Office of the Principal Scientific Adviser
to the Government of India

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Climate Adaptive Livelihoods

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

Climate Adaptive Livelihoods

Technologies for livelihoods in the Indian Himalayan Region

Technology Advisory Note
November 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

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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.

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

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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 सर्वांगीण 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
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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

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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

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Introduction | Objective and Method

PART A

Technology for Climate Adaptive Livelihoods in Indian Himalyan Region

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 livelihoods practices in the Indian Himalayan Region. *This innovation AI and Machine Vision, Blockchain, Sustainable Energy, Biotechnology, Digital Platforms,* along with incremental and frugal innovations to secure the livelihoods in Indian Himalayan Region amidst the constant threat of climate change.

The Office of the Principal Scientific Adviser (PSA) to the Government of India, in partnership with national government agencies, identifies and advises on how Indian emerging technologies (such as AI, 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), Government of Uttarakhand 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 Field Visits, Expert Consultations, Technology Operational Scenarios, Technology Capability Stacks, and Field Technology Showcases.

The field technology showcase was held at Champawat, Kumaon Division, Uttarakhand. The choice of the showcase site is aligned with the vision of the Uttarakhand Government to develop Champawat as an Adarsh Zila under the Uttarakhand @25 initiative of the hon'ble Chief minister of the state under the guidance of UCOST[1].

Box 1

National presence of BSF

The activities were undertaken in partnership and consultation with UCOST, and district administration. The Note and its advice aim to support practical, actionable administrative decision-making on technology engagement and acquisition for climate adaptive livelihood management. 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

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

technologies – whose innovator startups and laboratories volunteered to participate in Field 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.

Rural Livelihoods in the Indian Himalayan Region

The influence of climate change on rural livelihoods in the Indian Himalayan Region is profound and multifaceted. It disrupts traditional practices, challenges resource availability, and forces communities to adapt to an ever-changing environment. Addressing these climate-related challenges requires innovative and sustainable solutions that can help these communities build climate-resilient livelihoods while preserving the delicate ecosystems of the Himalayas.

Forest-Dependent Livelihoods

Climate change is significantly impacting forest-dependent livelihoods in the Indian Himalayan Region. Rising temperatures, changing rainfall patterns, and an increase in the frequency and intensity of extreme weather events have severe consequences for the forests and the communities dependent on them.

a. *Shift in Vegetation Zones:* As temperatures rise, there is a noticeable shift in vegetation zones at higher altitudes. The vegetation zones in the Indian Himalayan Region are shifting upwards by an average of 0.7 meters per year[2]. This directly affects the types of non-timber forest produce available, making it challenging for communities to rely on traditional practices and resources.

b. *Increased Forest Vulnerability:* Climate change has made the forests more susceptible to pests, diseases, and wildfires[3]. This not only endangers the trees themselves but also disrupts the collection of forest produce and threatens the livelihoods of those who depend on these resources.

c. *Altered Farming Patterns:* Traditional agricultural practices, which are closely tied to forest-dependent livelihoods, are facing disruptions due to changing weather patterns. Unpredictable rainfall can lead to crop failures and affect the overall food security and economic stability of these communities.

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2 Quamar, M. F. (2019). Vegetation dynamics in response to climate change from the wetlands of Western Himalaya, India: Holocene Indian summer monsoon variability. The Holocene, 29(2), 345-362. https://doi.org/10.1177/0959683618810401

3 Forest Fire in India. (2018). In Forest Research Institute. Retrieved October 31, 2023, from https://icfre.gov.in/UserFiles/File/Books/FRI-Forest-Fire-in-India_26July19.pdf

Allied Sector Livelihoods

The allied sector, particularly livestock farming, is highly vulnerable to the impacts of climate change in the Himalayan region. The indigenous livestock in Indian Himalayan Regions have been found to be more susceptible to environment, diseases and nutritional stresses than the exotic animals[4].

a. *Feed and Water Scarcity*: Changing monsoon patterns and increasing temperatures have led to water scarcity, affecting the availability of fodder and water for livestock. This directly impacts the health and productivity of the animals and, consequently, the income and sustenance of the communities.

b. *Disease Spread:* As temperatures rise, some diseases that were previously confined to lower altitudes are now spreading to higher elevations, affecting the livestock. This requires increased efforts in disease management and prevention.

c. *Livestock Migration:* In response to changing climatic conditions, communities are sometimes forced to migrate with their livestock to find suitable grazing areas and water sources. This disrupts settled livelihoods and poses challenges in terms of logistics and access to essential services.

Women Centric Livelihoods

a. Climate change affects women's livelihoods in the Indian Himalayan Region in multiple ways, as they play crucial roles in managing households, agriculture, and forest resources. The women however do not have the decision-making power aligned to these roles[5].

b. Migration of men

c. Women often bear the brunt of the increased workload resulting from climate change impacts. For instance, erratic weather patterns can lead to more labour-intensive agricultural practices, and the need to travel further to collect forest resources.

Choosing the Exemplar Location

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[6]. At the district level, only two districts of Uttarakhand – Dehradun and

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4 Kumar, Pardeep & Sharma, Pradeep & Kumar, Praveen & Sharma, Munish & Butail, Nagender. (2021). Agricultural Sustainability in Indian Himalayan Region: Constraints and Potentials. Indian Journal of Ecology. 42. 649-662.

5 Kumar, Pardeep & Sharma, Pradeep & Kumar, Praveen & Sharma, Munish & Butail, Nagender. (2021). Agricultural Sustainability in Indian Himalayan Region: Constraints and Potentials. Indian Journal of Ecology. 42. 649-662.

6 Kumar, Pardeep & Sharma, Pradeep & Kumar, Praveen & Sharma, Munish & Butail, Nagender. (2021). Agricul6

Udham Singh Nagar have low vulnerability; however, four districts of the state namely Haridwar, Tehri Garhwal, Bageshwar, and Pithoragarh 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 state government[7] is continuously making efforts to create development models that balance ecology and economy. Livelihood generation 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 an Aadarsh Zilla (model district) under the state government's Uttarakhand@25 initiative in the context of Indian Himalayan ecosystem[8]. 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 meter, having abundance of water and good soil.

Shivalik which is situated at a height of 250 to 1,200 meter. 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).

The altitudinal range and topographical variability is indicative of diverse livelihood avenues specific to particular topography.

6 Rural Sustainability in Indian Himalayan Region: Constraints and Potentials. Indian Journal of Ecology. 42. 649-662.

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

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

Climate Variability

The climate of the district is very differential, and the temperature varies from one degree Celsius in the year to 35 degrees Celsius. The temperature in the plain 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 extremely high (about 20 cm. yearly). The climate of Shivalik is same but the lower region of Himalayas experiences cold climate throughout the year.

The variable climate leads to variation in livestock, forest produce as well as vegetation thus expanding the study on impact of climate change.

Forest Cover Variability

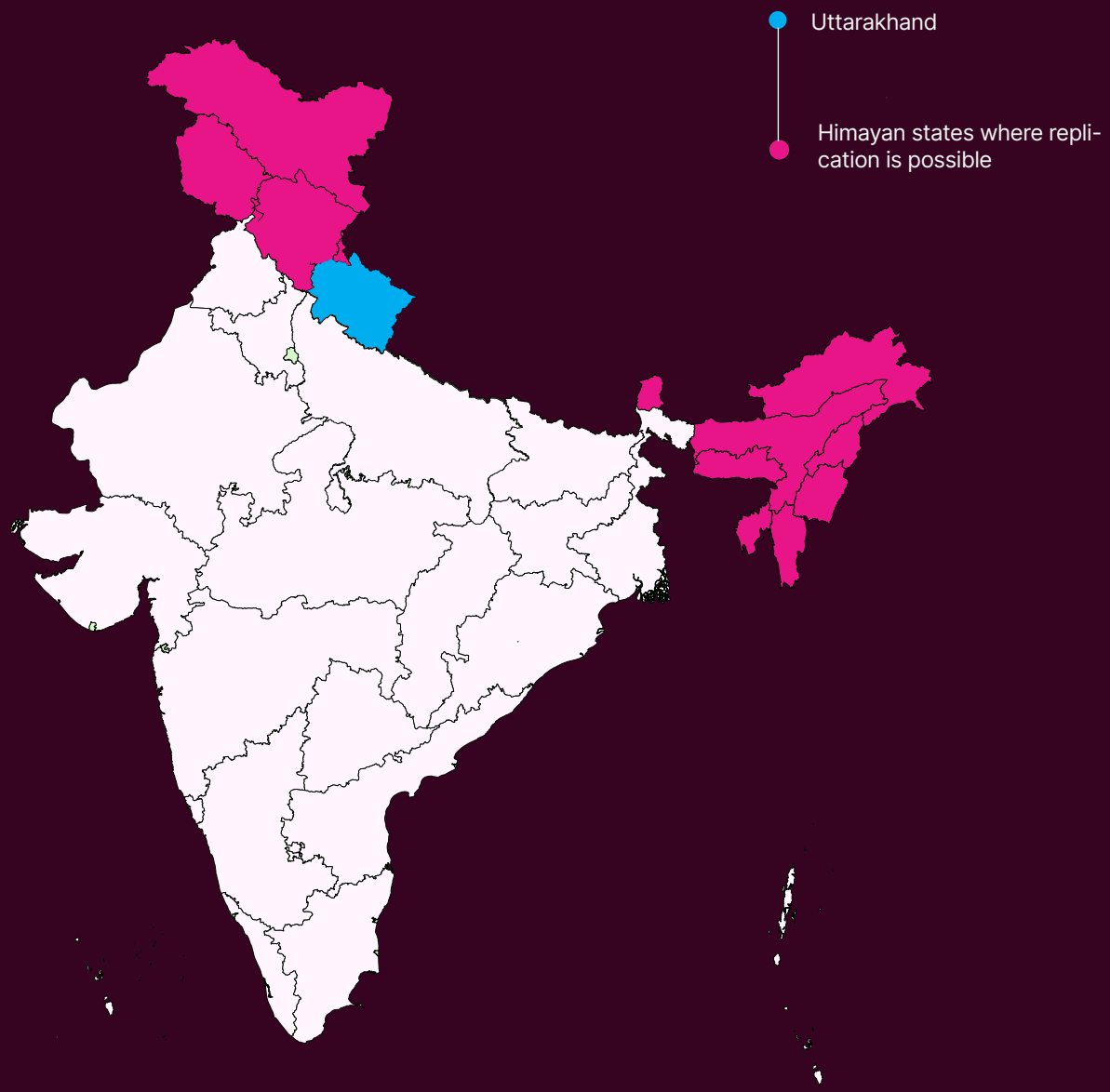
The forests in Champawat range from 200-2,000 mts, making the operational models developed highly scalable across the montane sub-tropical forests and (1,000-1,500 mts [Pine forests]) and montane temperate forests (1,500 – 2,400 mts. [Himalayan temperate and Himalayan dry temperate])[9].

The district has diverse agro-forestry avenues across various blocks due to variability present in the forest types.

