ADDRESSING CLIMATE CHANGE IN THE MOUNTAINS

OUTCOME OF THE

SUMMIT ON CLIMATE RESILIENT MOUNTAIN AGRICULTURE

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PREFACE

In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality. Based on many studies covering a wide range of regions and crops, negative impacts of climate change on crop yields have been more common. Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability.

In the context to Himalayan region these impacts are influencing the livelihoods of mountain farmers to a great extent. Like in the other Himalayan States, in Uttarakhand, over 60 per cent population is engaged in agriculture, climate-induced weather exigencies continue to limit contribution of agriculture to the economy. Governments at various levels are starting to develop adaptation plans and policies and to integrate climate-change considerations into broader development plans.

To understand and capture various adaptation and mitigation practices in the present changing climate scenario, a three day Summit on Climate Resilient Mountain Agriculture was organized by Watershed Management Directorate from 2nd to 4th May 2018. This summit was conceptualized on the idea and inspiration of Hon'ble Minister of Watershed Management, Shri Satpal Maharaj and under the direction and guidance of Mrs Manisha Panwar, Principal Secretary Watershed and Chief Project Director, Watershed Management Directorate.

The summit brought together all stakeholders, like farmers, practitioners, scientists, and government departments on the same platform, to discuss the challenges and perspectives of climate-resilience issues in mountain agriculture. This event witnessed the congregation of subject matter experts from across the country and farmers from project areas, who share their experiences, expressed their views and discussed to achieve a robust agriculture system to cope with the changing climate.

This Summit was inaugurated by Hon'ble Chief Minister of Uttarakhand, Shri Trivendra Singh Rawat, Hon'ble Minister of Watershed Management, Tourism, Culture, Irrigation& Minor Irrigation, Uttarakhand Government Shri Satpal Maharaj was the Guest of Honour. The Historian, Founder of PAHAD and a well-known Social Activist, Padma Shri Prof. Shekhar Pathak was the Key Note Speaker, while the session was presided over by Hon'ble MLA Shri Harbans Kapoor.

The valedictory session was graced by H.E, Governor of Uttarakhand, Dr. Krishan Kant Paul, as Chief Guest. Hon'ble Minister of Agriculture, Uttarakhand Government Shri Subodh Uniyal and Shri Ranjan Samantaray, Senior Agriculture Specialist, The World Bank, were the distinguished guests in the session.

The suggestions and recommendations of the summit, compiled in these proceeding will provide a way forward to all Himalayan states for the implementation of landscape approach to achieve the objective of building climate resilience in mountain agriculture through mitigation and adaptation interventions.

We are thankful to all the dignitaries, scientists, subject specialists and farmers who whole heartedly participated in the summit and were instrumental in making the event a success. We thank all the officers, staff members and consultants of Directorate for their active contribution during the summit. We are thankful to all officers, scientists and staff members from Forest Research Institute, Dehradun, who were associated in summit organizing team. We are grateful to Dr Savita, Director, Forest Research Institute, Dehradun for her guidance, effective participation and for providing FRI premises as the venue for summit events. We are grateful to Shri Ranjan Samantaray, Senior Agriculture Specialist, The World Bank and Dr Sudhirendar Sharma, Environmentalist, for their continued guidance in organizing the summit and compiling the proceedings.

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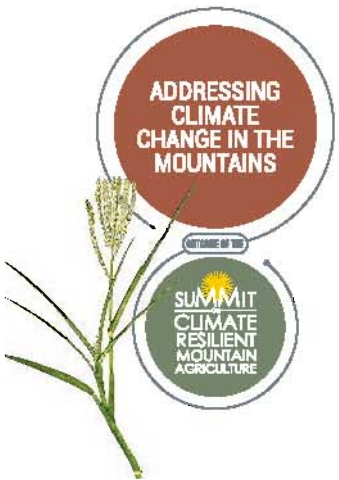
India is the world's highest producer of rain-fed agricultural commodities and the world's second-highest producer of farm outputs overall. Agriculture accounts for 17 per cent of the nation's GDP and about 12 per cent of its exports (2016-17). It is India's dominant land uses with almost 46 per cent of land considered to be under agriculture. The Economic Survey[1], released in January 2018, made some startling revelations. It warned that farm incomes in India may fall by up to 25 per cent in unirrigated areas in the medium term as a result of climate change, while pointing out that agriculture gross domestic product growth and farm revenues have stagnated in the past four years due to repeated monsoon failures.

Climate variability and changes are the emerging challenges for Indian agriculture with the growing population to ensure national food security. It was also the first time that 'Climate Change' featured significantly in the country's Economic Survey, which not only highlighted climate change as a significant development challenge but brought home interconnections between climate change, temperature, rainfall, and agriculture. In last three decades the average annual rainfall has declined by about 86 mm across the country. What is more, rainfall extremities have increased steadily in the last one decade. Extreme rainfall shocks are much potent than temperature shocks in impacting crop yields. While extreme rainfall shocks have resulted in a 12.8 per cent decline in Kharif yield and 6.7 per cent in Rabi yields, the extreme temperature shocks have resulted in about 4 per cent decline, during both the seasons.

With some 60 per cent population directly dependent on agriculture, and the remainder 40 per cent indirectly on farm supplies, adaptation to climate change in the agricultural and allied sectors is a major challenge for a large agrarian society.

Given the fact that the global long-term effects are still a matter of speculation and may remain so, capturing the impact of climate change amidst low-carbon communities (communities in mountains contribute far less to the global carbon emissions) remains largely undetermined. It has been recognized that mountain regions represent small pockets of habitation wherein communities develop a way of life on minimally modified environment. Consequently, slightest of climate change has multiplier impact on people and their livelihoods in the mountain areas, who contribute little to this change. Although, all ecosystems and communities are influenced, but mountain ecosystems and agriculture systems in particular, are projected to be more vulnerable to climate change.

CONTEXT



With some 60 per cent population directly dependent on agriculture, and the remainder 40 per cent indirectly on farm supplies, adaptation to climate change in the agricultural and allied sectors is a major challenge for a large agrarian society.

The climatic conditions are more variable in the Himalayan region due to change in land use patterns, increased urbanization and industrial growth. Climate change induced hazards such as floods, landslides, and droughts are imposing significant stress on the livelihoods of the Himalayan populations. According to the IPCC's Fourth Assessment Report (2007), significant stresses have been imposed on the inhabitants and agriculture due to floods, landslides and drought.

While climate change has steadily permeated the consciousness of communities in the mountains, research has lagged behind in ascertaining location specific impact, and on developing adaptive solutions to perceived as well as unanticipated changes. Some recent studies have dealt with the effect of climate change on glaciers, on temperature regimes, on vector movement and on precipitation[ii], as indicators of change for mountain communities. Adaptive strategies, on the other hand, have relied on broad parameters of climatic change at the regional level. However, a review of available studies and policy reports display consensus on some of the important aspects related to climate change in mountain areas. These are:

Increased incidence of warming and aridity in winters - frequent droughts and low crop production has been noticed at various districts in Uttarakhand due to uneven spatial and temporal variation of rainfall.

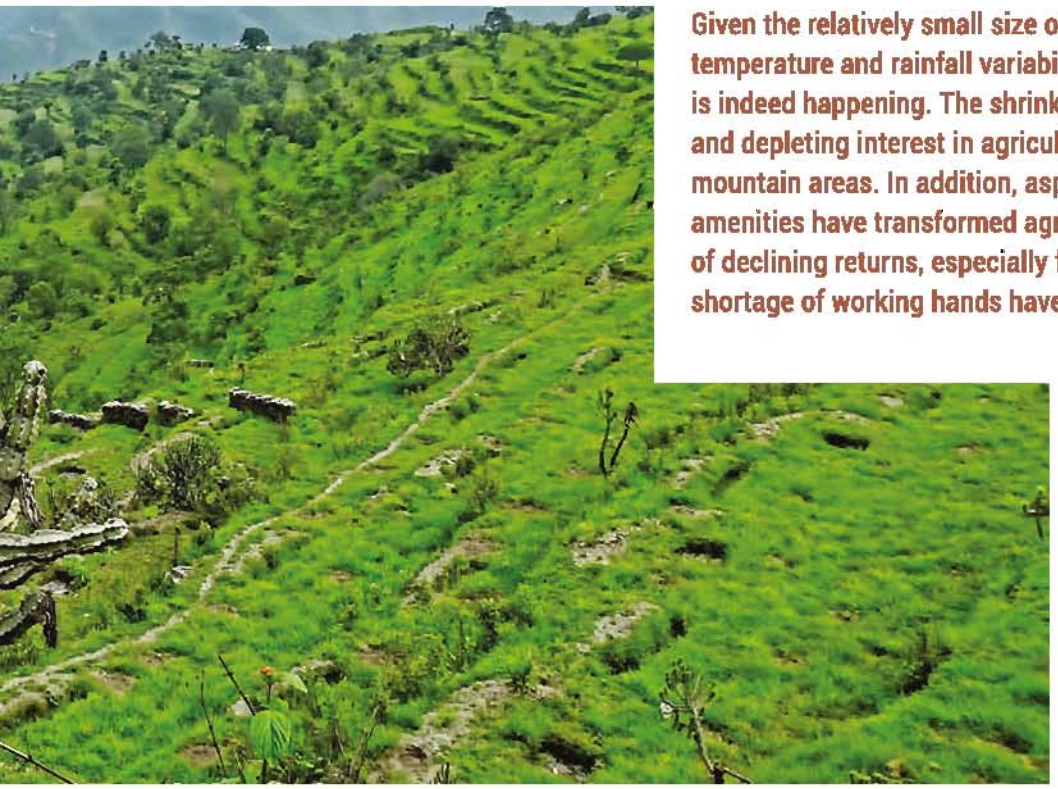
Variability in timing and duration of rainfall - the decadal increase in rainfall intensity has been noticed from 2008. The increase in intensity may create high runoff and have a direct impact on bare soil causing loss of productivity and loss of top productive soil.

Shift in cropping pattern and adoption of new crops - Drastic and sudden changes in critical variables including temperature and precipitation have adversely affected agriculture patterns in the area causing the adoption of plantation crops and a decrease in the cultivation of grain crops.

In isolation and in combination, the fallout of such changes could be considered `risk multipliers' in relation to natural resource degradation, as they exacerbate the fragility of the natural resource base – particularly in environments prone to degradation, in areas of widespread water stress

MOUNTAIN PERSPECTIVE

and wherever poverty undermines the capacity of poor rural people to take the needed preventive steps[iii]. The cumulative impact of climate change on crop yields and food security has been variedly estimated. According to the World Bank, at the minimum forecasted temperature rise of 2°C permanent reductions in GDP could be as high as 4 to 5 per cent[iv], causing widespread food insecurity in south Asia. While various simulations using dynamic crop models indicate a drop in crop yields, regional variations in the effect of climate change on agriculture across the region has been well evident.



Given the relatively small size of landholdings in the mountain areas, the net impact of temperature and rainfall variability on farm-based economy could be pronounced, and it is indeed happening. The shrinking population-land ratio, reduced economic viability, and depleting interest in agriculture have only amplified the impact of climate change in mountain areas. In addition, aspects of remoteness and lack of infrastructural amenities have transformed agriculture into a non-remunerative vocation. On account of declining returns, especially from conventional crops, migration and resultant shortage of working hands have led to a reduction in the net sown area.

