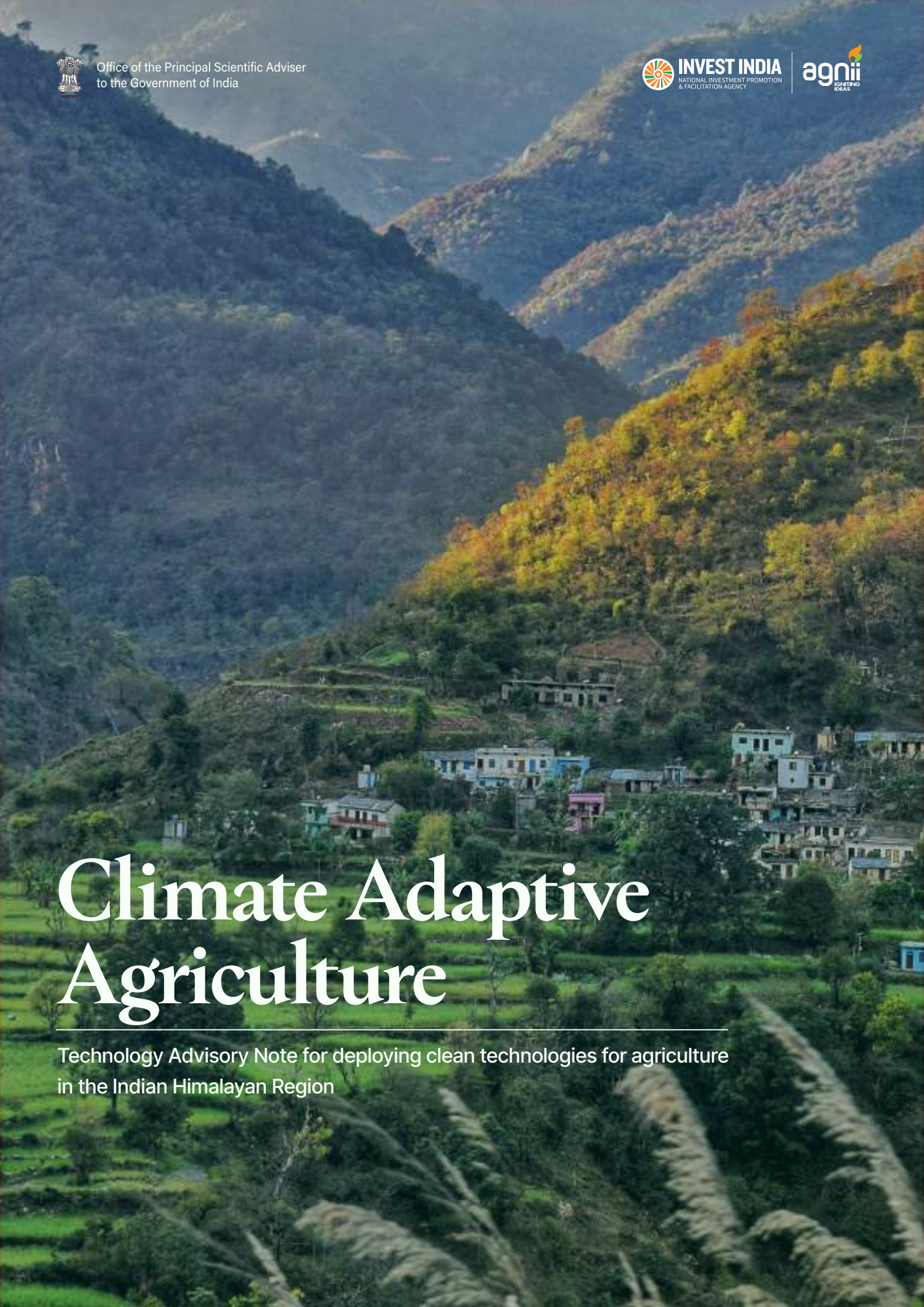

Office of the Principal Scientific Adviser
to the Government of India

INVEST INDIA
NATIONAL INVESTMENT PROMOTION & FACILITATION AGENCY

agnii
IGNITING IDEAS

Climate Adaptive Agriculture

Technology Advisory Note for deploying clean technologies for agriculture in the Indian Himalayan Region

Climate Adaptive Agriculture

Technologies for agriculture in the Indian Himalayan Region

Technology Advisory Note
June 2023

AGNIi Mission
Office of the Principal Scientific Adviser to the Government of India
Conducted in collaboration with Uttarakhand State Council for Science and Technology

Project Team - Sanchita Joshi, Sanish Kulkarni, Vishad Vivek Singh, Naitik Dharmesh Udeshi, Shubham Tomar

Research Team - Garima Raj, Prakarsh Mishra, Nidhi Sharma *with contribution acknowledged from Tanvi Sangri*

Project Oversight: Sanid Patil, Rahul Nayar, Vikrant Khazanchi

Cover, Design and Composition: Shubham Tomar

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Please send queries to: AGNIi, 110, Vigyan Bhavan Annexe, 001, Maulana Azad Rd, New Delhi, Delhi 110001, Tel.: (011) 011-2304-8155, Email: agnii.innovator@investindia.org.in

Acknowledgments

This Technology Advisory Note elaborates the work undertaken by AGNIi Mission under Project Climate Adaptive Agriculture to develop a scalable pioneering example of how Indian technological innovation can enable climate adaptive agriculture; and will subsequently support administrative action. The project was conceptualized and executed by the AGNIi Mission (from the Office of Principal Scientific Adviser, Government of India executed in partnership with Invest India) in collaboration with Uttarakhand State Council for Science and Technology (UCOST), Department of Information and Science Technology, Government of Uttarakhand.

At the onset, we extend our gratitude to the Office of the Principal Scientific Adviser to the Government of India for their guidance and support. We sincerely thank Prof. Ajay Kumar Sood, Principal Scientific Adviser to the Government of India for his encouragement and vision. Our gratitude to Dr. Parvinder Maini (Scientific Secretary, Office of the Principal Scientific Adviser to the Government of India) for her guidance and oversight during the projects. We are very grateful to Dr. Preeti Banzal (Adviser/Scientist 'G', Office of the Principal Scientific Adviser to the Government of India) for her consistent advice, direction, and support.

As Uttarakhand emerges as a pioneer state for implementing technologies to tackle climate change, we extend our gratitude to the Hon'ble Chief Minister of Uttarakhand Shri Pushkar Singh Dhami for entrusting AGNIi Mission to enable technology enabled interventions for climate resilience, which will help develop Champawat as an Adarsh Zilla under the Uttarakhand@25initiative under the guidance of UCOST; which can also be emulated and scaled across the other Indian Himalayan states. We acknowledge and extend our gratitude to Prof. Durgesh Pant (Director General, UCOST), Dr. Piyush Joshi (Sr. Scientific Officer, UCOST), and Mr. Prahalad Adhikari (Coordinator, Adarsh Champawat) for their guidance and support during the Project.

We express our sincere gratitude to Ms. Jyotsna Sitling (Principal Chief Conservator of Forests – Van Panchayats, Uttarakhand during the project) for sharing of her experience and advice about community behaviour and helped facilitate AGNIi Mission's fieldwork among rural hill communities in different Van Panchayats across Champawat district.

We express our sincere thanks to Mr. Narendra Singh Bhandari, IAS (District Magistrate, Champawat), Mr. Rajendra Singh Rawat (Chief Development Officer, Champawat), Mr. Ramesh Chandra Kandpal (Divisional Forest Officer, Champawat) and representatives from various line departments for their unstinting support in the field.

We are especially grateful to Padma Bhushan Dr. Anil Joshi (Founder, HESCO), Dr. K.V. Ramana Rao (Principal Scientist and Head, Irrigation and Drainage Engineering Division, ICAR-Central Institute of Agricultural Engineering, Bhopal), Dr. Nitin Maurya (Scientist E, National Innovation Foundation - India) and Dr. Lal Singh (Director, Himalayan Research Group) for their expert inputs primarily with respect to technology evaluation furnished to AGNIi Mission during the Technical Session (Pioneering Climate Adaptive Innovations for the Himalaya: Uttarakhand as an Exemplar) organised by the Mission under the aegis of the Rural Science Congress, Dehradun.

Also, we acknowledge and extend our gratitude to community collaborators - Dr. Dinesh Raturi (Project Officer, BAIF Research Development Foundation), Dr. Himani Purohit (Himalayan Environmental Studies and Conservation Organisation [HESCO]), Dr. Ravish Joshi (HESCO/Kumaon Agriculture and Greenery Advancement Society), Ms. Ruth Joanne D'Costa (Hai Jalo), Ms. Pratibha Krishnaiah (Himalayan Blooms), and the citizens of Champawat, especially its women for giving us their time and sharing in detail the various problems that afflict the agriculture practices of the hill.

Finally, and importantly, we deeply appreciate all the innovators who overcame significant logistical and weather challenges to showcase their innovations that can significantly help rural communities residing in the Indian Himalayan Region develop resilience in the face of the challenges climate change poses.

FOREWORD

Pushkar Singh Dhami

Hon'ble Chief Minister, Uttarakhand

पुष्कर सिंह धामी

मुख्यमंत्री, उत्तराखण्ड

उत्तराखण्ड सचिवालय,
देहरादून - 248001
फोन : 0135-2650433
0135-2716262
फैक्स : 0135-2712827

कैम्प कार्यालय
फोन : 0135-2750033
0135-2750344
फैक्स : 0135-2752144

संदेश

मुझे यह जानकर अत्यन्त प्रसन्नता हो रही है कि भारत सरकार के मुख्य वैज्ञानिक सलाहकार कार्यालय द्वारा उत्तराखंड विज्ञान एवं प्रौद्योगिकी परिषद (UCOST) के साथ मिलकर **'आदर्श चम्पावत'** के अन्तर्गत दूरस्थ ग्रामीण क्षेत्रों सहित सम्पूर्ण चम्पावत जिले के सर्वांगींण विकास एवं आजीविका संवर्धन हेतु देश में उपलब्ध अत्याधुनिक तकनीकी हस्तक्षेपों के अनुप्रयोगों में प्रयासरत है।

मा0 प्रधानमंत्री जी की विराट सोच के आधार पर उत्तराखण्ड को हिमालयी क्षेत्र के लिए **'आदर्श राज्य'** के रूप में स्थापित करने की दिशा में प्रदेश सरकार अति महत्वाकांक्षी उत्तराखंड @ 25 पहल पर बहुत संवदेनशील है। आदर्श चम्पावत इस विराट मुहिम की एक प्रयोगशाला है, जिसके माध्यम से हम जिले के दर्जनों रेखीय विभागों, केंद्र सरकार के संस्थानों, स्थानीय स्तर पर कार्यरत विभिन्न स्वयं सहायता समूहों तथा नागरिकों को एक मंच पर लाकर विज्ञान एवं प्रौद्योगिकी के सही इस्तेमाल से सतत् एवं एकीकृत विकास की रूपरेखा बनाने में अग्रसर हैं। चम्पावत का जनप्रतिनिधि और प्रदेश का मुख्य सेवक होने के नाते आदर्श चम्पावत के क्रियाकलापों, खासकर विज्ञान आधारित समाधानों में मेरी विशेष व्यक्तिगत रूचि भी है।

मुझे ज्ञात हुआ है कि मुख्य वैज्ञानिक सलाहकार के कार्यालय के अन्तर्गत अग्नि मिशन के दल द्वारा चम्पावत जिले के दूरस्थ ग्रामीण इलाकों का भ्रमण कर रोजमर्रा के जीवन की चुनौतियों का सघन अध्ययन किया जा रहा है। इस अध्ययन के आधार पर पहले चरण में देश भर से करीब एक दर्जन चुनिंदा स्टार्ट–अप कम्पनियों को साथ लेकर नरसिंह डांडा में स्थानीय लोगों के समक्ष जल एवं कृषि आधारित चुनौतियों से निपटने में सक्षम तकनीकों का भी प्रदर्शन किया गया। इस कार्यक्रम से सम्बंधित लोगों की प्रतिक्रियाओं, विभिन्न हितधारकों एवं प्रशासनिक अधिकारियों के सुझावों का संज्ञान लेते हुए गहनता से तकनीकियों का अध्ययन करने के उपरान्त अग्नि मिशन द्वारा संकलित यह तकनीकी सलाह पुस्तिका **(टेक्नोलॉजी एडवाइजरी नोट)** एक गुणवत्तापूर्ण दस्तावेज है जो आदर्श चम्पावत के साथ–साथ प्रदेश के सतत् विकास के क्रियान्वयन के लिए भी अत्यन्त महत्वपूर्ण सिद्ध होगी।

मैं इस तकनीकी सलाह पुस्तिका के प्रकाशन तथा राज्य को हस्तांतरण के लिए UCOST एवं अग्नि मिशन के पूरे दल सहित इस तकनीकी प्रदर्शन में उपस्थित सभी स्टार्टअप और स्थानीय नागरिकों को बधाई और हार्दिक शुभकामनाएँ प्रेषित करता हूँ।

(पुष्कर सिंह धामी)

FOREWORD

Prof. Ajay Kumar Sood

Principal Scientific Adviser to the Government of India

अजय के. सूद
भारत सरकार के प्रमुख वैज्ञानिक सलाहकार
Ajay K. Sood
Principal Scientific Adviser to the Govt. of India

सत्यमेव जयते

विज्ञान भवन एनेक्सी
मौलाना आजाद मार्ग, नई दिल्ली - 110011
Vigyan Bhawan Annexe
Maulana Azad Road, New Delhi - 110011
Tel. : +91-11-23022112
Fax: +91-11-23022113
E-mail : sood.ajay@gov.in
office-psa@nic.in
Website : www.psa.gov.in

Message

The Office of the Principal Scientific Adviser (PSA) to the Government of India is committed to advise and facilitate solving pressing socio-economic challenges with the intervention of science and technology. We believe that Indian technological innovation can, under the aegis of Aatmanirbhar Bharat, help better public service delivery, governance of schemes and welfare of the society.

Office of PSA is glad to work via our AGNIi Mission, with the Government of Uttarakhand via Uttarakhand State Council for Science and Technology (UCOST), on technological innovation for climate-sustainable development in the region.

For the Himalayan States, covering approximately 18% of India's geographical area and home to about 5% of her population, climate change is a crucial challenge. Climate change can potentially affect agriculture, livelihood, water, ecology, and the wider citizenry of the region. UCOST with the Office of PSA's support, intends to explore how technological innovation can help Uttarakhand's Mountain communities adapt and acquire resilience to these challenges. This partnership has identified, assessed, and demonstrated examples of technological interventions to meet out Himalayan State's climate resilience needs.

The results of this exercise, captured in this Technology Advisory Note, could support decision-making by public agencies on leveraging such innovation. Further, this initiative can offer important examples for wider emulation across India's Himalayan States.

I extend my sincere appreciation for the support and cooperation extended by UCOST, and State and District agencies; and look forward to touching further milestones through this important partnership.

Ajay K Sood

(Ajay K. Sood)

Dated: 15th June, 2023

FOREWORD

Prof. Durgesh Pant

Director General, Uttarakhand Council for Science and Technology (UCOST)

Prof Durgesh Pant
Director General

UTTARAKHAND STATE COUNCIL FOR SCIENCE AND TECHNOLOGY
Deptt. of Information and Science Technology, Govt. of Uttarakhand
VIGYAN DHAM, Vigyan Sadan Block, Jhajra, Chakrata Road
Dehradun - 248 015, Uttarakhand, INDIA
t) 0135-2976266; e) dg@ucost.in, ucost.dg@gmail.com; w) www.ucost.in

MESSAGE

I am delighted to note that AGNIi team from office of Principal Scientific Advisor (PSA) to Government of India is working very closely with Uttarakhand State Council for Science and Technology (UCOST) in Adarsh Champawat initiative. Being a test bed for ambitious Uttarakhand@25 mission of Honorable Chief Minister Pushkar Singh Dhami Ji, Adarsh Champawat is an important and critical initiative not only for Uttarakhand state but also for all the states in Himalayan region.

It gives me pleasure to learn that a qualified, young and energetic team has been deputed on the ground which is working cohesively with UCOST to drive Science and Technology interventions in remote villages of Champawat. I am confident that the first sprint of Technology showcase covering climate adaptive Water and Agriculture held on 16th March, 2023 at Narsinghdanda has helped people from nearby areas to understand relevance and use of innovative technology solutions to address local challenges.

These initial efforts through field studies, rural immersion, interactions and showcases would not only help us in enabling holistic development of the state but also in ensuring value addition towards larger objective of creating a climate adaptive Technology Solution Architecture (TSA) for Himalayan ecosystem.

This Technology Advisory Note (TAN) is an important document for all of us. I believe this would provide much needed guidance in flawless execution of Adarsh Champawat now and Uttarakhand@25 subsequently in near future.

I extend best wishes to AGNIi and UCOST teams for the grand success of subsequent sprints of Technology showcases in Champawat which will help in driving both Adarsh Champawat as well as Uttarakhand@25 initiatives under the guidance of Honorable Chief Minister Shri Pushkar Singh Dhami Ji.

(Prof. Durgesh Pant)
Director General
Uttarakhand Council for Science and Technology, Dehradun

Contents

Introduction | Objective and Method

Technology for Climate Adaptive Agriculture

This Technology Advisory Note (TAN) focuses on how emerging technology and innovation – capabilities for which exist in India's innovation ecosystems, startup and laboratory – can support climate adaptive agriculture practices in the Indian Himalayan Region. This innovation includes artificial intelligence, advanced sensing, and cyber-physical systems to enable precise action against the impact of climate change on agriculture.

The Office of the Principal Scientific Adviser to the Government of India, in partnership with national government agencies, identifies and advises on how Indian emerging technologies (such as artificial intelligence, blockchain technology, nanotechnology, advanced sensing, and others) can be leveraged to help address national priorities. Key among these is climate change. The Office's advisory is optimised for relevance, supporting specific decisions; and for execution, providing

decision-makers with guidance they can use in the field. This allows Government agencies with a usable basis for drawing on emerging technology and innovation. By shaping scaled Government engagement with Indian innovation: Office advisory, if executed by agencies concerned, will generate scaled opportunity for Indian startup and laboratory innovation.

The TAN summarises guidance developed in collaboration with the Uttarakhand State Council for Science and Technology (UCOST), Uttarakhand Government acting as a Pioneer Agency. Pioneer Agencies are select organisations within the Government which are mandated to engage these national priorities; in doing so, demonstrate a high degree of proactiveness and progressiveness in their engagement with innovation, technology, and new ideas; and share these priorities with a wider community of similar institutions – allowing scaled impact against these priorities to be assured by the emulation and adaptation of Pioneer Agencies' examples.