9 District Survey Report Champawat available at < https://cdn.s3waas.gov.in/s3eda80a3d5b344bc40f3bc04f-65b7a357/uploads/2018/08/2018082543.pdf> last accessed 22 March 2023.

Box 1

Scalability of Adarsh Champawat project across Indian Himalayan Region^



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

Part B | Process | What, Why & How?

In the pursuit of addressing the pressing challenges posed by climate change affecting the rural livelihood landscape and bolstering the resilience of communities in Champawat District, we have conducted comprehensive field visits and engagement activities.

In the pages that follow, we thoroughly explore the findings from our field visits, where we actively engaged with various key stakeholders to uncover the issues they encounter, gain insight into their operational realities, and meticulously construct detailed user personas. These insights serve as a compass, guiding our efforts to scout for and adopt climate-resilient livelihood-centric technologies that will make a meaningful impact. Our journey takes us through the distinct tiers of decision-making—strategic, operational, and field—each layer presenting its unique set of priorities, backgrounds, attitudes, and functional requirements. By understanding

and aligning with the aspirations and needs of these stakeholders, we aim to forge a path toward a climate-resilient future that is not just sustainable but also transformative for Champawat which qualifies as a testbed for the Indian Himalayan Region (IHR)

Insightful Journeys: Delving Into Rural Livelihoods And Resilience In The IHR Region

As we delve into the forthcoming exploration of the outcomes from our rigorous field visits and community engagements, we immerse ourselves in the intricacies of Champawat District's rural livelihood landscape for building our understanding about IHR. These field visits, conducted with precision, serve as windows into the lives, challenges, and aspirations of the communities inhabiting this region. These endeavours transcend mere journeys; they represent comprehensive studies of the individuals and communities at the core of our mission. By immersing ourselves in their daily experiences, we have sought to understand the nuances of their unique circumstances, the hurdles they face amidst the evolving climate dynamics, and their unwavering commitment to resilience and progress. These field insights form the foundation upon which our subsequent efforts are constructed, seamlessly leading us into the realm of user personas within various livelihood sub-categories and the strategic mapping of decision-making tiers. These livelihood sub-categories encompass Horticulture, Agro-forestry, Dairy, Fisheries, and Apiary, each of which will be elaborated upon below:

HORTICULTURE

Issue at Hand

Wildlife Intrusions

The primary concern, as elucidated during the field visit, revolves around relentless nocturnal intrusions by wildlife. These intrusions have far-reaching consequences, causing extensive damage to the crops that are central to the livelihoods of Champawat's farmers, namely Lychee and Malta. These crops are not mere sources of income; they are symbolic of the aspirations and sustenance of the farming community. Regrettably, the havoc wreaked by these nightly raids results in avoidable destruction and substantial financial losses.

Operational Realities:

The operational scenario in Champawat underscores the dedication and diligence of its farmers. As they tend to their crops during daylight hours, employing various pest control measures, the vastness of their agricultural lands becomes apparent. Farmers rely on traditional methods of vigilance, such as periodic visual inspections and physical scouting, in an effort to detect pests at their early stages. However, these manual approaches often prove inadequate in identifying infestations promptly. Consequently, there is a regrettable delay in detecting pest infestations, leading to reduced crop yields and substantial financial setbacks.

As twilight descends upon Champawat, the tranquil village undergoes a transformation. It becomes a battleground as nocturnal intruders, descend upon the fields. Armed with limited resources and traditional monitoring techniques, farmers endeavour to protect their precious crops. However, the

sheer size of the agricultural lands makes this task daunting. Under the cover of darkness, the marauding wildlife feasts upon the succulent Lychee and Malta crops, leaving behind a trail of destruction.

In this challenging scenario, the farmers of Champawat find themselves not only grappling with crop loss but also with a sense of helplessness in the face of these nightly assaults. The need for effective solutions that can mitigate these issues and preserve the farmers' livelihoods is paramount.

PACKAGING AND STORAGE

The foremost challenge in horticulture revolves around the packaging and storage of stone fruits, citrus fruits which include the likes of rhododendron, Lychee and Malta juice. This is of critical importance as it directly impacts the financial well-being of farmers in the Champawat region. Presently, the absence of reliable storage mechanisms is leading to substantial losses for farmers.

Operational Realities:

Through our field visits, we have witnessed the operational realities faced by farmers. Lychee and Malta juice production is a major source of income for these farmers. However, their inability to efficiently store the juice results in spoilage, leading to significant financial challenges. Current storage practices fall short of preserving the juice's quality and extending its shelf life, ultimately affecting the farmers' livelihoods.

AGRO FORESTRY

The key concern here revolves around the absence of robust value capture mechanisms in the supply chain of high-value forestry and agro-forestry products, such as pine needles, Lantana, Chyura amongst others. This absence impedes opportunities for rural income generation and contributes to the deterioration of forests.

ISSUE AT HAND

Value Capture Mechanisms

The agro-forestry landscape in the region grapples with a formidable challenge - the conspicuous absence of effective value capture mechanisms within the supply chain of high-value forestry and agro-forestry products. This deficiency is particularly pronounced in the case of pine needles, a resource abundant in the region. The repercussions of this limitation are multifaceted and warrant a closer examination.

Foremost, the absence of robust value capture mechanisms impedes the realization of the full economic potential of high-value agro-forestry products. Pine needles, for instance, possess substantial commercial value owing to their diverse applications, including as raw material for paper and packaging and heightened industries, biofuel production, and handicrafts. The failure to capture

this value hampers income generation opportunities for rural communities and leaves untapped the economic potential of the very resources that surround them.

Moreover, this challenge reverberates through the region's ecological fabric. The lack of incentives for sustainable forest management practices, including responsible harvesting of pine needles, can result in over-exploitation and degradation of forests. This, in turn, has adverse environmental consequences, including soil erosion, loss of biodiversity, vulnerability to natural and man-made disasters such as Forest fires.

Operational Realities:

The operational scenario within the region portrays a shifting landscape where dependence on forests has dwindled due to limited forest-based livelihood opportunities. This transformation is underscored by the noteworthy phenomenon of male out-migration, which leaves behind a demographic composition primarily composed of women, young girls, and older men within the region's villages.

Historically, forests have been a critical source of livelihood for communities residing in these areas. Traditional forest-based activities, such as the collection of non-timber forest products, including pine needles, once formed the economic backbone of these communities. However, changing economic dynamics, coupled with the challenges associated with accessing and harnessing forest resources, have led to a reduced reliance on forest-dependent livelihoods. Consequently, communities have diversified their income sources, seeking opportunities beyond the boundaries of the forest.

Our engagements with local communities have revealed a multifaceted operational landscape. Currently, the region experiences reduced dependency on forests, primarily due to the limited availability of forest-based livelihood opportunities. Despite the presence of Van Panchayats, Collective Action Groups (SHGs), and implementing agencies like BAIF, there exists untapped potential in leveraging products such as pine needle products to enhance profitability. Furthermore, the lack of institutional procurement of value addition technologies represents a significant gap in the current operational setup.

DAIRY

In the domain of cattle farming, a profound and multifaceted challenge is encountered, rooted in two fundamental issues. Firstly, the region grapples with a persistently low success rate in cattle insemination. Secondly, the procurement of essential vaccines for cattle presents formidable hurdles. These challenges have far-reaching consequences for the local agricultural and allied sectoral landscape, influencing breeding efficiency and milk supply, both of which are integral to the dairy industry's vitality and prosperity.

ISSUE AT HAND

Low Success Rate In Cattle Insemination

The operational scenario within the region offers valuable insights into the challenges faced by cattle farmers. The foremost challenge revolves around the consistently low success rates in cattle insemination. This low success rate is detrimental to breeding efficiency and has several cascading effects:

• Prolonged Calving Intervals: Low insemination success rates lead to prolonged calving intervals among cattle herds. Extended calving intervals decrease the frequency of new births, limiting the rate at which cattle herds can expand and improving their genetic potential.

• Increased Operational Costs: Prolonged calving intervals and lower breeding efficiency result in increased operational costs for cattle farmers. Extended intervals mean more resources are required to maintain cattle, resulting in financial strain for farmers.

• Limited Genetic Improvement: Low success rates hinder the potential for genetic improvement within cattle herds. The inability to introduce superior genetics effectively limits the overall quality and productivity of the cattle population[1].

Difficulty In Procuring Vaccines

The second significant challenge relates to the procurement of vaccines for cattle, a critical aspect of disease prevention. This challenge arises due to multiple factors:

• Limited Availability: Vaccines may not be readily available or accessible in the region, leading to delays in disease prevention.

• Increased Disease Vulnerability: The absence of accessible vaccines increases the vulnerability of cattle herds to various bovine illnesses. Disease outbreaks can result in substantial economic losses and threaten cattle health.

Operational Realities:

The operational realities within the region reflect the evolving landscape of cattle farming. Historically, forests have been a crucial source of livelihood for communities in these areas. Traditional forest-based activities, including cattle farming, played a vital role in sustaining local economies. However, changing economic dynamics and the challenges associated with accessing and utilizing forest resources have led to a reduced reliance on traditional forest-dependent livelihoods.

This change is highlighted by the significant trend of men migrating out of the area, resulting in a demographic make-up in the region's villages that is predominantly composed of women, young girls,

1 Expert Consultations conducted at Uttarakhand State Council for Science and Technology (UCOST) on 6th September, 2023

and elderly men. While the shift away from traditional forest dependency showcases adaptability and resilience, it also underscores the need for interventions that can revitalize and harness the untapped potential of cattle farming within the region. This transition away from traditional forest dependency presents both challenges and opportunities that warrant strategic and sustainable approaches.

High Adulteration Of Milk

The dairy sector grapples with a substantial challenge related to the high adulteration of milk sold in the market. This adulteration jeopardizes both the quality and safety of the milk, consequently undermining the livelihoods of dairy farmers.

Operational Realities:

Our observations during field visits have highlighted the pressing operational issue of milk adulteration. It has become a prevalent practice, where milk available in the market is frequently tainted with water, synthetic milk, or other substances. These additives are introduced to increase the milk's volume or extend its shelf life. Such practices not only pose health risks to consumers but also diminish the nutritional value of the milk. This operational scenario directly impacts the livelihoods of dairy farmers and the quality of dairy products available to the community.

FISHERIES

In the realm of fish farming, a profound challenge has surfaced in recent years due to the region's changing environmental dynamics. Rising temperatures, a hallmark of contemporary climate change, have triggered a series of challenges for local fish farmers. Additionally, during the monsoon season, water contamination issues further compound the difficulties faced by those engaged in fish farming.

ISSUE AT HAND

Climate Induced Fish Variety Discontinuation

The operational scenario within the region underscores the profound impact of climate change on traditional fish farming practices. The primary challenge stems from the discontinuation of local fish varieties that once thrived in the region's waters. Species like rohu, katla, and mrigal carp/naini, which were historically the backbone of fish farming, are increasingly vulnerable to the rising temperatures. These fish species are highly sensitive to temperature fluctuations, rendering them unsustainable in the face of warming waters. This transition necessitates a significant shift in farming practices as farmers must now turn to alternative fish varieties, such as trout, silver carp, common carp, and grass carp, which are better suited to the changing climate. However, this adaptation is not without its own set of challenges, particularly concerning water quality management.