Mainstreaming environmental concerns into agriculture sector is also important to fulfill the sector's commitment to the nation's environmental targets and to meet India's wider obligations under international conventions, such as the UNCDB, UNFCCC, UNCCD as well as the Sustainable Development Goals. With approximately one billion people living in mountain areas across the world, specific pro-mountain solutions alone can contribute significantly to progress towards the implementation of the Sustainable Development Goals (SDGs). The protection of healthy mountain ecosystems is the target of the SDGs (6 and 15), as their role in the provision of goods and services is considered essential to sustainable development. If the Sustainable Development Goals (SDGs) of ending poverty (SDG 1), achieving food security (SDG 2), and promoting sustainable agriculture (SDG 2) are to be realized, climate change adaptation interventions in the mountains need to be implemented in earnest.

With the understanding that climate change is real, happening and inevitable, oral testimonies have been gathered to identify and quantify impact on the ground. Though conducted at sub-basin levels, this has helped corroborate weather data with perceptions of local communities. The findings have not only been revealing but raise strong argument for focused research to reduce scientific uncertainty on the ground. While peoples' perception of climate change gives a definite sense of increasing temperatures and unpredictable precipitation, the issues it raises provide insights on several regional variations:

ON WEATHER 1

reduction in winter temperatures, unreliable rainfall pattern and unexpected weather extremes (cloud bursts and hailstorms) have been reported in most of the mountains.

ON FARM 2

inadequate chilling during flowering and moisture stress has impacted apple production in traditional apple growing areas in north-western Himalayas.

ON FOREST 3

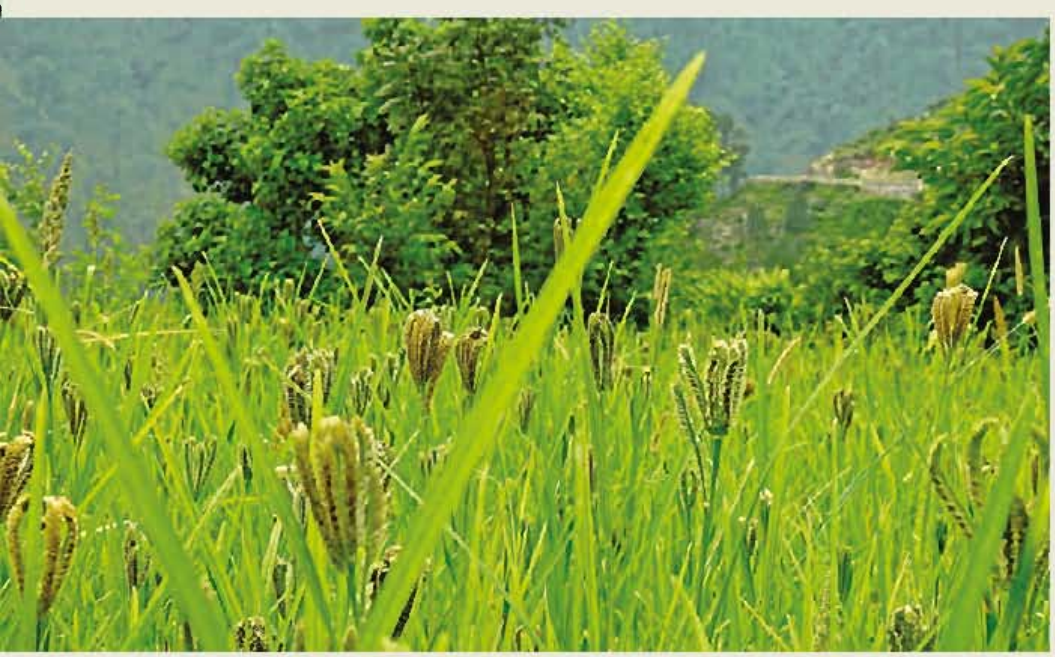
the upward shift of the snow line and depleting natural resources has severe repercussions on mountain farmers' livelihood.

ON WILDLIFE 4

on account of forest degradation, cropped areas are consistently ravaged by wildlife. As a consequence increased incidents of man animal conflict are reported, farmers are being forced to leave agriculture practices".

GROUND REALITY

Agriculture being the mainstay of people in the mountain region, traditional farming and cropping systems are under threat from multiple effects of growing unpredictability in precipitation and rising temperatures. The physiographic constraints along with variability in altitude, slope, and aspect limit the adoption of modern agricultural technologies. Confronted with climatic variability on marginal farms, and rising costs of agricultural inputs with low returns, mountain farming is facing production crises impacting local food security and livelihood opportunities.



Uttarakhand could easily be the microcosm of the impact of climate change in the mountains. The advanced flowering and fruiting has impacted on phenology of native tree species like Rhododendron arboreum, Prunus pashia, P. persica and P. aromeniaca. Reduced availability of palatable forage species and reduced regeneration of fodder-yielding tree species, such as, Celtis australis, Ficus palmata, Grewia optiva and Quercus leucotrichophora have adversely affected animal husbandry practices. Reduction in crop yields has also been reported in both winter and summer crops. The cumulative impact has led to simultaneous migration from hill villages.

Across mountain regions, climate change has not only impacted on local resource availability but has introduced new elements of uncertainty as well. For instance, farmers from some parts of Uttarakhand have reported losing their seed stocks because their crop calendars are no longer in sync with the seasons. On the other hand, animal husbandry, an integral part of rural farm economy, has been dramatically affected on account of reduced availability of fodder. It has been reported that increased demand for fodder and extensive summer grazing by pastoral nomads has led to over grazing, which has contributed to the degradation of land and forest resources. However, the impact of climate change induced natural resource degradation has yet to be scientifically acknowledged and assessed in the mountains.

Forest degradation, both anthropogenic as well natural, has forced wildlife to stretch itself for food into nearby cultivated fields. While farmers have abandoned agriculture at several locations on account of this onslaught, only the enterprising farmers have ventured into alternate land use including horticulture. The indirect impact of climate change is pronounced on traditional agriculture and local food security.

Unlike the plains, mountain regions face unique challenges due to climate change in terms of remoteness and geographical setting in fulfilling their ecological obligations towards local inhabitants. In addition to meeting the human and ecological needs, mountain communities are burdened with an unwritten added responsibility of sustaining ecosystem services for the downstream populations. In the wake of climate change, the upstream-downstream linkages are poised for a change – from ecological obligation to economic transaction of ecosystem services with the downstream communities.

The need for a climate resilient approach to agriculture is imminent in the mountain context wherein 90% agriculture is rainfed with 78 per cent farmers having small and scattered land holdings. Like other mountainous regions, only 13 per cent of the gross cultivated area of 76,228 ha in the hill districts of Uttarakhand is irrigated, with most of it located at the bottom of valleys. Exacerbated by climate change, the state has 24 per cent land classified as degraded, making it one of the leading states with most area under wasteland? What is a worse, drought-like condition cause remotely located springs in the hills to start drying, and their discharge is reduced to such a level that they are unable to satisfy the basic needs of the residents.

In this context a landscape approach and more specifically taking watershed as a geographical unit for treatment and interventions, wherein all natural resources can be managed simultaneously to have a significant impact on building climate resilient of the mountain region, is one of the logical, appropriate option.

Adopting a watershed approach to resource conservation and rejuvenation, the World Bank funded Uttarakhand Decentralized Watershed Development Project popularly known as Gramya-II promotes bottom-up preparation, implementation and monitoring of Gram Panchayat Watershed Development Plans which help in building Gram Panchayats' institutional capacity and develop community based organizations. Being implemented over a period 2014-2021, Gramya–II has ensured that the entire landscape of 82 Micro Watersheds (MWS) spread in 8 hill districts having 524 Gram Panchayats (GPs) is implementing climate resilient agriculture practices, with an aim to share its approaches and methodology for creating a network of climate resilient practitioners in the mountain regions, for mainstreaming such practices in ongoing development programs, and for influencing policy change.

Managed and implemented by the Watershed Management Directorate (WMD), Gramya-II is a follow-up to its predecessor Gramya-I, the project is working on a multi-sectoral approach wherein natural resource management, soil moisture conservation, spring rejuvenation, diversified farming, and animal husbandry are being promoted and implemented in the selected micro-watersheds with the objective of achieving sustainable agricultural productivity for the farmers. The communities have shown their inclination towards adapting their survival and livelihood strategies in accordance with the ecological flow of the watershed. The watershed provides a natural and ideal environmental unit for planning development initiatives. It is also in line with the Sustainable Development Goals, with climate change becoming a growing reality, and Government of India's priority of doubling the farmers' income by 2022, watershed projects stand to deliver for improving agricultural economy.

MANAGING CHANGE


SUMMIT
ON
CLIMATE
RESILIENT
MOUNTAIN
AGRICULTURE

THE SUMMIT

Based on the global and national scenarios, it was imperative for the Government of Uttarakhand to take stock of the present knowledge base, and take measures that can strengthen its ongoing efforts for combating the effects of climate change. With an aim to capture various adaptation and mitigation practices that are economically viable for the mountain agriculture in the changing climate scenario, explore various alternate livelihoods options, and assess how these could be up-scaled and marketed, a Summit on Climate Resilient Mountain Agriculture was organized by the Watershed Management Directorate from May 2-4, 2018. The event witnessed the congregation of around 70 subject matter experts from across the country, who expressed their ideas, observations and recommendations to achieve a robust agriculture system to fight the changing climate in the mountains.

The summit brought together farmers, practitioners, scientists, and government departments on one platform to discuss issues challenging climate-dependent mountain agriculture. The Summit was divided in various sessions which included a farmers' session, three plenary sessions and four technical sessions along with an exhibition wherein the farmers showcased various climate resilient interventions/innovations being implemented in hills with the support of the World Bank funded Uttarakhand Decentralised Watershed Development Project-II (Gramya-II) and IFAD funded Integrated Livelihood Support Project-Watershed Development. Besides 22 oral presentations, 65 poster presentations and farmers exhibition with 30 stalls were also put up.

SH.TRIVENDRA SINGH RAWAT

Hon'ble Chief Minister,
Govt. of Uttarakhand

Climate change happening around us is majorly affecting the agricultural sector. There is a need to bring about change in the agriculture techniques. The government is dedicatedly working on water conservation and watershed management. It is trying to make sure that all areas get drinking water supply. Land consolidation is needed to safeguard crops from wild animals. Land parcels too are needed to be rearranged to achieve better productivity and profit.

SH. SATPAL MAHARAJ

Hon'ble Minister, Watershed, Tourism and Culture, Govt. of Uttarakhand

The geomorphology and ecology of the mountainous region of the state of Uttarakhand are sensitive to the climate change happening due to the emission of greenhouse gases. As a result, the agriculture sector is bearing the brunt.

PADMA SHREE PROF SHEKHAR PATHAK,

Keynote Speaker

There is a need for reassessing land resources in the state. Such database can provide insights on location specific issues and help the state draw strategic actions to transform the farming scenario in the state.