The guidance in the TAN was developed via fieldwork, Technology Operational Scenarios, Technology Capability Stacks, and Field Technology Showcases.

The field technology showcase was held at Champawat. The choice of the showcase site was aligned with the vision of the Uttarakhand Government to develop Champawat as an Adarsh Zila Model under the Uttarakhand @25 initiative of the Honourable Chief Minister of the state under the guidance of UCOST[1].

Box 1
National Relevance of TAN

Its generating activities undertaken in partnership and consultation with UCOST, and district administration: the Note and its advice aims to support practical, actionable administrative decision-making on technology engagement and acquisition for climate adaptive agriculture. This in Uttarakhand – but also in other Himalayan states that bear similarities with respect to geography, demography, and climate change concerns. Aligned to the Government's Aatmanirbhar Bharat priority, the TAN focuses on Indian technological innovation.

Equally: The TAN – and the exercises that generate it (technology operational scenarios, stack development, field technology showcases, etc.) – are exercises in change management. They seek to support leadership in driving a wider technology-enabled transformation to improve the populaces' various parameters associated with human development, multi-dimensional poverty, and climate resilience. The analyses and output provide leadership with tools and levers with which to do so.

No part of any TAN should be construed as, or be interpreted or derived to generate, support for any individual vendor, startup, innovator, or private actor of any kind. The TAN features specific technologies – whose innovator startups and laboratories volunteered to participate in Field

1 Presentation by UCOST at CM Review Meeting, Champawat held on 24th February, 2023.

Technology Showcases – merely as examples of broader technological capabilities' existence and readiness within Indian innovation ecosystems, and of how Aatmanirbhar Bharat can be effectively advanced even while supporting key national priorities. At every stage, Government agencies must follow due process under competent authority in engaging, selecting, procuring, and deploying technology.

Scaled Impact: Are TAN and technologies applicable across the Himalayas?

Set at a diverse range of high-altitudes, the Himalayan geography has birthed a socio–economic paradigm attuned to its specific needs and distinct from the existent frameworks more widely and easily applicable to the plains where urban development is more convenient. The Itner Governmental Panel on Climate Change (IPCC) reports have specifically recognised the fragility of the mountains, with specific attention paid to the vulnerability that results from the loss of glaciers and more extreme events. The peculiar geographical conditions and the sheer diversity of it also means that the region is ecologically fragile and specifically more vulnerable to climate change, putting its population, especially the impoverished, at extreme risk.

The Indian Himalayan Region is a 2,500 km long arc, cutting across 13 states and UTs of India. The region is home to approximately five per cent of the Indian population and covers 18 per cent of the geographical area of the country.[2] The entire Himalayan zone, including the foothills and the tarai region, constitutes an extremely fragile ecological zone. The diversity of the region divides the range into extremely small groups of distinctive socio-cultural regions and sub-regions, most of which have a slow pace of economic growth. The local communities derive their livelihood opportunities in the challenging terrain with a dwindling resource base.

Choosing Champawat as an Exemplar

Uttarakhand emerges as a state having low vulnerability to climate change in a relative sense with other Himalayan states. However, the vulnerability of the state to climate change in the absolute sense cannot be discounted.[3] At the district level, only two districts of Uttarakhand – Dehradun and Udham Singh Nagar have low vulnerability; however four districts of the state namely Haridwar, Tehri Garhwal, Bageshwar, and Pitthoragarh have high vulnerability. Meanwhile, seven districts including Uttarkashi, Pauri Garhwal, Rudra Prayag, Chamoli, Almora, Nainital, and Champawat have medium vulnerability.

Understanding that majority districts in the state either have medium or high vulnerability to climate change but also have immense potential with respect to agriculture and horticulture, the

2 Status of Ecosystem Health In The Indian Himalayan Region, 2019

3 Department of Science and Technology 'Climate Vulnerability Assessment for the Indian Himalayan Region Using A Common Framework' available at https://dst.gov.in/sites/default/files/IHCAP_Climate%20Vulnerability%20Assessment_30Nov2018_Final_aw.pdf (Last accessed on March 29, 2023)

state government[4] is continuously making efforts to create development models that balance ecology and economy. Water conservation also remains priority of the state government.

To further its objectives, Uttarakhand government with UCOST as its Nodal Agency is proactively working on technology enabled operational models for developing Champawat as a Adarsh Zila under the state government's Uttarakhand@25 initiative in the context of Himalayan ecosystem.[5] The choice of Champawat in Uttarakhand is because the district shows a range of geographical and topographical markers, making it an ideal testbed to execute technology enabled operational models that can be replicated across Uttarakhand and subsequently across the Himalayan belt. Some of these features include:

Altitudinal range and topographical variability.

- The altitude in Champawat ranges from 200 – 2,200 mts. Champawat can be divided in three main parts:
- The 35 villages of Tanakpur (Purnagiri) Tehsil fall in Terai area and are important from the viewpoint of plain and agricultural land and a warm area of an average height of 200 to 250 meters, having abundant water and good soil.
- Shivalik which is situated at a height of 250 to 1,200 meters. It represents a sloping and uneven topographical land consisting of dense forests.
- Hilly area with average height of 1,500 mts (from 1,200 to 2,200 mts).

Climate variability. The climate of the district is very differential, and the temperature varies from one degree Celsius to 35 degrees Celsius. Terai area is hot whereas hilly region is comparatively cold. High mountain ranges are covered with snow. The climatic condition of Terai and plains are similar, the seasonal rain is very high (about 20 cm. yearly). The climate of Shivalik is same but the lower region of Himalayas experience cold climate throughout the year.

Forest cover variability. The forests in Champawat range from 200-2,000 mts, making the operational models developed highly scalable across the montane sub-tropical forests and (1,000-1,500 mts [Pine forests])and montane temperate forests (1,500 – 2,400 mts). [Himalayan temperate and Himalayan dry temperate]).

4 https://www.pressreader.com/article/281779927944826 (Last accessed on March 29, 2023)

5 Presentation by UCOST at CM Review Meeting, Champawat held on 24th February, 2023.

Table 1

Classification and Geographic Distribution of Indian Forests (Altitudinally)[1] [2]

S.No	Broad Forest Classifications	Other areas of India besides Uttarakhand where the broad forest type is found
Tropical Forests (up to 1,000 m)		
1	Moist Deciduous	Western Ghats; Manipur, Mizoram; Hills of Eastern Madhya Pradesh and Chhattisgarh; Chota Nagpur Plateau; Odisha; West Bengal; Andaman and Nicobar Islands
2	Dry Deciduous	Occur in an irregular wide strip running from the foot of the Himalayas to Kanyakumari except in Rajasthan, Western Ghats and West Bengal
Montane Sub-tropical Forests (1,000 – 1,500 m)		
3	Pine Forest	Jammu and Kashmir; Himachal Pradesh; Sikkim
Montane Temperate Forests (1,500 – 2,400 m)		
4	Himalayan Temperate	Kashmir, Himachal Pradesh, Darjeeling; Sikkim
5	Himalayan Dry Temperate	Ladakh, Lahul, Chamba, Kinnaur, and Sikkim
6	Sub-alpine	Jammu and Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh
Alpine Scrub		
7	Moist alpine	Jammu and Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh
8	Dry alpine	Jammu and Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh

1 Sources: https://fsi.nic.in/isfr-2021/chapter-13.pdf ; http://wmduk.gov.in/ManualsUDWDP/TM/Forestry.pdf ; https://www.ceeindia.org/CEE-Academy-resouce/PDF/Forest%20ecosystem%20Forest%20Types%20of%20India.pdf;http://ecoursesonline.iasri.res.in/maod/page/view.php?id=14441; http://www.utrenvis.nic.in/data/classification%20forest.pdf ;

2 The forest types highlighted in Blue are found in Champawat district of Uttarakhand

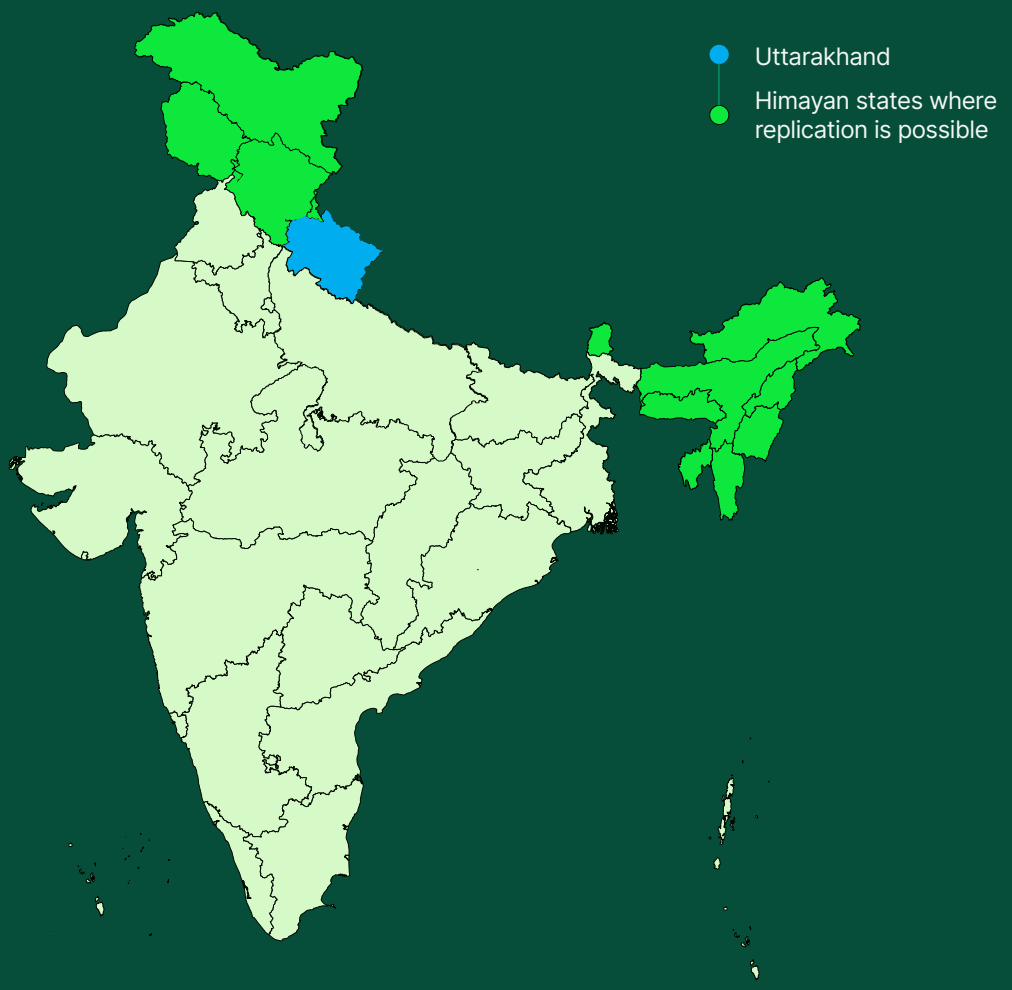
Scalability of TAN across the Indian Himalayan Region

The state of Uttarakhand constitutes 10.02 per cent of the Indian Himalayan Region which is fourth highest among the Himalayan states. The commonalities of terrain and weather patterns present across the Himalayan states are evident. Uttarakhand represents the microcosm of the Indian Himalayan macrocosm given the altitudinal range and the resulting variability in the forest cover.

Thus, the technological capabilities that addresses the various pain points that are afflicting rural communities and reduce their vulnerability to climate change as proxied by various indicators can be effectively tested in Uttarakhand and it presents a significant scaling potential (refer table 2).

Box 1

Scalability of Adarsh Champawat project across Indian Himalayan Region^



^ Map not drawn to scale. For illustrative purposes only.

Table 2

Scaling Potential of the TAN across the Indian Himalayan Region#

Pain Points and Technology Use case	Vulnerability Factor	Indicators	Uttara-khand	Jammu and Kash-mir	Him-achal	Assam	Megha-laya	Mani-pur	Mizo-ram	Tri-pura	Arun-achal	Sik-kim	Na-galand	India Average
Pain points: • Change in cropping patterns • Limited availability of plain & continuous agricultural land, which necessitates terrace farming **Technology use case:** • Hyperlocal soil testing and advisory • UAV based scientific farm input delivery	Sensitivity of agricultural production	Cropping Intensity	155	154	169	145	123	100	130	190	133	177	131	141.2

 # Source: Analysis by the authors, Refer Annexure 1 for supporting data
Please note that for the present purpose the state of West Bengal has not been included in the table as the state has less than one per cent of share of geographical area in the Indian Himalayan Region (Source: http://gbpihedenvis.nic.in/him_states.htm [Last accessed on March 30, 2023])

Pain Points and Technology Use case	Vulnerability Factor	Indicators	Uttara-khand	Jammu and Kash-mir	Him-achal	Assam	Megha-laya	Mani-pur	Mizo-ram	Tripu-ra	Arun-achal	Sikkim	Na-galand	India Average
Pain point: • Dense coverage of forests and proximity of farmlands to forests increased likelihood of animal intrusion Technology use case: • Improvement in crop yields	Per centage of area under hilly terrain#	Hilly Terrain	100	100	100	24.2	100	100	100	100	100	100	100	18
	Net irrigated area to net sown area	Irrigation Intensity##	164	146	172	131	159	100	194	144	100	100	110	143

 # Source: https://fincomindia.nic.in/writereaddata/html_en_files/oldcommission_html/fincom14/others/29.pdf
Source: https://www.nabard.org/auth/writereaddata/tender/1710224557farmers-welfare-in-india-a-state-wise-analysis.pdf
Source: https://fsi.nic.in/isfr-2021/chapter-2.pdf
Source: https://www.nabard.org/auth/writereaddata/tender/1710224557farmers-welfare-in-india-a-state-wise-analysis.pdf
Source: https://www.nabard.org/auth/writereaddata/tender/1710224557farmers-welfare-in-india-a-state-wise-analysis.pdf
Source: https://www.nabard.org/auth/writereaddata/tender/1710224557farmers-welfare-in-india-a-state-wise-analysis.pdf

Pain Points and Technology Use case	Vulnerability Factor	Indicators	Uttarakhand	Jammu and Kashmir	Himachal	Assam	Meghalaya	Manipur	Mizoram	Tripura	Arunachal Pradesh	Sikkim	Nagaland	India Average
Pain point: • High dependence on agriculture and lack of value capture mechanisms: Difficulties in securing livelihoods of farmers with small landholding and tackling challenges to the value chain which are accentuated by climate change Technology use cases: • Increasing shelf life of agri/ horticulture produce • Value capture services	Percentage are under forest	Forests Cover (% of geographical area) t###	45.44	40.5	27.73	36.09	76	74.34	84.53	73.64	79.33	47.08	73.9	21.71
	Access to infrastructure	Number of cold storage (number) ####	47	55	65	37	4	3	3	14	2	2	4	7916
	Sensitivity of agricultural production	Share of Small and Marginal Farmers (%) ######	99.5	85.9	89.8	90.6	80.1	54.8	100	100	99.4	84.2	100	81.7
	Share of Small and Marginal Farmers (%)	Ratio of average monthly household income to average monthly non-agricultural household income (ratio – unit free) ########	1.5	0.6	1.0	1.2	1.0	1.0	1.2	0.8	0.8	1.0	1.0	1.2

Methodology | Actionable Advice for Scaled Impact: Exemplar Projects

1. **Practicality: Ensuring Technology Decision-Making Support is Actionable.** To ensure that agency decision-makers receive technology and innovation advice that is actionable in the field: the Office's AGNIi Mission, under the Prime Minister's Science Technology and Innovation Advisory Council develops this advice through;

2. **Exemplar Projects, executed in collaboration with a Pioneer Agency.**

    - Exemplar Projects address pain-points identified by senior Government authorities in that sphere as comprising a major and scaled national priority.
    - Pioneer Agencies are select organisations within the Government which
        - are mandated to engage these national priorities;
        - in doing so, demonstrate a high degree of proactiveness and progressiveness in their engagement with innovation, technology, and new ideas; and
        - share these priorities with a wider community of similar institutions – allowing scaled impact against these priorities to be assured by the emulation and adaptation of Pioneer Agencies' examples.

3. **Ensuring Decision-Making Relevance: Technology Operational Scenarios.** AGNIi targets emerging technology innovation to support agency priorities and requirements, as follows:

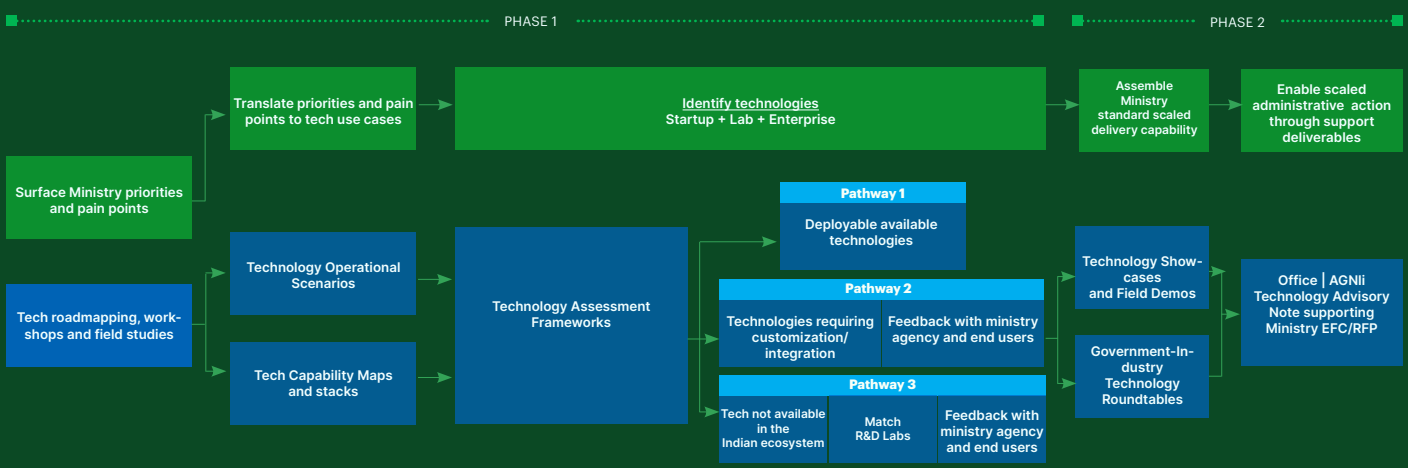
    - The Exemplar Project analyses and characterises this pain-point, determining its dimensions and decision-factors:
        - Field Level, which have bearings for officers directly dealing with rural communities on the field. In the present scenario, this would involve the District Magistrate/District Collector, line departments, officials at the block level, and Gram Panchayat level personnel;
        - Operational, which senior administrative tiers must resolve. In the district, this would include the District Magistrate, and Chief Development Officer
        - Strategic, affecting leadership-tier decision-making. This would include the state level leadership (Chief Minister's Office and line departments) and Pioneer Agency - UCOST in the present scenario.
    - To ensure decision-making relevance: AGNIi executes that analysis and characterisation as follows:
        - To determine field level and operational decision-making dimensions: AGNIi team visits field locations – selected for representing the most challenging circumstances the Pioneer Agency faces – to research and characterise pain-points as they are experienced and determined at the ground.
        - To determine operational and strategic decision-making dimensions: the AGNIi Mission also consults, via a series of meetings, with Pioneer Agency representatives and the District Magistrate.

