected severely 4) Situation arising out of melting glaciers and flooding of rivers 5)

Atmospheric sciences/greenhouse gases/emissions. **Prof Pramod Tandon**, former Vice-Chancellor, North-Eastern Hill University (NEHU), Shillong and **Dr Amit P. Sharma**, Scientist, International Centre for Genetic Engineering & Biotechnology, New Delhi were requested to be the conveners of the session; and **Prof R. N. Gohil**, Secretary, NASI-Jammu Chapter & formerly at Jammu University, Jammu coordinated the event. Dr. Ram Vishwakarma, Director, IIIM, Jammu hosted the session.

The brainstorming session on Climate Change was thus held at CSIR-IIIM, Jammu from 19th- 20th May 2015, under the aegis of NASI-Jammu Chapter.

Inaugural Session

Dr. Ram Vishwakarma welcomed the chief guest Hon'ble Union Minister Dr. Jitendra Singh, dignitaries from NASI, speakers of the brainstorming session, eminent citizens of Jammu and Kashmir,other distinguished scientists and students of local academic institutions.Hon'ble Minister Dr. Jitendra Singh, Minister of State in PMO & other Ministries, GOI on 19th May 2015, inaugurated the event. Dr. Jitendra Singhemphasized on having a holistic approach, more public awareness and increase of stakeholders among common people for the prevention of further environmental erosion and catastrophes, as well as to involve common public in mitigation process. Dr. Amit P. Sharma spoke on the genesis of the idea of holding the session; and also expressed his concern about the alarming situation of environmental stress and strain, which is gradually leading to chaos. Prof Akhilesh K. Tyagi, President, NASI, briefly emphasized the role of NASI in such societal issues; and said that in developing countries like India, climate change could cause an additional stress on ecological and socioeconomic systems, that are already facing tremendous pressures due to rapid unplanned urbanization, industrialization and economic development. The Academy

has, therefore, decided to discuss the major issues related to climate change; and Prof Tandon and Dr. Amit Sharma have well tried to include all the major areas of concern with the help and kind support of Dr. Ram Vishwakarma and Prof R.N, Gohil.

Prof. Gohil presented a vote-of-thanks in the end of the inaugural function.

Technical Session -I Climate change and national/international perspective

Dr. Jyoti Parikh (Executive Director, (IRAD) Integrated Research and Action for Development, New Delhi) made a presentation on strengthening climate resilience of Indian cities. IRAD is a think tank, which aims at connecting various stakeholders such as government, nongovernmental organizations, corporations, academia and financial institutions. Dr. Parikh emphasized that during the span of past 30 years, i.e. from 1980 to 2010, there have been 431 disasters involving the death of approximately 143,039 people. More than 49 million people are affected each year due to such disasters. The adaptation and mitigation initiatives taken up by state authorities involve early warning, coordinated search and rescue, emergency relief, recovery and rehabilitation. Long-term risk reduction measures involve, minimizing the effects of disasters through vulnerability analysis and public education, and better preparedness through emergency drills. This comes under the HIGS framework, where H stands for Hazard exposure; I stand for Infrastructure, G for governance and S for socio-economic variables. Ten cities namely Hyderabad, Pune, Bhopal, Vishakapatnam, Ahmedabad, Bhubaneshwar, Shillong, Guwahati, Dehradun and Srinagar were studied and it was found that all the cities were exposed to multiple hazards such as earthquakes, urban floods, cyclones, water scarcity, thunderstorm, landslides and cold waves. These cities have a population of more than one million and 20% of the population is slum dwelling. A vulnerability and resilience matrix was plotted for these cities qualifying them for various parameters in the range of highly vulnerable, medium vulnerable or low vulnerable. Fully functioning and sustainable cities with adequate urban infrastructure with good management and governance are desirable. The institutional framework should be resilient; it should be able to function at the time of disasters, having ability to oversee the rescue and rehabilitation efforts. Disaster prone areas should be mapped for the cities. Dr. Parikh also presented a case study of Srinagar. The city constitutes for 2/3'd of the urban population of the state. The development is mostly unplanned and haphazard with acute problems in drainage and irregular narrow lanes. The north-west area of the city is particularly vulnerable to floods. Critical infrastructure such as hospitals,

school, control room and power station lie in the flood prone zones. Natural drainage has been blocked due to irregular construction and expansion of the city. The city has in the past seen 13 instances of major floods between the year 1900 to 1950, while 16 such instances have been recorded between 1951 and 2000. In 1928 flood the water carried a discharge of 2265 m^3/s while it has been continuously increasing, in 2014 flood, the estimated discharge was about 70,000 m^3/s. **Apart from the need for disaster resilient planning, proper implementation of the policies are also important to make the city safe. Further, the disaster database should be periodically updated.**