Water Quality Management During Monsoons:

The monsoon season, while essential for replenishing water resources, introduces a set of unique challenges for fish farmers. Heavy rainfall can lead to contamination of fish ponds and water bodies.

This poses a particularly acute problem for fish like trout, which are highly sensitive to water quality. Managing and preserving water quality during the monsoon season becomes paramount to ensure the health and wellbeing of the fish population.

Operational Realities:

The operational realities within the region reflect the need for adaptive strategies to address these climate-related challenges in fish farming. Farmers, driven by the imperative of sustainability and economic viability, have been compelled to transition from traditional fish varieties to those better suited to the changing climate. Moreover, the evolving climate dynamics necessitate a comprehensive approach to water quality management during the monsoon season. Farmers must adapt their practices to safeguard their fish stocks and ensure continued productivity in the face of changing environmental conditions.

Inadequate Market Linkage Preservation

In the fisheries sector, the primary challenge in Champawat revolves around inadequate market linkages and the preservation of fish for extended periods. The region's limited local demand for fish, and low tourist footfall, followed by the absence of proper preservation infrastructure hampers the economic prospects of fish farmers.

Operational Realities:

Our field visits have unveiled the operational realities of the fisheries sector in the Champawat region. The low tourist footfall throughout the year results in limited demand for fish. However, during festive seasons, there is a significant surge in demand. To capitalize on this demand and ensure maximum profits for fish farmers, there is a pressing need for improved fish preservation methods. Currently, the region lacks the necessary infrastructure for preserving fish for extended periods, making it challenging for fish farmers to meet market demands efficiently.

APIARY

ISSUE AT HAND:

Early Disease Detection And Control

A significant challenge in apiary management is the timely detection and effective control of diseases and infestations affecting bee colonies. Honeybee colonies are vulnerable to various diseases and parasites, and swift intervention is crucial to prevent the rapid spread of these issues. Detecting diseases at their early stages is vital to minimize colony losses and maintain healthy bee populations.

Operational Realities:

Within apiaries, beekeepers confront the operational reality of disease detection complexity. Regular

hive inspections are a fundamental part of disease monitoring, but this process can be time-consuming, particularly in large apiaries. Additionally, certain diseases may not exhibit overt symptoms in their initial stages, making early detection challenging. Beekeepers must invest significant effort in mastering disease identification and monitoring techniques.

Beekeeping Training Gap

Another pressing challenge is the lack of comprehensive beekeeping training. Beekeeping is a specialized and intricate practice that demands knowledge and skills in hive management, bee behavior, disease prevention, honey extraction techniques, and more. Insufficient training can hinder beekeepers from effectively tending to their hives, leading to reduced productivity and increased susceptibility to bee health issues.

Operational Realities:

Quality honey production stands as a pivotal operational objective in apiary management. Beekeepers must employ efficient hive management techniques to yield honey with desirable attributes, such as flavor, color, and purity. Achieving high-quality honey production entails meticulous extraction and processing methods, coupled with adherence to quality standards and regulatory guidelines governing honey production.

Bee And Bee Colony Insurance

Ensuring the protection and well-being of bee colonies and hives is a paramount concern for apiary management. Beekeepers face potential risks such as hive losses due to diseases, extreme weather events, theft, or unforeseen emergencies. Having insurance coverage for both individual bees and bee colonies is essential to provide financial security to beekeepers in the event of such losses. However, establishing and managing effective bee and bee colony insurance programs can be a complex undertaking.

Operational Realities:

Sustaining hive health is an ongoing operational concern for beekeepers. This encompasses various aspects, including ensuring bees have access to diverse forage sources, proper hive construction and maintenance, and implementing disease prevention measures like hive sanitation and pest control. The continuous upkeep of bee colonies is essential for their longevity and the production of high-quality honey.

Inexpensive Packaging Alternatives

Within the apiary sub-category, a crucial challenge is the use of inexpensive packaging alternatives, which compromise the quality and marketing appeal of honey products.

Operational Realities:

Our observations have revealed that honey is commonly packaged in alcohol bottles due to cost considerations. While this may reduce packaging expenses, it inadvertently diminishes the product's marketing potential and quality perception in the market. The operational scenario highlights the need for premium packaging solutions to enhance the quality appeal of honey products and improve their market

positioning.

In conclusion, our field visits have been a profound exploration of Champawat District's rural livelihood landscape, marked by the complexities and challenges faced by its communities. These expeditions have not only uncovered the intricacies of their daily lives but have also shed light on their remarkable resilience and determination. The insights garnered during these immersive experiences will serve as the guiding star as we transition into the critical phase of user persona mapping. This transition moves us from grasping the operational aspects to strategically outlining the levels of decision-making, all under the broad goal of promoting climate-resilient change in the Indian Himalayan Region, using Champawat as a model for experimentation.

User Persona Mapping

SECTION 3

This section unfolds in the form of user persona mapping—an essential step in addressing the profound climate change challenges focused on rural livelihood confronting Champawat District. Our extensive field visits have not only unveiled the nuanced pain points and operational intricacies of local communities but have also laid the foundation for constructing comprehensive user personas. These personas serve as archetypes that offer deep insights into the priorities, backgrounds, and needs of decision-makers and potential technology adopters across multiple tiers. By delving into the strategic, operational, and field decision-making layers, our aim is to align our endeavours with the aspirations and requirements of both community members and government stakeholders. Together, we embark on this pivotal phase with a solemn commitment to

Table 1

Decision Making Tier- Strategic Partners

Role and Key Priorities	Background	Attitudes and Interests	Behaviour and Decision Triggers
High-ranking officials from UCOST (Uttarakhand State Council for Science and Technology) and District Magistrate from Champawat District. Responsible for long-term planning, policy formulation, and resource allocation for climate-resilient technologies in the region.	Backgrounds in government administration, environmental sciences, or related fields. Extensive experience in policy development and scientific research.	Strongly committed to making Champawat District a model district for Uttarakhand by focusing on climate change and environmental issues, and keen on implementing scalable, efficient technological solutions for these challenges.	Decisions driven by the need to create sustainable and impactful climate-resilient initiatives. Influenced by scientific evidence, public opinion, and funding availability.

Table 2

Decision Making Tier- Operational

Role and Key Priorities	Background	Attitudes and Interests	Behaviour and Decision Triggers
Line managers, department heads, allied agencies, and allied government agencies responsible for implementing and managing climate-resilient technologies in Champawat District. Focus on effective technology deployment and project management.	Varied backgrounds including engineering, project management, environmental sciences, and government administration. Experience in overseeing technology implementation projects and policy execution.	Interested in practical, cost-effective, and seamlessly integrable technologies that improve operational efficiency and sustainability.	Decisions influenced by budget constraints, project timelines, alignment with organizational needs, and government policies. Driven by the desire to execute successful projects within defined budgets and timelines.

Table 3

Decision Making Tier- Field

Role and Key Priorities	Background	Attitudes and Interests	Behaviour and Decision Triggers
Farmers residing in the Champawat region, the end-users who directly interact with climate-resilient technologies. Focus on improving agricultural practices and livelihoods while mitigating climate challenges.	Diverse backgrounds related to agriculture and community life. Farmers have extensive experience in farming, while others may have community development experience.	Prioritize practical, livelihood-improving, culturally sensitive, and environmentally sustainable technologies. Value cost-effectiveness, ease of use, and technology's direct impact on crop yields and income.	Decisions influenced by the immediate impact on daily life, agricultural productivity, and income generation. Adoption depends on perceived benefits, ease of use, and community support.

Translating Field Understanding To Identify Relevant Technological Capabilities

Converting field knowledge into the identification of pertinent technological capabilities is a vital phase in creating technological solutions. These solutions are intended to improve rural livelihoods in the Indian Himalayan Region, with Champawat serving as a practical model for implementation. This translational process commences with gaining an in-depth comprehension of the challenges and requirements of farmers. This understanding serves as the foundation for crafting use cases, which are specific scenarios outlining how users, particularly farmers in this context, would interact with a system to address their challenges effectively. Subsequently, these use cases are deconstructed into functional requirements, which delineate the precise technical capabilities that a system must possess to fulfil the outlined use cases.

The Translational Process involves a systematic series of steps:

Identifying the Problem: This initial step revolves around comprehending the specific challenges confronted by end-users, in this case, the farming community.

Developing Use Cases: After identifying the challenges, the focus shifts to creating scenarios that elucidate the desired outcomes.

Defining Functional Requirements: The use cases then lead to the definition of detailed technical specifications indispensable for realizing the objectives outlined in the use cases.

The Process of Use-Case to Functional Requirements:

In this translational process, the guiding principle for addressing operational challenges is the driving force behind shaping the use cases. These use cases, in turn, dictate the functional requirements, ensuring that the solutions developed are not only technologically sound but also finely tuned to the specific needs of the community. This approach guarantees that the end product is both effective in resolving the identified issues and practical for the users to implement in their daily lives.

fostering sustainable development and bolstering climate resilience in IHR.

For example, in the realm of Horticulture:

- **Use Case**: Enhancing the cultivation of lychee and malta by mitigating nocturnal wildlife intrusions and pest infestations.
- **Explanation**: This use case aims to improve the cultivation of lychee and malta crops by addressing two specific challenges: nocturnal wildlife intrusions and pest infestations. Here's how the use case operates:
- **Problem Statement:** Farmers in the Champawat region grapple with significant challenges caused by nocturnal wildlife intrusions, particularly attacks by monkeys, which result in extensive damage to their lychee and malta crops. Additionally, delayed detection of pest infestations affects timely intervention, leading to reduced yields and financial losses.
- **Use Case Objective:** The use case is designed to alleviate these challenges and enhance crop cultivation outcomes.
- **Operational Scenarios**: This phase involves a comprehensive understanding of the current

situations and scenarios. Farmers currently rely on periodic visual inspections or physical scouting to detect wildlife intrusions and pests, which may not be efficient.

- **Functional Requirements:** The functional requirements outline the specific solutions or mechanisms required to achieve the use case's objectives. In this example:
    - **Sensors:** Deploy systems with the ability to detect animal intrusion from an appropriate distance. These systems should provide real-time data on wildlife movements, enabling farmers to take timely actions to deter intrusions.
    - **Fencing**: Install fencing around the farms, with heights ranging from 10-20 feet. These fences provide a physical barrier and a safe deterring mechanism, discouraging wildlife from entering the fields.

By implementing these functional requirements, the use case seeks to reduce the instances of nocturnal wildlife intrusions and enable early detection of pest infestations. This, in turn, assists farmers in safeguarding their Lychee and Malta crops, resulting in improved cultivation outcomes and reduced financial losses.