4. **Solving Challenges with Technology: The Technology Stack.** The Project then formulates a 'stack' of emerging technologies – within Indian startup and laboratory capability, demonstrated through specific examples – which can engage these challenges.
    - Technology Stacks integrate innovation across multiple technologies – for example, Artificial Intelligence, Internet of Things (IoT), advanced sensing;
    - They position these technologies against operational capabilities required at various stages of an agricultural cycle – for example, pre-sowing, sowing, or crop care;
    - Where these technologies and capabilities intersect – solutions are identified – for example, animal detection and deterrent (at the intersection of sensors and crop care);
    - For each of these solutions – examples of concrete Indian innovation are identified; in the form of startup or laboratory innovation. This offers the agency clarity that Indian innovation is available, under Aatmanirbhar Bharat objectives, to solve its challenges.
    - Crucially, these examples (and the wider TAN) do not recommend or endorse any vendor;
    - These technologies and capabilities are framed in terms of how they work together, to offer workable solutions to the broader operational challenge that the Technology Operational Scenario identifies and characterises.

5. **Demonstrating Workability and Options**: **Field Technology Showcases**. To demonstrate this innovation's practical potential – actual impact on the ground, for Government decision-makers, against these priorities – the AGNIi team conducts Field Technology Showcase in locations representative of those where these priorities are encountered.
    - Hosted by the Pioneer Agency, startups and laboratories are invited to demonstrate how their innovation resolves these pain-points in the field.

Box 2

AGNIi Work Flow



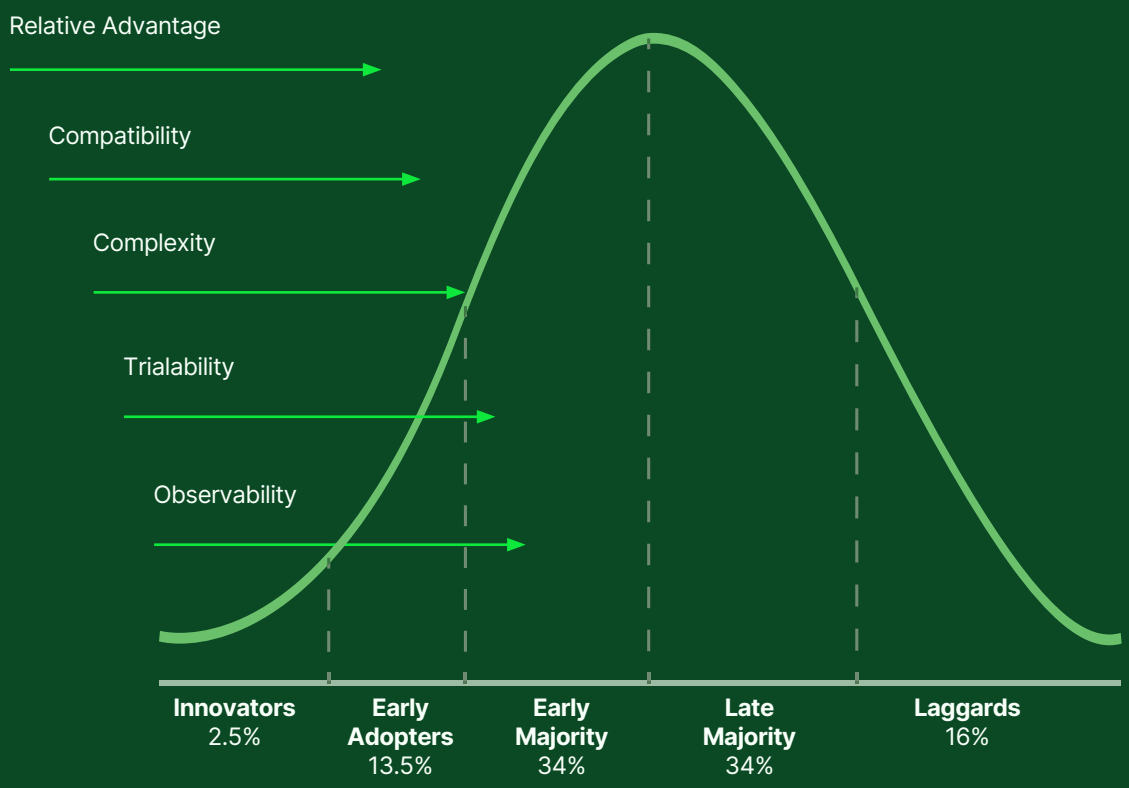
- The Showcases generate assessments for decision-makers on whether, and to what extent, innovation in its current form can resolve these pain-points.
- The Exemplar Project consequently seek to represent the microcosm of the sphere they are working in. Pioneering Agency, one which deals with the 'microcosm' as a part of their regular functioning.
- Importantly: Field Technology Showcase do not substitute technology evaluations conducted as part of the public tender process. Instead, they seek to help agency officers expand decision-making options in their quest to engage key priorities.
- Crucially: Field Technology Showcase seek to support the actual adoption of relevant, effective innovation, by activating five crucial levers of innovation diffusion. First identified by innovation scholar Everett Rogers, in his development of the Diffusion of Innovation curve (or Rogers' Curve): these factors, if demonstrated, drive adoption decisions. Each Field Technology Showcase seeks to demonstrate these.

6. **Advice (and supporting analyses) are captured in Technology Advisory Notes:** supporting specific administrative action to engage and leverage Indian emerging technology within Uttarakhand and across other Himalayan states facing similar challenges, in fulfilling national priorities at scale.

7. **Change Management: Supporting Agencies in Transformation through Innovation.** The Office of PSA's key objective, in its collaborations with agencies engage Indian emerging technology and innovation in answering national priorities – through the collaborative model outlined above. This embrace of innovation, with Office support, involves institutional change: with agencies upgrading their organisational capabilities through technology. The AGNIi advisory project cycle described above supports this, activating eight change management levels.

Box 3

Innovation Diffusion - Roger's Curve^



^ Rogers, Everett M, Diffusion of Innovations. New York, Free Press of Glencoe, 1962. Rogers, Everett M. Diffusion of Innovations.

Table 3

Change Management

Step	Change Management Lever	Collaborative Action	AGNIi Technology Advisory (Workflow Phase)
Step 1	**Establish and identify urgency**	Leadership consultations: Hon'ble Chief Minister, Director General, UCOST, Himalayan Environmental Studies and Conservation Organisation (HESCO), District Administration aligned to priorities / guidance / values set by them. • Priorities on safeguarding rural communities against climate change • Profile, risk, capabilities of hilly communities: traditional practices, operational models of farming, livelihoods forest and water management • Terrain Analysis: terrain and geography, population distribution, infrastructure, market linkages	Agency Pain-Point Mapping Workshops / Consultations Field Visits
Step 2	**Form guiding coalition of authority**	Collaboration with leadership and field agencies intersecting operational and tactical interests and urgencies. Develop Technology Operational Scenarios with UCOST.	Agency Pain-Point Mapping Workshops / Consultations Field Visits Technology Operational Scenarios
Step 3	**Collaborate to surface Agency vision**	Develop Technology Operational Scenarios via focus group discussions and key informant interviews conducted among community members; and stakeholder consultations with the Chief Minister's Office and state line departments, Pioneer Agency (UCOST), district administration, and civil society organisations like Himalayan Environmental Studies And Conservation Organization (HESCO) and Bharatiya Agro Industries Foundation (BAIF): describing baseline scenarios and target end-state. Develop Technology Stacks: reflecting functional requirements generated by Operational Scenarios. Collaborating with the Chief Minister's Office, Pioneer Agency (UCOST), district administration, civil society organisation like HESCO and BAIF, and rural communities to implement Field Technology Showcases: demonstrating how Indian innovation (representing Stack elements), in realistic field scenarios, delivers target end-state.	Technology Operational Scenarios Technology Stacks Field Technology Showcases

Step	Change Management Lever	Collaborative Action	AGNIi Technology Advisory (Workflow Phase)
Step 4	**Communicate the vision**	Demonstrate Indian innovation providing solutions – and alternatives to conventional decision-making options – in realistic field scenarios. Showcases demonstrated to- • strategic leadership (District Magistrate, Heads of Line Departments, Community members) • representing solutions answering interests and imperatives across decision-making tiers.	Field Technology Showcases
Step 5	**Enable decision-makers to act on that vision**	Evaluation (e.g., via UCOST and District Administration) of Field Technology Showcases: supporting further administrative action. TAN supports scaled action in Uttarakhand and across other Himalayan states.	Field Technology Showcases TAN
Step 6	**Build momentum via successful short-term action**	Advising the stakeholders like UCOST, District administration and the Office of the Chief Minister for technology pilots. Formation of a Himalayan states Innovations committee with relevant members – AGNIi, UCOST, District Administration, etc. .	Field Technology Showcases Follow up meetings
Step 7	**Consolidate improvements for further change**	Feedback delivered from evaluations to Stack innovators (on product feature sets), UCOST, district administration and AGNIi (on technology functioning vs. Technology Operational Scenarios)	Technology Operational Scenarios Technology Stacks TAN Field Technology Showcases
Step 8	**Support institutionalisation of new approaches**	Supporting administrative action.	TAN

Part B | Climate Adaptive Agriculture

SECTION 2

India's Vulnerability to Climate Change and Need for Adaptation

India is the 3rd most vulnerable country to climate change impacts[1] , with various regions already experiencing the adverse effects of extreme weather events such as heatwaves, floods, droughts, and cyclones. With a 1.4 billion population[2] , 7500km vast coastline[3] , and 58 per cent of the population with agricultural dependence , India is particularly susceptible to climate change.

1 XDI Gross Domestic Climate Risk, https://xdi.systems/xdi-benchmark-gdcr/

2 World Bank: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=IN

3 Achieving Aatmanirbharta in Agriculture, Nov 2022: https://pib.gov.in/FeaturesDeatils.aspx?NoteId=151185&-ModuleId%20=%202#:~:text=It%20accounts%20for%20around%2019,is%20dependent%20on%20the%20sector

India is highly vulnerable to climate change with 65 per cent of its geography being drought prone, 12 per cent being flood prone, and eight per cent being susceptible to cyclones.[4] Over the past century, maximum temperatures in India have increased by 0.71 degree Celsius and mean minimum temperatures by 0.27degree Celsius . In the pre-monsoon season, the frequency of hot days shows a gradual increase, while the frequency of cold days shows a noticeable decrease . As per Indian Meteorological Department, number of heatwaves in India has increased from 413 over 1981-1990 to 600 over 2011-2020. Increasing heatwaves, which can cause heat exhaustion, dehydration, and even death, are a common occurrence in the country.

Since 2005, extreme events have increased by almost 200 per cent in frequency and intensity in India.[5] According to the latest report by the UN Intergovernmental Panel on Climate Change (IPCC), the country has already lost 16 per cent of its per capita GDP because of rising sea levels and changing monsoon patterns.[6]

According to the Climate Transparency Report, 2022, India lost $159 billion or 5.4 per cent of its gross domestic product, in the service, manufacturing, agriculture, and construction sectors due to extreme heat in 2021. 167 billion potential labour hours were lost, a 39 per cent increase from 1990-1999. Extreme events such as flash floods, cyclones, floods, and landslides caused crops damage in over 36 million hectares. This resulted in a $3.75 billion loss for farmers in the country, between 2016–2021.[7] As per the Ministry of Agriculture, hydro-meteorological calamities, including heavy rainfall and floods, have damaged 33.9 million hectares of India's cropped area between 2015-16 and 2021-22.[8] As per a 2018 report by NITI Aayog, 50 per cent of the springs in the Indian Himalayan Region are drying up. This has further added to the drudgery of women since they need to manually carry water from springs located at other villages during the lean season.[9]

Impacts of Climate Change in the Indian Himalayan Region

Climate change poses a particular threat to the Indian Himalayan Region due to its unique geography, fragile ecosystem, and reliance on natural resources. The Indian Himalayan Region is an arc of 2,500 km that traverses 13 states and UTs of India. It is inhabited by more than 52 million people, about five per cent of India's population, and covers 18 per cent of the geographical area of the country.[10]

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4 Project: Climate Smart Actions and Strategies in North Western Himalayan Region for Sustainable Livelihoods of Agriculture-Dependent Hill Communities, Implementing Entity: National Bank for Agriculture and Rural Development (NABARD)

5 Abhinash Mohanty and Shreya Wadhawan, 2010. Mapping India's Climate Vulnerability, A District Level Assessment, CEEW

6 Simrin Sirur, 2022. What the latest IPCC report on climate vulnerability & adaptation means for India, Article in The Print

7 Climate Transparency Report 2022, https://www.climate-transparency.org/g20-climate-performance/g20report2022

8 https://india.mongabay.com/2022/11/in-india-climate-impact-on-agriculture-is-already-a-reality-now/

9 https://www.downtoearth.org.in/news/water/crisis-in-the-himalayas-nearly-50-perennial-springs-in-the-region-have-dried-up-61482

10 Status of Ecosystem Health In The Indian Himalayan Region, 2019

In the last decade, several climate change-related disasters have occurred in the Indian Himalayan Region, highlighting the urgent need for mitigation and adaptation measures. This region has witnessed various floods, landslides, and avalanches. The rivers of the Himalayas are some of the most important rivers in the world. The three great rivers of India – the Indus, the Ganges and the Brahmaputra collectively provide close to 50 per cent (320 km^3) of the total country's utilizable surface water resources (690 km^3). Contribution from snow and ice melt to the total annual river discharge has been estimated as 60 per cent, nine per cent and 21 per cent for Indus, Ganga and Brahmaputra basins, respectively.[11]

There are about 15,000 glaciers which prominently include Gangotri, Yamunotri, Khumbu, Langtang, Zemu among others. Since glaciers are contributing significantly to river flow, the impact of climate change on glacier is the most important from the point of view of water availability and ecosystem balance. Recent studies based on satellite imageries also indicate a continuing retreat of glaciers in Himalayas (refer Box 4).[12]

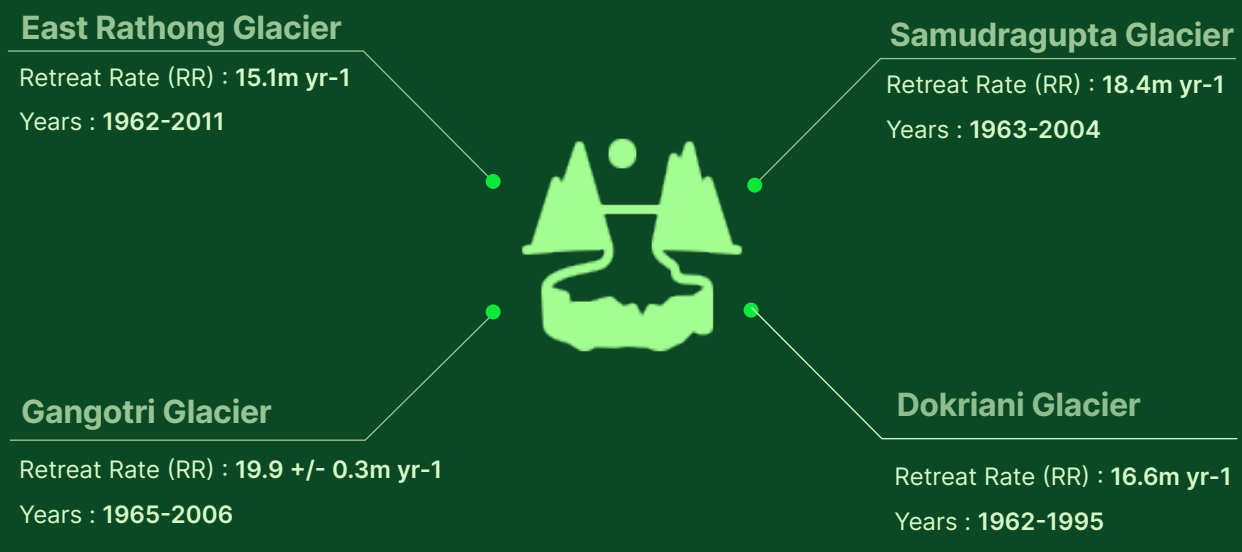
A region wide study conducted on seven of glaciers distributed across different basins shows retreating pattern for almost 77 per cent of the glaciers. Both, number of retreating glaciers and the

11 Dr. Shresth Tayal, 2019. Climate Change Impacts On Himalayan Glaciers And Implications On The Energy Security Of The Country

12 Dr. Shresth Tayal, 2019. Climate Change Impacts On Himalayan Glaciers And Implications On The Energy Security Of The Country

Box 4

Retreating Glaciers of the Himalayas



extent of retreat are reported to be highest for western Himalayan glaciers.[13]

The Indian Himalayan Region has experienced an increase in maximum temperature up to one degree Celsius. Winter precipitation has declined over the years with shorter and warmer winters and reduced snowfall. The region has also experienced changed precipitation conditions such as reduced winter rains, delayed onset of monsoon rains, and increased frequency of intense rainfall events. These intense rainfall occurrences are coupled with sloping terrain and loose soil, deforestation, resulting in soil erosion, land degradation, and loss of fertile soil . According to the IPCC, climate change impact in Indian Himalayan Region will range from glacial melt to reduced genetic diversity of species leading to increased flooding affecting water resources, within the next few decades.

Climate Adaptive Agriculture: A Conceptual Primer

The agricultural sector plays a vital role in promoting economic and social progress in developing nations. This is because a significant proportion of the global population living in poverty relies on agriculture as a primary source of household income (FAO, 1995). In South Asia, over 75 per cent[14] of people reside in rural areas and rely on rain-fed agriculture, livestock, and forests for their sustenance. In India, agriculture is the primary source of livelihood for about 70 per cent[15] of India's rural population.

According to Union government estimates, India's food production is estimated at record 3,235.54 lakh Tonnes, which is higher by 79.38 lakh metric Tonnes as compared to previous year.[16] Food production must double by 2050 to match the country's population and income growth. Agriculture, therefore, has a major role in the country's food security and meeting the Sustainable Development Goals goals. One of the critical challenges faced by agriculture is climate change.