Dr. Ram Boojh, Programme Specialist, Ecological and Earth Sciences, UNESCO Cluster Office for South Asia, New Delhi, delivered the second lecture on the UNESCO perspective on climate change. Dr. Boojh expressed that the climate change has been one of the most pressing challenges on the international agenda these days and United Nations System along with UNESCO is playing a vital role to promote green development. Road to Paris is one of the most important events being held on "the 21st Session of the Conference of the Parties (COP21/CMP11) to the United Nations Framework convention on Climate Change" from November 30 - December 11, 2015 and about 40,000 participants are expected to attend the event. During the event, a new international agreement on the climate is planned, which would be applicable to all countries with the aim to keep the global warming below 2°C. According to NOAA reportpublished on 7 May 2015, monthly global average CO_2 concentrations surpassed 400 ppm in March 2015 for the first time. According to the IPCC, approx. 80% of known fossil fuel reserves would need to stay in the ground for atmospheric CO_2 concentrations to remain below 450 ppm, which would lead to a 50% chance of limiting temperature to below 2ºC. Global climate change is certainly the most significant environmental challenge of our time having dynamic complexities ensuing severe impacts on economic and social development as well as the environment. The complexities of climate change are related to the uncertainty of range, intensity, regional patterns, and timescale of ensuing effects. The 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report has indicated that the global average temperature rise since 1750 is mainly due to anthropogenic activities. These facts were further supported by the indication of increased Carbon Dioxide (CO_2) concentration by 35% (primarily from fossil fuel burning and deforestation), Methane concentration by 148% (predominantly due to fossil fuel combustion and agricultural activities) and Nitrous Oxide (NO_2) concentration by 18% (from fertilizers and other agriculture activities). He also said that these drastic changes in atmospheric greenhouse gas concentrations if left

unchecked may result in a 65 cm increase in average sea levels and global average temperature rise by 1.4°C-5.8°C by next century. His presentation clearly mentioned that the magnitude and severity of possible impacts of these indicators are calamitous to global economy, social development, environmental conservation, and human survival itself. In this directions India has taken initiatives and Signed UNFCC on 10th June 1992, ratified the Kyoto protocol and developed Missions under National Action Plan on climate change, viz., National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a“Green India", National Mission for Sustainable Agriculture, and National Strategic Mission on Climate Change.

Technical Session -II Information & services and carbon sequestration

Dr. Sukumar Devotta (former Director, NEERI, Nagpur) spoke on carbon capture sequestration as an option for climate change mitigation. Dr. Devotta mentioned that the key message in 2014 report of IPCC mentions that energy production remains the primary driver for green house gas emissions. Implementation reductions in greenhouse gas emissions pose substantial technological, economic, social and institutional challenges. However this needs to be immediately addressed so as to limit the warming to 2°C. Similar to global trend carbon dioxide holds the largest share of green house gas emissions in India. Different strategies for carbon sequestration that fall under carbon capture and storage (CCS) has been suggested, such as afforestation, geological storage, and ocean storage. Carbon capture through CCS scheme involves capture, compression and dehydration. Different methods have been suggested for CCS, such as absorption by solvents, adsorption, chilled ammonia, mineral carbonization, chemical looping, membrane separation and biological methods such as microbial and algal. It would be better if economic value can be added with schemes such as carbon capture and valorization (CCV) which involves being major contributor converting CO_2 to raw material used by industries. Dr. Devotta also mentioned various CCS projects going on around the world and talked about identification of sink sites in India. US and China presently dominate the CCS demonstration. CCS is recognized as critical for CO_2 stabilization and it has to be C -ve and economically viable. Solvent-based carbon capture is the most studied method. India needs to develop more expertise in CCS.

Prof. GM Bhat (University of Jammu) talked about major contributors of climate change, with CO_2 emissions being the major contributor, followed by energy generation, transportation, deforestation and agriculture. He

showed satellite data, which suggested that if preventive measures are not taken, all the major glacierswould melt by the year 2035.