A comprehensive breakdown of each pain-point and use-case alongside its corresponding functional requirements is available in Annexure I for detailed reference.

Technology Interventions

PART C

The imperative need for technological intervention stands as a cornerstone for the successful implementation of climate-adaptive livelihood practices. In recognition of this critical requirement, a systematic technology stack framework has been developed to map technological capabilities that possess the inherent capacity to address these pressing needs. This framework not only identifies these capabilities but also evaluates their relevance to the end-users, thereby bridging the gap between technological potential and practical application.

The framework consists of multiple layers that work in unison to provide a holistic view of technological intervention. These layers are designed to provide a structured approach to

understanding and assessing the potential technological solutions for climate-adaptive livelihoods. Below, we detail each layer and its significance within the framework:

a) Feature and Its Description

This layer serves as the foundation, where each feature pertinent to climate-adaptive livelihood practices is meticulously defined and described. Features encompass a wide spectrum of technological aspects, ranging from data collection methods and sensors to decision support systems and community engagement tools. Each feature is articulated with utmost clarity to ensure a comprehensive understanding of its purpose and functionality.

b) Technological Capabilities and Specific Layers:

Building upon the foundation of features, this layer delves into the technological capabilities that underpin each feature. Technological capabilities encompass the tools, systems, and methodologies that empower these features to function effectively. Moreover, this layer categorically identifies the specific layers within the technological ecosystem where these capabilities are situated. For instance, a feature related to livestock data collection may draw upon capabilities within sensor systems, data transmission, and data analytics layers.

c) Relevance to End Adopter: Tying Needs to End User:

The ultimate litmus test of any technological solution is its relevance to the end adopter—the individuals or communities whose livelihoods are directly impacted. In this layer, the framework systematically evaluates the alignment between the identified features and technological capabilities with the actual needs and preferences of the end-users. The relevance assessment takes into account factors such as usability, cultural appropriateness, and economic viability. This step ensures that technological interventions are not only technically sound but also genuinely beneficial and accessible to those they are intended to serve.

Henceforth, the technology stack framework for technological intervention as explained in table 1 and 2 in relation with climate-adaptive livelihoods provides a structured and comprehensive approach to identify, assess, and align technological capabilities with the needs of end-users. By systematically analysing the features, capabilities, and relevance, this framework empowers decision-makers and stakeholders to make informed choices that drive sustainable and impactful technological interventions in the realm of climate-adaptive livelihood practices.

Note: In the following sections related to the technological capabilities, "livelihoods" has been divided into two parts:

1. Livelihood (Processes) encompass a range of activities and practices that contribute to the sustenance, improvement, and overall management in the sectors of dairy, horticulture, apiary, fisheries.
2. Livelihood (Products) is using the yields from horticulture, apiary, and dairy operations, like fruits, honey, and dairy products. These products are used to generate income and support livelihoods.

For example - Beekeeping and any products/technologies to aid the process of bee keeping will come under "process", whereas processing the collected honey and creating a market linkages for it will come under "product".

Box 2

Technology Stack framework for climate adaptive livelihoods (process)

	Quality Assessment	Processing	Paackaging
Traditional 	1. Sensory Evaluation 2. Physical Testing 3. Chemical Testing 4. Microbiological Testing 5. Visual Inspection	Gentle Processing: 1. Canning 2. Drying 3. Fermentation Intensive Processing: 1. Thermal Processing (e.g., pasteurization, sterilization) 2. Smoking 3. Salting	1. Canning 2. Bottling 3. Vacuum Packaging 4. Wrapping 5. Jarring 6. Box Packaging
Blockchain 	Immutable record of quality assessment data for transparency and accountability.	Verification of processing steps for compliance and food safety	Tracking and verification of packaging materials for safety and traceability
AI/ML 	Automated and objective quality assessment using computer vision, spectroscopy, and sensor data analysis	Optimization of processing parameters (Temperature, time, ingredient ratios, mixing or blending speed, processing pressure, pH or acidity) for improved outcomes and monitoring of processing equipment for efficiency and consistency	Optimize packaging processes, including selection of packaging materials, design of packaging structures, and monitoring of packaging integrity
Advanced Sensing 	Sensors such as spectrometers, colorimeters, and gas sensors to assess the quality of raw materials, ingredients, and final products by measuring attributes such as color, texture, moisture content, pH, temperature, and gas composition	Optimization of processing parameters (Temperature, time, ingredient ratios, mixing or blending speed, processing pressure, pH or acidity) for improved outcomes and monitoring of processing equipment for efficiency and consistency	Sensors such as oxygen sensors, carbon dioxide sensors, and moisture sensors can monitor the packaging environment to ensure proper preservation, freshness, and shelf-life of the packaged food products

	Storage	Distribution	Waste Processing
Traditional 	1.Root Cellaring 2. Smokehouse Storage 3. Salt Curing 4. Drying/Dehydration 5. Fermentation 6. Pickling 7. Cold Storage (e.g., ice houses, ice boxes)	1. Local Markets 2. Street Vendors 3. Self-help groups and Village level entrepreneurs 4. Food Cooperatives 5. Online Marketplaces 6. Wholesale Distribution 7. Food Aid Programs	. Composting 2. Animal Feed 3. Biogas Production 4. Vermiculture 5. Fermentation 6. Traditional Crafts
Bloockchain 	Monitoring and recording of storage conditions for food safety and quality	Real-time visibility and traceability of food products along the supply chain	Transparent record of waste management practices for sustainability
AI/ML 	Monitoring and analysis of storage conditions for food freshness, quality, and safety	Optimization of logistics and supply chain management including route planning, inventory management, and demand forecasting for efficient delivery and reduced food waste	Optimize waste processing methods, such as recycling, composting, and disposal, by analysing data on waste composition, volume, and environmental impact
Advaanced Sensing 	Temperature sensors, humidity sensors, and gas sensors to monitor the storage conditions to ensure optimal temperature, humidity, and gas composition for maintaining food quality, safety, and shelf-life during storage	GPS trackers, temperature sensors, and humidity sensors to monitor the transportation conditions, including temperature, humidity, and location, to ensure proper handling and transportation of food products, minimize spoilage, and reduce food waste	Sorting sensors, weight sensors, and composition sensors for sorting, separation, and characterization of food waste for appropriate waste processing methods such as composting, anaerobic digestion, or recycling

Box 2 (Continued)

Technology Stack framework for climate adaptive livelihoods (process)

	Quality Assessment	Processing	Paackaging
UAVs	UAVs equipped with high-resolution cameras or multispectral/hyperspectral sensors can capture aerial images or data of agricultural fields, orchards, or fisheries to assess crop health, growth, and quality		
Mechanised Equipment	Immutable record of quality assessment data for transparency and accountability.	Automated sorting and grading machines for fruits, vegetables, or grains 2. High-pressure processing (HPP) equipment for preserving food quality and safety 3. Continuous processing systems, such as extruders or pasteurizers, for efficient food processing	Modified Atmosphere Packaging (MAP) systems for extending shelf life 2. Vacuum packaging machines for preventing spoilage and extending shelf life
Digital Platforms	Web-based or mobile-optimized digital platforms or dashboards can help in the food processing cycle by providing real-time monitoring and control, optimizing processes, managing inventory, tracking transportation logistics, and managing food waste. These technologies enable data-driven decision-making, leading to improved efficiency, traceability, and quality control		

	Storage	Distribution	Waste Processing
UAVs		. Last-mile delivery of food products to remote or inaccessible locations, reducing transportation costs, and improving delivery efficiency 2. Monitoring and optimizing transportation routes, scheduling, and logistics	
Mechanised Equipment	Robotics and automation technologies for organizing food products in storage facilities	Automated sorting, packing, and labeling systems for efficient distribution	. Composting equipment for converting food waste into compost. 2. Anaerobic digestion systems for converting food waste into biogas. 3. Bioconversion technologies, such as insect rearing or mealworm farming, for processing food waste
Digital Platforms	Web-based or mobile-optimized digital platforms or dashboards can help in the food processing cycle by providing real-time monitoring and control, optimizing processes, managing inventory, tracking transportation logistics, and managing food waste. These technologies enable data-driven decision-making, leading to improved efficiency, traceability, and quality control		

Box 3

Technology Stack framework for climate adaptive livelihoods (product)

	Diagnosis	Prevention and Control	Veterinary Delivery Services
Blockchain 	Centralised and secured repository of cattle diagnostic data for easier and transparent access to all stakeholders	Livestock tracking and management - health records, vaccination schedules, and disease outbreaks, aiding in disease prevention and control	
AI/ML 	AI algorithms to analyse images of diseased animals or their biological samples to identify diseases accurately and quickly	Analysis of environmental conditions, animal health records, and disease patterns, to identify risk factors and provide early warning systems for disease control measures	AI algorithms to analyse clinical data, laboratory results, and treatment protocols to provide personalized treatment recommendations and optimize care delivery
Advanced Sensing 	Thermal imaging cameras, RFID (Radio-Frequency Identification) tags, and wearable health monitoring devices can collect real-time data on animal health parameters like body temperature, heart rate, and activity levels, enabling early detection of health issues IoT-based sensors to provide real-time hive monitoring, environmental analysis, and remote access for apiaries, enabling precise data-driven insights into hive health, bee behaviour, and environmental factors IoT sensors enable real-time water quality monitoring, fish tracking, aquaculture optimization, and early warning systems in fisheries, fostering sustainable practices and informed decision-making	Environmental sensors, weather stations, and soil sensors can provide data on environmental conditions such as temperature, humidity, and air quality, helping to identify potential disease risk factors and implement preventive	Remote monitoring sensors, GPS trackers, and video surveillance systems can aid in monitoring livestock location, movement patterns, and behaviour, enabling remote veterinary care and ensuring timely delivery of services

	Breeding	Value Addition
Blockchain	Transparent and traceable records of pedigree, genetics, and breeding history.	
AI/ML	Analysis of genetic data, pedigree information and performance to optimise livestock breeding programs	Urban waterbody management system to maintain optimal conditions of an aquaculture farm
Advanced Sensing	Ultrasound scanners, and reproductive sensors can collect data on genetic traits, reproductive status, and fertility parameters, supporting optimal breeding decisions	Optimization of logistics and supply chain management including route planning, inventory management, and demand forecasting for efficient delivery and reduced food waste

Box 3 (Continued)

Technology Stack framework for climate adaptive livelihoods (product)