SETTING THE TONE

The Summit on Climate Resilient Mountain Agriculture was inaugurated by the Hon'ble Chief Minister of Uttarakhand, Sh. Trivendra Singh Rawat on May 2, 2018 in the presence of Sh. Satpal Maharaj, Hon'ble Minister of Watershed Management, Tourism, Culture, Irrigation & Minor Irrigation, and Sh. Harbans Kapoor, Hon'ble MLA. The Chief Minister hinted at making the mountain region water secure by conservation measures that lead to gravity supply of water to both rural and urban areas. Stressing the need for consolidating and developing land parcels to counter the growing wildlife menace, Sh. Rawat reiterated his government's commitment to take forward the outcome of the Summit for the betterment of the mountain farming communities.

Sh. Satpal Maharaj was candid in admitting that climate change has sinister proportions if the Kedarnath tragedy is any indication, and yet efforts have to be mounted to make ecosystem resilient to absorb moderate shocks. A combination of conservation techniques, advanced weather forecasting, and cross-sector climate-smartness is the need of the hour. The minister invoked the scientists and practitioners to suggest measures and draw a roadmap for meeting the climate challenge for government's consideration.

Delivering the key note address, noted historian Prof. Shekhar Pathak made the case of mountain agriculture from the perspective of imminent threat from global climate change. Articulating his concerns of mountain agriculture from the historical perspective of Jal, Jangal,Jameen, and Janwar (Water, Forest, Land and Animals), the keynote speaker highlighted the mounting pressure on natural resources in the region from the early days of the colonial rule. Notable is the fact that the region that was self-sustaining for food, fuel and fiber a century ago now thrives on what is commonly known as 'a money order economy', a phrase for money remitted by migrants back home. Diversion of cultivable area, which is only 12 per cent of the total area in the state, to non-agricultural uses is the bane of agriculture. Prof. Pathak highlighted the need for reassessing land resources in the state, and called for initiating the long overdue process of land consolidation. With large areas now lying abandoned on account of out-migration and growing wildlife menace, the government must initiate an out-of-box thinking for incentivizing land owners to take part in collective farming for bringing ecosystem sanity in the hills.

Home to the illustrious peoples' movement to save forests, the Chipko movement, the forests have continued to remain under duress in the mountain state of Uttarakhand. Such being the case, the official figure of 63% forest cover in the state is considered by locals as somewhat bloated. The key note presentation stressed the need for ensuring that at least 30% of the new plantations in the forest areas should be fruiting kind, and economic prospects of forest products should be explored by developing value chains of products like yarsagumba, cheura, wild honey and the like.

The essence of the lead presentation was on the need for a holistic appreciation of mountain diversity, and the interconnectedness between various facets of the ecosystem. Clearly, there is no one-size-fits-all prescription for addressing the ground realities of change in the mountains. Addressing the core issue of sustaining mountain agriculture is daunting as statistics indicate that here has been 5 per cent decline in land under plough during the last decade. Land diversification for roads, dams, and infrastructure has its direct and indirect toll on mountain farming. Yet, there is little denying that the value of mountain products and the role of mountain landscapes in buffering climate change would need a paradigm shift in our understanding of the region. There are no easy answers though, but a mix of approaches in a mission mode can create viable options for reviving mountain economy and usher in a new era of conservation-led growth. Could agro-tourism be the new avenue for reviving mountain farming? Can pockets of protected diversity usher in a new forest-based farm economy? Should ecosystem services be the leitmotif for conservation linked to economic returns? Can mountain products be used as geographical markers to generate a new economy?

It is a task before for scientists and researchers to address such challenges in creating and demonstrating workable modules with the potential of scaling up. Such modules/field stories validated by research institutions should be widely discussed and piloted in various development projects with an aim to influence policy.

Given the increase in number of extreme events, it is time collaborative research and development gets a fillip under an institutional mechanism that can spearhead climate-smart approaches across all sectors of the economy in the mountains. Lest it is overlooked, cautioned Prof. Pathak, mountains are the water towers on the earth. While focusing on issues of local importance it must not be forgotten that mountains have a much bigger role to play for the survival of the humanity, and every effort must contribute to letting mountains be!

The Climate Summit was designed to be on a participatory discussion mode. While it created space for presentations (both oral and poster) on recent research on climate-related science, it organized panel discussions on macro issues challenging mountain agriculture. With a sizeable number of farmers from across the state of Uttarakhand in attendance, the Summit identified inter-related aspects of climate resilience, doubling income, and conserving water as focus areas for wide participation.

SUMMIT DESIGN

ADDRESSING CLIMATE CHANGE IN THE MOUNTAINS

SUMMIT ON CLIMATE RESILIENT MOUNTAIN AGRICULTURE

RESILIENCE

RESILIENCE

Can agroforestry make mountain agriculture climate resilient?

Agroforestry is the use of trees and shrubs as part of the agricultural systems. It contributes to prevent soil erosion, facilitates water infiltration, and diminishes the impacts of extreme weather. Agroforestry also helps diversify income sources, generates energy and provide fodder for livestock. As they are more efficient in the use of land, agroforestry reduces the pressure on forests, avoiding deforestation which contributes to climate change mitigation. As wood is produced in the fields, these systems also contribute to preventing forest degradation. Agroforestry systems use less fertilizer, reducing GHG emissions created through fertilizer production. By increasing biomass above ground and in soils, they help create carbon sinks.

Agroforestry offers a potentially sustainable land-use solution, which could re-establish forests, restore ecosystem services, and stabilize local livelihoods in mountains. Through the integration of trees on farms and within the agricultural landscape is essential for increased social, economic, and environmental benefits. The introduction of more complex agroforestry systems can increase the biodiversity in the systems and broaden the range of products produced; both of which will build resilience in local farming systems in hills. The panel sought to analyze and discuss the potentials of agro-forestry from the following standpoints:

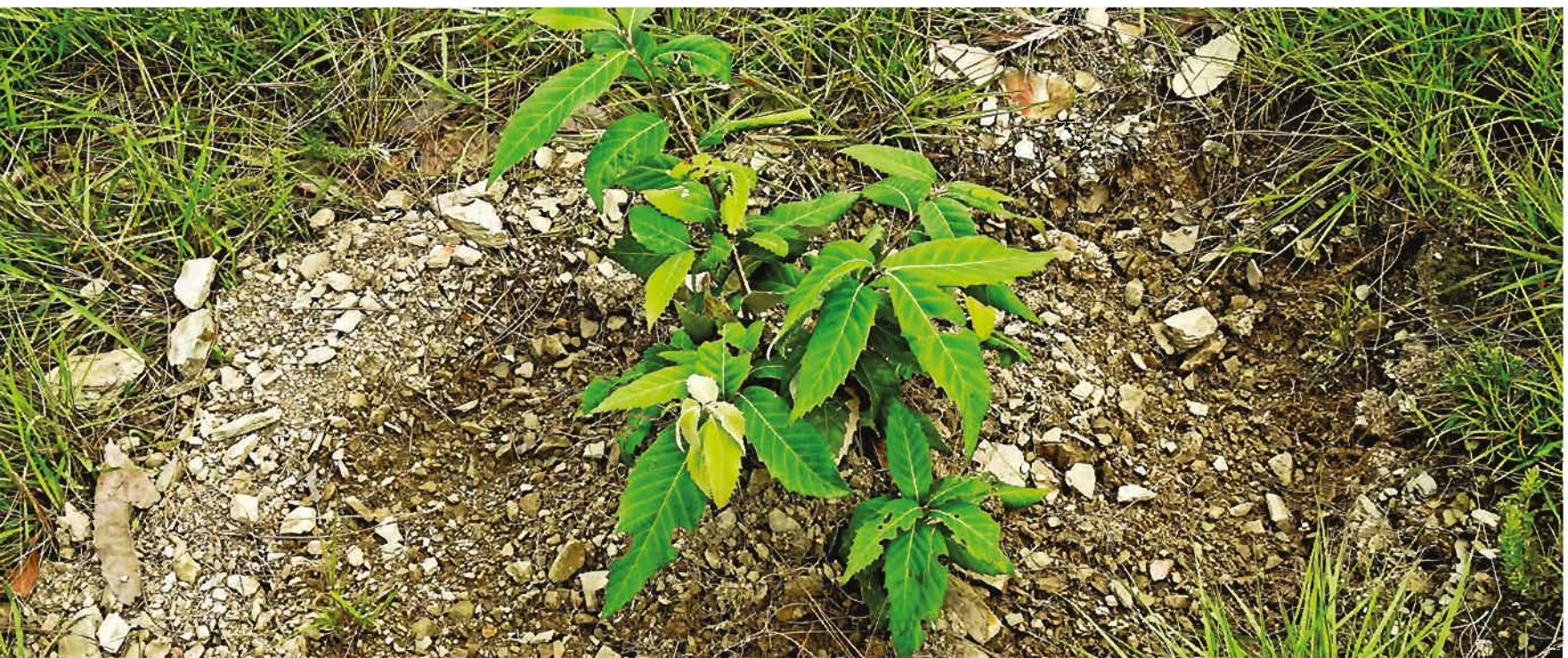
- Can improving the existing and adopting new, integrated agroforestry systems act as a viable way forward toward sustainable livelihoods to mountain farming?
- Is the unavailability of quality planting materials a major bottleneck in adopting new agroforestry systems?
- Is there evidence that farming systems that integrate agroforestry practices are more resilient than in other systems?
- What are market and policy imperatives for expanding agroforestry systems in the mountains?

The discussions concluded that agroforestry is virtuous on account of that fact that; 1) yields are less variable, because of better humidity retention; 2) it provides diverse production which creates a buffer against both the variability of crop yields and price volatility; 3) it offers diversified sources of income, through sale of wood, which can provide liquidity to overcome unexpected economic shocks; and 4) agroforestry protects conserves soil, protecting it from erosion by as much as a factor of 10.

The panelists discussed the potential of agroforestry in view of its inherent advantages, and its potential under changing climatic conditions in the mountains.

- The panel emphasized that agroforestry could play an important role in sustainable development of mountain agriculture. It offers land use solution by establishing forests, to restore ecosystem services, and stabilize local livelihoods in the mountains. On the other hand, agroforestry practices enhance the efficiency of biodiversity in the farming system, broaden social, economic, and environmental benefits, help in maintaining ecosystem services, enhance economic benefits to the general masses, and promote resilience under changing climatic conditions.
- Mountains in general have better forests than plains, as traditional practices and participatory approaches of farming practices have held them in good nick. However, diverse genetically superior material is required for different agroforestry systems to be developed in supporting mountain agriculture. To make agroforestry commercially viable, there is a need to ease trade of wood and timber for the communities. The State also needs to make industrial policy of promoting setting up of timber based industries in the hills. Depending upon the requirement, integrative and intensive agroforestry system approach can better solve the problems of mountain peoples, more so as vast stretches of land have been left abandoned on account of wildlife menace.