Technical Session -III Climate change and Health

Dr. R.C. Dhiman (National Institute of Malaria Research, New Delhi) made a presentation on effect of climate change on health and disease spread. As per his data, there has been an appreciable increase in temperature, in last 40 years. This has a major impact on vector borne and water borne diseases as well as respiratory diseases. Malaria, Filariasis, Kala-azar, Dengue, Chikungunya and Japanese encephalitis are the major vector borne diseases in India, with Malaria and Dengue presently dominating the scene. An impact assessment of climate change on transmission window based on temperature and relative humidity has been assessed and projections have been made regarding the spread of disease in areas where earlier the disease was less prevalent. In Jammu and Kashmir, the incidence of *Plasmodium vivax* malaria is projected to increase, for instance. The transmission window for dengue is projected to increase by 1-2 months in Chilas, Gilgit, Kathua and Srinagar, while it has been projected to decrease in Pulwama and Udhampur by one month. Such projections are then confirmed through evidence-based assessment of biophysical determinants and a framework for adaptation measures is developed under the climate change scenario. He finally concluded saying that we need better and robust epidemiological data, generation of region specific health education material, situation analysis for present status of vector borne diseases and general strengthening of health system.

Prof. V.P. Sharma, former Addl. Director General, Indian Council of Medical Research, New Delhi, delivered his presentation on Climate change and malaria and explained how global warming would affect transmission of malaria. Prof. Sharma presented that the global warming plays significant role in mosquito life cycle by lengthening the breeding season, shortening immature life cycle and adult emergence, boosting their reproductive rate, make them bite more frequently, and shortening the time of sporogony. Therefore, malaria can expand to higher elevations and more northern latitudes, potentially putting previously unexposed populations at risk. He asserted that climate change over the years would shift malaria transmission window in India. The habitats of the mosquitoes that carry the malaria parasite might shift the boundaries of latitude and altitude for malaria transmission. For example, many highland areas in Burundi, Kenya and Uganda that have historically been malaria-free are now experiencing epidemics. It is also estimated that in Ethiopia, 1°C rise in temperature may result in additional 3-million malaria cases. He said that an increase in temperature has allowed the

introduction of malaria into higher altitude areas in Kenya, Colombia and Ethiopia, where it was previously too cold for the disease to thrive. People living in these areas lack immunity against malaria, and more cases of severe malaria may be encountered; particularly poor and marginalized population would be worst hit. Another factor responsible for malaria transmission is high rainfalls, which initially cause flushing of mosquito breeding but as the water recedes, puddle formation and other stagnant water bodies become the source of mosquito breeding, starting a fresh wave of malaria transmission. Mosquitoes need 60% or more humidity to complete extrinsic cycle, and rains increase the humidity and prolong the life of mosquitoes resulting in increased malaria transmission. Drought may also bring malaria epidemics as reported in Sri Lanka. The receding water in rivers produced enormous *An. culicifacies* breeding, and adjacent villages faced the epidemic. Some other factors such as amount of precipitation and climate change are expected to affect malaria indirectly by changing ecological relationships that are important to the vector, parasite in the malaria transmission. The indirect forces responsible are deforestation, urbanization and habitat changes due to climate change that may affect species, which are able to survive in that changed climate. Poverty has been directly related to malaria as it is rightly said "Malaria is a diseases of poverty and cause of poverty". Globally, malaria map has been shrinking from 1900 to 2013 and it is expected that it will further shrink by 2025; and will be confined to certain countries of S. Asia, S. America and Africa. According to World malaria report 2014, malaria mortality rates have been decreased by an impressive 47% between 2000 and 2013 globally, and by 54% in the WHO African Region. An estimated 4.3 million deaths & 670 million cases were averted between 2001 and 2013. Thus, reductions in malaria deaths have contributed substantially to progress towards achieving the target for MDG 4, which is expected to be reduced, by two thirds, the under-5 mortality rate between 1990 and 2015. He showed that The World Wild Life enlisted 12 germs that can spread into new regions due to climate change, affecting human and wildlife health. These include Avian Influenza, Babesiosis, Cholera, Ebola, Intestinal parasites, Lyme Disease, Red Tide (Algal Bloom), Plague,Rift Valley Fever (RVF), Tuberculosis (TB), Sleeping Sickness and Yellow Fever.