	Diagnosis	Prevention and Control	Veterinary Delivery Services
UAVs		UAVs equipped with high-resolution cameras or multispectral/hyperspectral sensors to enable aerial surveillance of livestock to detect signs of diseases, monitor animal behaviour and movement patterns, and identify potential disease outbreaks	Transport veterinary supplies, medications, and vaccines to remote or inaccessible areas, ensuring timely delivery
Digital Platforms	Provide real-time data management, analytics, and communication capabilities to enhance various components of livestock, bees, fishery management, including diagnosis, disease prevention, veterinary services, breeding, product packaging, and value addition services		
Advanced Sensing	Thermal imaging cameras, RFID (Radio-Frequency Identification) tags, and wearable health monitoring devices can collect real-time data on animal health parameters like body temperature, heart rate, and activity levels, enabling early detection of health issues IoT-based sensors to provide real-time hive monitoring, environmental analysis, and remote access for apiaries, enabling precise data-driven insights into hive health, bee behaviour, and environmental factors IoT sensors enable real-time water quality monitoring, fish tracking, aquaculture optimization, and early warning systems in fisheries, fostering sustainable practices and informed decision-making	Environmental sensors, weather stations, and soil sensors can provide data on environmental conditions such as temperature, humidity, and air quality, helping to identify potential disease risk factors and implement preventive	Remote monitoring sensors, GPS trackers, and video surveillance systems can aid in monitoring livestock location, movement patterns, and behaviour, enabling remote veterinary care and ensuring timely delivery of services

	Breeding	Value Addition
Blockchain	Transparent and traceable records of pedigree, genetics, and breeding history.	
Digital Platforms	Provide real-time data management, analytics, and communication capabilities to enhance various components of livestock, bees, fishery management, including diagnosis, disease prevention, veterinary services, breeding, product packaging, and value addition services	
Advanced Sensing	Ultrasound scanners, and reproductive sensors can collect data on genetic traits, reproductive status, and fertility parameters, supporting optimal breeding decisions	Optimization of logistics and supply chain management including route planning, inventory management, and demand forecasting for efficient delivery and reduced food waste

Field Technology Showcase

SECTION 5

In an endeavour to demonstrate the practical potential and real-world impact of innovative technology solutions for government decision-makers, the AGNIi team organised a Field Technology Showcase (FTS) in Champawat, Uttarakhand. This FTS served as a pivotal event aimed at aligning cutting-edge technologies with the region's development priorities. In pursuit of ensuring the effectiveness of the showcase for harnessing technology-driven rural livelihood opportunities, a series of strategic actions were meticulously implemented. These actions were thoughtfully designed to optimize the impact and relevance of the technology showcase in the context of rural Champawat from the perspective of IHR. This subsection provides a comprehensive overview of the initiatives undertaken to maximize the potential of technology for enhancing rural livelihoods:

Virtual Technology Showcase and Stakeholder Engagement:

Prior to the physical FTS, a virtual technology showcase was conducted, gathering officials from the Uttarakhand Council for Science and Technology (UCOST) and Champawat District Administration. The virtual demonstration was designed to assess the level of interest and response from key stakeholders. It featured a diverse array of technologies, ranging from emerging high-tech solutions like artificial intelligence, blockchain, sensor systems, to pragmatic and cost-effective innovations tailored to enhance and enable rural livelihoods.

On-Ground Demonstrations and Key Participants:

Following the virtual showcase, a selected set of technologies were chosen for on-ground demonstrations in Champawat. District Administration officials, the Director General of UCOST, representatives, local community members, and student bodies actively participated in these field demonstrations. The event witnessed the presence Indian innovators, who showcased their eleven technologies to address local challenges and drive positive change.

Selection Criteria and Diversity of Solutions:

The selection of technologies for both the virtual and physical showcases was guided by rigorous criteria that underscored their relevance to local challenges and government priorities in Champawat. The showcased technologies represented a broad spectrum, ranging from emerging, high-tech innovations to cost-effective, frugal solutions. This diversity ensured that there were options suitable for various contexts and challenges prevalent in the region.

Community Engagement and Hands-on Experiences:

Crucially, the FTS encouraged active participation and engagement from the local community and student groups. Attendees, especially government officials, were afforded hands-on experiences with the technologies, fostering a deeper understanding of their capabilities and potential impact. Interactive sessions and demonstrations provided participants with direct opportunities to engage with these solutions.

Alignment with Government Priorities and Long-term Adoption:

Throughout the showcases, the emphasis was on how the presented technologies closely aligned with the UCOST's regional goals and Champawat District Administration's priorities. The discussions also encompassed strategies for the sustainable, long-term adoption and integration of these technologies into local governance and livelihood improvement initiatives.

Awareness Building and Stakeholder Collaboration:

An integral component of the FTS was to raise awareness among stakeholders about the transformative potential of these technologies. By fostering collaboration and dialogue between technology innovators, government officials, local communities, and students, the event aimed to catalyse a collective effort

towards leveraging technology for the betterment of Champawat's rural livelihoods and governance.

Technology Matrices For Climate Adaptive Livelihoods

The "Technology Matrices for Climate-Adaptive Livelihoods" represents a comprehensive and forward-looking framework designed to illuminate the transformative potential of various technologies in the context of climate-resilient livelihoods. Within this framework, we explore four distinct technological domains: Artificial Intelligence & Machine Vision, Blockchain, Digital Platforms, and Incremental & Frugal Innovations. Each domain offers a unique set of capabilities and applications that can be harnessed to address the challenges in different sub-sectors such as dairy, apiary etc. under rural livelihood posed by a changing climate.

- **Artificial Intelligence & Machine Vision,** for instance, is harnessed to create facial recognition systems for cows in the dairy sector, allowing for precise tracking of their health, breeding, and ownership. In the apiary sector, machine vision-enabled cameras monitor bee behavior and hive conditions, offering valuable insights into pollination, colony health, and pest infestations.
- **Blockchain**, known for its transparency and security, is applied in dairy and apiary management to enhance traceability, quality assurance, and consumer trust. Through blockchain, consumers can access detailed information about the origin of products, animal husbandry practices, and processing methods, promoting transparency and ethical production.
- **Digital Platforms** emerge as powerful tools for dairy finance management and agriculture & allied sectors, facilitating data-driven decision-making, enhancing transparency, and promoting financial inclusion. These platforms play a pivotal role in connecting stakeholders, streamlining operations, and expanding market reach.
- The domain of **Incremental & Frugal Innovation**s encompasses a range of practical solutions designed for resource efficiency, environmental sustainability, and economic empowerment. From solar-powered silk reeling machines to multi-parameter water testing kits, these innovations address critical aspects of climate-adaptive livelihoods

Table 4

Artificial Intelligence & Machine Vision

Artificial Intelligence (AI) encompasses computer systems designed to simulate human intelligence, enabling tasks that typically require human cognition, such as learning, problem-solving, and decision-making. Machine Vision, a subset of AI, involves equipping machines with visual perception capabilities, allowing them to interpret and understand images or videos. By leveraging advanced algorithms, AI and Machine Vision empower various sectors with data-driven insights, automation, and enhanced decision-making, revolutionizing industries through efficient, accurate, and intelligent processing of visual information.	
Sector	**Capability**
Dairy	• Facial Recognition for Cows
	• Functionality: • Utilize facial recognition technology, by using the cow's muzzle pattern as the unique identifying factor, to authenticate cow identities, linking to extensive databases for health, breeding, and ownership records.
	• Benefits: • Facilitates precise monitoring, optimizing health care, enhancing breeding programs, and improving overall productivity.
Sector	**Capability**
Apiary	• Machine Vision Enabled Camera
	• Functionality: • Utilize image processing and machine vision to classify bees entering and exiting the hive. • Data Collection: Records bee characteristics, including pollen carried, deformities, and quantity, at specified sample times. • Data Analysis: Analyses collected data for forage availability, colony health estimation, potential swarming, and pest infestation. • Alert System: Automated SMS alerts stakeholders if key performance metrics are breached, enabling timely actions.
	• Benefits: • Enhances beekeeping skills by bridging the gap between novices and experienced practitioners. Through data-driven decision-making, it optimizes crop cycles around hives, reducing the need for migration and potentially saving up to 30% compared to traditional methods. The system provides remote monitoring options with long range and Wifi connectivity, ensuring real-time data access.

Table 5

Blockchain

Blockchain technology is a secure, decentralized digital ledger system that records transactions across multiple computers in a way that ensures the security, transparency, and immutability of the data. Each block in the chain contains a cryptographic hash of the previous block, creating a linked and tamper-proof record of transactions. It enables transparent, verifiable, and traceable transactions, making it ideal for applications requiring data integrity, such as supply chain management, financial transactions, and verifying the authenticity of digital assets. Blockchain revolutionizes industries by providing a reliable and trustful framework for various decentralized applications and transactions.	
Sector	**Capability**
Dairy	• Blockchain in Dairy Management:
	• Functionality: • 1. Cattle Registration: Small-scale farmers register cows using facial recognition, assigning unique Identifiers. • 2. Seamless Integration: Identifiers remain linked as cows progress through production stages. • 3. Batch-Level Tracking: Milk batches are linked to producer groups, enabling traceability to specific cows. • 4. Digital Records: Data is compiled into digital records, detailing milk's journey from cow to processing. • 5. Consumer Transparency: QR codes on milk pouches provide insights into origin, animal husbandry practices, and processing details. • 6. Quality Assurance: Information on certifications and processing standards assures consumers of product quality. • 7. Feed Traceability: Blockchain incorporates traceability across the feed and fodder value chain.
	• Benefits: • 1. Enhanced Transparency: Provides transparent and detailed information to consumers about milk's source and processing. • 2. Quality Assurance: Assures consumers of product quality, certifications, and adherence to standards. • 3. Traceability: Enables traceability of milk batches to specific cows and producer groups, ensuring accountability. • 4. Efficiency: Streamlines record-keeping, reducing paperwork and enhancing operational efficiency. • 5. Consumer Confidence: Builds consumer trust through verifiable information, improving market reputation. • 6. Data Integrity: Ensures data integrity and immutability, enhancing the reliability of records.

Table 6

Digital Platforms

Digital platforms serve as versatile web-based solutions and mobile applications, catering to diverse sectors and stakeholders. These platforms enable seamless interaction, facilitating activities such as procurement, market linkage, transparency, and efficient program management. With features like product discovery, standardized commodities, and tailored consumer engagement, digital platforms revolutionize various industries. They enhance transparency, streamline operations, and contribute to socioeconomic development by promoting efficient resource utilization and market expansion across sectors.	
Sector	**Capability**
Dairy	• Digital Platform for Dairy Finance Management
	• Functionality: • Objective Credit Scoring: Utilize a data-driven approach, analyse farmers' financial history, daily farm operations, and animal health assessments to calculate objective credit scores. • Data Collection: Gather data on daily farm activities, production metrics, veterinary interventions, and animal health indicators to assess creditworthiness and overall farm health. • Advanced Analytics: Employ advanced data analytics and machine learning algorithms to accurately calculate credit scores and animal health scores, enabling precise lending and insurance decisions. • Financial Inclusion: Reach smallholder dairy farmers in remote rural areas, promoting financial inclusion by providing access to institutional finance where traditional banking services are limited.
	• Benefits: • 1. Improved Lending Efficiency: • 1.1 Informed Decision-Making: Enables financial institutions to make informed lending and insurance decisions based on accurate credit and animal health scores, reducing risks and improving operational efficiency. • 1.2 Streamlined Operations: Streamlines lending processes, enhancing the efficiency of financial institutions by automating credit assessments and reducing manual workload. • • 2. Financial Inclusion and Trust Building: • 2.1 First-Time Access: Facilitates first-time borrowing for dairy farmers, granting them access to institutional finance, fostering economic growth in rural communities. • 2.2 Trust Establishment: Builds trust between smallholder farmers and financial institutions, promoting engagement and encouraging farmers to actively seek financial products. • • 3. Customer Acquisition and Outreach: • 3.1 Customer Base Expansion: Serves as a powerful customer acquisition channel for banks, providing access to a vast farmer base actively seeking financial products and services. • 3.2 Market Expansion: Expands the market reach of financial institutions, allowing them to cater to previously underserved regions, stimulating economic development in these areas.