- Production and supply of quality planting material is prerequisite for adopting agroforestry system in the mountain region. Government of India and the State Governments should formulate rules and regulations in such a way that farmers get regular supply of quality materials, learn techniques for proper harvest of timber, and are able to market the same without any hurdles.
- Through sound agroforestry policies, the country could reduce the current burden of wood imports worth US $8 million. Agroforestry is an efficient mechanism for enhancing carbon sequestration on per unit area, and species such as Melia dubia whose yearly productivity per unit area gets tripled has already demonstrated its value in boosting local economy. There is a need for research to establish species/varieties that can be grown under varying altitudes and diverse conditions to reduce the effect of biotic and abiotic stresses under changing climatic conditions.
- Agroforestry model should be developed and adopted in place of concrete structures for stabilization of riverine beds across major river systems under projects like Namami Gange Project. Tree species like Pinus roxburghii, Rhododendron arboreum, R. campanulatum, Betula utilis, Terminalia bellirica, T. chebula, Juglans regia, Myrica esculenta, Prunus armeniaca, Aegle marmelos, Emblica officinalis, and Moringa oleifera have multipurpose uses and their potential should be explored in stabilizing mountain agriculture. Agro-forestry by itself provides multiple benefits of soil stabilization; it is a source of animal fodder, wild fruits, medicines and aromatic oils along with timber.
- Agroforestry with intercropping with off season agricultural crops should be promoted in hilly regions to enhance productivity and farm income. Concerted efforts need to be made to draw benefits from diversified agro-farming systems by adopting mushroom cultivation, animal husbandry, poultry farming, fish farming, and by promoting traditional food markets and local crafts.
- Sacred groves have bearing on rich cultural traditions of conservation in the mountains. Not only are sacred groves rich in biodiversity, these extend tangible and intangible ecosystem services. The panel stressed the need to bring sacred groves into planning process by incentivizing communities to revive some of the abandoned sacred groves, and to bring new areas under such groves.
- The session argued that as commercial agroforestry system is not yet fully adopted in mountain agriculture system, Tree Outside Forests (TOFs) is a concept that needs currency in enhancing forest cover on non-forest areas.



INCOME

Can mountain farmers' income be doubled through agriculture?

Resource constraints (both land and water) and climate change are playing up on the mountain farms, with forced migration being the inevitable result. The panel sought to analyze and discuss the following issues

- Can income from mountain agriculture be doubled?
- Can diversification and niche farming contribute to doubling farmers incomes? Are there examples worth emulating?
- What could drive farmers to change from business-as-usual approach to precision agriculture with weather forecast information?
- What are the policy imperatives to induce such transformative approach in the mountains?

In the plenary discussions, taking cue from the government's focus on doubling farmers' income by 2022, speakers deliberated upon the issue from mountain agriculture perspective, and sought possible contribution from diversification and niche farming as examples in doubling farmers' incomes worth emulating. Curiously, however, the present income scenario in the mountain regions has been pathetic. As per the Dalwai Committee Report, known as the report on Doubling Farmers' Income of the Niti Aayog, farmers' average annual household income in the state of Uttarakhand stands (at 2015-16 prices) at Rs 61, 833 or a mere Rs 5,152 per month only. Although almost double that of farmers' income in Uttarakhand, the corresponding figure for the state of Himachal Pradesh stands at Rs 9,573 per month only.

The report has projected that by all accounts the income of farmers' in Uttarakhand may increase by 53 per cent over next 6-7 years. It further stated that income increase will come from a mix of increase in sub-sectors by: crop productivity: 14.8%; livestock: 10.7%; input efficiency: 12.8%; cropping intensity: 1.8%; diversification: 0.6%; better price: 8.1%; and, non-farm activities: 5%. While these values may play up different under local conditions, the broad picture of change has nevertheless been projected. The panel discussion took upon these projections in deciphering a roadmap for improving agriculture in the mountains in the backdrop of doubling farmers' income as the goal. The discussions advocated a shift from business-as-usual approach to precision agriculture driven on input efficiency backed by weather forecast information for transforming mountain agriculture.

The experts discussed that people have been demoralized due to unsatisfying remuneration in agriculture. The mass migrations of farmers have been observed due to other lucrative income options, jobs etc. Wild animal crop depredation problem has also badly impacted agriculture. Moreover, the farmers don't have access to information on impact of climate change on agriculture, market and technology. Income generated by agricultural produce, are shared by intermediaries and the farmers get only 30-40 per cent of actual sale values. 3M's i.e. monsoon, market and middleman, can be tackled by policy change and technology adoption to increase farmers' income.

- The panelist suggested that the farmer's income can be increased by integrating farming with animal husbandry, poultry and non-farm resources like agri-tourism. Productivity can be enhanced by timely supply and use of resilient seeds, both new and traditional. Better crop yields need to be suitably remunerated. Cultivation of climate-resilient traditional crops should be incentivized, both at cultivation stage as well as at post-harvest stage by way of minimum support price. Mechanism for higher price for niche crops should be explored by pitching by giving mountain products a geographical mark. Direct income support, on the lines of Mukhyamantri Bhavantar Bhugtan Yojana in Madhya Pradesh, should be explored for the mountain regions.
- A shift from subsistence agriculture to business approach is needed to meet growing market demand for niche products, including off-season crops. This includes timely market information, public private partnership, collective farming approach, and reduction in post-harvest losses through infrastructure development.
- Market intelligence and production strategies are needed to manage agri-business. Keeping an eye on the local and global markets and the agri-market cycle is also important. The institutional supports like collective agri-marketing, integrated approach in developing storage facilities, reducing farming costs, and maintaining soil health are critical.
- Lack of knowledge on nutrient status of the soil is resulting into wide yield gaps. Balanced use of fertilizers, mechanization, adoption of improved tools and machineries' can reduce the cost of cultivation.
- Improved micro-irrigation techniques like drip and sprinkle irrigation for vegetable cultivation can reduce labour and water use efficiency significantly, and help in reducing costs.
- Livestock also has immense potential in increasing agriculture income. Stall feeding practices, fodder and grassland development, diversification of crops especially medicinal crops etc are important aspects to focus on.
- Training farmers on value addition in rural areas can help to increase the farmers' share of income. Primary processing can increase farmer's income by 50-60 per cent.

WATER

Is improving water productivity and water use efficiency solution to the productivity-sustainability conundrum afflicting mountain agriculture?

Mountain farming on small plots is largely rain dependent, and reasonably productive in its potential. However, in the quest to increase agriculture productivity moisture has been considered an impediment, and efforts have increasingly been made in recent years to harvest water from all sources. Given the fact that as much as 90 per cent cultivable area is rain dependent, the issues related to optimum water harvesting and conservation have yet to be fully addressed. Some of the leading questions the panel took up for discussions were:

- What are the limits to which water can be stored/harvested to attain levels of optimum productivity, and is water stored being managed and used inefficiently?
- How can productivity-sustainability conundrum be resolved keeping the ecosystem integrity intact in the long run?
- Can improving water efficiency be co-related to economic efficiency in agriculture in the hill scenario?

Himalayan region is witnessing a declining trend in rainfall in last 10 years. Apart from this, a huge spatial and temporal variability in rainfall is being observed in the mountains. Extreme events have been on the rise, posing formidable challenges to protect life and property. Since an estimated 0.4 per cent of rain water gets stored in the mountain regions, runoff from fertile topsoil from farmers' field is a recurring phenomenon. Introduction of cash crops, which the ecosystem can hardly support, needs more water. Extending irrigation means drawing more water from the eco-system, and extracting ground water in the mountains has its hydrological limits.

Water is most significant variable in the mountains. Even though only 12 per cent of land (in hill districts of Uttarakhand) is cultivated, 90 per cent of it is rainfed. With little variation, the trend is common across other mountain regions in the country. Rainfall distribution has spatial variability, manifest in either late onset or early withdrawal, leading the subsistence farmers high and dry. Within a watershed, there is wide variability between northern and southern slopes too. Subsistence farming is caught in the trap of such emerging changes, challenging farmers to quickly adapt from one season to the other.

In many river basins, water scarcity is already the main challenge facing agriculture. In areas where water is scarce, climate change is expected to exacerbate tensions and increase competition for water. If agriculture is to continue meeting the demand for food and other commodities, efforts will be needed both on the supply side and on the demand side. The panelists discussed wide ranging issues, both terrestrial and atmospheric, to propose a range of suggestive actions to address water challenge in the mountains:

- Unlike plains, most crops in the mountains need approximately 200-400 mm rainfall for their survival, and these crops have critical stages of water demands. A fine tuning of irrigation during such stages becomes very important. In the changed scenario, lifeline irrigation support in form of small water storages can help farmers to cultivate traditional crops. More than 20 technologies are available for water harvesting. One of the most important technologies is roof water harvesting. There is no denying the fact that farmers need access to precision technologies to make best use of stored water.
- Improved weather forecasting and hydrological monitoring will become a critical element of modern

adaptation strategies. India Meteorological Department (IMD) supports 30 million farmers with information on evaporation-transpiration rates of water along with suggestions on when and how much to irrigate. Such information should also cover mountain farmers widely. The meteorological department would need to forecast weather accurately at the level of watersheds for the farmers to make informed choices.

- Importance and need of water budgeting was highlighted. There is a need for studies on inter-relation between water stored and crop yields. India has crop models only for regular crops. New crop models are needed for less favored and traditional crops too. The problem associated with crop modeling is that it needs large data sets on various variables. Impact of changing climate cannot be predicted in the absence of such data. Such models will also help in increasing productivity from small water storages.
- Generating data on net primary productivity of micro watershed is very important. Water productivity and water use efficiency studies can result in managing available water for maximizing productivity by making right crop choices. An integrated approach is needed for all line departments to cooperate in making water footprint and water productivity a necessary pre-requisite for planning at the watershed level.
- From a livelihood perspective, building resilience involves reducing farmers' exposure or sensitivity to shocks, or increasing their capacity to respond. Of prime importance is the ability to increase farming systems' buffering capacity in the face of more variable supplies of rainwater. This necessitates an increased capacity to store water in the soil, in surface reservoirs or in underground reservoirs. Any action that increases the capacity to access water when needed will increase resilience to climate variability. These actions include: on-farm water harvesting; enhancement of soil's capacity to hold moisture; on-farm water retention and enhanced infiltration. Supplementary irrigation at critical periods of the cropping season can reduce losses and boost productivity.
- Crop selection and changes in crop calendars will help farmers adapt to new temperatures and rainfall patterns. The use of crops or varieties with better resilience to dry spells should be preferred. Increased agricultural diversification, including better integration of trees, crops, fish and livestock will reduce risk and increase the resilience of farming systems.
- As efforts focus on improving the accuracy of these forecasts, more emphasis should now be given to improving the way information is conveyed to farmers, and building their capacities to make best use of climate information. Moreover, only broad advisory for major crops may not be enough, farmers need to be updated with good knowledge on choice of crops, water-saving intercropping, and crop specific advisory. Monitoring and early warning during the cropping season should be given a priority to help farmers make informed decisions.

The Summit tried to capture current state of knowledge on understanding economic imperatives, capturing mitigating approaches, building alternative mechanisms, and creating effective markets in the context of changing climate in the mountains. Researchers brought rich technical insights and development case stories on these sub-topics, which will help draw a future roadmap of actions.

TECHNICAL INSIGHTS

ADDRESSING CLIMATE CHANGE IN THE MOUNTAINS

SUMMIT CLIMATE RESILIENT MOUNTAIN AGRICULTURE

Understanding economic imperative of climate resilient agriculture practices

Like most mountain regions in the country, Uttarakhand is traditionally an agrarian state. Close to 78 per cent of its population is dependent on agriculture for livelihoods, contributing 27 per cent to the state domestic product. Climate change is likely to result in reduced productivity of most crops with higher risk to Rabi crops. Higher incidences of pest and diseases are expected with rise in temperature.