Farming activities are carried out by the selection of crop, which is specific to suit climate, soil type, resource availability, etc. Therefore, farming production and productivity is completely dependent on climatic conditions. The predicted 1-2.5-degree Celsius temperature rise by 2030 can lead to reduction in crop duration, escalate crop respiration rates and influence pest population.

The impact map (refer Box 5) shows the direct and indirect interlinkages between climate change and the subsequent effects on agriculture and water resources.

13 Dr. Shresth Tayal, 2019. Climate Change Impacts On Himalayan Glaciers And Implications On The Energy Security Of The Country

14 Project: Climate Smart Actions and Strategies in North Western Himalayan Region for Sustainable Livelihoods of Agriculture-Dependent Hill Communities, Implementing Entity: National Bank for Agriculture and Rural Development (NABARD)

15 Technologies for Climate Change Adaptation Report [Last accessed on 17th March 2023]

16 https://dst.gov.in/sites/default/files/Report_DST_CC_Agriculture.pdf

Impact on Agriculture

a) Direct impact of increase in temperature

- Rising pest infestations, changes in natural pollination cycles and higher evapotranspiration – As temperatures rise, chances of pest infestation also rise because it creates ideal conditions for many pests to thrive and reproduce. Additionally, rising temperatures can lead to changes in plant and crop growth patterns, which can attract more pests. For example, pests such as Fall Armyworm (which feeds on a growing number of crops, including maize, sorghum, millet) is spreading in many states, including Karnataka, Maharashtra and Tamil Nadu.[17]
- Heatwaves causing crop loss and reduced agricultural labour productivity increase the vulnerability of agri-horticulture sectors and absence of any other livelihoods, leading to migration of productive labour.

b) Impact of changes in precipitation (erratic precipitation cycles, reduced snowfall)

- Sudden and increased instances of extreme weather events such as hailstorm, cloud bursts, landslides etc., leads to destruction of crops.
- Droughts can accelerate land degradation since dependence on groundwater and perennial water resources increases, which inturn heightens the risk of wildfires.
- Change in surface run-off (particularly reduction) due to changes in precipitation patterns can lead to drying up of perennial water sources, leading to decreased soil moisture, and subsequently causing reduced agricultural yield.
- Intense rains leading to land and soil degradation increases pressure on forests resulting into decline of biodiversity. This also leads to increase in instances of human-animal conflicts.
- The rising temperature and changes in precipitation lead directly to soil erosion or waterlogging, which means lower crop yields and crop failures.
- Rise in temperature has led to shrinking of glaciers and snowpacks because of which many regions that rely on meltwater for irrigation are facing a shortage of water. Additionally, increase in evaporation rates that has led to loss of moisture from soil and plants and change in rainfall patterns have exacerbated water shortages.

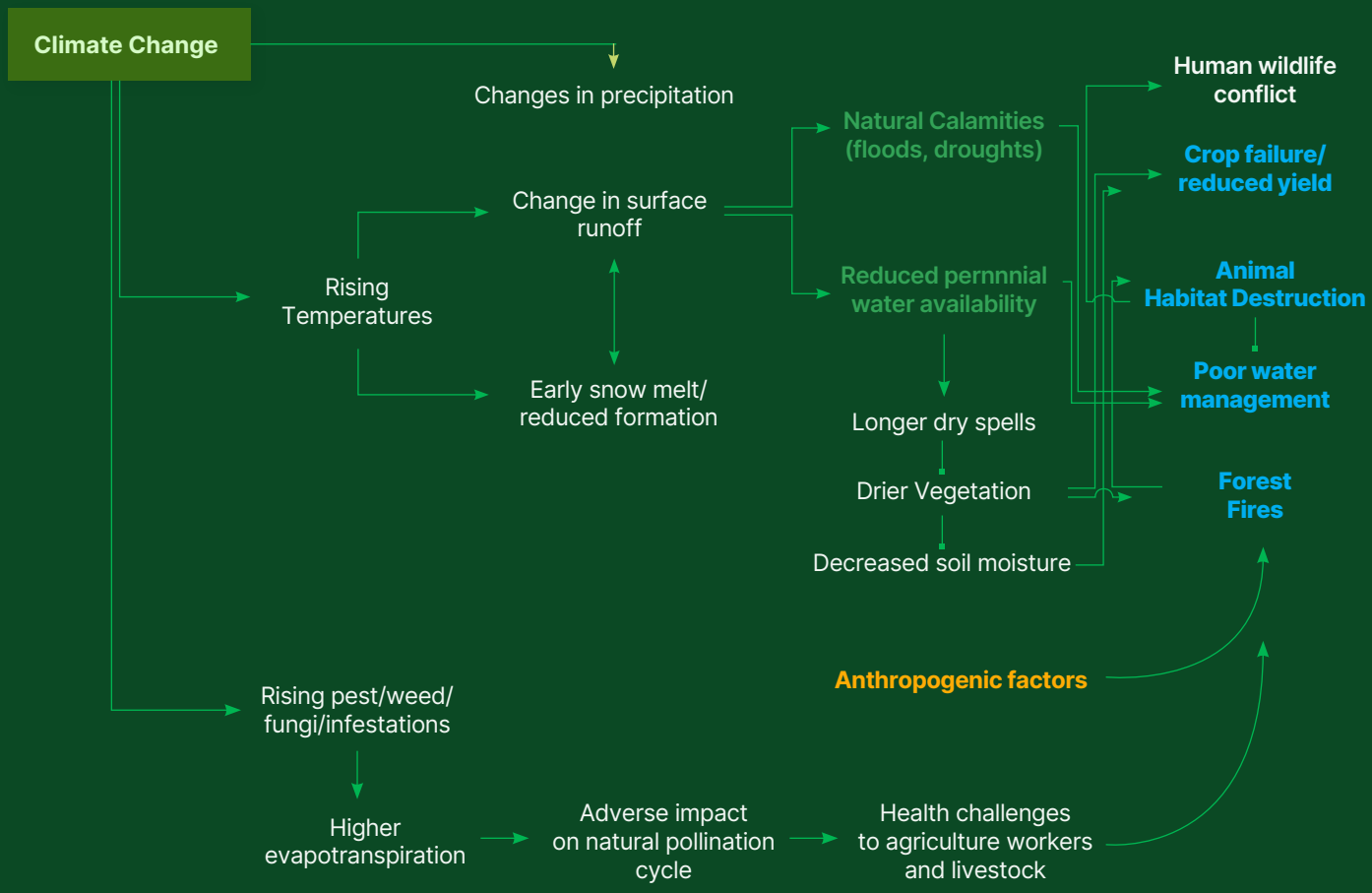
Field crops

An average of 30 per cent decrease in crop yields is expected by mid-21st century in South Asian countries. North Indian states are highly susceptible to crop failure due to erratic changes in rainfall. It is projected that a 2.5-to-4.9-degree Celsius increase in temperature across the country can lead to a decrease of 41-52 per cent in wheat yield, and 32-40 per cent in rice. The drastic change in temperatures alters the progressive stages of pathogens that eventually affect the growth and yield of crops severely and can eventually lead to an increase in pest population, devastating the overall productivity.

17 https://india.mongabay.com/2019/09/fall-armyworm-destroyer-of-maize-farms-causes-concern-in-india/

Box 5

Impact Map of Climate Change on Agriculture and Water Management



Horticulture

- Horticultural crops are sensitive to temperature changes, and most have specific temperature requirements for optimum yield and quality. The production and quality of fresh fruit and vegetable crops can be directly and indirectly affected by high temperatures and exposure to elevated levels of carbon dioxide and ozone. High temperature causes burning or scorching effect of blossoms, on young trees. High temperature also induces moisture stress condition leading to sunburn and cracking symptoms in fruit trees like apricot, cherries and apples.
- Rural livelihoods are threatened by climate change because the rural population heavily depends on natural resources. Natural resource-based based rural livelihoods are likely to bear an inconsistent burden of the different impacts of climate change. As the livelihoods are getting affected, there has been an increasing migration of the rural population to other suitable places to persist their family life.
- Agricultural adaptation effectively manages potential climate risks over the coming decades. Improved access and utilization of technology, increased adaptation of crops and livestock to climatic stress, and increased use of resources conservation technologies are some of the outcomes of climate adaptive agriculture practices.

Strategic Factors Defining Technology Adoption : Scaled Impact Against a Scaled Challenge

This TAN describes how emerging technology and innovation – capabilities of which exist in India – can make agriculture in the Himalayan states climate resilient and help the rural communities adapt to the challenges posed by climate change. Developed in collaboration with UCOST, the TAN engages a scaled challenge.

The Himalayan states (70 per cent of the rural population in the Indian Himalayan Region is dependent on agriculture[18]) due to their mountain topography and higher than global average global warming is highly vulnerable on a continuum to the impacts of climate change.[19] The United Nations Framework Convention on Climate Change (UNFCCC) defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity. Therefore, adaptation would also include any efforts to address these components."' [20]

Technology intervention answering its challenges – in use-case selection and solution deployment – be similarly scaled in impact.

18 Girish Chandra Bhatt, Ravindra Singh, Priyanka Baduni, Laxman Singh Kandari, L. S. Rawat, Chandi Prasad, Prakash Chandra Phondani, and R.K. Maikhuri, Education, Research and Policy Issues in Indian Himalayan Mountain Farming System: Priorities for Sustainable Development, 2022

19 Department of Science and Technology 'Climate Vulnerability Assessment for the Indian Himalayan Region Using A Common Framework' available at https://dst.gov.in/sites/default/files/IHCAP_Climate%20Vulnerability%20Assessment_30Nov2018_Final_aw.pdf (Last accessed on March 29, 2023)

20 UNFCCC available at <https://www4.unfccc.int/sites/NAPC/Pages/glossary.aspx#:~:text=Vulnerability%20The%20degree%20to%20which,including%20climate%20variability%20and%20extremes.> last accessed March 22nd, 2023.

To elaborate, the vulnerability of the Himalayan communities emanates from their 'sensitivity' i.e., 'susceptibility to harm' and 'lack of adaptive capacity' i.e., lack of capacity to adapt and cope .[21] This sensitivity and lack of adaptive capacity of the Indian Himalayan Region primarily stems from the following factors:

- Fragile mountain ecosystems, where evidence suggests that the Himalayan region will experience higher level of climate change and its impact on both biophysical, and social and economic systems.
- High dependence on natural resources, such as those derived from forests.
- Climate sensitive rain-fed agriculture being the primary source of livelihood for hill communities.
- Infrastructural constraints pertaining to power availability, transportations, markets, and communications with implications on livelihood options.

Development of adaptive capacities can play an instrumental role in reducing the susceptibility of the region to harm and making the agricultural sector of Indian Himalayan Region less vulnerable to the impacts of climate change. The technology stack will help achieve adaptability given a unique strategic context of the Indian Himalayan Region in the following manner (refer Table 4).

21 Department of Science and Technology 'Climate Vulnerability Assessment for the Indian Himalayan Region Using A Common Framework' available at https://dst.gov.in/sites/default/files/IHCAP_Climate%20Vulnerability%20Assessment_30Nov2018_Final_aw.pdf (Last accessed on March 29, 2023)

Table 4

Strategic Factors defining Technology Adoption

	Strategic Factor	Functional Implication	Technological Response: Consequences for Technology Stack Composition
1	**Hilly terrain and absence of plain and continuous agricultural land, which necessitates terrace farming.** **Terrace farming has implications for cropping yield, cropping intensity, and irrigation methods.** **Altitudinal shift in farming belts Implications for cropping patterns**	Hyperlocal dissemination of advisory to villagers pertaining to crop diversification that suits changing weather patterns and soil chemistry, and water-use efficiency for agriculture	Soil sensing: Sensors to detect structural properties, soil fertility, carbon exchange capacity, soil pH, soil acidity, per cent organic matter (OM) and soil salinity Cloud based platform for online farm input advisory, soil health record, map, farm analytics and fertilizer suggestions Geographic Information Systems (GIS) that blends the power of a map with the power of a database to allow people to create, manage and analyse information, particularly information about location
2	**Large areas under forest cover and proximity of farmlands to forests:** **Expansion of human settlements, resulting in animal intrusion and human-wildlife conflict**	Detection of animal intrusion with high frequency and from a distance suitable for the adopter	Motion sensors to detect movement in a defined area of interest, using passive and active infrared sensor (PIR & AIR sensor) Animal Intrusion and Detection Systems: deployed on the farm boundary to detect and deter any animal/bird within the range using sounds/mild electric shock
3	**High dependence on agriculture and lack of value capture mechanisms** **Difficulties in securing livelihoods of farmers with small and marginal landholdings and tackling challenges to the value chain which are accentuated by climate change** **Infrastructural constraints pertaining to power availability, transportations, markets, and communications impact livelihoods**	Insurance against yield losses Improved shelf life of Agri produce Enhancing transparency and traceability in agriculture value chain	Crop specific integrated value chain with blockchain technology to create a seamless, transparent and trustworthy end-to-end tracking of supply chain, and insuring against crop losses Agritech SaaS platforms use technology to manage the whole agriculture supply chain, from farming inputs to last-mile distribution. Cost effective cold storage boxes and dry ice to increase the duration for which various farm produce remains fresh for consumption

Source: Authors analysis based on field work in Champawat, Uttarakhand in November and December 2022, stakeholder interactions with the state government, district administration, and civil society organisations like HESCO and BAIF with subsequent technology scouting

Strategic Context

SECTION 3

Pain Points surfaced Through Fieldwork

1. Traditional varieties cannot be grown due to change in weather conditions.

The change in weather conditions has become a significant challenge for the preservation of traditional crop varieties in Uttarakhand. As highlighted in a report by the Food and Agriculture Organization, traditional crops are better adapted to local agro-climatic conditions and are an

essential source of food security for local communities. However, the changing climate has made it difficult to grow traditional varieties, resulting in a decline in their production and use. A study by the Indian Council of Agricultural Research (ICAR) reveals that the average temperature in Uttarakhand has increased by 0.5°C over the last decade, leading to changes in rainfall patterns and affecting the growth and development of traditional crops.[22] Furthermore, the report notes that traditional varieties are particularly vulnerable to changes in weather patterns, which have resulted in lower yields and crop failure.[23]

2. Lack of value capture mechanisms in the supply chain of high value forest/agro-forestry/ horticulture products with a limited shelf life (as well as otherwise) as well as livestock derived products and fisheries hindering rural income generating opportunities.

The lack of value capture mechanisms in the supply chain of high-value products with a limited shelf life has hindered rural income-generating opportunities in the region. According to a report by the National Bank for Agriculture and Rural Development (NABARD), Uttarakhand's agriculture and allied sectors contribute to 34 per cent of the state's Gross State Domestic Product (GSDP), with the sector employing around 70 per cent of the state's population.[24] Despite the high contribution of agriculture to the state's economy, the lack of value capture mechanisms in the supply chain of high-value products has resulted in a low share of profits for the producers. The inadequate infrastructure for cold storage, processing, and transportation of perishable goods further exacerbates the problem, leading to post-harvest losses and reduced prices for the producers. A study by ICAR revealed that the annual post-harvest losses of fruits and vegetables in Uttarakhand range from 10 to 30 per cent. The lack of value capture mechanisms in the supply chain not only affects the producers but also limits the potential for rural development in the region. The inadequate income generation opportunities in the agriculture sector can result in migration of the rural population to urban areas, leading to an imbalance in the population distribution and decreased agricultural productivity.

3. Crop destruction due to wild animals and higher pest infection due to climate change.

According to a report by the Ministry of Environment, Forest and Climate Change, the state of Uttarakhand experienced a loss of over 5,000 hectares of crops due to wild animal attacks

22 ICAR – Central Research Institute for Dryland Agriculture Heat Wave 2022: Causes, Impacts and Way Forward for Indian Agriculture' available at http://www.icar-crida.res.in/Pubs/Heat%20wave%202022%20-%20Causes%20Impacts%20and%20way%20forward%20for%20Indian%20Agriculture.pdf {Last accessed March 22, 2023]

23 ICAR – Central Research Institute for Dryland Agriculture Heat Wave 2022: Causes, Impacts and Way Forward for Indian Agriculture' available at http://www.icar-crida.res.in/Pubs/Heat%20wave%202022%20-%20Causes%20Impacts%20and%20way%20forward%20for%20Indian%20Agriculture.pdf [Last accessed March 22, 2023]

24 Uttarakhand Government Portal State Report – Uttarakhand Skill Gap Study available < https://ukrdd.uk.gov.in/wp-content/uploads/2022/08/Skill-Gap-Report_Uttarakhand.pdf> last accessed 22nd March 2022.

Table 5

Pain point mapping for Climate Adaptive Agriculture in the Indian Himalayan Region

S.No	Pain Point	Operational Scenarios	Use Case	Functional Requirements
1	Traditional varieties cannot be grown due to change in weather conditions	**Impact of changing weather conditions** • Difficult to match cropping patterns with the unpredictable weather patterns which majorly includes erratic rainfall. • Scarcity of water and drying up of water natural reservoirs. • Significant shift in traditional cropping patterns. The region earlier used to be a potato belt but difficulty in growing potatoes now due to weather and wild pig attacks. • Increase in temperature has shifted the cropping patterns to higher altitudes and hence the traditional varieties cannot be grown. For example, the traditional apple variety needs 1000 hrs of chilling at 5 degrees Celsius which is not possible in the changed weather conditions and hence the community is experimenting with a low chilling variety of mini apples from Netherlands which require 300 hrs of chilling (sunlight, moonlight, goldlane and redlane). These varieties start fruiting in the second year and after fifth year the average production from one plant is 5 to 6 kgs • Earlier plants like bayleaf, stonefruits could not grow but now could be grown due to changing weather conditions **Nature of Farming** • Farming is primarily subsistence based, extra produce is sold in the market **Collective Action Group** • No presence of farmer producer organizations • Farmer groups and polyhouse groups are present & are monitored by organizations like BAIF	Dissemination of advisory to villagers pertaining to crop diversification that suits changing weather patterns and soil chemistry	In-soil sensors to measure various parameters: temperature, moisture, pH, and nutrient levels. Drones used with sensors to collect data from the soil and other remote locations, and satellite imagery, which can provide a bird's-eye view of the soil and help identify areas of concern. Drones to be used for land analysis/ pesticide spraying and seeding. Parameters to consider: Payload capacity for farm inputs, Weight, Max flying height, Frame rate [30Hz, below this the video output would lag and not be comprehensive], Operating Temp [-5°C to 50°C; which is the average temperature range in the Indo-Himalayan belt with farming capacity], IP65 Rating to protect from Dust, Water and extreme weather. AI to analyse historical climate and soil data to identify trends and patterns in weather and soil chemistry. This information can be used to identify which crops are best suited for specific weather and soil conditions and to provide recommendations for crop diversification to farmers.