Sector	Capability
Agriculture and Allied Sectors	• Digital convergence tool
	• Functionality: • • 1. Web and Mobile Solutions: Web-based platforms and mobile apps, serving as digital convergence tools for stakeholders in rural agricultural ecosystems. • 1.1 Inputs Marketplace: Facilitate product discovery, price negotiation, and fulfilment support for agricultural inputs, enhancing procurement efficiency for farmers and organizations. • 1.2 Outputs Marketplace: Standardizes commodities, providing detailed farmgate/ FPO-level stock keeping units with visual aids such as pictures, videos, and quality certifications, ensuring transparency and trust in transactions. • 1.3 Consumer Marketplace: Customizes products with storytelling features, creating digital catalogues for Self-Help Groups (SHGs), enabling tailored offerings and expanding market reach. • FPO/SHG App: Engages users through Q&A, surveys, information sharing, program management, advisories, task creation, crop calendars, input and output transactions, bookkeeping, dashboards, auto-generated accounts, and aggregation capabilities.
	• Benefits: • 1. Efficient Procurement: Streamlines procurement processes for agricultural inputs, allowing farmers and organizations to discover products, negotiate prices, and receive support, ensuring timely access to essential resources. • 2. Transparency and Trust: Enhances transparency by standardizing commodities, providing detailed visual information, and certifications, building trust among stakeholders in the supply chain, from farmers to consumers. • 3. Market Expansion: Enables farmer producer organizations and SHGs to expand market reach by creating customized products, digital catalogues, and engaging with consumers, fostering market linkages and increasing sales opportunities. • 4. Effective Program Implementation: Provides implementation organizations with tools for program execution, engagement, and monitoring and evaluation (M&E) through dashboards, ensuring effective program management and alignment with development goals. • 5. Livelihood Enhancement: Contributes to broader development goals such as increasing farmers' income and creating rural livelihoods, aligning with government objectives and stimulating economic growth in agricultural communities.

Table 7

Incremental and Frugal Innovations

Incremental innovations involve gradual improvements made to existing products, processes, or services, refining and optimizing their functionalities over time. Frugal innovations, on the other hand, refer to the creation of cost-effective solutions that address specific challenges by maximizing resource efficiency and minimizing complexity, often with a focus on affordability and accessibility. These innovations emphasize practicality and minimalism, catering to the essential needs of users, particularly in resource-constrained environments, while ensuring sustainable and viable outcomes.

Innovation	Functionality and Technical Specifications	Benefits & Value Proposition
Silk Reeling Machine	• 1. Solar-Powered Operation: Compact machine (1'x1') powered by solar energy, ensuring grid-free operation and energy efficiency (<20W power). • 2. Li-Ion Battery: Equipped with a Li-Ion battery, enabling usage during afterhours and rainy days, ensuring continuous operation. • 3. High Productivity: Provides 4X higher productivity compared to traditional methods, generating high-quality silk output for diverse applications. • 4. User-Friendly Design: Light and compact (15kg), easy to use and train new users, promoting accessibility and usability in rural settings.	• 1. Income Multiplication: Multiplies income 4X, independently verified impact, utilizing local resources for rural job creation, enhancing economic prospects for communities. • 2. Promotes Climate-Resilient Livelihoods: Supports climate-resilient livelihoods by using renewable solar energy, protecting forest resources, and improving value capture from forest and horticulture products. • 3. Flexible Operation: Enables work anywhere, anytime, serving as an ideal 'Work from Home' solution for rural women, eliminating physical and mental drudgery, empowering them for sustainwable livelihoods.
Fodder growing station	• 1. Hydroponic Vertical Farming: Utilizes hydroponic systems for vertical farming, enabling the growth of fodder, mushrooms, and nursery plants in a compact space. • 2. Dual Purpose: Functions as a fodder station and agro-forestry nursery, providing additional cattle feed inputs and promoting sustainable agro-forestry practices. • 3. High Protein Fodder Production: Generates 0.5 tons of high-protein fodder daily, totalling 168 tons of live feed per year, with 95% less water usage and space requirement	• 1. Increased Milk Yield: Boosts milk yield by 1 to 3 litres per cattle per day, enhancing dairy farmers' income and livelihoods. • 2. Resource Efficiency: Maximizes resource efficiency with minimal water usage and space requirements, contributing to sustainable farming practices and environmental conservation. • 3. Economic Opportunities: Creates economic opportunities by providing high-protein fodder for cattle, reducing feed costs, and increasing overall productivity in livestock farming. • 4. Modular and Rapid Deployment: Containerized model allows modularity in size and capacity, facilitating rapid deployment in rural and remote locations, ensuring adaptability to local needs.

Innovation	Functionality and Technical Specifications	Benefits & Value Proposition
Active Packaging Sachet	• 1. Natural Plant Extracts: Contains natural plant extracts that activate a defence mechanism within fruits and vegetables, slowing down ripening and minimizing microbial attack at ambient temperatures. • 2. Defence Activation: Activates the defence mechanism in fresh produce, extending shelf life by 40-60% at room temperature. • 3. Customization and Adaptability: Customizable based on volume, days, fruit/vegetable type, and variety, ensuring versatility and adaptability throughout the supply chain.	• 1. Reduced Wastage: Extends the shelf life of fruits and vegetables by 40-60%, reducing wastage and losses, leading to increased income for farmers and traders. • 2. Cost-Effectiveness: Provides a cost-effective solution for preserving fresh produce, enhancing economic viability for farmers and traders, while also promoting sustainable agricultural practices. • 3. Supply Chain Efficiency: Improves efficiency in the fresh produce supply chain by enabling transportation and storage at room temperature for 10-15 days, reducing the need for costly refrigeration infrastructure. • 4. Empowering Rural Communities: Empowers rural communities by ensuring that their produce reaches markets in optimal conditions, enhancing market access, income, and overall economic opportunities for farmers, ultimately contributing to rural empowerment.
Advanced waste heat utilization and portable semiconductor cooling system	• 1. Semiconductor Temperature Difference Technology: Utilizes semiconductor technology (Thermoelectric Module solid state Cooler, TMSSC) based on the Peltier effect to achieve cooling without CFCs, offering a temperature range from -40°C to +60°C. • 2. Waste Heat Utilization: Harnesses waste heat generated during cooking, converting 10% of it into clean power through customized flexible modules, enabling rapid cooling from 28°C to 3°C within 5 minutes. • 3. Accurate Temperature Control: Employs fuzzy electronic linear temperature control technology for precise temperature regulation within the box, ensuring accurate cooling power control.	• 1. Environmentally Friendly: Eliminates the use of refrigerants and mechanical compressors, ensuring green environmental protection with no secondary pollution. • 2. Operates with low noise (<38dBA) during normal operation. • 3. Simple Structure: Utilizes semiconductor refrigeration sheets pasted on heat transfer aluminium sheets, creating a straightforward refrigeration system suitable for mass production and easy maintenance. • 4. Energy Efficiency: Harnesses waste heat for clean power generation, maximizing energy utilization and reducing dependence on traditional energy sources, contributing to sustainable practices. • 5. Economic Empowerment: Provides an affordable and portable cooling solution, enabling small businesses, farmers, and entrepreneurs to preserve perishable goods, reducing losses and enhancing economic viability. • 6. Versatility and Adaptability: Adaptable for various applications, including food storage, enabling businesses to expand their product offerings and market reach, fostering entrepreneurship and livelihood diversity.

Innovation	Functionality and Technical Specifications	Benefits & Value Proposition
Pelletiser and Briquetting Machine	• 1. Drying and Chopping: Pine needles and/or other forest waste is dried and finely chopped. • 2. Pressure Application: The machine applies pressure to the chopped material, forming briquettes or pellets through compression. • 3. Compact and Efficient: Converts waste biomass into compact, uniform pellets or briquettes, ensuring efficient storage, transportation, and utilization.	• 1. Higher Calorific Value: Biomass briquettes and pellets have a higher calorific value compared to wood, ensuring efficient and high-temperature combustion, providing more heat energy. • 2. Environmentally Friendly: Clean and low sulphur content briquettes reduce emissions of CO2 and CH4, contributing to reduced greenhouse gases and mitigating climate change impact. • 3. Efficient Heat Emission: 3 kg of pellets emit the same heat as 10 kg of wood, offering higher heat output and longer burning time, enhancing fuel efficiency. • 4. Reduced Deforestation: Encourages the use of forest waste, reducing the demand for fresh wood, curbing deforestation, and preserving natural ecosystems for future generations.
Mini Recirculatory Aquaculture System (*RAS*)	• 1. Recirculatory Aquaculture System (RAS) is a technology where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. • 2. This method is used for high-density culture of various species of fish, utilizing minimum land area and water. • 3. Water Recycling and Filtration: RAS recycles and filters water through mechanical and biological processes, maintaining high water quality for fish cultivation. • 4. Indoor/Outdoor Controlled Environment: Fish are reared in controlled indoor/outdoor tanks, minimizing space requirements and enabling high-density fish culture. • 5. Minimal Water Replacement: New water is added only to compensate for splash out, evaporation, and waste material flushing, with not more than 10% of the total volume replaced daily. • 6. Small-Scale Adoption: Mini RAS promotes small-scale fish farming in urban and semi-urban areas with limited land and water resources, encouraging entrepreneurship and sustainable aquaculture practices.	