Increasing efforts to mitigate and adapt to climate change imply an increasing complexity of interactions across all aspects of land use, biodiversity, livelihood, ecosystem services, water, agriculture and energy. Despite many odds, there is a huge potential in mountain areas to increase agricultural productivity from small landholdings to meet the food requirements of its growing population. Climate resilient agriculture practices have the potential to increase productivity along with sustainable management of natural resources.

Climate change projections for the Himalayan regions show that the region is projected to experience higher levels of warming and climate change, compared to the plains. Mountain agriculture systems, due to the undulating landscape, steep slope, degraded status of land, fragmentation of forests, landslides, dominance of small farmers, etc. are likely to be more vulnerable to climate change.

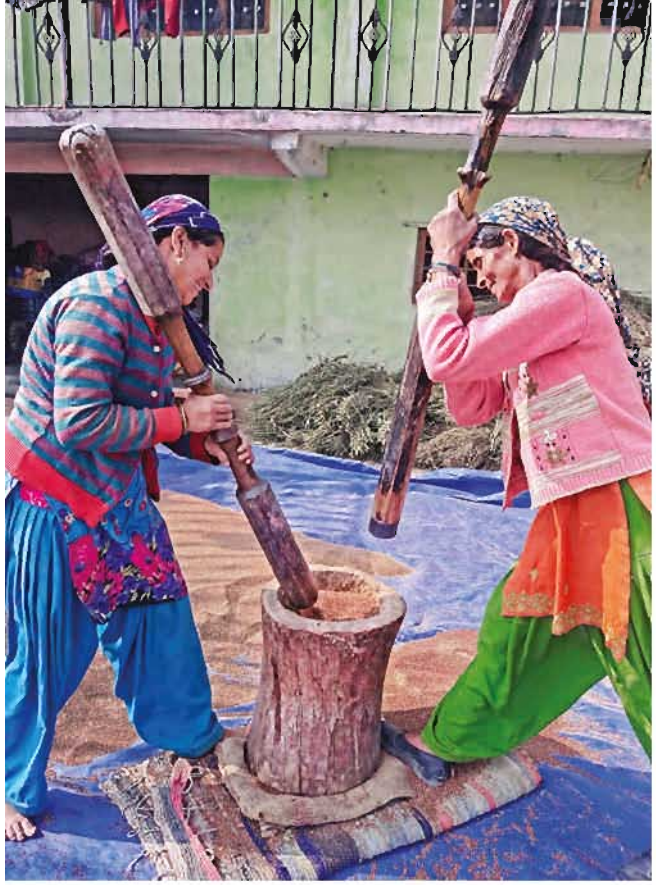
- An integrated approach to building climate resilient agriculture systems needs to be developed which includes water, soil, energy, biodiversity, crop production, livestock, fishery and forestry management.
- A healthy soil is fundamental to sustained agricultural productivity and the maintenance of vital ecosystem processes. To cope with climate change, different types of production systems (crop, livestock and forest) and specific practices to manage them need to be adopted to take into account the diversity and current status of soils (e.g. sand, loam and clay soils, peat soils, sodic soils, shallow soils, nutrient depleted soils), terrain (e.g. steep and flat lands, wetlands), and climatic conditions (e.g. short rainy seasons, erratic rains, high temperatures, storms).
- Integrated soil fertility management (inorganic and organic) can alleviate the problem of low nutrient retention capacity. Agronomic systems should be adopted which protect carbon and nitrogen from rapid mineralization in soils. Integrated soil fertility management is a strategy used worldwide in intensified cropping systems to combine inputs of organic matter (mulch, compost, crop residues, green manure) with fertilizers to address or prevent macro- and micro-nutrient deficiencies.
- The recycling of nitrogen on the farm by using manure and nitrogen fixing plants is the predominant technique used in organic and low external input agriculture to enhance soil quality and provide nutrients. When using this technique, proper timing and management are essential. Nutrients need to be delivered to the plant in times of peak demand. Organic and green manures, as well as nitrogen from legumes, can be managed precisely through crop rotations that include cover and cash crops.
- In cropping systems, good management practices would include: direct seeding (no-tillage); protective soil cover through cover crops, crop residues or mulch; and crop diversification through rotations (e.g. incorporating deep rooting plants and perennials pasture leys for integrated crop-livestock systems).
- Crop and livestock systems can also be improved by their better integration. Integrated crop and livestock systems, at various scales (on-farm and area-wide) increase the efficiency and environmental sustainability of both production methods. When livestock and crops are produced together, the waste of one is a resource for the other. Manure increases crop production and crop residues, and by-products feed animals, thereby improving their productivity. In these systems, livestock

is a strategic element for adaptation. The animals provide an alternative to cropping in areas becoming marginal for cropping, offer a way to escape poverty and represent a coping mechanism in vulnerable and variable natural environments. They also constitute a capital that can be converted to cash when needed.

- As a result of climate change, some farming practices may become less reliable as sources of income. For some farmers diversification to on-farm energy generation could be a coping strategy to strengthen resilience. Tapping into local energy sources can increase incomes and expand the diversity of energy sources. This increases resilience to climate change. The use of biogas cook stoves, optimization of local watermills (Gharats) illustrates both types of adaptation.
- A mix of appropriate energy technologies, equipment and facilities in farming communities is necessary to make the gradual shift to energy-smart food systems. The nature of this mix will depend on natural conditions, infrastructure and skills available in the labour force. There are many technologies that can be part of energy-smart food systems, including wind mills, watermills, solar collectors, photovoltaic panels, biogas units, solar water pumps. These technologies add value to production near the source of raw materials.
- When the survival of breeds or varieties of livestock and crops like red rice, madira etc. is threatened because they are falling out of use, efforts should be made, where feasible, to promote alternative uses for them. In this regard, there are opportunities, to develop niche markets for specialized products.
- Small-scale livestock keepers and pastoralists have developed animal breeds that are well-suited to local conditions. Hardy and disease-resistant, many of these breeds can survive on little water and scant vegetation like the local breeds of sheep, goat and cow (Badri breed) in Uttarakhand. They can continue producing meat, wool and milk in areas where modern, imported breeds cannot survive without expensive housing, feed and veterinary care. Traditional breeds allow people in inhospitable areas to earn a living and maintain valuable traits for future breeding efforts. However, these breeds are often in danger of disappearing, pushed out by modern production techniques and more competitive exotic breeds. Finding niche markets for their products is one way of ensuring the survival of these breeds and enabling the people who keep them to earn more.
- A number of traditional production systems increase the diversity of genetic resources and employ specific techniques for ensuring their optimal use like Baranaja (the old tradition of agriculture 'Baranaja' which means 12 anaja or grain) system in the hills. These systems can influence the agro-ecosystem in such a way that it improves systems ability to cope with expected secondary effects of climate change.
- The use of genetically diverse varieties and breeds should be promoted as it improves the resilience of agro-ecosystems, preserves future breeding options and helps to reduce genetic erosion.
- Cultivation of medicinal and aromatic plants is also a viable economic option. Benefit/cost ratio (BCR) of 15 important MAP species was found to be 2.32 as compared to the traditional crop cultivation. Thus, cultivation of MAP species in abandoned croplands and Van Panchayats is recommended. In the mid altitude zone of 1000-2000 m above sea level, promotion of Myrica esculenta (Kaifal), and Emblica officinalis (Amla) is suggested in community owned forests, along with promotion of silvi-pasture systems on highly degraded forests and rangelands owned by community, government or private individuals. Cultivation of aromatic plants such as Rosmarinus officinalis, Asparagus racemosus, Ocimum basilicum, Matricaria chamomilla etc. and cut flowers Gladiolus and Lilium spp. yield much higher profits as compared to traditional crop cultivation, thus having a greater potential for employment generation and economic up-lifting of local farmers, while simultaneously reducing dependence on forests.
- Cash-crop based agriculture, horticulture, and floriculture is identified as a promising activity in the low-altitude zone below 1000 m above sea level. In the Himalayas the option of producing off season vegetables is profitable due to its proximity to markets of the plains.

Mitigating the impacts of changing climate scenario

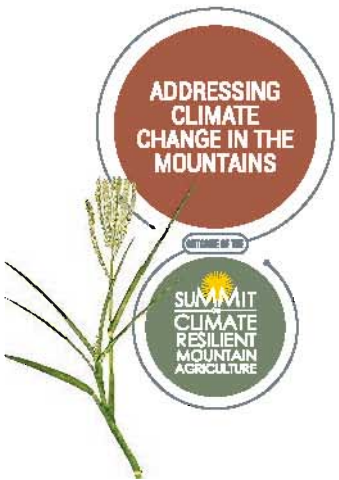
Hill agriculture is home to small land holdings that are largely rainfed, marginal and fragmented. As large areas in the hills are rainfed, there is a need to generate alternate sources of irrigation to increase the net irrigated area through rain water harvesting, and use of efficient water management techniques, initiatives/interventions to improve in-situ soil moisture regimes, and comprehensive landscape management. The session discussed on the approaches that mountain farming communities need to adopt to the changing climate scenario.



- In the changing climate scenario there is a need for sustainable crop production intensification (SCPI). As per FAOvi, SCPI means productive agriculture that conserves and enhances natural resources through an ecosystem approach that capitalizes on natural biological inputs and processes. It reduces the negative impacts on the environment and enhances natural capital and the flow of ecosystem services. SCPI also contributes to increasing systems' resilience – a critical factor, especially in light of climate change. SCPI can be achieved through good farming practices that are based on improving efficiencies and managing biological processes. It is based on agricultural production systems and management practices that include:
  - maintaining healthy soil to enhance soil-related ecosystem services and crop nutrition;
  - cultivating a wider range of species and varieties in associations, rotations and sequences;
  - using quality seeds and planting materials of well adapted, high-yielding varieties;
  - adopting the integrated management of pests, diseases and weeds; and
  - managing water efficiently.
- There are many different approaches and practices for sustainable crop production that can contribute to climate change mitigation. As with climate change adaptation, these approaches and practices can provide options for location-specific contexts and should be adapted with local farmers/farming communities. Examples include: conservation agriculture; soil compaction management; improved farming systems with several crop rotations; crop diversification; promotion of legumes in crop rotations; growing cover and mulch crops; restoration of degraded lands; soil management practices that reduce fertilizer use; integrated nutrient management; growing nutrient-use efficient crops; integrated crop and livestock systems; dedicated energy crops to replace fossil fuel; emission control and reduction (combustion engines, animal waste); water management/conservation, irrigation, water table management; and agroforestry.
- Participatory water resource development in hilly areas plays a crucial role in mitigating climate change. The experts outlined the water availability issue as: water distribution is not properly channelized and balanced in mountain areas as only 12 per cent agricultural land (in hill districts of Uttarakhand) is under irrigation. Inter-watershed water transfer model demonstrated by Indian Institute of Soil and Water Conservation (IISWC), Dehradun at Hattal and Sainj in Dehradun district, is worthy of emulation and replication. Small tanks are more sustainable than the large tanks as tremors often rock the region. Mud plastered and chir pine leaves can be layered to make these structures stronger and to reduce leakage.
- In the present changing climate scenario water harvesting linked with fish farming through advanced technological interventions is necessary to generate livelihoods, and reduce the impacts of environment change on animal husbandry. A model of polyculture of carp in low density poly ethylene (LDPE) film lined pond has been standardized for exotic carps (Hypophthalmichthys molitrix, Ctenopharyngodon idella, Cyprinus carpio) and algae phagus, eurythermal minor carp (L. dyocheilus) has been demonstrated by the ICAR-Directorate of Coldwater Fisheries Research, Bhimtal in the state, which is a climate resilient model

for the lower and middle Himalayan region with average fish production of 0.7 kg/ m3.