Technical Session IV - Climate Change and Agriculture

Dr. H. Pathak (IARI, New Delhi) spoke about impact, adaptation and mitigation of climate change with reference to agriculture. He said that the green house gas emission has accelerated despite reduction efforts. This has resulted in temperature rise and it is further accelerating. In India, 70% of land is drought prone, 12% is flood prone and 8% is prone to cyclones. Climate change is thought to further aggravate the problems of

water scarcity and excess. The accumulation of green house gases adversely affects soil health, leading to increased soil temperature, more mineralization, greater evapo-transpiration, increase in salination and soil water deficit. Further, changing temperature increases the problems associated with pest management. Irrigated rice, wheat and mustard productions may be reduced by 6%, 4% and 4% respectively. Pan India basis, increase in temperature of 1°C for 1 week reduces the wheat yield by ~300 kg/hectare. Long duration cultivars of wheat (HD 2932 and HD2967) gave higher yield under initial and terminal heat stress conditions, while medium duration cultivar (HD 2285) gave higher yield under very late sown conditions. Terminal rain is known to cause yield loss up to 30% and the incidence of terminal rain is increasing, so a solution needs to be found to counter this emerging trend in climate change. The rainfall data shows that although the total amount of rain has not changed significantly, the duration has reduced quiet a lot. The state of Jammu and Kashmir is showing a significantly warming trend over the past years, as per the data collected from 1900 - 2010. Poor communities contribute very little to climate change, but they are most vulnerable. They have limited adaptive capacities and are more dependent of climate sensitive resources such as local water and food supplies. The most important aspect to addressing these issues is to measure the vulnerability. Such an analysis has been carried out and areas that are highly vulnerable have been identified. Adaptation to climate change would involve development of crop varieties that are resilient to drought, flood, salinity, heat and pest have to be developed. In order to mitigate the effect of climate change, crop has to be made more efficient through the use of less water, less fertilizer, less energy and less pesticide. Climate-ready crops have to be developed. Waterproof rice varieties, which are able to stand submergence for 17 days, have been developed. Further, drought resilient varieties have also been developed. Crop diversification should also be looked as an option; for instance, small millets are climate savior crops. There is also a need to explore biodiversity to find varieties that are naturally resistant to various environmental factors. Demand driven nitrogen supplementation would be helpful to mitigate climate change. Real time crop monitoring using remote sensing needs to be further explored and exploited. Climate smart villages should be developed which have access to weather data, which are water smart - optimizing the use of water, carbon smart - leaving minimum CO_2 imprint, Nitrogen smart - demand based supplementation, Energy smart - use of renewable energy with low CO_2 emissions and knowledge smart - capability to monitor the real time growth and other parameters using satellites. It has been shown that adaptation options such as sowing date, variety, irrigation efficiency, fertilizer use and additional inputs can significantly decrease the net

vulnerability due to climate change. Further measures can be taken to reduce the emission of methane, which causes 21 times more heating than CO_2, For instance the submerged variety of rice causes the soil conditions to become anaerobic, leading to methane production. These varieties can be changed to those that don't require submergence.

Professor Zafar Ahmad Reshi, Department of Botany, University of Kashmir, Srinagar, spoke on 'Species distribution modeling of some endemic and invasive plant species under various climate change scenarios: Conservation and Management implications', emphasizing theapproach using geo-referenced occurrence data for species in combination with digital maps representing environmental parameters to build models characterizing ecological requirements of species. Prof. Reshi further explained the habitat-suitability models with suitable examples, used for predicting species distribution. As per his inference, globally *Parthenium* sp. may increase its range under climate change scenarios; and there is an increase in suitable habitats for *Azolla* and *Anthemis* under different scenarios as compared to current climatic conditions.

Technical Session V – Climate Change and Meteorological Dimensions

Dr. Sonam Lotus, Director, Dept, of Meteorology, Srinagar, presented his views very systematically on 'A Meteorological Analysis of Flood in parts of Jammu & Kashmir in September 2014'. As per his studies, the extreme weather and climate events, interacting with vulnerable human and natural systems, can lead to disasters, especially in absence of responsive social system; while timely preparation & reliable early warning of impending disaster help reduce impact of disaster and minimize the loses. The volume of flood discharge in September 2014 was three times more than the carrying capacity of the Jhelum River. The river has the capacity to hold the flow of 35,000 cusecs (cubic feet per second) of water. But during the floods, the flow water in Jhelum was recorded to more than one lakh cusecs. This submerged 70% of the region causing heavy loss of property, agricultural crop and life of human and domesticated animals.