Innovation	Functionality and Technical Specifications	Benefits & Value Proposition
Mini Recirculatory Aquaculture System RAS	• 1. Recirculatory Aquaculture System (RAS) is a technology where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. • 2. This method is used for high- density culture of various species of fish, utilizing minimum land area and water. • 3. Water Recycling and Filtration: RAS recycles and filters water through mechanical and biological processes, maintaining high water quality for fish cultivation. • 4. Indoor/Outdoor Controlled Environment: Fish are reared in controlled indoor/outdoor tanks, minimizing space requirements and enabling high-density fish culture. • 5. Minimal Water Replacement: New water is added only to compensate for splash out, evaporation, and waste material flushing, with not more than 10% of the total volume replaced daily. • 6. Small-Scale Adoption: Mini RAS promotes small-scale fish farming in urban and semi-urban areas with limited land and water resources, encouraging entrepreneurship and sustainable aquaculture practices.	• 1. Equipment Durability: Extends the lifespan of tanks and equipment, ensuring long-term operational efficiency. • 2. High-Quality Fish: Reduces dependency on antibiotics and therapeutants, resulting in superior quality fish for consumers. • 3. Cost Reduction: Lowers operational costs related to feed, predator control, and parasites, enhancing economic viability for fish farmers. • 4. Environmental Impact: Minimizes the release of parasites to recipient waters, reducing ecological impact and preserving natural aquatic ecosystems. • 5. Climate and Disease Resilience: Reduces risks associated with climatic factors, diseases, and parasites, ensuring stable and secure fish production. • 6. Flexibility and Market Access: Provides flexibility in farming location and proximity to markets, enabling diverse species cultivation and secure production of non-endemic species. • 7. Enhanced Feed Management: Allows 24-hour monitoring of feeding, improving feed management practices and optimizing fish growth. • 8. Stress Reduction: Minimizes stress factors such as adverse weather, temperature fluctuations, pollution, and predation, ensuring healthier and more productive fish populations. • 9. Water and Land Conservation: Facilitates judicial use of water and land areas, promoting sustainable aquaculture and environmental conservation.

Innovation	Functionality and Technical Specifications	Benefits & Value Proposition
Multi parameter Water Testing Kit	• This kit can test multiple parameters of water quality: • • 1. pH Test: pH strips covering a range from 6.5 to 9.0. • 2. Turbidity Test: Measures turbidity within the range of 10-500 NTU, with options for 10 and 25 NTU. • 3. Chloride Test: Detects chloride levels from 10-200 mg/L (ppm) and 50-1000 mg/L (ppm). • 4. Total Hardness Test: Measures total hardness from 25-600 mg/L (ppm) as CaCO3. • 5. Fluoride Test: Detects fluoride levels ranging from 0.0-5.0 mg/L (ppm). • 6. Nitrate Test: Measures nitrate levels within the range of 0.0-250 mg/L as Nitrate (N). • 7. Iron Test: Detects iron levels from 0.0-2.0 mg/L (ppm) as Iron. • 8. Residual Chlorine Test: Measures free chlorine levels from 0.0-3.0 mg/L (ppm) as free chlorine.	• 1. Comprehensive Analysis: Provides a wide range of parameters, ensuring comprehensive water quality assessment for effective aquaculture management. • 2. Quick and Accurate Results: Enables rapid testing, allowing aqua culturists to swiftly assess water quality, diagnose issues, and take necessary corrective measures. • 3. Prevents Disease Outbreaks: Helps in early detection of potential issues, preventing disease outbreaks and promoting healthier aquatic environments for fish and other organisms. • 4. Optimized Conditions: Allows precise adjustment of water parameters, ensuring optimal conditions for aquatic life, leading to better growth rates and overall productivity. • 5. Data-Driven Decision-Making: Facilitates data-driven decision-making by providing accurate and reliable information, enhancing the efficiency and sustainability of aquaculture practices.

Fostering Technology Adoption

A central objective of the FTS was to facilitate the adoption of innovative technologies by government decision-makers and the local community. To achieve this goal, the event focused on aligning each showcased technology with Everett Rogers' Adoption Levers. This strategic approach ensured that the exhibited solutions not only demonstrated technological excellence but also addressed the unique needs and adoption dynamics of the local context. By addressing key attributes such as compatibility, simplicity, trialability, observability, and relative advantage, the FTS aimed to pave the way for the adoption of these technologies by government decision-makers.

Exploring Adoption Levers:

Everett Rogers, in his seminal work "Diffusion of Innovations," [1] emphasized that individuals' perceptions of innovation attributes play a pivotal role in determining the rate of adoption. Rogers identified five vital attributes of innovation, including:

- Relative Advantage: This attribute measures the extent to which an innovation is perceived as superior to the idea it replaces. Various factors, such as economic benefits, social prestige, convenience, and satisfaction, contribute to assessing the degree of relative advantage.
- Compatibility: Compatibility gauges how well an innovation aligns with the existing values, past experiences, and needs of potential adopters.
- iComplexity: The degree of complexity reflects how challenging it is to understand and use an innovation. Some innovations are straightforward and easily adopted, while others may pose complexities that slow down the adoption process.
- Trialability: Trialability assesses the extent to which an innovation can be experimented with on a limited basis, allowing individuals to explore its functionality.
- Observability: Observability measures how visible the results of an innovation are to others. The more easily individuals can witness the outcomes of an innovation, the greater the likelihood of its adoption.

The significance of these perceived attributes cannot be overstated, particularly in the context of end adopters within the local communities. Information asymmetries exist concerning both the functionalities and benefits of technological innovations. Therefore, a primary objective of the FTS was to vividly illustrate and contextualize these innovation attributes.

Based on these adoption levers[2], the subsequent section in this report enumerates the essential attributes of innovation and outlines how they were effectively conveyed to decision-makers and technology adopters through the field showcase, with specific reference to the different layers and technologies of the technology stack. Consequently, the FTS served as a dynamic platform

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

2 In the context of the subsequent tables, "High," "Moderate," and "Low" are qualitative assessments of each innovation in relation to Everett Rogers' five factors for innovation adoption. Here's what each term generally signifies:

High: This indicates that the innovation strongly exhibits the given characteristic. For example, a "High" rating in "Relative Advantage" means the innovation offers significant improvements over existing solutions. A "High" in "Complexity," however, would mean the innovation is quite complex to understand or implement.

Moderate: This suggests that the innovation exhibits the characteristic to a noticeable but not overwhelming degree. It's more of a middle ground. For instance, a "Moderate" rating in "Trialability" implies that the innovation can be tested before full adoption, but there might be some limitations or challenges in doing so.

Low: This indicates that the innovation exhibits the characteristic to a lesser extent. In terms of "Complexity," a "Low" rating would mean the innovation is relatively easy to understand and use. Conversely, a "Low" in "Relative Advantage" would suggest that the innovation does not offer substantial improvements over existing methods.

These assessments help in understanding how likely an innovation is to be adopted, based on Rogers' theory. An innovation that scores "High" in Relative Advantage, Compatibility, Trialability, and Observability but "Low" in Complexity, for example, would theoretically be adopted more quickly and widely.

Table 7

Incremental and Frugal Innovations

Innovation	Relative Advantage	Compatibility	Complexity	Trialability	Observability
• Facial Recognition for Cows	• High: Provides tamper proof recognition system for cows using their muzzles as the unique identifier	• High: Integrates smoothly with existing dairy farming systems and can be accessed via mobile phones	• Moderate: The software requires initial training but becomes intuitive with use.	• High: Can be tested on a small scale before full implementation.	• High: Instant recognition of cows and their historical data which can enable better decision making
• Machine Vision Enabled Camera for Beekeeping	• High: Significantly enhances beekeeping efficiency and decision-making as compared to visual inspection.	• Moderate: Complements existing beekeeping practices but requires initial hardware setup	• Moderate: Some learning curve due to data-driven approach but manageable	• High: Can be trialled on a small scale to demonstrate effectiveness in a cost-effective manner	• High: The technology was able to capture the movement of bees and other data metrics that can enable data driven decisions to improves bee health and the yield
• Blockchain in Dairy Management	• High: Offers unparalleled transparency and traceability in record-keeping.	• Low: Aligns with the need for secure supply chains but requires data transfer from existing collection centres' data repository	• High: Involves a steep learning curve due to technical nature.	• Moderate: Pilot projects can demonstrate benefits before wider adoption.	• Moderate: Provenance tracking is observable and can improve transparency and traceability of the supply chain

Innovation	Relative Advantage	Compatibility	Complexity	Trialability	Observability
• Blockchain for Apiary Management	• High: Provides superior data analysis for hive management.	• Low: Offers valuable insights but may require changes in traditional practices.	• High: Complex due to lack of data capturing mechanisms in the existing eco-system. The results will get better over time.	• Moderate: Effectiveness can be observed in controlled trials.	• Low: Data collection is almost instantaneous but the requisite quantum of data to derive insights will be collected over a longer period of time.
• Silk Reeling Machine	• Moderate: Reduces time for reeling wild silk as compared to traditional manual practices as well as makes the process more sustainable	• High: Easily integrates into existing sericulture processes post basic training.	• Low: User-friendly and easy to operate.	• High: Can be tested in small-scale operations.	• High: Increases in productivity are immediately noticeable.
• Fodder Growing Station	• Moderate: Improves fodder production efficiency.	• Low: Meets the needs of dairy farmers for sustainable feed solutions but initial setup is cost intensive.	• Low: Simple to use and adopt.	• Moderate: Benefits can be observed in small-scale trials.	• Low: Visible increase in milk yield and quality of fodder over time.

Innovation	Relative Advantage	Compatibility	Complexity	Trialability	Observability
• Active Packaging Sachet	• High: Significantly extends shelf life and reduces spoilage and cost-effective storage alternative.	• High: Fits well into existing supply chains and meets preservation needs.	• Low: Straightforward and easy to use.	• High: Can be demonstrated effectively in small-scale applications.	• High: Extended shelf life and reduced spoilage are easily observable within 2 weeks.
• Advanced Waste Heat Utilization System	• Moderate: Offers a sustainable solution for energy generation and cooling.	• Moderate: Suitable for specific rural areas, may require infrastructural changes.	• Moderate: Technically complex and may require training for functional knowledge.	• Moderate: Effectiveness can be observed in pilot projects.	• High: Reductions in energy consumption and improved cooling are visible.
• Pelletiser and Briquetting Machine	• High: Provides a sustainable fuel alternative with high energy value.	• High: Aligns with sustainable practices in forested regions along with reducing the risk of forest fires.	• Moderate: User-friendly but requires some initial training.	• Moderate: Benefits can be seen in small-scale applications but at a slightly higher logistical cost.	• Low: Fuel efficiency is noticeable over a period of time.

Innovation	Relative Advantage	Compatibility	Complexity	Trialability	Observability
• Mini Recirculatory Aquaculture System (RAS)	• Moderate: Allows efficient fish farming in limited spaces.	• High: Ideal for urban and semi-urban areas but needs to be customised according to the size of the fishery setup.	• Low: Designed for ease of use and accessibility.	• High: Can be trialled on a small scale to assess benefits.	• Moderate: Advantages in terms of system durability and cost-effectiveness are evident.
• Multi-parameter Water Testing Kit	• Moderate: Offers comprehensive and accurate water quality analysis within one kit as compared to the traditional method of doing these tests separately.	• High: Meets the specific needs of water quality monitoring in aquaculture.	• Low: User-friendly and easy to understand.	• High: Can be easily tested and observed in small-scale settings.	• High: The accuracy and speed of testing are immediately observable.