- El Nino trend is significantly correlated to drought and flood in many parts of the country. Climate change exacerbates the effects of El Nino in agriculture. Farmers and governments needs to be aware about the effect, and develop measures to overcome the impact of El Nino on agriculture. Contingent crop planning is critical, and farm advisories are crucial for farmers to delay planting in mountain regions to mitigate impact of El Nino. Several short duration crop varieties have been identified for both Kharif and Rabi seasons.
- There is a strong need to ensure seed security, through creation of traditional seed banks. Cryogenic preservation must be promoted in cooperation with National Bureau of Plant Genetic Resources (NBPGR) and other such institutions, to preserve mountain biodiversity and to sustain mountain agriculture.
- Use of Remote sensing and GIS applications are important techniques in planning mitigating measures, and in soil and water conservation activities. Drainage pattern, morphology and geological history available through remote sensing and overlaying of layers through GIS could be used for improved agriculture, improved terracing, and enhancing irrigation facilities. Erosion control and mitigation measures through 3-D model can be planned accordingly. Potential erosion area could be mapped, and conservation plans can be accordingly drawn.



Alternative economically viable livelihood options for the mountain farmers

The hill farmers traditionally practice an integrated farming system which includes agriculture, horticulture and livestock. In Uttarakhand, the geographical attributes and climatic conditions are favorable for various livelihood options including orchards, off-season vegetables, spices and floriculture. Also, at the same time traditional practice of livestock rearing is critical to rural prosperity. How these livelihood options can be integrated to create a triple win situation for the hill farmers is the question?

To identify such economically viable livelihood options, various ideas and case studies were presented and discussed during the session:

- Wide range of agro-biodiversity is available in the mountains, which has yet to be exploited scientifically for livelihood improvement and employment generation of rural population. Biodiversity is not a choice but it is our necessity which needs to be understood and conserved for sustainable utilization in the long term. Community-managed agriculture system based on groups of producers and consumers (Farmer Producer Organisations-FPOs, Farmer Federations-FFs) connected through identified products could open new avenue for livelihoods promotion.
- Various farming situations adopted in the mountains like mixed farming (crops and livestock) in diverse mountain regions – from alpine meadows and to river valleys - were discussed in detail, but mixed farming was found most suitable and important based on production and demand for major food groups.
- Direct use of diverse food resources of wild species is also very useful for healthy diets in mountain regions which have a huge demand in the emerging nutra-ceutical market. Traditional spices such as jamboo and gandhraini also need to be revitalized along with traditional millets like red rice, barn-yard millet, pearl millet etc. to bring forth as frontline nutrient crops. The existing food and nutrition related health and agriculture policies need to be reassessed, and cross sectoral implementation strategies should be developed.
- Animal husbandry is also affected from adverse impacts of climate change and one of the most important indicators is gradual reduction in milk production. Therefore, conservation of indigenous breeds is a must to counter the emerging trend. The reproductive potential of each normal newborn calf is significant but only a fraction of this reproductive potential of an outstanding individual is realized by natural breeding. Livestock improvement through embryo transfer technology is suggested as best viable alternative to exploit and enhance the natural ability of

conception and reproductive potential of cattle. About 300 calves of Red Sindhi breed have been developed using embryo transfer technology and distributed to various users by the Animal Husbandry department of the Uttarakhand State.

- As informed by Center for Aromatic Plants, Dehradun about 3 lakhs hectare of barren land of Uttarakhand can be rehabilitated using cultivation of aromatic plants as these are stress tolerant, suitable under rainfed conditions, good soil binders which check soil erosion, safe from wildlife, and may be suitable candidate for carbon sequestration. Further, development of aroma enterprises may provide new employment opportunities. On farm establishment of distillation units may also be useful value addition for employment generation.
- Off-season tomato farming has become a lifeline for Chakrata (Jaunsar babhar region) in Dehradun, and in Uttarkashi and Tehri Garhwal districts, but productivity is declining every year due to various reasons like lack of appropriate awareness among cultivators, disease and pest attack, poor nutrient management, and availability of improved seeds. Therefore, climate smart agricultural practices need to be promoted among farmers by providing demonstration and training for better package and practices and productivity enhancement. Seeds of improved and hybrid variety need to be distributed to farmers.

Creating an ecosystem of remunerative markets under changing climate

With migration from hills a growing trend, developing infrastructure in the hinterland with business plans that ensure better return on investment in developing a marketing chain holds special significance. Improving the lack of basic infrastructure in the remote hills, poor connectivity and absence of livelihood opportunities can transform local livelihoods. Can organizing farmers into federations, value additions /processing units, transit storage and collection centers, and marketing facilities offer innovative marketing solutions?

Globally, mountains are being considered more vulnerable due to higher rate of observed changes in climate and extreme events. Such trends in Uttarakhand are more than the global averages. Changes in climatic patterns will influence the distribution of agro-ecological zones (as reflected by cultivation of apple in higher elevations), stresses to crops (drought and temperature), and introduction of new pests and re-distribution of diseases. Such new events have long-term implications for the viability of agro-ecosystems of the region where large part of population falls in the category of marginal or small cultivators. In this light, the deliberations highlighted following products and their market potential:

- Alongside productivity enhancement techniques for each crop; there is a strong need for adopting collective approach of production and marketing. For this purpose the community capacity building is required for increasing awareness on collective farming, and strengthening of local institutions to facilitate such a transition.
- Apart from off season vegetable cultivation, floriculture is one of the alternate sources of income. Especially, chrysanthemum and lilium have potential for their self-propagation properties, and flower quality under prevailing environmental conditions. These are short duration crops and can provide alternate source of income to the farmers under wildlife infested small land holdings.
- Spice cultivation in the hills e.g., ginger, turmeric, garlic, is an economically viable option. These could fetch a good price due to its geographical mark both in the food and pharmaceutical sector. However, promotion of spices would need quality grading, packaging,

grinding, value addition and effective market channel for wider adoption.

- Cultivation of essential oils is another viable livelihood option in the hills. Lemongrass oil is one of the most important essential oils produced in the world. India is the largest producer of lemon grass and about 80 per cent oil is being exported. There is a huge export market for it, and mountain environments are conducive to its growth.
- Diploknema butyracea (Cheura or Indian butter tree) is an important oil seed tree. The oil known as phulwa or phulwara ghee is used for cooking and frying. It is also used for preparing medicines, ointment, candles, cream and other user friendly products. The cake produced after processing of cheura is used as manure, and has properties for use as a wide-ranging pesticide.
- For the successful dairy development intervention there is a need to design a project which aims to build the value chain in the particular area by identifying its potential at a cluster level to create surplus, and generate opportunities for value-addition and marketing by enhancing the forward linkages to the niche markets. To further this concept, mass artificial insemination with Female Sorted Sexed Semen Technology can be helpful to induce heat through the process of 'Heat Synchronization' followed by 'Induction of ovulation' through hormonal therapy for building a productive herd.
- Besides such potential options, developing understanding on rural people's adaptive capacity to ascertain the effectiveness of such interventions is critical towards designing a mitigation strategy. Effectiveness will also be ascertained by sharing of lessons across different mountain regions and sub-regions, and by working out partnership between institutions in enhancing capacity of different stakeholders in managing climate change risks in agriculture and allied sectors.
- Driving actions, use of traditional knowledge, and locally evolved innovations in diverse conditions are pre-requisites for developing product range for building mountain agro-supply chain for improving local incomes. An early investment in infrastructure development and prioritized research will accelerate adaptation at a large scale, and will contribute significantly to improving local economy.

The implementation of ongoing Gramya-II and ILSP-WD in the natural calamity prone rainfed areas of Uttarakhand has come as a boon to the villagers. The projects are aimed to promote sustainable agriculture, vegetable farming, animal husbandry, rainwater conservation and harvesting. The project activities are creating alternate employment opportunities for the youth, which was evident in the presentations made by the participating farmers. Many farmers shared their success stories/ experiences of building climate resilience and livelihood opportunities generated in their villages.

FARMERS VOICE

ADDRESSING CLIMATE CHANGE IN THE MOUNTAINS

SUMMIT ON CLIMATE RESILIENT MOUNTAIN AGRICULTURE

The underlying theme of the presentations was:

- Improved water availability is helping in cultivation of abandoned and rain-fed agriculture lands.
- Diversification into off-season vegetable production is giving good economic returns to the farmers.
- Rejuvenation of traditional drying up water sources through various moisture conservation interventions is yielding positive results.
- Improved agriculture practices like- Poly house, drip irrigation, use of bio-pesticides, vermi-composting are giving promising results to the farmers.
- Farmers are motivated to do cluster based agriculture and horticulture farming.

Ranjeet Singh from Dehradun shared his success story on tomato cultivation which helped him earn Rs 80,000 during the year. In addition, he produced 48 quintals of vermi-compost which helped cultivate many off-season vegetables in polyhouse.

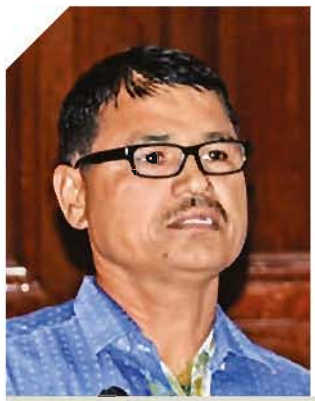
RANJEET SINGH

Birendra Singh Bisht, Dehradun talked about the cultivation of promising horticultural crops such as malta, citrus, apple, walnut, and vegetables (tomatoes and peas) in his own land with facilities of polyhouses, water tanks, and pipes provided by the project.

BIRENDRA SINGH BISHT

Jagat Singh Chauhan, inspired by the farming community in Himachal Pradesh, adopted 'Samuhik-Kheti' (community farming) to maximize limited irrigation facility in the village. With the help of fellow farmers, he successfully converted 60 nali (1.2 ha.) of barren land to arable land where the cultivation of tomato, brinjal, and capsicum has been successfully taken up.

JAGAT SINGH CHAUHAN



Anand Singh, an enthusiastic farmer from Pithoragarh, shared his experience about successful cultivation of vegetables (tomato, potato, brinjal) on 8 ha of land that was lying fallow before water tanks and pipelines were laid out in his village. Revival of village ponds helped in development of fish farming as an economic activity. The impact of six units of solar lighting systems reduced wildlife menace.

ANAND SINGH

Lokendra Prasad Raturi from Uttarkashi was exuberant about his experience with poly-houses which helped him harvest 6-7 times higher production of off-season vegetables like potato, tomato, lady finger, and brinjal. He emphasized on reviving cultural and aesthetic values, and generation of livelihood opportunities to check migration of peoples from villages.