S.No	Pain Point	Operational Scenarios	Use Case	Functional Requirements
		Technology Baseline • Solar lift irrigation interventions deployed by BAIF in certain locations (Narsinghdanda)		
2	Lack of value capture mechanisms in the supply chain of high value forest/ agro-forestry/ horticulture products with a limited shelf life (as well as otherwise)	**Social Realities** • At present, forest-based livelihood opportunities in the region are limited, reduced dependency on forests key reason for their degradation • Money order economy – high rates of male (working age) out migration • Demographic composition – primarily women and young girls and older men • Local communities are hesitant to undertake labor intensive work. **Collective Action Group** • The presence of a network of Van Panchayats, Collective Action Groups (SHGs), and implementing agencies like BAIF to help drive initiatives at the community level. **Potential Products** • Products whose production can be leveraged for profitability in the region include stone fruits like Malta, Peach, Plums, Kafal, Apricots, Walnuts; large Cardamom; Medicinal herbs and plants; Kiwis; Hisalu; Saffron; Mini Apples (low chilling); Geranium; Rosemary; Lavender; Cold water fishery (Trout); Liliums; Honey; Cow Dung-based products; Pine needle products; Potato; Bay Leaf; Butter Tree (Churu); Reetha; Ghee; Gehad Dal; Madua	Improving shelf life of products	Temperature sensors for maintaining the refrigeration of cold storage. Temperature sensors be used in cold storage to accurately measure and control the temperature within a range of -40°C to +30° [This level of sensitivity allows for early detection of any deviations from the desired temperature range and enables corrective actions to be taken to maintain the temperature within the desired range]. Electric Cold storage to control humidity levels, as high humidity can lead to spoilage and mould growth on stored goods. Adequate ventilation is required to ensure that the air inside the facility is fresh and free of contaminants that can affect the quality of the stored goods. To prevent heat transfer from the outside environment, ensuring that the stored goods remain at the desired temperature.

S.No	Pain Point	Operational Scenarios	Use Case	Functional Requirements
2	Lack of value capture mechanisms in the supply chain of high value forest/ agro-forestry/ horticulture products with a limited shelf life (as well as otherwise)	**Logistics** • Transportation and logistics costs are high. • Electricity (for example during the field visit, power cut of 6 hours) and water shortages. • Low shelf life of certain products **Technology baseline** • Pine compactors utilized by Sanctuary Paper Mills for easy transportation of pine needles at lower costs. • At present value addition technologies are not being procured institutionally like via the forest department – something on the lines of Common Facility Centers (Handloom) that can provide scale.	Improving shelf life of products	Parameters: Storage Capacity, Portability to reduce transportation cost, travel range up to (80km/charge). Use of Blockchain technology: 1. Supply chain transparency: This can help to improve food safety and reduce the risk of food fraud and counterfeiting. 2. Traceability: to help track and trace food products through the supply chain, allowing consumers and regulators to quickly identify the source of any issues in the event of a food safety concern. 3. Food safety: to securely store and manage food safety data, such as inspection reports, health certificates, and testing results, to help ensure the safety and quality of food products. 4. Sustainability: to track and verify sustainability claims made by food companies, such as organic, fair trade, and environmentally friendly labels, to help increase transparency and

S.No	Pain Point	Operational Scenarios	Use Case	Functional Requirements
				5. Livelihoods: to support small-scale farmers and rural communities by connecting them directly to consumers, enabling them to receive fairer prices for their products and to improve their livelihoods.
3	Crop destruction due to wild animals and higher pest infection due to climate change	• Proximity of forests land and agricultural areas have increased over the years due to expansion of human settlements. • Due to degradation forests, animal wildlife conflicts in recent years have proliferated, primarily wild pigs and monkeys and wild pigs dig-up the soil and even destroy underground crop varieties like potatoes, local Gaderi. • Monkeys destroy the fruits, vegetables and other crops on the ground and trees. **Nature of Farming** • Subsistence farming extra produce is sold in the market. • Terrace farming is preferred as the land is not plain and hence monitoring becomes a challenge. • Significant shift in traditional cropping patterns due to changing weather conditions the region earlier used to be a potato belt but difficulty in growing potatoes now due to weather. **Collective Action Group** • No presence of farmer producer organizations • Farmer groups and polyhouse groups are present and are monitored by organizations like BAIF **Technology Baseline** • Barbed wires and wooden sticks are used for fencing (very rudimentary)	Improving crop yield	Sensors with ability to detect animal intrusion with a) the frequency required to specifically determine animal movement and b) from a distance suitable for the adopter. Passive Infrared Sensors (PIR) - HC-SR501, with 30 meters range [to cover substantial areas within a small land holding, thus allowing one device per land holding] and minimum frequency of 20kHz [beyond which human ears cannot hear the sound but animals can]. A wireless sensor network based on UWB technology. To deploy intrusion detection by analyzing the Ultra-Wide Band (UWB) signals, the collected signal is reconstructed the phase space to show its characteristic. Then the automatic feature extraction of CNN (convolutional Neural Network) is to find out the difference between intrusions of species.

S.No	Pain Point	Operational Scenarios	Use Case	Functional Requirements
3	Crop destruction due to wild animals and higher pest infection due to climate change		Improving crop yield	Electric fencing: Height ranging from 10-20 feet depending on the farm location and animals nearby. Electric Fence is required to give a strong but safe shock which creates a psychological barrier in the minds of the intruders. It should also adhere to IEC 600335:2:76 standard. Adequate barrier to protect the farm from animal intrusion with following characteristics: a) high enough to shield cropped land from animal trespass b) made from a material robust enough to sustain animal attack/ weather condition and c) made from material that does not adversely affect biodiversity.

between 2019 and 2021. This has led to a decrease in crop yields and a decline in the income of farmers, who depend heavily on agricultural production for their livelihoods. Additionally, higher temperatures and changes in precipitation patterns caused by climate change have increased the risk of pest infestations in crops, leading to further crop losses. As per a study by the ICAR, the yield losses in crops due to pest infestation in Uttarakhand have increased by seven per cent in the last decade. These alarming statistics highlight the urgent need for effective strategies to mitigate crop destruction caused by wild animals and pest infestations resulting from climate change in Uttarakhand.

User Persona Mapping

User persona mapping refers to the process of collating and segmenting information about potential decision makers[25] and technology adopters. The key objective of the process is to create archetypes of potential technology adopters and decision makers pertaining to procurement and financing. The creation of decision maker and technology adopter archetypes helps in ensuring that the process of

25 Please note that in certain scenarios the decision makers and adopters of technology can be different

technology scouting is precise. This feeds into the larger goal of ensuring technology adoption by bringing the technology that solves the user problem most effectively. This section (refer Table 6-10) presents details of user persona mapping at the three different tiers - strategic, operational, and field, which involves decision makers and potential adopters for each layer in the climate adaptive agriculture technology stack.

Table 6

User Persona Mapping for Smart Soil Health Monitoring

Decision-Making Tier	• Strategic • State Administration: Represented by UCOST (Nodal Agency for Uttarakhand @ 25) under the Department of Information and Science Technology, Government of Uttarakhand	• Operational • District Administration: District Magistrate | Line Departments | DFO | Allied Govt. Agencies	• Field • Gram Panchayat | Van Panchayat | Collective Action Groups | End adopters

Role and Key Priorities	• Role:
	  • Facilitate deployment of innovations and technologies for soil health monitoring that help farmers of Uttarakhand to take adequate measures while farming to ensure high yields.
	  • Designing procurement and technology funding mechanisms.
	• Key Priorities: Uttarakhand@25, Adarsh Champawat, science, and technology led development of Uttarakhand; improved soil qualities across the districts of Uttarakhand; increased state agricultural output; doubling farmers income levels; increased tea exports from the state.
		• Role:
		  • Incorporating mechanisms to deal with agricultural impacts of climate change via district development plans.
		  • Operationalising procurement; sanctioning funds; capacity building of local communities.
		• Key Priorities: Adarsh Champawat; improvement in quality of district soils; enhancement for district income levels; enhancement of district agricultural output; enhancing Champawat tea exports.
			• Role:
			  • Delivery & adoption of the technology for climate adaptive agriculture.
			  • Funding and procurement; Awareness about new technologies; Change Agents; Capacity building of local communities.
			• Key Priorities: Improvement in household incomes; enhancement of individual farm level agricultural output.

Background	Climate change has bearings on the weather patterns of the region. There is an attitudinal shift in the belt where traditional varieties were grown (higher altitudes). Simultaneously, it has become possible to grow certain crops, fruits, and vegetables, which initially could not be grown in the area. In addition to rainfall and temperature patterns, understanding of soil chemistry is vital to grow new varieties. • In this context, portable soil testing technologies assume importance as setting up of lab-based soil testing infrastructure could be a cumbersome process both in terms of time and cost. • Portable in-situ soil testing technologies assume importance for rural communities to equip them with knowledge to take corrective actions to improve yield from their farmlands with minimal cost implications.		

Attitudes and Interests	• The state administration is keen on promoting climate adaptive agriculture throughout the state and soil health monitoring is one of the key elements in this. • Soil health monitoring will enable the state administration to devise appropriate agricultural programs and strategies across different districts of the state. • Aligning initiatives of the district administration with the vision of the Chief Minister and national priorities.	• The administration wants to bring down the time and cost expended by the farmers, especially small & marginal in ascertaining soil quality which has implications for crop yield. • The District Magistrate directed the line departments to explore subsidizing the costs of the kits through relevant schemes to facilitate direct purchase by the farmers. • The District Magistrate has expressed interest in shifting towards smart & portable soil sensing technologies.	• Representatives expressed interest in portable soil testing technologies. • Representatives were of the view that some units of the portable soil testing kits can also be bought at their level, which can then be utilized by certain trained community members to perform tests for farmers in 2-3 villages.
Behaviour and Decision Triggers	• Uttarakhand is a state with hilly terrain with many small and marginal farmers and hence the administration is keen to adopt cost effective decentralised solution. • Their focus is to establish a balance between emerging technologies & frugal innovations which would facilitate faster adoption. • The administration focuses on solutions which are scalable across the state.	• The low-cost soil testing solutions are preferred by the administration. • Portable & instant soil testing mechanism are highly sought for by the administration as it reduces the time & cost expended by the farms.	• Representatives' interests stemmed from the fact that farmers at present do not engage in testing as they are marginal and small. Such technologies will empower 'the last mile at the last mile' and help improve output from landholdings.
Functional Requirements from Technology	• Portable and can be easily carried to agricultural land located in difficult and inaccessible regions of the hill districts. • The technology should not be very costly so that adoption by individual farmers or collective action groups is possible. • Advisory in local language, if possible.	• Portable and can be easily carried to agricultural land located in difficult and inaccessible regions of the hill districts. • The technology should not be very costly so that adoption by individual farmers or collective action groups is possible. • Advisory in local language, if possible.	• Simple and inexpensive technology that rural communities can use to test soil samples in-situ very easily in a time efficient manner. • Lucidly informs rural communities of the steps they need to take to enhance the quality of their soil – goes beyond monitoring to advisory.

Table 7

User Persona Mapping for soil sensors and UAVs

Decision-Making Tier	• Strategic • State Administration: Represented by UCOST (Nodal Agency for Uttarakhand @ 25) under the Department of Information and Science Technology, Government of Uttarakhand.	• Operational • District Administration: District Magistrate | Line Departments | DFO | Allied Govt. Agencies.	• Field • Gram Panchayat | Van Panchayat | Collective Action Groups | End adopters

Role and Key Priorities	• Role:
	  • Facilitate deployment of innovations and technologies that help improve farm input delivery in the state.
	  • Designing procurement and technology funding mechanisms.
	• Key Priorities: Uttarakhand@25, Adarsh Champawat, science, and technology led development of Uttarakhand; improve the drudgery involved in farm input delivery in the hilly terrains; increased state agricultural output; doubling farmers income levels; increased tea exports from the state .
		• Role:
		  • Incorporating mechanisms to deal with agricultural impacts of climate change via district development plans.
		  • Operationalizing procurement; sanctioning funds; capacity building of local communities.
		• Key Priorities: Adarsh Champawat; Improvement in rural incomes; Enhancement of District Agricultural Output; Rural youth employment generation; Enhancing tea exports .
			• Role:
			  • Delivery & adoption of the technology for climate adaptive agriculture.
			  • Funding and procurement; Awareness about new technologies; Change Agents; Capacity building of local communities.
			• Key Priorities: Improvement in household incomes; enhancement of individual farm level agricultural output.

Background	Sowing and farm input delivery is a labour-intensive process, where terraced farmlands are necessitated by a mountainous terrain. This is especially relevant in the context of plantation crops like tea, bigger orchards, and farmlands. For example, the tea gardens of Champawat managed by the Uttarakhand Tea Development Board are spread over an area of approximately 240 hectares.[26] Hence, deployment of unmanned automated systems for sowing and farm input delivery over large expanse of plantation/farmlands/orchards could make the method precise and lead to significant time savings.		

26 Source: Mr. Desmond Birbeck, Manager, Tea Gardens Champawat, Uttarakhand Tea Development Board (Meeting with AGNIi Mission members on March 17, 2023 at Champawat)

Attitudes and Interests	• The state of Uttarakhand comprises of hilly terrain and large number of marginal farmers which makes the terrace farming labour intensive. The administration wants to reduce the physical labour of the farmers by leveraging technology. • The state administration aims at rationalizing the amount of farm inputs which directly impacts the quality of soil and land in the state with implications for crop yield and cropping intensity. • Aligning initiatives of the district administration with the vision of the Chief Minister and national priorities.	• The administration is exploring technologies which could make terrace farming activities less arduous. • The administration prefers cost-efficient and easy to use solutions.	• Representatives concurred that sowing and farm input delivery via UAVs will make the associated processes less arduous. • Representatives expressed doubts over individual farmers adopting these technologies owing to cost and operational reasons.
Behaviour and Decision Triggers	• The administration is looking at cost-efficient and easy to use farm input delivery technologies. • Their focus is to establish a balance between emerging technologies & frugal innovations which would facilitate faster adoption. • The administration focuses on solutions which are scalable across the state.	• The cost of UAVs is high compared to the frugal technologies and hence the district administration will deploy it for groups of farms and allied agencies having large landholding. • Subscription based models wherein small and marginal farmers via collective action groups can reduce the drudgery entailed in farm input delivery in terraced farm.	• Representatives asserted that this set of technologies will have to be procured by the district administration due to the higher costs. • They highlighted that training and capacity building of the youth to use the technology is required to promote the adoption.
Functional Requirements from Technology	• Unmanned and automated smart systems that can help facilitate farm input delivery in large tracts of terraced lands with slopes and undulating terrain, for example orchards and tea gardens. • Possibility of leveraging the data generated through smart platforms for implementing state schemes and plans related to soil health and agri-inputs.	• Ensuring improvements in district soil quality for enhancing yield to generate volumes for trade (especially in the context of Tea). • Possibility of leveraging the data generated through smart platforms for micro-level planning and has instructed the line departments for the same.	• Reducing arduous physical labor involved in sowing and farm input delivery. • Generating rural employment opportunities.

Table 8

User Persona Mapping for Animal Intrusion and Detection Systems

Decision-Making Tier	• Strategic • State Administration: Represented by UCOST (Nodal Agency for Uttarakhand @ 25) under the Department of Information and Science Technology, Government of Uttarakhand	• Operational • District Administration: District Magistrate | Line Departments | DFO | Allied Govt. Agencies	• Field • Gram Panchayat | Van Panchayat | Collective Action Groups | End adopters

Role and Key Priorities	• Role:
	  • Facilitate deployment of innovations and technologies that help reduce instances of human wildlife conflict in the state.
	  • Designing procurement and technology funding mechanisms.
	• Key Priorities: Uttarakhand@25, Adarsh Champawat, science, and technology led development of Uttarakhand; increased state agricultural output; doubling farmers income levels; increased tea exports from the state.
		• Role:
		  • Incorporating mechanisms to deal with agricultural impacts of climate change via district development plans.
		  • Operationalising procurement; sanctioning funds; Capacity building of local communities.
		• Key Priorities: Adarsh Champawat; reduction in human-wildlife conflict in the district; enhancement of district agricultural output; improvement in rural incomes; enhancing tea exports from the region.
			• Role:
			  • Delivery & adoption of the technology for climate adaptive agriculture.
			  • Funding and procurement; Awareness about new technologies; Change Agents; Capacity building of local communities.
			• Key Priorities: Improvement in household incomes; enhancement of individual farm level agricultural output.

Attitudes and Interests	• Uttarakhand is a state with large forest cover and hence the administration must establish a balance between welfare of the citizens and conservation of forests and wildlife. • The state wants to reduce the friction due to human-wildlife conflict without physically harming the animals as well as not risking the lives of the forest officials as well as residents. • Aligning initiatives of the district administration with the vision of the Chief Minister and national priorities.	• The district administration is exploring smart technologies to prevent animal intrusion. • The technologies which are easy to operate are preferred.	• Representatives expressed great interest in smart animal intrusion, detection, and prevention systems as the region is extremely afflicted by wildlife ravaging farmlands and destroying production. • Their primary concern is that technology should primarily keep wild pigs and monkeys away from the farmland.
Behaviour and Decision Triggers	• The administration wants to use cost-effective smart technologies to prevent animal intrusion to reduce destruction of crops as well as ensure safety of the residents & forest officials. • Their focus is to establish a balance between emerging technologies & frugal innovations which would facilitate faster adoption. • The administration focuses on solutions which are scalable across the state.	• The cost of the technology is high hence the district administration will explore to deploy the box system for a group of farms and for allied agencies having large landholdings.	• Considering costing, representatives were of the view that one system can be installed for 2-3 family farms. • The community needs to see the efficiency of the technology hence deployment can also be facilitated by organizations like BAIF and Saigal Foundation on pilot basis.
Functional Requirements from Technology	• Portable technology solutions that can be easily installed and used by rural hill communities to prevent and detect animal intrusion into their farmlands. • Light-weight portable animal prevention and detection systems that ensure the security of forest guards during their patrolling and monitoring vigils.	• Reducing human-wildlife conflict in the district. • Protecting farmlands. • Ensuring the security and safety of forest guards during patrolling and surveillance.	• Reducing instances of wild pigs and monkeys raiding and destroying farmlands. • Reducing deaths and injuries to villagers because of human-wildlife conflict.