Dr. Manju Mohan, Professor, Centre for Atmospheric Sciences, Indian Institute of Technology, Hauz Khas, New Delhi, while speaking on Atmospheric Pollutants and Climate Change, dealt in detail on the Nexus of urban dynamics, air quality and human health. The Changing LULC due to development activities and anthropogenic heat emissions leads to temperature increase in urbanised pockets of cities known as Urban Heat Islands; the UHI puts an additional cooling energy demand leading to higher emissions and higher temperatures setting a vicious cycle of

increased temperature and energy demand. The UHI in general at other times morning, and evening transition and in the afternoon hours are also high thereby indicating that urban canopy and anthropogenic heat generation is playing a dominant role throughout the day in changing the dynamics of urban heat island circulations, needing more in-depth study.

Technical Session VI – Climate Change and Eco-economic Perspective

Prof B. K. Tiwari, NEHU, Shillong, while delivering his address on 'Socio-economic implications of climate change in North-East India: Impacts, Vulnerability and Adaptation', emphasized that the North East Indian region has 'warmed' significantly during that last decade. The annual mean temperatures are also increasing at a rate of 0.04°C per decade in the region, thereby causing a long-term positive trend in precipitation over North East India for the period 1901-2007. The frequency of "extreme events" with respect to rainfall has been increasing over the past 100 years. There is about 38% increase in number of days when the rainfall exceeds 150mm per day. Thus, geographical distribution pattern of crops may be affected; and incidence of pest's outbreak and crop diseases may increase. Therefore, a net loss of agro-biodiversity is predicted.

Prof Pramod Tandon was of the opinion that Global warming is the single greatest threat to plant diversity, which drives to extinction of plants that hold importance. Current predictions estimate increase in temperatures of 1.4 - 5.8°C by 2100; whilewarming of 3 - 4°C could eliminate 85% of all remaining wetlands. 15–37% of land plants and animals would become extinct by 2050. By 2055, up to a quarter of all potato, peanut and cowpea species could become extinct; and50% of the land area suitable for cultivation could be gone. The Mangroves would decrease in extent as coastal zone becomes "squeezed" between sea and inland agriculture. Further citing several reports and analyses, Prof Tandon suggested the following measures-

- Conserve plant genetic resources especially sensitive to climate change,
- Preserve habitats to facilitate the long-term adaptation of biodiversity,
- Improve our understanding of climate change – biodiversity linkages, and
- Fully integrate biodiversity considerations into mitigation and adaptation plans.

Dr Suman Sahai, Gene Campaign, forcefully advocated to incorporate climate change impacts in development programs to reduce vulnerability,

stabilizes food production and better secure livelihoods. She stressed that there is no single indicator of the impacts of climate change on biodiversity. Impact is seen through changes in - distribution pattern & life cycles, development of new physical traits as species struggle to adapt to the changing climatic conditions.

Technical Session VII – Climate Change: Threat & Impact

Prof. G.M. Bhat presented data on the climate change in geological past and explained that climate had changed during Geological past mostly due to cooling. Present increment in temperature caused due to anthropogenic activities is alarming and has impacted glaciers across the globe including several glaciers of Himalayas. He emphasized on water resources of South Asia particularly the river systems, which originate in neighboring countries. He particularly underlined on the security concerns related to Brahmaputra River, which originates in Tibet and in absence of any treaty it may affect water security of India and Bangladesh.

Prof Gohil and Dr. Amit P. Sharma, Concluding the inferences drawn in last two days of the discussions, also addressed the session. Prof. Gohil presented the sorrow state of dwindling species, while Dr Sharma, through his beautiful presentation attracted the attention of one and all on the disastrous impact of climate change. Dr. Sharma's presentation focused systematically, with live examples on the following-

1) Impact on public health and infectious disease
2) Impact on agriculture and animal health
3) Impact on regions that will be affected severely
4) Situation with melting glaciers and flooding of rivers
5) Atmospheric sciences/greenhouse gases/emissions.

Finally, after the panel discussion, which was addressed by the Chair & Co-Chairpersons, the following recommendations were made-

1. The Academy should spread awareness for conserving the natural resources and concerns regarding climate change through social media. It was also recommended to include 'climate change' in the curriculum at primary education level to educate and create awareness about climate change among school going children. This recommendation be submitted to Ministry of Human Resource Management, Government of India for implementation.

2. Appropriate measures need to be taken to halt degradation of forests and biodiversity. The major challenges of climate change at national, regional and local levels need to be investigated and action points be identified so that effective steps could be taken to

prevent situation from worsening further. All stakeholders including the civil society be involved in discussions and debates on the climate change so as to generate awareness among the masses, which is imperative to minimize the impact of climatre change and associated disasters.