LOKENDRA PRASAD RATURI

Jeevan Singh Dhanu from Pithoragarh, focused on the need for land, water and forest conservation in vulnerable regions. People have migrated and continue to do so in search of better livelihood options. Fortunately, with the construction of check dams, ten water sources are now revived. Many people are engaged in farming, and are leading safe and healthy life now.

JEEVAN SINGH DHANU

Rajendra Singh, shared his experience on the successful cultivation of tomato and broccoli after the establishment of poly houses, vermi-compost pits and drip irrigation system. His innovative work of using bio-pesticide made of walnut leaves, garlic, and cow urine as the main ingredients helped in the cultivation of 17 quintals of tomato within a short span of 3 months, valued at Rs. 17000.

RAJENDRA SINGH

Mukesh Tewari from Dehradun mentioned that the establishment of 19 vermi-compost pits is highly remunerative as the production of 48 quintals per annum/ pit has been achieved which he is successfully marketing. and also using it for his own farming purposes. He successfully cultivated Chrysanthemum and many off-season vegetables in the established poly houses.

MUKESH TEWARI

The farmers session was concluded by Padma Sri Prof. Shekhar Pathak by putting succinctly:

"We cannot make a farmer learn agriculture but facilitate him by imparting knowledge of improved agriculture practices and motivating the community to replicate the same in other agriculture lands"

The Climate Summit concluded with a valedictory function chaired by the H.E Governor of Uttarakhand, Dr. Krishan Kant Paul, in the presence of the Hon'ble Minister of Agriculture, Uttarakhand Government, Shri Subodh Uniyal and Mr Ranjan Samantaray, Senior Agriculture Specialist, Agriculture Global Practice, The World Bank.

VALEDICTORY MESSAGE

DR KRISHAN KANT PAUL

H.E The Governor
of Uttarakhand

Since the average landholding size of hill farmers is small and the state is facing production crisis on account of climatic variability, it is high time an integrated farming approach is adopted, where horticulture, off-season vegetable cultivation, animal husbandry, poultry, mushroom cultivation, and bee-keeping are packaged to improve livelihood options in the mountain areas.

SH. SUBODH UNIYAL

Hon'ble Minister of Agriculture,
Agriculture Marketing & Processing
and Horticulture

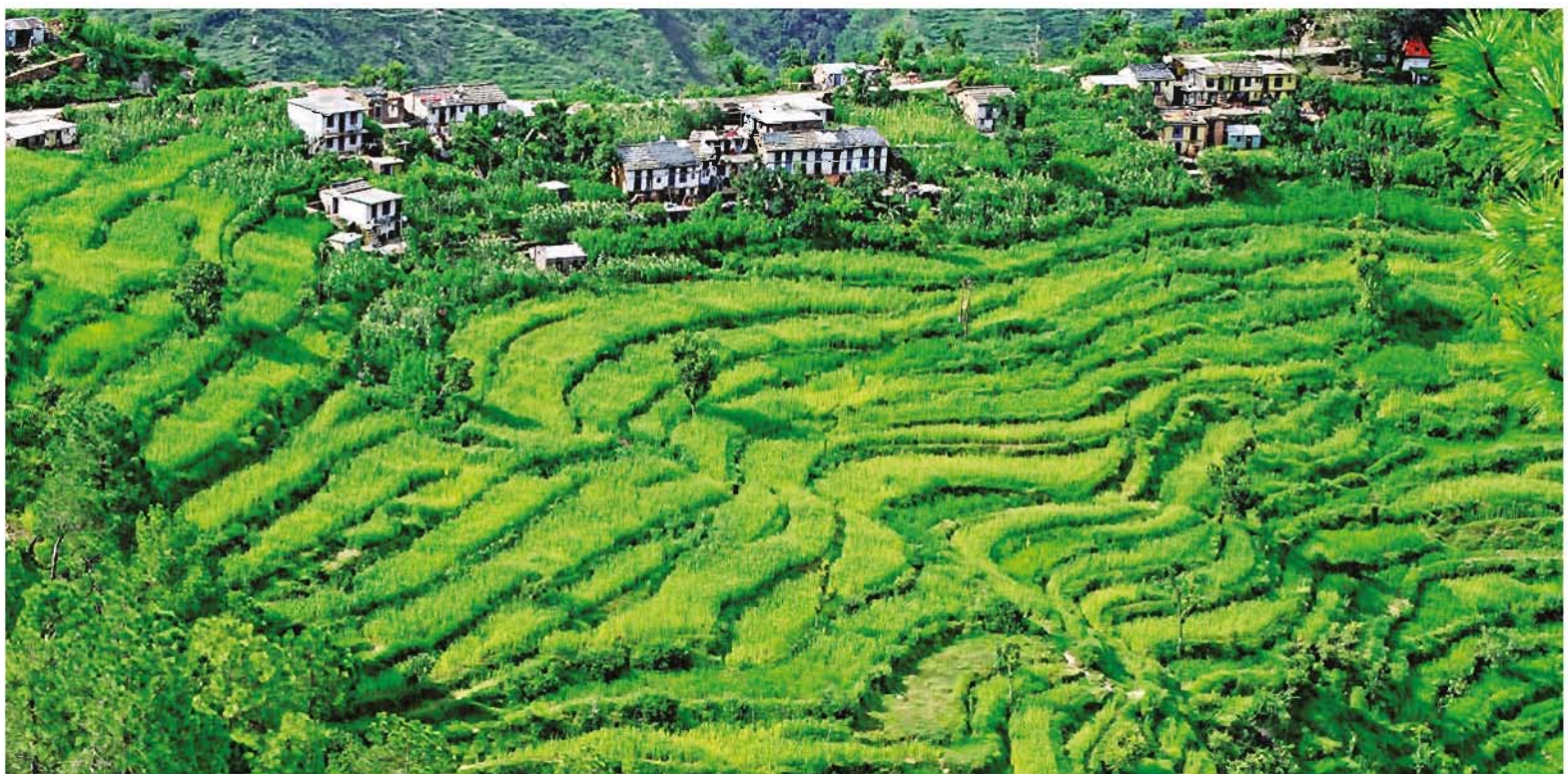
Farmers do not know the trends in the market. If they know which crop will be more profitable next season, they can cultivate those crops. Also, there are many farmers who have small lands and cannot bear the cost to transport their produce to market. Thus, co-operative farming is necessary, where a group of farmers can share the cost of transportation and other related expenses.

SH. RANJAN SAMANTARAY

Senior Agriculture Specialist,
World Bank

Gramya project has already demonstrated the farmers' income could be doubled through efficient natural resource management by the communities along with diversification of agriculture, backed by value addition and agri-marketing.

- Whilst the plenary discussions addressed macro policy challenges before the agriculture sector including the long-overdue land consolidation of fragmented landholdings, technical sessions presented scientific developments and take home alternatives/messages for the farmers. That a large number of farmers were in attendance and there were dedicated sessions where farmers spoke on their experiences and challenges, the Summit created an interactive forum for science-practice-policy interface on a subject that is of greater significance in light of the stated policy for 'doubling farmers income'.
- Avenues for doubling farmers' income through cooperative farming integrating agriculture, horticulture, fishery, and animal husbandry were showcased. Improving storage facilities at the local level is critical for improving farmers bargaining power with a volatile market. Although successful cases have been demonstrated, the challenge is to scale up climate-smart initiatives at the state level to enthuse younger generation to take up agriculture as a remunerative vocation, and to create a conducive ecosystem for reversing migration to bring abandoned lands under cultivation again.
- Average land holding of less than 1/3rd of a hectare poses formidable challenge in sustaining productivity at desired levels. The deliberations stressed the need for reassessing land resources in the state from its current land use status, and the households dependent on agriculture. Land database can provide insights on location specific issues and help the state strategize actions to transform the farming scenario in the state. While the terai region provides food security in the state, niche crops (traditional and off-season) in the hills deserve attention through incentives for the farmers to grow such crops. Whether it is done through a Support Price Mechanism or Payment for Biodiversity Services, it needs to be taken up at the highest level of policy making in the state. There is growing demand for mountain biodiversity of crops, fruits and herbal wealth.
- Water is critical to mountain agriculture, and assumes special significance as climate change induces spatial variability with untimely rain events. Experts stressed the need for a decision support system that brings weather forecast to farmers on a weekly basis. Crop water requirements and crop water budgeting are other areas that need focused attention in helping farmers adopt crops and agronomic practices that are proven resilient to such fluctuations in temperature and available water in the mountain regions.



In the three-day deliberations wherein scientists, researchers, policy makers, project managers and farmers came together on a common platform, it became clear that resilience in the mountain agriculture can be built by implementing a climate smart agriculture (CSA) approach. While there is no denying that there is a need for an integrated farming systems which includes agri-horti-livestock production system along with fisheries and apiculture, CSA approach can only yield desired results if implemented at the landscape level with a participatory approach wherein the community plans, implements and monitors the various sustainable natural resource management interventions, an approach that World Bank funded UDWDP-II (Gramya) has successfully piloted and institutionalized at the local level.

Climate-smart agriculture (CSA), as defined by FAO, integrates the three aspects of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars:

1. sustainably increasing agricultural productivity and incomes;
2. adapting and building resilience to climate change;
3. reducing and/or removing greenhouse gases emissions, where possible.

Enhancing food security while contributing to mitigate climate change and preserving the natural resource base and vital ecosystem services requires the transition to agricultural production systems that are more productive, use inputs more efficiently, have less variability and greater stability in their outputs, and are more resilient to risks, shocks and long-term climate variability. It warrants a major shift in the way land, water, soil nutrients and genetic resources are managed to ensure that these resources are used more efficiently. Making this shift requires considerable changes in policies, and local governance to deliver effective actions on the ground.

Though different on scale, the landscape approach is akin to watershed management approach as it manages production systems and natural resources to produce vital ecosystem services, and is small enough so the action can be carried out by the people using the land and producing those services. Key strategies for ensuring that the landscape approach and watershed management approach can adapt to change include: sustainable soil and water management practices; the active promotion of biodiversity; and the diversification of income sources inside and outside the farms. However, managing landscapes demands an understanding of how the needs of local communities can be addressed without eroding biodiversity and disprupting the functioning of ecosystems. To achieve successful outcomes, the people who have an impact on the landscape must come together to plan and negotiate acceptable practices and management actions.

CSA is not a standalone approach but one that complements ongoing research and development activities in relation to climate change adaptation in agriculture, and seeks to mainstream objectives that lead to scaling-up practices that can make agriculture smart enough to confront climatic variability. These include actions:

- to identify, test and screen prominent climate-smart agriculture (CSA) technologies, practices and services for the different agro-ecological and socioeconomic contexts, with the participation of local communities and small businesses.
- to develop 'pathways to scale-up' – defined as the sequence of steps used to promote the diffusion of technologies to scale, to have broader positive impact – and implementation plans to champion CSA technologies in collaboration with local communities and government stakeholders.

THE WAY FORWARD

- to communicate and engage with key stakeholders to make informed decisions for climate change adaptation in agriculture by creating an institutional base to forge inter-departmental and inter-stakeholders synergies including markets and private operators.