Table 9

User Persona Mapping for Digital Platforms

Decision-Making Tier	• Strategic • State Administration: Represented by UCOST (Nodal Agency for Uttarakhand @ 25) under the Department of Information and Science Technology, Government of Uttarakhand	• Operational • District Administration: District Magistrate | Line Departments | DFO | Allied Govt. Agencies	• Field • Gram Panchayat | Van Panchayat | Collective Action Groups | End adopters

Role and Key Priorities	• Role:
	  • Facilitate deployment of innovations and technologies that effectively provide farmers in remote regions of the country facing significant challenges in reaching physical markets with alternatives of in-situ digital markets and are able to establish the authenticity of the products for better cashflows.
	  • Designing procurement and technology funding mechanisms.
	• Key Priorities: Uttarakhand@25, Adarsh Champawat, science, and technology led development of Uttarakhand; doubling farmers income levels; increased tea exports from the state; building a brand for Agri/horticulture products originating from different districts of Uttarakhand
		• Role:
		  • Incorporating mechanisms to deal with agricultural impacts of climate change via district development plans.
		  • Operationalising procurement; funds sanction; capacity building of local communities
		• Key Priorities: Adarsh Champawat; Improvement in rural incomes; Enhancement of high value agriculture and horticulture exports from the region (domestically and internationally); Enhancing tea exports from the region; Rural youth employment generation.
			• Role:
			  • Delivery & adoption of the technology for climate adaptive agriculture.
			  • Finding and procurement; Awareness about new technologies; Change Agents; Capacity building of local communities.
			• Key Priorities: Improvement in rural incomes; enhancement of individual farm level agricultural output.

Background	• Removal of intermediaries, and marketing and branding of products originating from the region is an important priority to develop and strengthen agriculture/horticulture value chains and to improve rural incomes. • Rural communities engage in producing high value products such as Buransh Juice, Hemp seed products, pickles, jams. However, at present the branding of these products is very basic and not very catchy and attractive. Meanwhile, marketing is essentially limited to word of mouth or stalls in fairs across the country, which entails significant efforts with minimal returns.		

Attitudes and Interests	• The state administration wants to digitize and optimize the rural economy which would reduce the problems arising due to the geographical barriers of hilly terrain. • Aligning initiatives of the district administration with the vision of the Chief Minister and national priorities.	• The District Magistrate and administration are interested in digitizing the value chain. • They want to explore the digital marketplaces for premiumization of the indigenous produce. • However, an important pre-requisite for adoption of digital platforms would be strengthening of the Farmer Producer Organisation (FPO) and Self Help Group (SHG) network.	• Representatives asserted that developing an end-to-end value chain (especially marketing and branding of products produced in the region) is of utmost importance for value capture. • At present, the main medium for women associated with SHGs to sell the high value products is fairs (example Saras Mela) happening across the country. Representatives asserted that on-boarding of such women on digital platforms will provide them an additional avenue (better) for selling their products and do away with the need to travel long distances. • It was expressed that onboarding on digital platforms of individual farmers would require mass awareness on benefits and capacity building.
Behaviour and Decision Triggers	• The state of Uttarakhand has many small & marginal farmers thus the onus of providing market access is on the administration. • Their focus is to establish a balance between emerging technologies & frugal innovations which would facilitate faster adoption. • The administration focuses on solutions which are scalable across the state.	• The complexity of digitizing the value chain and lack of required infrastructure & expertise forces the administration to only focus on online marketplaces. • The district administration is willing to experiment the technology in the beginning with agencies having substantial turnover like Uttarakhand Tea Board.	• Representatives stated that such technologies will have to be adopted at the district administration level due to the infrastructure cost involved and technical expertise required.

Functional Requirements from Technology	• Simple digital platform solutions on which the farmers and collective action groups like FPOs can onboard easily and quickly • Provenance tracking to ensure the development of a Brand of Uttarakhand products. • Payment tracking to ensure that farmer incomes are boosted.	• Ensuring value capture and tracking/ traceability throughout the value-chain. • Payment tracking to help increase incomes of the farmers in the district. • Enabling provenance tracking and premiumization.	• Provide information to villagers on how they can build a better brand and market their products in an inexpensive manner. • Remove intermediaries and help villagers (especially women associated with SHGs engaged in producing high value products) directly access the markets, as market access at present is a logistical problem considering the region's geography

Table 10

User Persona Mapping for Mechanised Equipments

Decision-Making Tier	• Strategic • State Administration: Represented by UCOST (Nodal Agency for Uttarakhand @ 25) under the Department of Information and Science Technology, Government of Uttarakhand	• Operational • District Administration: District Magistrate | Line Departments | DFO | Allied Govt. Agencies	• Field • Gram Panchayat | Van Panchayat | Collective Action Groups | End adopters

Role and Key Priorities	• Role:
	  • Facilitate deployment of innovations and technologies that effectively help farmers to ensure quality of low-shelf life agri/horticulture products till they reach the Mandis.
		• Role:
		  • Incorporating mechanisms to deal with agricultural impacts of climate change via district development plans
			• Role:
			  • Delivery & adoption of the technology for climate adaptive agriculture

	• The objective is to both reduce wastage and ensure farmers get a high price for better quality. • Designing procurement and technology funding mechanisms. • Key Priorities: Uttarakhand@25, Adarsh Champawat, science, and technology led development of Uttarakhand; increased state agricultural output; doubling farmers income levels; increased tea exports from the state.	• Operationalising procurement; sanctioning funds; capacity building of local communities. • Incorporating mechanisms to deal with agricultural impacts of climate change via district development plans. • Key Priorities: Adarsh Champawat; Improvement in rural incomes; Enhancement of District Agricultural Output .	• Funding and procurement; Awareness about new technologies; Change Agents; Capacity building of local communities. • Key Priorities: Improvement in rural incomes; enhancement of individual farm level agricultural output.
Background	• Primary sector products grown in the region, especially horticulture produce of fruits have a short shelf-life. Additionally, the geography and terrain increase the time expended in reaching local mandis. However, setting up of conventional cold storage units are constrained by geography and have cost implications. • Primary sectors produce with lower shelf life grown by rural communities are products that fetch high prices in the market. However, storage and transportation of these products to increase shelf-life is a challenge at present as cold storage infrastructure is not present and transportation from remote locations to Mandis takes time. Due to lack of cold storage facilities in-situ and while transportation leads to wastage and deteriorates product quality, which has implications for revenue.		
Attitudes and Interests	• The state administration wants to reduce the operational and logistical challenges faced by the farmers due to the geography as the reduction in crop wastage would have significant impact on state's agricultural output. • The state administration wants to leverage the technology to support the growth of horticulture across different districts by building the necessary infrastructure.	• The District Magistrate is open to explore innovative yet cost-effective solutions that reduce spoilage and wastage of agricultural and horticultural produce both in-situ and during transportation as it would help to give a boost to rural incomes. • The administration intends to adopt technologies which can be used in areas with limited electrification.	• Representatives expressed interest in technologies for in-situ preservation to increase the shelf-life as well as the technologies to maintain the shelf-life even during transportation to the nearest Mandi.

Behaviour and Decision Triggers	• The state administration is keen to facilitate adoption of cost-effective, decentralised and energy efficient technologies. • Their focus is to establish a balance between emerging technologies & frugal innovations which would facilitate faster adoption. • The administration focuses on solutions which are scalable across the state.	• The low cost of the technologies vis-à-vis the conventional cold storage is an important factor for adoption. • The administration is willing to deploy the technology through SHG networks due to the simplicity, efficiency, and mobility.	• Representatives thought that, given the cost-effectiveness of the solutions, deployment is possible at the individual/ household level.
Functional Requirements from Technology	• Low-cost decentralized cold storage systems in-situ and transportation related which can be leveraged by small and marginal farmers in remote hilly regions of the state.	• Low-cost decentralized cold storage systems in-situ and transportation related which can be leveraged by small and marginal farmers in the hill region of the districts.	• Reduces spoilage and wastage of agricultural and horticultural produce both in-situ and during transportation.

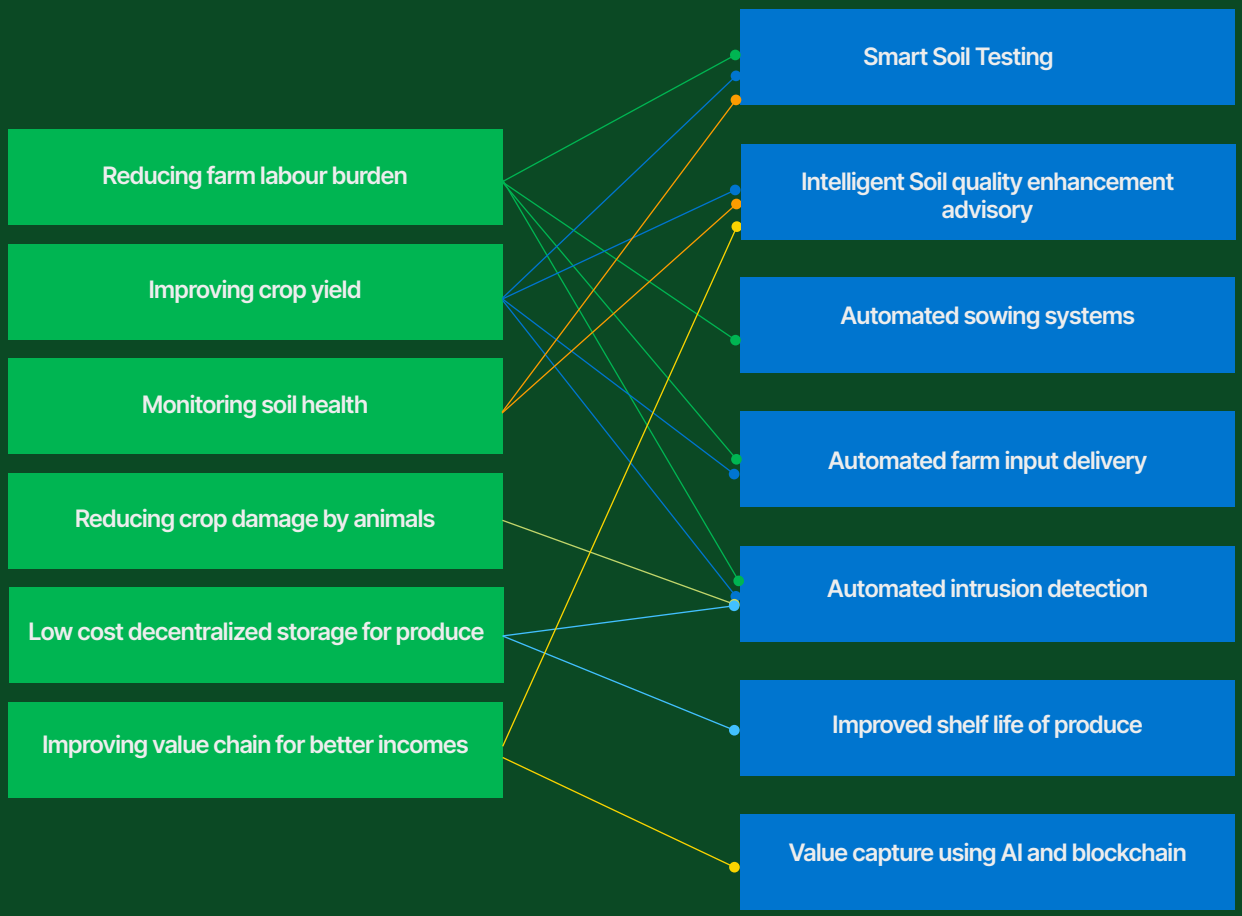

Dhara Shakti

Need Feature Mapping

The pain-points and operational scenarios for climate-adaptive agriculture were surfaced via field work, which comprised focused group discussions and key informant interviews with relevant stakeholders (representatives of the state administration, district administration and rural communities). Subsequently, the pain-points and operational scenarios were translated into technology functional requirements, which were utilised for scouting relevant innovators. The figure (refer Fig 12) maps the pain-points and needs of end adopters with relevant technology use cases.

Box 6

Need Feature Mapping for Climate Adaptive Agriculture for Indian Himalayan Region



Technology Stack

SECTION 4

The need for technological intervention is of utmost importance for successful implementation of climate adaptive agricultural practices. Based on the above-mentioned need-feature mapping, technological capabilities that have the capacity to address the needs, and their relevance to the end-user are mapped in the following figure and matrix. The various layers of the matrix are:

- Feature and its description,
- technological capabilities and the specific layers that have the said features,
- relevance in terms of the end adopter to tie the need with the end user.

Box 7

Technology Stack for climate adaptive agriculture

	Preparation for cropping	Sowing	Crop Care
Sensors	pH Sensor – Acidity/Basicity of soil sample Optical Transducers – N, P, K levels in soil DHT11 Microclimate sensor – Air and soil temperature, Soil humidity	Optimised fertilizer application Hyperlocal weather data collection Animal Intrusion Detection System	UAV and drone based field surveys UAS mounted sensing for soil and weather parameters, IoT sensors for micro-area weather monitoring and alerting
AI	Credit Risk Assessment for non traditional variety growers (Crop Insurance) Sowing recommender system : Personalised recommendation systems	Optimised sowing cycle AI based robots for automated and intelligent sowing, Hyperlocal weather data analysis and prediction Drone based sowing	Scouting, monitoring and weeding using farm robots & autonomous ground vehicles (AGVs)
Digital Platforms	Language translation platforms to educate farmers, in their local language/dialect, on the adoption of right package of practices and inputs On-demand equipment rentals AI voice-bots for know-how sharing Online marketplace and e-commerce		Vernacular weather and crisis advisories
Mechanised Equipment	Electric Tractor, Mini Tractor, Compact Ploughing implements		Compact lightweight farm inputs delivery modules

	Harvest	Post Harvest	Market Access and Linkages
Sensors	Animal Intrusion Detection System	Storage hotspot identification and forecast	Blockchain based supply chains Transport optimization via GPS-tagged elements to reduce transportation costs
AI	Sorting using image recognition AI-enabled robots for harvesting and simultaneous assaying, grading and sorting to improve efficiency	Image recognition for grading of produce	Demand forecasting, Price forecasting, Granular geo-mapping of agricultural commodities and demand pockets
Digital Platforms		Vernacular advisory On-demand mobile storage-as-a-service model	Produce pick up as a service
Mechanised Equipment	Electric Tractor, Mini Tractor, Compact Ploughing implements	Loading trucks with dry ice bricks using CO2 cylinders [30kg C)2 → 5 kg of dry ice] Storage for Cold Temperatures [0-5](Solar, Electric) Humidity Control, Temperature Control, Ventilation Control Thermal Efficient Biomass ChullahStorage CapacityPortability (Travel Range)	

Table 10

Technology Stack for climate adaptive agriculture in the Indian Himalayan Region

Feature	Description	Capability				Relevance	
		Sensors	AI & Blockchain	Digital Platform	Mechanised Equipment	Strategic Tier	Operational and Field Tier
Smart Soil Testing	To provide the soil testing services at the farmers' doorstep by determining all the soil parameters such as pH, moisture, nitrogen, potassium, phosphorus contents	Various sensors to test: 1. Structural properties (soil texture, type, and bulk density); 2. Soil fertility (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Carbon Exchange Capacity, soil pH, soil acidity, per cent organic matter (OM); 3. Soil salinity (Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR: used to evaluate the effect of sodium on soil structure))	Machine learning based optical analyser, which is connected to cloud, battery operated and is GPS enabled	Cloud based platform for online farm input advisory, soil health record, map, farm analytics and fertilizer		• State administration is keen on promoting climate adaptive agriculture throughout the state and soil health monitoring is one of the key elements in this. • Soil health monitoring will enable the state administration to devise appropriate agricultural programs and strategies across different districts of the state. • Strategically, such technologies can assist the state administration in generating soil advisory, which can also be incorporated in the agriculture extension services provided to farmers on maintaining soil health	• Portable and smart soil health monitoring technologies will bring down the time and cost expended by farmers, especially small & marginal in ascertaining soil quality which has implications for crop yield. • Some units of the portable soil testing kits can also be bought at the level of the collective action groups, which can then be utilized by certain trained community members to perform tests for farmers in 2-3 villages. • Intelligent soil advisory is important for small and marginal farmers as at present the application of nutrients on soil is not substantiated by evidence.

Feature	Description	Capability				Relevance	
		Sensors	AI & Blockchain	Digital Platform	Mech-anised Equipment	Strategic Tier	Operational and Field Tier
Intelligent soil quality enhancement advisory	Online advisory system on a website giving insights on how to enhance the various nutrients level in soil of a particular area post inputs from the farmer/ adopters		AI Layer (GIS software that blends the power of a map with the power of a database to allow people to create, manage and analyse information, particularly information about location) which uses historical data insights to deliver tailormade inputs regarding best farm practices in a particular geographical area along with the capability to send custom notifications to farmers for the required inputs	Mobile optimised web-based dashboards for advisory on soil enhancement according to the location inputs from farmners	-	• State administration is keen on promoting climate adaptive agriculture throughout the state and soil health monitoring is one of the key elements in this. • Soil health monitoring will enable the state administration to devise appropriate agricultural programs and strategies across different districts of the state. • Strategically, such technologies can assist the state administration in generating soil advisory, which can also be incorporated in the agriculture extension services provided to farmers on maintaining soil health	• Portable and smart soil health monitoring technologies will bring down the time and cost expended by farmers, especially small & marginal in ascertaining soil quality which has implications for crop yield. • Some units of the portable soil testing kits can also be bought at the level of the collective action groups, which can then be utilized by certain trained community members to perform tests for farmers in 2-3 villages. • Intelligent soil advisory is important for small and marginal farmers as at present the application of nutrients on soil is not substantiated by evidence.