3. Space technologies have potential to play a role in detecting and predicting adverse effect of climate change. There is a need to train human resources in this area.

4. Many studies have emphasized that Climate change will have serious implications on food and nutrition security. The challenge is how to achieve enhanced agriculture productivity without any associated ecological harm. Immediate research studies are needed to identify climate resilient genotypes of major crops and their wild relatives. It would be useful to establish Genetic Resources Centers for a warming planet and rising oceans for conservation of identified genotypes and their characterization and validation.

5. There is a need for establishing Genetic Enhancement Centers, in leading institutions, for undertaking studies on identification of genes resistant to biotic and abiotic stresses.

6. Development of climate resilient agriculture, based on soil factors as well as emerging threats of low water availability is a greater challenge in ensuring agriculture productivity. This calls for an integrated approach on application of technological interventions in the area of biotechnology, space and information technology. Knowledge intensive agricultural practices, being followed by the grass roots level communities, as an adaptation measure needs to be documented and scientifically validated.

7. There is huge cost attached particularly in urban areas, to deal with mitigation of climate change. These include: storm water management; flood control; disaster management; and ensuring that farm income is not significantly reduced. These aspects require more research in order to evolve appropriate policy guidelines to deal with these issues.

8. Training and awareness campaigns are needed on the observed and predicted effects of global warming on health in India and urgent remedial measures need to be taken. Studies on the climate change and their impact on water borne diseases in various regions of the country are essential.

9. Possibility of using satellite images to predict outbreak of infectious diseases Need to be explored.

10. There is a need to generate reliable, relevant, and up-to-date information on impacts of climate change on disease incidence and human health to enhance our capacity to respond to the negative health effects of climate change.

11. Disease surveillance and rapid dissemination of information are important components for including in any plan made for enhancing preparedness for adapting to climate change.

12. More scientific and technical seminars and discussion meetings need to be organized for prioritizing the goals and evolving scientific & technical remedies to the climate change related problems.

13. Establishment of long-term observational and monitoring network in respect of meteorological and ecological data for critical habitats, species and ecosystems in the various eco-regions of country especially in Indian Himalayan Region is urgently needed.

14. There is a need to develop a disaster resilient sustainable master plan for the cities. It needs to be particularly included in the plans of smart cities.

15. Involvement of local communities in adaptation and refinement of traditional cropping mechanisms needs to be promoted. This is especially required for adopting good practices in respect of climate change adaptation and mitigation.

16. Urgent action is needed to develop local solutions to biodiversity loss. Sustaining biological diversity and ecosystem services are hence important to deal with climate change. There is a need to shift to environmentally sustainable technologies and promote energy efficiency, renewable energy, forest conservation, reforestation and water conservation.

17. Overuse of carbon-based energy viz., coal and oil is resulting in large-scale generation of green house gases. This has to be checked by moving towards renewable sources of energy.

18. The governmental and non-governmental agencies need to be enthused/encouraged to adopt solar powered energy systems, to reduce the use of conventional energy resources.

19. An interdisciplinary approach is needed to combat the climate change. The local chapters of NASI could take up a movement on Climate Literacy of local communities including school students by developing and showing films/clippings on climate change and its impact.

20. The NASI needs to join hands with ministries of Science and Technology; Environment, Forests and Climate Change, Earth Sciences, Human Resource Development, Indian Council of Agricultural Research and Indian Council of Medical Research to achieve its objective of readying the country to adapt to the impacts of climate change and take appropriate steps to mitigate the same.

21. There is need to involve the universities, colleges, research institutions, NGOs etc. in the implementation of the recommendations of the this brain storming session particularly in areas of generation of new knowledge and creation of awareness among people.

22. Involvement of young scientists aptly equipped with instrumentation and analytical support is essential to study paradigm of climate change in India. As such NASI should also create awareness about specialized institutions and potential funding agencies to support young individuals and institutions for taking up collaborative research on climate change.

23. The National Academy of Sciences, India should organize 3 more brain storming sessions in other parts of India and to periodically disseminate climate change information. Implementation of social media networking is critical for NASI to achieve its objectives in this context.

24. Establish climate change study centers in key institutions as nodal offices for monitoring and reporting.

25. Prepare CDs, short films and videos in local languages and particularly the chapters can be entrusted with the task of giving publicity, creating awareness especially in rural areas and amongst school children.

26. Training programs at various levels be organised by NASI so that in a couple of years we have a **cadre of climate change experts and workers.**