Local stakeholders and institutions responsible for coordinating and facilitating landscape management activities need to be empowered to make informed decisions with a long-term perspective. It is essential to audit the state of land, water and other natural resources in a way that quantifies the impacts of climate change. Ideally this should be done at the river basin, watershed, or agro-ecosystem level. CSA approach to build climate resilience and adaptation in mountain agriculture is the way forward which on one hand would address the ecological issues in the Himalayan region and address the socio economic issues facing the marginalized mountain farming communities on the other. Specific climate smart recommendations include:

1. Weather Smart: There is need to conduct modeling studies to assess the impact of climate change under varying altitudes and diverse agro-climatic zones, by using regional climate change projections and future vulnerabilities to develop short term adaptation and long term resilience strategies for mountain agriculture. Develop reliable agro-met services for a smaller unit of area (preferably at a watershed scale), and link farmers to such services on a real time basis.

2. Water Smart: Crop water budgeting needs to be assessed to help farmers adapt to water-saving crops and agronomic practices. Such assessments should be the precursor to development of water corpuses in the areas where agriculture is solely dependent on rain water. Reviving traditional ponds and water sources, constructing structures for harvesting and storage of rain water based on water demand need to taken up by line departments at the earnest.

3. Carbon Smart: Integration of agroforestry and horticulture by providing necessary planting materials is imperative for building carbon stocks in soils. Promotion of organic practices by research and extension agencies will not only reduce cost of production but reduce dependency on external inputs on small farms. Enhancing organic carbon in soils is critical for making smallholder farming resilient to location specific moisture and temperature variations.

4. Resource Smart: Land consolidation or any other alternate practical solution should be adopted to cope with the challenges of fragmented hill farming. Cooperative farming should be adopted as a policy, by giving incentives to absentee land owners to contribute to resource conservation and productivity enhancement in the villages which is being adopted by the Uttarakhand Govt. IUCN has developed Restoration Opportunities Assessment Methodology (ROAM) which should be utilized to identify degraded lands for restoration and afforestation/cultivation.

5. Market Smart: Collective production, value chain creation and marketing for nutritious coarse grains could help in increasing farmers' income. Crop diversification, off-season cultivation of crops, promotion of medicinal and aromatic crops, and building transit storage facilities are critical for product aggregation and linkage with the markets. With mobile technologies having made inroads into the mountains, market intelligence should merit urgent consideration. Uttarakhand government has taken an initiative of setting up Agribusiness Growth Centers in the hill districts of the State with an objective to support the farmers in exploring, developing, processing, marketing, knowledge sharing, information dissemination and financing of the niche farm produce in the village clusters.

To achieve the objective of building climate resilience in mountain agriculture, there is a need to bring the policy makers, research institutions and implementing departments on a common platform, so that the mitigation and adaptation interventions are implemented on a landscape approach. It was suggested that at government level, a nodal agency may be setup to develop the cross sectoral linkages for sharing and replication of experiences and technical expertise to implement climate smart approaches.

Unless institutional development is engineered at micro, meso and macro levels, the system may not be resilient to address challenges of changing climate. To embody such transformative agenda, and for scaling-up climate smart techniques and practices at the state-level some serious efforts on convergence would need to trigger the integration of climate-smart approaches in inter-departmental development programs.

GLIMPSES OF FARMERS' EXHIBITION

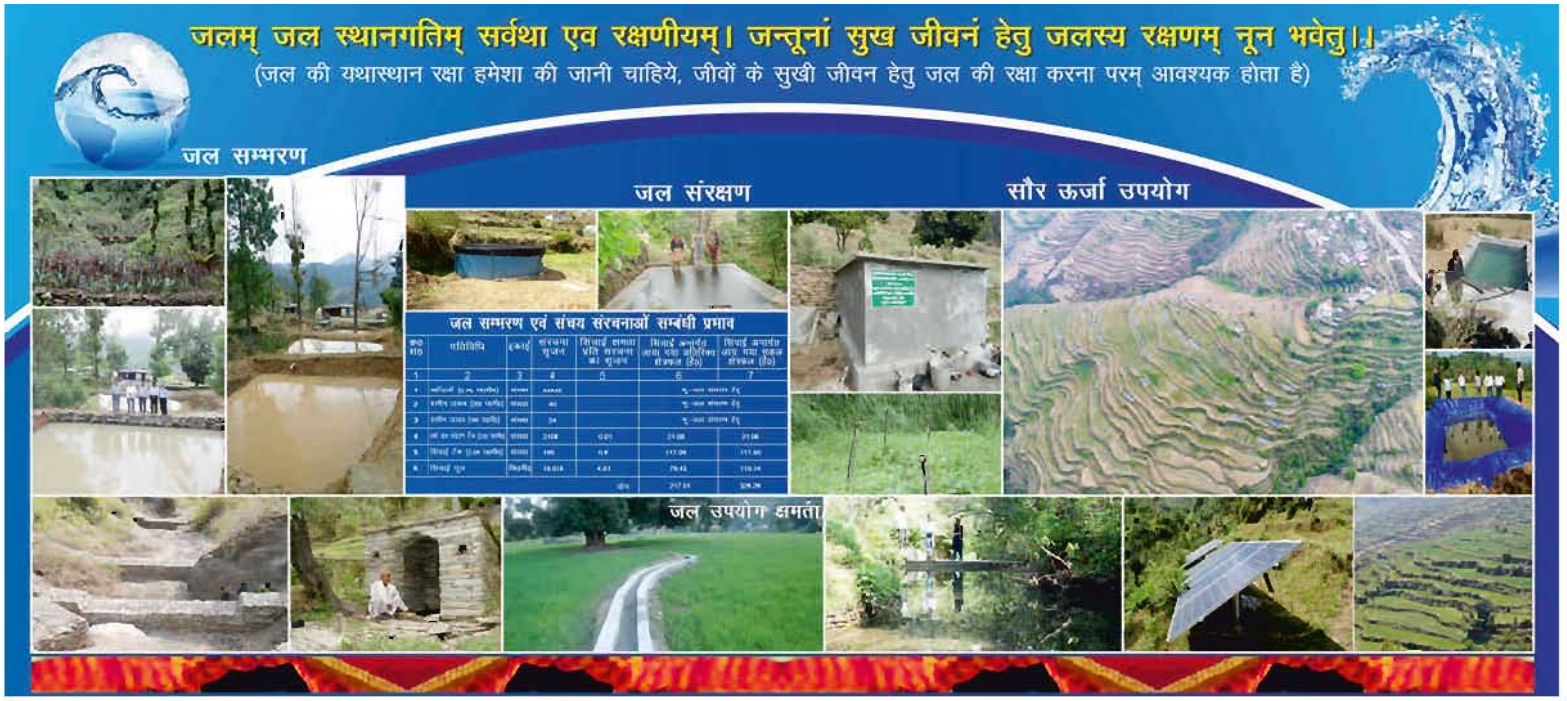
ADDRESSING CLIMATE CHANGE IN THE MOUNTAINS

SUMMIT
CLIMATE RESILIENT MOUNTAIN AGRICULTURE


सौर ऊर्जा (Solar Energy) तथा जल संरक्षण कार्यों के सम्मिलन से ठोस विकास
उत्तराखण्ड विकेन्द्रीकृत जलागम विकास परियोजना- 2, पौड़ी


कृषि उत्पाद, मूल्य वर्धन एवं विपणन
उत्तराखण्ड विकेन्द्रीकृत जलागम विकास परियोजना (ग्राम्या) फेज-2, टिहरी प्रभाग- चम्बा


अर्थेभ्योऽपि हि वृद्धेभ्यः संवृतेभ्य इतस्ततः।
प्रवर्तन्ते क्रियाः सर्वाः पर्वतेभ्य इवापगाः।।
(जिस प्रकार कठोर पर्वतों से निकलकर नदियों का जल सभी को तृप्त करता है, उसी प्रकार कठिन परिश्रम द्वारा
अपने आसपास अवस्थित स्रोत को पहचान, उससे धनार्जन करते हुए जीवन की आवश्यकताओं की पूर्ति संभव है)


जलम् जल स्थानगतिम् सर्वथा एव रक्षणीयम्। जन्तूनां सुख जीवनं हेतु जलस्य रक्षणम् नून भवेतु।।
(जल की यथास्थान रक्षा हमेशा की जानी चाहिये, जीवों के सुखी जीवन हेतु जल की रक्षा करना परम् आवश्यक होता है)
जल सम्भरण
जल संरक्षण
सौर ऊर्जा उपयोग
जल सम्भरण एवं संचय संरचनाओं सम्बंधी प्रभाव
जल उपयोग क्षमता


सुबीजम् सुक्षेत्रे जायते सम्पादयते – ऋग्वेद
(Good Seed in Good Soil Yields Abundant!- Rigveda)
प्रमाणित बीज उत्पादन (कु.)
जागनाथ कृषि बीज उत्पादक संघ, आरतोला स्थापना

PLENARY SESSION 1

Agroforestry : Means for Climate Resilient Mountain Agriculture

Moderator

Dr. Savita, Director, Forest Research Institute, Dehradun

Panelists

Dr. Jagdish Chander, IFS, Chief Conservator of Forest, Haryana

Dr. R.C. Dhiman, Ex. CEO, WIMCO Seedling Ltd. Rudrapur

Sh. Ranjeet Raina, President, Haryana Agroforestry Farmers Association

Dr. Ashok Kumar, Scientist F and Head Genetics and Tree Propagation Division, FRI

PLENARY SESSION 2

Can mountain farmers' income be doubled through agriculture?

Moderator

Dr. Sudhirendar Sharma, Environment Consultant

Panelists

Dr. Suhas Wani, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad

Dr Brij Mohan Pandey, ICAR–Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora

Prof. N. P. Melkania, Gautam Buddha University, Noida

Dr. Sanjay Dwivedi, Director, Defence Research and Development Organisation, Tejpur, Assam

PLENARY SESSION 3

Is improving water productivity and water use efficiency solution to the productivity-sustainability conundrum afflicting mountain agriculture?

Moderator

Dr. Sudhirendar Sharma, Environment Consultant

Panelists

Prof N H Ravindranath, Indian Institute of Science, Bangalore

Prof. M. Sekhar, Dept. of Civil Engg., Indian Institute of Science, Bangalore

Dr Anand Sharma, Regional Coordinator western and central Himalayas/Scientist-F at AASD unit of IMD, New Delhi

TECHNICAL SESSION 1

Understanding economic imperative of climate resilient agriculture practices

Session chaired by

Dr P K Mishra, Director, ICAR-Indian Institute of Soil and Water Conservation, Dehradun

Prof. Y P S Dabas, Director Extension, GBPUAT, Pantnagar

TECHNICAL SESSION 2

Mitigating the impacts of changing climate scenario

Session chaired by

Dr. R. Dobhal, Director General, UCOST, Dehradun

Dr. Anand Sharma, Scientist-F, IMD, New Delhi

TECHNICAL SESSION 3

Alternative economically viable livelihood options for the mountain farmers

Session chaired by

Ms. Jyotsna Sitling, JS, Govt. of India

Dr. B.S. Negi, Retired Director, Horticulture, Govt. of Uttarakhand

TECHNICAL SESSION 4

Creating an ecosystem of remunerative markets under changing climate

Session chaired by

Mr Kapil Lall, Project Director, ILSP, WMD Dehradun

Mr M S Kunwar, HARC, Dehradun

LIST OF PANELISTS

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