Feature	Description	Capability				Relevance	
		Sensors	AI & Block-chain	Digital Plat-form	Mechanised Equip-ment	Strategic Tier	Operational and Field Tier
Automated sowing systems	Deploying a technology which enables automation of the process of sowing seeds over a user defined area and along a user defined pattern				GPS enabled drone systems with different payload capabilities to geo-fence a particular area and deposit seeds, pesticides, etc within the defined area	• Uttarakhand comprises of hilly terrain and large number of marginal farmers which makes the terrace farming labour intensive. The administration wants to reduce the physical labour of the farmers by leveraging technology. • The state administration aims at rationalizing the amount of farm inputs which directly impacts the quality of soil and land in the state with implications for crop yield and cropping intensity	• Automated sowing and farm input delivery systems have the potential to make terrace farming activities less arduous. • The administration prefers cost-efficient and easy to use solutions. • Doubts were expressed over individual farmers or even collective action groups adopting these technologies in a product-based model due to cost and operational reasons.
Automated farm input delivery	Spraying of pesticides and/ or other nutrient enhancing products to the farm using automated delivery systems with minimal human intervention						

Feature	Description	Capability				Relevance	
		Sensors	AI & Block-chain	Digital Plat-form	Mechanised Equipment	Strategic Tier	Operational and Field Tier
Animal intrusion detection and deterrent	Detection of animals around the farm boundary and mechanism to deter them from intruding the secured area and thereby preventing them from destroying the crops	Motion sensors detect movement in a defined area of interest. They use a passive infrared sensor (PIR & AIR sensor) which is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. The sensor radius can vary from as little as 30mm right up to 240m for covering significantly larger areas.			Systems deployed on the farm boundary to detect and deter any animal/bird within the range using sounds/ electric shock	• Uttarakhand is a state with large forest cover and hence the administration must establish a balance between welfare of the citizens and conservation of forests and wildlife. • The state wants to reduce the friction due to human-wildlife conflict without physically harming the animals as well as not risking the lives of the forest.	• District administration is fencing farmlands (rudimentary methods of barbed wires) under MGNREGA for farmland protection. • Portable and smart animal intrusion and detection systems can go a long way to prevent crop destruction and reduce menace for rural communities with implications for household incomes especially for small and marginal farmers. • Considering the geography of the region and proximity with forests, manual night-time monitoring by forest guards poses significant risks.
Improved shelf life of horticulture/ Agri produce	Using cost effective systems to enhance the life cycle of produce post-harvest to ensure a longer shelf life, thus reducing wastage				Cost effective cold storage boxes and dry ice is used to increase the duration for which various farm produce remains fresh for consumption		

Table 11

Technology Stack for climate adaptive agriculture in the Indian Himalayan Region

Feature	Description	Capability				Relevance	
		Sensors	AI & Blockchain	Digital Platform	Mech-anised Equipment	Strategic Tier	Operational and Field Tier
Value capture services	Connect farmers, traders, input dealers, logistics providers, academia, institutional buyers, POs, government departments and consumers. Interactions such as Information, help, advice, buy, sale and service happen between them solving each other's problems and benefitting together	Optical scanner to read QR codes and convert the output into user accessible data	Crop specific integrated value chain with blockchain technology to create a seamless, transparent and trustworthy end-to-end tracking of supply chain	Agritech platforms use technology to manage the whole agriculture supply chain, from farming inputs to last-mile distribution. suggestions		• The state administration wants to digitize and optimize the rural economy which would reduce the problems arising due to the geographical barriers of hilly terrain.	• District administrations are interested in digitizing the value chain. They want to explore the digital marketplaces for premiumization of the indigenous produce. • For field personnel developing an end-to-end value chain (especially marketing and branding of products produced in the region) is of utmost importance for value capture. • At present, the main medium for women associated with SHGs to sell the high value products is fairs (example Saras Mela) happening across the country. For field personnel on-boarding of such women on digital platforms will provide them an additional avenue (better) for selling their products and do away with the need to travel long distances. • Onboarding on digital platforms of individual farmers would require mass awareness on benefits and capacity building.

Field Technology Showcase

SECTION 5

To demonstrate technology stack's practical potential – actual impact on the ground, for Government decision-makers, against these priorities – the AGNIi team conducted a demonstration, and a field showcase in Champawat. The first was conducted at Uttarakhand Rural Science Congress 2023 at Dehradun. In this demonstration, eight innovators participated from across India. Primarily, this demonstration gauged the level of response from the key stakeholders including the Hon'ble Chief Minister of Uttarakhand. After a successful demonstration, AGNIi organised an Field Technology Showcase in Champawat. In this, five innovators participated by demonstrating their technology capabilities in front of both the District and State Administration. To enable adoption of these technologies by the decision makers, Field Technology Showcase focused on demonstrating Everett Roger's adoption levers for each technology.

Adoption Levers

Everett Rogers in his seminal work Diffusion of Innovations[1] stated that the perceived attributes of innovation (characteristics of innovations, as perceived by individuals) play a key role in determining the rate of adoption of innovation. According to Rogers, there are five important attributes of innovation, these include:

1. **Relative Advantage:** Refers to the degree to which an innovation is perceived as better than the idea it supersedes. The numerous factors by way of which the degree of relative advantage can be measure include – economic terms, social prestige factors, convenience, and satisfaction.

2. **Compatibility:** Refers to the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters.

3. **Complexity:** Refers to the degree to which an innovation is perceived as difficult to understand and use. Some innovations are easy to understand and hence, easily adopted. Meanwhile, others may not be very straightforward, which slows the adoption process.

4. **Trialability:** Refers to the degree to which an innovation may be experimented with on a limited basis.

5. **Observability:** Refers to the degree to which the results of an innovation are visible to others. The ease with which individuals can see the results of an innovation has a direct impact on the probable likelihood of their adoption.

The perceived attributes of innovation are instrumentally important. This is because end adopters are primarily rural communities and there exist information asymmetries with respect to both functionalities and the benefits of technology innovation. In this context, one of the key objectives of the Field Technology Showcase is to exhibit and contextualise the above attributes of innovation both to the decision makers and the end adopters.

The subsequent tables (refer Table 12-16) in the section enumerate the five important attributes of innovation and how each was conveyed to the decision makers and technology adopters during the field showcase. This showcase focused on different layers and technologies of the climate adaptive agriculture technology stack.

The perceived attributes of innovation are instrumentally important. This is because end adopters are primarily rural communities and there exist information asymmetries with respect to both functionalities and the benefits of technology innovation.

1 Rogers, E. M. (1962). Diffusion of innovations. New York, Free Press of Glencoe.

Table 12

Adoption levers for Soil Heath Monitoring Technologies

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
1	**Relative Advantage**	• Farmers should be able to scientifically perform soil testing in-situ. This would save them an average travel of at least 20-30 kms (which in the hilly terrain can take about 1.5 hours one way and entail costs), which they at present undertake for accessing lab-based soil testing services. • There is a need to reduce the gestation period of soil test results to less than a day (at present it is 3-4 days) as this has implications for agricultural operations. Additionally, reports need to be collected in-person. Considering the geography and terrain of the region, soil health reports should be made available to farmers electronically to save costs and do away with the hassle of repeated travelling. • The farmers of the region do not have government issued soil health cards. So certain sections of farmers, who do not have wherewithal to access soil testing facilities, have no information on their soil quality. There is need to equip them with testing facilities as well through FPO and collective action group networks.	• IoT based soil testing solutions provided instant analysis and results on multiple channels of mobile devices to the community members who performed the test with the assistance of technology providers. • Farmers and officials found the portable soil testing technologies to be hassle free and concurred that they would reduce time and costs as compared to conventional labs (considering the organization involved). • It was also iterated that cost per test would further reduce for an individual farmer if the technology were adopted by the district administration or collective action groups (FPOs and SHGs).
2	**Complexity**	• The procedure for soil testing needs to be simplified for farmers. Farmers cutting across income groups, gender, and geography should be able to perform soil tests in-situ. • Farmers should be able to understand test results and should also be advised on requisite actions they need to take enhance quality of their soil.	• Local woman in the community was trained to perform the soil health tests utilizing portable soil testing solutions. • Local woman in the community easily grasped the test methodology, performed the test, and explained the process to the community members.

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
3	**Compatibility**	• In the past, civil society organizations have engaged in portable soil testing through SHGs on a pilot basis, which reflects that farmers have time and again expressed a need for the same	• Farmers and SHG members showed willingness to adopt the Portable & IoT based soil testing technologies as they do not require soil health cards or any other due diligence
4	**Trialability**	• Farmers should be able to use the portable soil testing technologies themselves with some initial handholding	• Local woman from the community was trained to perform the soil health tests utilizing portable soil testing solutions • Local woman from the community easily grasped the test methodology, performed the test and explained the process to the community members • District administration concurred that the low cost of the kits vis-à-vis the cost of setting up conventional labs also makes it easy for the administration to deploy
5	**Observability**	• The process of soil testing as well as the results should be available instantaneously for the farmers and community members to see for themselves	• Results of portable soil testing technologies were available to the community members and officials instantaneously • Farmers and officials for themselves could witness complex chemical reactions, in certain cases and map it with color coded legends to understand soil nutrient deficiencies • Farmers and officials were instantaneously advised on steps that need to be taken to improve soil quality for better yield

Table 13

Adoption Levers for Smart Sowing and Farm Input Deliveries

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
1	**Relative Advantage**	• Considering the mountainous terrain of the region, which results in terrace farming activities pertaining to sowing and input delivery are arduous and involve manual labor especially in case of plantation crops like tea, where landholdings are large. There is a need to make the process less intensive of physical labor. • There is need to make the process of farm input delivery more scientific as compared to the present situation where it is based on guestimates	• Smart sowing & farm input delivery via UAVs were shown to eliminate the limitations set by the terrain in hilly regions. It was observed that they are easier to deploy on terrace farms • These systems also reduce the strain on the farmers as it reduces the need of physical labor • The AI based platforms help in managing the quantities of farm inputs scientifically
2	**Complexity**	• The technology should be easy to operate with sustained handholding provided by the technology providers	• It was categorically ascertained in the showcase and iterated by the district administration that rural youth will have to be trained, which will also generate employment in the region
3	**Compatibility**	• There is limited use of technology for sowing & farm input delivery even in large handholding institutions like Uttarakhand Tea Board • The rural communities are open to adopt new technology with requisite financial and training support	• The allied organizations like Uttarakhand Tea Board already use mechanized equipment and technology for farming. Hence the district administration would be keen to adopt the UAVs for these organizations

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
4	Trialability	• The rural community want to try less arduous methods of sowing & farm input delivery in terrace farms	• The district administration agreed to train the rural community in operating the UAVs
5	Observability	• The farmers should be able see the use of UAVs in sowing of seeds and delivery farm inputs	• The farmers and the administration witnessed the UAVs traversing the terrace farmlands in a matter of few minutes, which is an extremely arduous and time-consuming process if done physically

Table 14

Adoption levers for Animal Intrusion and Detection Systems

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
1	**Relative Advantage**	• Animal wildlife conflict in the region has proliferated in recent years - primarily wild pigs and monkeys. Wild pigs dig up the soil and even destroy underground crop varieties like potatoes and local Gaderi. Meanwhile, monkeys destroy the fruits, vegetables and other crops on the ground as well as trees. At present, farmers are using barbed wires and wooden sticks for fencing, which are only effective for wild pigs. These solutions are futile for monkeys and burrowing animals like porcupines. District Administration is also undertaking fencing (तार बाड़) within MNREGA activities. This directly hampers the income/cashflows of marginal and small farmers in the region. Hence, there is need for better methods of farmland protection from human-wildlife conflict. • There is a need to technologically equip forest guards and other forest officials against human-wildlife conflict and provide safeguards while they are patrolling	• The solar-powered animal detection & alarm box as well as the smart sticks were observed to be effective in repelling away from the farmland based on motion detection. • The district administration concurred that the battery powered safety stick is much more effective than wooden sticks given its features like illumination & 1000 V current. The stick was seen as useful for ground truthing in the dark and to neutralize the animals in case of close encounters.
2	**Complexity**	• New technology systems must be simple like the existing solutions but need to be more effective than the traditional fencing mechanism.	• The system utilized simple light and sound alarm animals to repel animal encroachment. • There was no sophistication involved in operating the technology post installation. The device just needs to be mounted on a pole. • Meanwhile, the safety sticks are just a smart replacement of wooden sticks with additional features like a phone charger.

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
3	**Compatibility**	• The community currently addresses the animal intrusion by barbed wires fencing and using wooden sticks (individual farmers). • Solar fencing is deployed in the tea gardens under the Uttarakhand Tea Board.	• Institutions like Uttarakhand Tea Board already use solar fencing hence the animal detection and prevention systems is suitable to secure their farms. • The administration is already focusing on strengthening the forest department's forest patrolling as well as animal response mechanism, the safety stick would be an upgrade to their conventional tools being used.
4	**Trialability**	• The community as well as the administration is open to explore innovative solutions for protecting the agricultural areas from animal intrusion.	• District administration concurred on trying one animal detection & alarm box for a group of 3-4 farms considering the cost effectiveness of the solution based on the rough calculations of the line departments. • The District Magistrate believed the safety sticks can be experimented by the forest guards to check for their impact on a sustained basis by the forest guards considering the cost effectiveness of the solution based on the rough calculations of the line departments. • The communities were eager to adopt the smart systems on an individual or a group basis for their farmlands.
5	**Observability**	• The showcase participants should be able to witness that animals are deterred and repelled by the systems installed and used and animal intrusion is prevented.	• The effectiveness of the animal detection & alarm box as well as the safety stick was clear to the farmers as well as the District Administration as the animals on showcase site were where successfully repelled by the light and sound alarm.


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Table 15

Adoption Levers for Digital Platforms for Market Access

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
1	**Relative Advantage**	• There is a need to make the rural economy of the hilly regions more organised and make requisite infrastructure available at various stages of the value chain. • Considering the number of FPOs and collective action groups are substantially less in the region and are short of creating a movement, there is need to create forward linkages for high value products of the region especially horticulture – for example, tea, honey, dairy products, citrus fruits, bay leaf, ginger – the district administration has also highlighted the same time and again.	• The technology providers appraised the district administration and rural communities of the benefits of developing digital platforms to build market access and linkages via the success stories they have created in other states of the country. • The gains to farmers due to wiping off the intermediaries were conveyed.
2	**Complexity**	• The digital platform systems should be lucid and should explain the process at different nodes of the value chain very simply to the farmers who might have lower educational levels and language constraints	• The district administration recognized the need for digitizing & organizing the agriculture/horticulture/animal husbandry sectors however solutions proposed require mass awareness campaigns and strengthening of the FPOs and collective action groups to help in development of forward linkages as well as to support technology adoption.
3	**Compatibility**	• District administration as well as communities recognize success stories where forward market linkages have been improved (for example, Hilans) and there is an intent to adopt something on similar lines for ensuring better cashflows. • However, the use of technology in value capture mechanisms and marketing is limited.	• Community individuals who make products like pickles, Uttarakhand special Hemp salt were using some rudimentary form of branding to make their products stand out in the market to ensure better prices and the district administration expressed that the same could be digitized with the help of the technology.

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
4	Trialability	• All the stakeholders are interested to adopt the technology first for marketing the products and then for digitizing the other parts of the value chain.	• The district administration concurred on adopting the solutions in stages, moving from simple solutions to complex solutions over a period. • The district administration concurred on leveraging the online marketplaces for premiumization of the high-value products as a first step towards digitization.
5	Observability	• The stakeholders should be able to see the benefit (for e.g., increase in revenue) of joining an online marketplace.	• The process of digitizing & organizing the rural economy is a slow process and requires consistent efforts. • The district administration concurred on leveraging the online marketplaces for premiumization of the high-value products as a first step towards digitization.

Table 16

Adoption Levers for Cold Storage and Post-Harvest Mechanised Equipment

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
1	Relative Advantage	• There is need to help farmers to be able to improve the shelf-life of their agricultural and horticultural products in-situ in a manner, which is not dependent on electricity (electricity in the region might be a problem in the region, for example during the field visit, power cut of 6 hours) • There is also a need to improve the shelf-life of products while the products are in transit from remote location of the district to the main mandis.	• The portable dry-ice technology was utilized to produce dry ice bricks at the showcase site without utilization of any electricity or water, which they can utilize to line the storage boxes to transport the produce. • The Sabjee Cooler technology also operated without electricity and could be utilized to keep the produce fresh till it is transported to the market (Collaborators from BAIF had kept vegetables in the cooler four days before the showcase and they were fresh as ascertained even by district officials).

	Adoption Lever	Technology / Op Scenario Summary	How did Showcase achieve this?
2	**Complexity**	• The cold-storage facilities need to be decentralized and simple to operate.	• The Sabjee Cooler technology did not have any operational requirements as such except for provisioning of water. • The portable dry-ice technology can be operated by community members very simply with minimal precautions
3	**Compatibility**	• There is a lack of cold storage facilities on the community as well as institutional level. • Conventional cold-storage facilities are too costly to setup and might not be cost-efficient for marginal and small farmers.	• One portable cold storage unit has been deployed by BAIF in Khetikhan which has received appreciation from the community hence the administration is willing to deploy similar innovations.
4	**Trialability**	• Majority of the stakeholders are willing to adopt low-cost portable cold storage & transport mechanisms	• The District Magistrate concurred that the technology can be tried via the SHG networks both with respect to operations as well as procurement.
5	**Observability**	• Making dry ice bricks in under five minutes. • The freshness of the vegetables kept in the cold storage units should be visible and perceptible to the stakeholders.	• The district officials and rural communities witnessed the making of dry-ice bricks instantaneously in under five minutes. • Collaborators from BAIF had kept vegetables in the cooler four days before the showcase and they were fresh as ascertained even by district officials.

Performance Matrix[1]

This section summarises the idealised technological capabilities of the innovations vis-à-vis the performance and parameters of these innovations as assessed during the field technology showcase. The key objective of the performance matrix (refer Table 17) is to help the adopter in understanding the extent to which the technological capabilities tackle the adopter's pain points, thereby aiding in the deployment of climate adaptive agricultural practices.

1 The technologies were showcased and tested within a frame of 16 hrs due to adverse weather conditions at the location and hence the performance assessment is limited by the time frame.

Table 17

Performance Matrix

Feature	Description		Capability				Performance Assessment
			Sensors	AI & Blockchain	Digital Platform	Mech-anised Equipment	
Smart Soil Testing	To provide the soil testing services at the farmers' doorstep by determining all the soil parameters such as pH, moisture, nitrogen, potassium, phosphorus contents	**Ideal Requirement**	Various sensors to test: 1. Structural properties (soil texture, type and bulk density); 2. Soil fertility (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Carbon Exchange Capacity, soil pH, soil acidity, per cent organic matter (OM); 3. Soil salinity (Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR: used to evaluate the effect of sodium on soil structure))	Machine learning based optical analyser, which is connected to cloud, battery operated and is GPS enabled	Cloud based platform for online farm input advisory, soil health record, map, farm analytics and fertilizer suggestions	-	• The soil testing device was able to test multiple parameters involved in a holistic soil quality test and deliver the results within a turnaround time of 120mins. • The technology was used first hand by a local farmer with basic operational level knowledge of smart phones. The farmer was able to use the technology with ease and was also able to read the soil reports.
		Showcase Indication	The device had the capability to test EC, pH, OC, N, P, K, S, Mg, Ca, Fe, Mg, Zn, Mn, Cu in soil	The optical analyser had the following features: 1. Weight = 300gm 2. Battery operated = lithium ion (3000 mAH) 3. GPS = Uses hotspot to connect to the user's mobile device and uses the device coordinates to pinpoint location	The soil health data recorded on site was uploaded to the cloud and finally available on the web-based platform		

Feature	Description		Capability				Performance Assessment
			Sensors	AI & Blockchain	Digital Platform	Mechanised Equipment	
Intelligent soil quality enhancement advisory	Online advisory system on a website giving insights on how to enhance the various nutrients level in soil of a particular area post inputs from the farmer/adopter	**Ideal Requirement**		AI Layer (GIS software that blends the power of a map with the power of a database to allow people to create, manage and analyse information, particularly information about location) which uses historical data insights to deliver tailormade inputs regarding best farm practices in a particular geographical area along with the capability to send custom notifications to farmers for the required inputs	Mobile optimised web-based dashboards for advisory on soil enhancement according to the location inputs from farmers	-	• The web-based dashboards were optimised for a mobile phone display and were accessible in areas with a good network connectivity.
		Showcase Indication	The dashboard was displayed for an already existing project to draw a comparison and make the farmers understand exactly how the technology can help them with active farm inputs and advisory related to the same				

Feature	Description		Capability				Performance Assessment
			Sensors	AI & Blockchain	Digital Platform	Mechanised Equipment	
Automated sowing systems	Deploying a technology which enables automation of the process of sowing seeds over a user defined area and along a user defined pattern	Ideal Requirement	-	-	-	GPS enabled drone systems with different payload capabilities to geo-fence a particular area and deposit seeds, pesticides, etc within the defined area	• Smart sowing & farm input delivery via UAVs were shown to eliminate the limitations set by the terrain in hilly regions. It was observed that they are easier to deploy in terrace farms.
Automated farm input delivery	Spraying of pesticides and/ or other nutrient enhancing products to the farm using automated delivery systems	Ideal Requirement	-	-	-	Drone Specifications: 1. Camera - Digital (First Person View) 1080p 2. Material - Carbon Fiber + Plastic (IP 65 Waterproof) 3. Modes of Flying - Autonomous, Semi-autonomous & Manual 4. Wheelbase - 1460mm 5. Dead Weight - 25kg 6. Spray Speed - 1m/s to 10m/s 7. Max Height - 200ft 8. Flight Time - 30 Mins	
		Showcase Indication	-	-	-		

Feature	Description		Capability					Performance Assessment
			Sensors	AI & Block-chain	Digital Platform	Mechanised Equipment		
Animal intrusion detection and deterrent	Detection of animals around the farm boundary and mechanism to deter them from intruding the secured area and thereby preventing them from destroying the crops	Ideal Requirement	Motion sensors detect movement in a defined area of interest.They use an infrared sensor (PIR & AIR sensor) which is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. The sensor radius can vary from as little as 30mm right up to 240m for covering significantly larger areas	-	-	Systems deployed on the farm boundary to detect and deter any animal/bird within the range using sounds/electric shock		• The animal detection & alarm box was observed to be effective on animals (dog) as the system is based on motion detection. • The box was able to detect motion in a 25m radius. • The smart stick proved to be a better solution in terms of the features and level of safety that it provides as compared to the wooden sticks that the forest rangers currently use. • The technology was able to detect motion even in a hailstorm.
		Showcase Indication	1. PIR Sensor range = 30m Horizontal Detection Angle = 180deg Vertical Detection Angle = 30deg 2. AIR Detection range = 100m Day/night mode = Yes Detection Area = straight line			FIXED 1. Detection Accuracy = 91% 2. Solar Powered 3. Range of detection = 30 m 4. GSM variant (for real time alerts) / non-GSM variant	PORTABLE 1. Li-ion battery (6000 mAH, 720hr backup) 2. IP54 Rating (weather resistant) 3. Robust body - 6063 Al 4. Height = 42in - 54in 5. Weight = 1 Kg 6. Shock = 1000V and 3mA	

Feature	Description		Capability					Performance Assessment
			Sensors	AI & Block-chain	Digital Platform	Mechanised Equipment		
Improved shelf life of horticulture/ Agri produce	Using cost effective systems to enhance the life cycle of produce post-harvest to ensure a longer shelf life, thus reducing wastage	Ideal Requirement	-	-	-	Cost effective cold storage boxes and dry ice is used to increase the duration for which various farm produce remains fresh for consumption		• The portable dry-ice technology was utilized to produce dry ice bricks at the showcase site within 5 minutes without utilization of any electricity or water, which they can utilize to line the storage boxes to transport the produce. • The portable dry-ice technology can be operated by community members very simply with minimal precautions. • The cold storage box was effective in keeping the vegetables fresh for at least 4 days until the day of the showcase. • There was a significant difference in the outside temperature versus the temperature inside the cold storage box. • The technology did not have any operational requirements as such except for provisioning of water.
		Showcase Indication	-	-		DRY ICE 1.Dimension = 111mm x 111mm x 240mm 2. Weight = 250gm 3. 30Kg CO2 cylinder gives 5 Kgs of dry ice	STORAGE BOX 1. Power Input = N/A (20L of water) 2. Internal Dimension = 1m x 1m x 0.75m 3. Capacity = 100 Kg 4. Dead weight = 60 Kg 5. Temperature = 15 deg less than the outside temperature	

Feature	Description		Capability				Performance Assessment
			Sensors	AI & Block-chain	Digital Platform	Mechanised Equip-ment	
Value capture services	Connect farmers, traders, input dealers, logistics providers, academia, institutional buyers, POs, government departments and consumers. Interactions such as Information, help, advice, buy, sale and service happen between them solving each other's problems and benefitting together	Ideal Requirement	Optical scanner to read QR codes and convert the output into user accessible data	Crop specific integrated value chain with blockchain technology to create a seamless, transparent and trustworthy end-to-end tracking of supply chain	Agritech platforms use technology to manage the whole agriculture supply chain, from farming inputs to last-mile distribution.	-	• The technology providers apprised the district administration and rural communities of the benefits of developing digital platforms to build market access and linkages via the success stories they have created in other states of the country.
		Showcase Indication	The platforms have the capability to digitize details like date of produce, farm location, etc.	The system was able to enable traceability by using blockchain throughout the value chain	The platform demonstrated both digitisation of data inputs and effective traceability		

Conclusions & Way forward

SECTION 6

The Field Technology Showcase conducted at Champawat, Uttarakhand has provided a platform for the development and sharing of innovative climate adaptive agricultural technologies and practices. These technologies and practices have the potential to increase agricultural productivity in the region and to help the community adapt to the changing climate. The final deployment of the demonstrated technologies is ongoing, and the document will be updated once it has been shared with the AGNIi Mission. Till then, the indicative way forward is indicated below (refer Table 18).

Table 18

Assessment and Advisory Matrix

Strategic Context Factor	Operational Scenario	Emerging Technologies	Idealised Capability Requirement	Capabilities Indicated in Field Technology Showcase	Course of Action
Hilly terrain and absence of plain and continuous agricultural land, which necessitates terrace farming. Terrace farming has implications for cropping yield, cropping intensity, and irrigation methods. Altitudinal shift in farming belts Implications for cropping patterns	1. Dissemination of advisory to villagers pertaining to crop diversification that suits changing weather patterns and soil chemistry, and water-use efficiency for agriculture	1. Advanced Sensing 2. AI (GIS) 3. Blockchain	1. Various sensors to test: a) Structural properties (soil texture, type and bulk density); b) Soil fertility (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Carbon Exchange Capacity, soil pH, soil acidity, per cent organic matter (OM); c) Soil salinity (Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR: used to evaluate the effect of sodium on soil structure)) 2. Machine learning based optical analyser, which is connected to cloud, battery operated and is GPS enabled 3. Cloud based platform for online farm input advisory, soil health record, map, farm analytics and fertilizer suggestions 4. AI Layer (GIS software that blends the power of a map with the power of a database to allow people to create, manage and analyse information, particularly information about location) which uses historical data insights to deliver tailormade inputs regarding best farm practices in a particular geographical area along with the capability to send custom notifications to farmers for the required inputs	1. The soil testing device was able to test multiple parameters involved in a holistic soil quality test and deliver the results within a turnaround time of 120 minutes 2. The technology was used first hand by a local farmer with basic operational level knowledge of smart phones. The farmer was able to use the technology with ease and was also able to read the soil reports 3. The web-based dashboards were optimised for a mobile phone display and were accessible in areas with a good network connectivity	The technology in its current form can be deployed across the 4 blocks of Champawat. However, the district administration may start deploying it in a phased manner as, initially, capacity building of farmers will be required too. As observed in the field, an individual farmer could learn to use the technology in 120 minutes. Hence, phased implementation of soil sensors initiated with a small pilot in an area of administration's discretion could be rolled out. Recommended course of action: Under competent authority, technology is ready to be deployed in both a pilot and full-scale deployment in Champawat, Uttarakhand.

Strategic Context Factor	Operational Scenario	Emerging Technologies	Idealised Capability Requirement	Capabilities Indicated in Field Technology Showcase	Course of Action
Large areas under forest cover and proximity of farmlands to forests: Expansion of human settlements, resulting in animal intrusion and human-wildlife conflict	Detection of animal intrusion with high frequency and from a distance suitable for the adopter	1. Sensors 2. IoT	1. Motion sensors detect movement in a defined area of interest. They use an infrared sensor (PIR & AIR sensor) which is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. The sensor radius can vary from as little as 30mm right up to 240m for covering significantly larger areas. 2. Systems deployed on the farm boundary to detect and deter any animal/bird within the range using sounds/ electric shock	1. The animal detection & alarm box was observed to be effective on animals (dog) as the system is based on motion detection 2. The box was able to detect motion in a 25m radius 3. The smart stick proved to be a better solution in terms of the features and level of safety that it provides as compared to the wooden sticks that the forest rangers currently have 4. The technology was able to detect motion even in a hailstorm	The technologies in their current state can be deployed across farms which are in proximity of forest areas. These technologies need no capacity building as far as the usage is concerned. The forest rangers can be equipped with this ready-to-deploy technology and thus reduce human-animal conflict further. As observed in the field technology showcase, the technology cannot differentiate between animals and humans and raises an alarm in both the cases; a layer of machine vision can be added to differentiate between the two, keeping in mind the capital increment that would come with this layer. Recommended course of action: Under competent authority and on the field level, the technology is ready to be deployed at a full scale in Champawat, Uttarakhand.

Strategic Context Factor	Operational Scenario	Emerging Technologies	Idealised Capability Requirement	Capabilities Indicated in Field Technology Showcase	Course of Action
High dependence on agriculture and lack of value capture mechanisms Difficulties in securing livelihoods of farmers with small and marginal landholdings and tackling challenges to the value chain which are accentuated by climate change	1. Insurance against yield losses 2. Improved shelf life of Agri produce 3. Enhancing transparency and traceability in agriculture value chain	1. Blockchain 2. Sensors 3. AI	1. Cost effective cold storage boxes and dry ice is used to increase the duration for which various farm produce remains fresh for consumption 2. Optical scanner to read QR codes and convert the output into user accessible data 3. Crop specific integrated value chain with blockchain technology to create a seamless, transparent and trustworthy end-to-end tracking of supply chain 4. Agritech platforms use technology to manage the whole agriculture supply chain, from farming inputs to last-mile distribution.	1. Crop specific integrated value chain with blockchain technology to create a seamless, transparent and trustworthy end-to-end tracking of supply chain, and insuring against crop losses 2. Agritech SaaS platforms use technology used to manage the whole agriculture supply chain, from farming inputs to last-mile distribution. 3. The portable dry-ice technology was utilized to produce dry ice bricks at the showcase site within 5 minutes without utilization of any electricity or water, which they can utilize to line the storage boxes to transport the produce 4. The portable dry-ice technology can be operated by community members very simply with minimal precautions 5. The cold storage box was effective in keeping the vegetables fresh for at least 4 days until the day of the showcase 6. There was a significant difference in the outside temperature versus the temperature inside the cold storage box 7. The technology did not have any operational requirements as such except for provisioning of water	The value chain capture technology in its current state cannot be deployed on a full-scale basis due to lack of FPO's which are essential to ensure a successful capture of the supply-chain. The cold storage technology is ready to be deployed across the 4 blocks of Champawat and would be beneficial if acquired at a community level. The major upper hand with these is the low capital demand in terms of the technology and the fact that these are not dependant on electricity for their functioning. Recommended course of action: The relevant authorities can activate the FPOs at a larger scale and deploy the value chain capture and AgriTech platform technologies on a pilot basis to make the farmers understand the benefits and acquaint them with the technology. The cold storage technology is ready to be deployed at a full scale under the competent authority or on a community level.

Annexures

Annexure 1

Follow Through Operationalisation and Scale Up

The Field Technology Showcase conducted at Champawat, Uttarakhand has provided a platform for the development and sharing of innovative climate adaptive water management and practices. These technologies and practices have the potential to strengthen water management in the region and to help the community adapt to the changing climate.

To maximize the potential of these technologies and practices, the concept of Innovation Diffusion by Everett Rogers has been explored, to provide an understanding of how to further develop and diffuse climate adaptive water management in the Indian Himalayan Region. To do this in a structured way, a set of indicative next steps have been listed in the section below.

Creation of a District Innovation Fund for pilot projects

To ensure the successful implementation of climate adaptive agriculture in the Indian Himalayan Region, it is important to ensure that the necessary resources and infrastructure are in place. The District Innovation Fund should be established as soon as possible, to provide the necessary resources and infrastructure for deploying ad scaling of successful pilot projects in Champawat. Once the technology achieves scale in Champawat, it could be scaled up in other districts of Uttarakhand followed by implementation throughout the Indian Himalayan Region. During Field Technolgy Showcase, the District Magistrate has proposed to set up this fund for Champawat district.

Creation of a Steering Committee

To monitor and scale up Climate Adaptive technologies in Uttarakhand, it is important to create a steering committee with the head being the Hon'ble Chief Minister, Uttarakhand. This committee should comprise of members from the agricultural, research and industry sectors, as well as members from the local government. In this committee, UCOST could act as the member convener.

This committee will be responsible for researching and developing innovative climate adaptive

agriculture practices for the region. It will also be responsible for advocating for the implementation of these practices across the region. The committee will also direct the district administrations to ensure that the necessary resources and funding are available to support the implementation. Furthermore, the committee should be empowered to take decisions and implement strategies that are in line with the regional objectives. The committee should meet regularly and provide the Chief Minister with updates on the progress of the projects. It should also be responsible for ensuring that the projects are implemented in a timely manner and that the outcomes are in line with the expected results. Overall, the steering committee with the Chief Minister at the helm will be instrumental in driving the implementation of climate adaptive agriculture in the Indian Himalayan Region

Capacity Building

To ensure successful implementation of climate adaptive agriculture in the Indian Himalayan Region, it is critical that local stakeholders are equipped with the necessary skills, knowledge, and resources to carry out activities related to climate adaptive agriculture.

Capacity building of local stakeholders should include training on scientific and technological advancements in climate adaptive agriculture, community-led research and analysis, and the development of tools and strategies for monitoring and evaluation of climate adaptive agriculture initiatives.

Local stakeholders should also be empowered to undertake participatory planning and decision-making processes that enable them to identify their local needs and develop actions plans that incorporate climate adaptive agriculture solutions. The District Administration may undertake capacity building in close association with the technology providers.

Scouting for innovative technologies for new and existing use cases

As demonstrated in this TAN, the first step in deploying technology for climate adaptive agriculture in the Indian Himalayan Region, is to identify potential use cases for technology deployment. To do this, a comprehensive scouting exercise should be undertaken to identify suitable areas where the deployment of technology can have a positive effect on climate adaptive agriculture. This scouting exercise should involve a systematic process of data collection, analysis, and evaluation.

The data collected should include information about the local climate and geographical conditions, the type of crops being cultivated, and the existing agricultural practices. This data should be analysed to identify areas where the deployment of technology could help improve agricultural production, reduce the risk of crop failure, and increase the resilience of the local farming communities.

Field exercises conducted by team AGNIi to populate this TAN could be used as a reference by the decision makers to produce a list of ready use cases and technologies to engage. It is important to note

that during these exercises, relevant stakeholders should be engaged with to ensure the holistic view on use cases and technology options.

Scaling up of pilots in neighbouring districts of Champawat

To move forward with the development and diffusion of climate adaptive agriculture in the Indian Himalayan Region, it is recommended that pilots of the field technology showcase conducted at Champawat, Uttarakhand be conducted in other areas of the region. Based on the results of these pilots, successful technologies and practices should be identified and scaled across the region.

Furthermore, it is recommended that policy makers in the region consider the use of Everett Roger's Innovation Diffusion Model (described earlier in this TAN) to understand how to effectively spread the implementation of climate adaptive agriculture in the region.

Conclusion

Climate change is an undeniable reality that affects the livelihoods of millions of people, particularly in the Indian Himalayan Region. As a result of rising temperatures, unpredictable weather patterns, and shifting precipitation, farmers in the region are increasingly vulnerable to food insecurity, poverty, and other economic challenges.

Therefore, it is essential that the government take proactive measures to promote climate adaptive agriculture in the Indian Himalayan Region. Adopting the learnings and approaches outlines in this TAN will provide a solid foundation which the key decision makers could use to chart their way across these newer areas of emerging technologies in climate adaptive agriculture.

Annexure 2

Innovators Shortlisted by Pioneer Agency, UCOST for Field Technology Showcase

UTTARAKHAND STATE COUNCIL FOR SCIENCE & TECHNOLOGY

Department of Science & Technology
(Govt. of Uttarakhand)

Dr Piyush Joshi
Sr. Scientific Officer

VIGYAN DHAM,
Vigyan Sadan Block
Jhajra, Premnagar,
Dehradun – 248 007
Uttarakhand, India
(t): +91-8193099152,
(e): piyush@ucost.in
(w): www.ucost.in

No. 23375/UCS&&T/RSC (USSTC)/2023 Dehradun,
Dated 10th March, 2023

TO WHOSOEVER IT MAY CONCERN

Sub: Invitation to attend field technology showcase at Champawat

Dear Sir,

This is to certify and inform that Uttarakhand Council of Science and Technology (UCOST) in conjunction with AGNIi Mission, Office of Principal Scientific Advisor to the Government of India is organising a Technology Showcase at Champawat, Uttarakhand from 15th – 16th March 2023.

The following Start-ups have been mutually shortlisted for the showcase at Champawat

The names of the shortlisted innovators are as follows:

1. Kalgudi Digital Pvt Ltd.
2. Aigroedge Technologies
3. Zone 4 Disaster Solutions Pvt. Ltd.
4. GasKon Engineers Pvt. Ltd.
5. Kyari Innovations Pvt. Ltd.
6. EmerTech Innovations Pvt. Ltd.
7. Kritsnam Technologies Pvt Ltd.
8. Intech Harness Pvt. Ltd.
9. WaterQuest Hydroresources
10. Navariti Innovation
11. CESTA Enterprise
12. Arogyam Medisoft Solution Pvt. Ltd.
13. Garuda Aerospace Pvt Ltd.

In case of any queries or concerns, please contact me at piyush@ucost.in.

(Dr. Piyush Joshi)
Joint Director, UCOST

AGNIi, 110, Vigyan Bhavan Annexe, 001,
Maulana Azad Rd, New Delhi,
Delhi 110001, Tel.: (011) 011-2304-8155