Conclusions & Way forward

PART D

Embracing Technological Innovation

In this era of rapid change, technological innovation emerges as a linchpin in our strategy. The judicious integration of cutting-edge technologies like AI, blockchain, and nanotechnology, meticulously tailored to align with the distinctive environmental and socio-economic fabric of the Himalayan communities, has the potential to be game-changing. These technologies are envisaged not just as mere tools but as catalysts that can fundamentally redefine sectors like agriculture, forestry, livestock management, and allied sectors. They promise resilience, efficiency, and a sustainable future. The key, however, lies in their accessibility and contextual relevance, ensuring that these technological marvels resonate with the communities and become integral to their daily lives

and livelihoods. For example, the integration of Facial Recognition for Cows within the technological strategy stands as a pivotal example of the commitment to community-centric innovation. This technology, tailored for the unique needs of livestock management in the Himalayan communities, embodies the essence of contextual relevance and accessibility. By leveraging AI-powered identification systems, meticulously designed to track cow health, breeding, and ownership, this innovation ensures a seamless alignment with the socio-economic fabric of these regions. Its promise extends beyond mere identification; it catalyses a paradigm shift in dairy management, offering resilience, efficiency, and sustainable practices. The technology's success hinges on its seamless integration into the daily lives and livelihoods of the community, becoming an indispensable tool for their agricultural pursuits.

Fostering Collaborative Ecosystems

The path to resilience and sustainability is not one to be walked in isolation. It demands an organized effort that converges the capabilities of government bodies, private sectors, local communities, and international organizations. By pooling resources, sharing knowledge, and aligning goals, we can construct a resilient framework for climate adaptation and mitigation that is robust and inclusive. As we know climate change affects every state in the Indian Himalayan Region (IHR), each facing unique challenges due to their distinct geography, like extensive forests and high altitudes. While these states encounter similar threats, they hold valuable traditional conservation knowledge. Key research institutions in these areas, including GB Pant National Institute of Himalayan Environment, CSIR-IIP, IIT-Roorkee in Uttarakhand, IIT-Mandi in Himachal Pradesh, and IIT-Jammu in Jammu & Kashmir, are crucial in developing tailored technological solutions for the IHR's unique challenges. A unified network of these institutes is essential for sharing knowledge and developing collaborative technologies. An inter-state network, possibly using existing platforms like the Himalayan Knowledge Network (HKN), implemented at G.B. Pant National Institute of Himalayan Environment (NIHE) can facilitate this collaboration, bringing together government representatives, researchers, and stakeholders. This network would aid in strategizing technology adoption, monitoring, evaluation, and stakeholder collaboration. Continuous data collection and reviews within this network would support effective technology integration and informed policy recommendations for sustainable development in the IHR.

Tailoring Solutions To Local Needs

The Indian Himalayan Region, with its diverse topographies, climates, and cultures, presents a unique set of challenges and opportunities. Addressing these requires solutions that are not only effective but also culturally sensitive and locally relevant. The learnings and triumphs from one part of the region need to be intelligently adapted and replicated in others, fostering a widespread and positive impact across this vast and varied landscape. For instance, the conventional Recirculatory Aquaculture System (RAS) stands as a significant infrastructure, designed for intensive fish culture and demanding substantial land and water resources. To cater to the requirements of small landholding farmers and aqua-culturists, there's an essential need to downsize this elaborate system into a more manageable and cost-effective version—the Mini RAS. This adaptation ensures compatibility with limited spaces and resources while providing an efficient and controlled

environment for fish farming. The transition to Mini RAS allows for broader accessibility and utilization in contexts where traditional RAS might not be feasible or practical, catering precisely to the needs of smaller-scale practitioners in aquaculture.

Building Capacity And Empowering Communities

Central to our transformative agenda is the empowerment of local communities. This transformation entails a shift from viewing communities as mere recipients of technology to recognizing them as active agents in their developmental narrative. This requires equipping them with the necessary tools and technologies and, crucially, providing education, training, and ongoing support. Such capacity-building efforts are vital to ensuring that these communities can effectively leverage and benefit from technological advancements. The community collectives like Self Help Groups and Van Panchayats could be leveraged to facilitate deployment of innovations and technologies at scale. Collective action groups would be instrumental to deploy cost intensive technologies having high impact for example UAVs for pesticide spraying could be deployed by farmer groups collectively to spray the pesticides on farms of multiple farmers having small landholding. District administration could support the Women Self Help Groups to procure cost intensive technologies on subsidised rate which the SHGs could further rent out thus creating income generation activities.

Looking Towards A Sustainable Future

In navigating the complexities of climate change and technological advancements, our vision for the IHR must be firmly anchored in sustainability. This involves striking a delicate balance between economic growth and ecological conservation. The livelihood strategies and developmental initiatives we embark on today must be sustainable, ensuring the well-being of not just the present but also future generations. Our approach must seamlessly integrate environmental stewardship with economic and social development, creating a harmonious synergy that benefits both the planet and its inhabitants.

The Pelletiser machine for pine needles serves as a tangible embodiment of our commitment to sustainability within the IHR. By ingeniously addressing the challenge of pine needle waste, this technology perfectly aligns with our vision of fostering economic growth in harmony with ecological conservation. Its transformative capability turns forest waste into high-calorific briquettes, presenting a sustainable alternative to conventional fuels like wood. This not only addresses environmental concerns related to forest debris but also creates economic opportunities for the community. The conversion of waste into valuable fuel sources underscores a balanced integration of environmental stewardship and economic development, laying the foundation for a sustainable future in the Himalayan region.

Recognizing the intrinsic challenge of the low market value of pine needles and its

discouragement for community engagement, our consultations have explored innovative incentive mechanisms. Drawing parallels from successful case studies where government interventions spurred positive change, a similar approach could be a strategic avenue to address the intricate issues surrounding pine needles, encouraging their collection and fostering community involvement.

The Technology Advisory Note indicates that collaboration among various groups, such as policymakers, local communities, technologists, environmentalists, and other key players, might be beneficial in addressing the challenges facing the IHR. It suggests that these collaborative efforts could potentially contribute significantly. While acknowledging the complexities of the journey, the document also recognizes the existence of meaningful opportunities. It hints that unity, creativity, and a sustainable focus might be key elements in this approach. The overarching aim is to cultivate a strategy that may foster resilience against climate change, aspiring to ensure the prosperity and well-being of the IHR communities and to preserve the region's natural beauty and resources for future generations.

Annexures

Annexure 1

Pain Point Mapping

Livelihood (Process)

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
1	Horticluture	1. Instances of nocturnal wild animal attacks resulting in extensive damage to agricultural crops. 2. Delayed Detection of Pest Infestations impacting timely intervention	1. Farmers in the Champawat region are confronted with a significant challenge pertaining to nocturnal wildlife intrusions, specifically attacks by monkeys. This issue poses a detrimental impact on the cultivation of lychee and malta crops, resulting in avoidable destruction. 2. Farmers diligently cultivate their crops, implementing various pest control measures. However, due to the vast expanse of their fields and the limitations of manual monitoring, pest infestations often go undetected. This delay occurs because farmers rely on periodic visual inspections or physical scouting, which may not be sufficient to identify pests at an early stage. This prolonged exposure to pests and delayed identification leads to reduced yields and financial losses for the farmers.	Improving cultivation of lychee and malta by reducing nocturnal wildlife intrusions and pest infestation	Systems 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. 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. 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.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
2	Dairy	1. Low success rate in cattle insemination	The current success rate of cattle insemination is low, resulting in reduced breeding efficiency and lower productivity in cattle farming. Low success rates lead to prolonged calving intervals, increased costs, and limited genetic improvement in cattle herds.	Impoving yield and early disease detection in cattle	Systems 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. 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. 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.
		2. Difficult to procure vaccine for cattle	Farmers face challenges in procuring vaccines for their cattle, which can lead to delays in disease prevention and increased vulnerability to various diseases. Lack of access to vaccines increases the risk of disease outbreaks, loss of productivity, and higher treatment costs for cattle farmers.		A cattle insemination prediction system which can analyze historical data on cattle insemination outcomes. Should include factors such as breed, age, health, and environmental conditions to predict successful insemination probabilities. Should be able to provide farmers with personalized recommendations for optimal insemination timing and techniques to increase breeding success rates.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
2	Dairy	3. Early and timely detection of disease in cattle (foot and mouth disease, Blackwater (HS) disease)	Early and timely detection of disease in cattle is critical to preventing the spread of disease and protecting the health of the herd. Two of the most common diseases that affect cattle are foot-and-mouth disease (FMD) and blackwater (HS) disease. FMD is a highly contagious viral disease that can cause lameness, fever, and blisters in the mouth and on the feet of affected animals. HS disease is a bacterial disease that can cause severe diarrhea, dehydration, and death in affected animals.	Aggregating small holder diary producers	A digital vaccine procurement and distribution platform to create a centralized system where farmers can place vaccine orders online. A real-time inventory tracking and automated alerts to ensure timely restocking.
		4. Low supply of milk due to small holder diary producers in the region	The region faces a low supply of milk due to the presence of numerous smallholder dairy producers, resulting in limited production capacity and inadequate milk availability. Insufficient milk supply affects the dairy industry's ability to meet consumer demand, limits market opportunities, and may lead to increased milk prices.		A disease monitoring system for cattle that integrates wearable sensors to monitor health parameters such as body temperature, heart rate, and activity levels. Should be able to utilize data analytics and anomaly detection algorithms to identify early signs of diseases like foot-and-mouth and blackwater diseases. Farmers need to receive alerts when abnormal health patterns are detected, enabling early intervention and preventing disease spread. A user-friendly platform for smallholder dairy producers to record milk production, quality, and quantity. Integration of GPS for location tracking and timestamps for accurate data collection.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
2	Fisheries	3. Early and timely detection of disease in cattle (foot and mouth disease, Blackwater (HS) disease)	Rising temperatures in the region due to climate change has led to discontinuation of cultivation of local variety of fishes such as rohu, katla, mrigal carp/naini. The farmers have shifted to cultivating other variety of fishes such as trout, silver carp, common carp and grass carp.		A platform-based advisory system for farmers to provide guidance on fish diversification that aligns with changing weather patterns to recommend suitable fish species based on temperature trends and adaptability.
		2. Contamination of water supplies during monsoon season	Since fishes cannot be cultivated in chlorinated water, there is a continuous requirement of fresh and flowing water, especially for trout which are susceptible to polluted water. Existing mechanism • Currently, every 10 days, 30% water is drained and re-filled with freshwater. This requires higher manual intervention. • Re- circulating aquatic system (RAS) provided under Pradhan Mantri Matsya Sampada Yojana (PMMSY). The issue with RAS is that it requires continuous electricity supply to operate.		A water quality monitoring and management system to preserve water quality during the monsoon season for fish farming. Should be able to continuously monitor water quality parameters such as pH, dissolved oxygen, and contamination levels. A real-time alert mechanism that notifies farmers of any drastic deviations from optimal conditions. Enhance the efficiency of the existing Recirculating Aquatic System (RAS) under Pradhan Mantri Matsya Sampada Yojana (PMMSY) to reduce dependence on continuous electricity supply.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
2	Apiary	1. Early and timely disease detection and control	Timely and early detection of disease in beekeeping is critical because it can help save hives and prevent the spread of diseases. Currently, farmers have to manually check each box every few days to visually detect signs of any disease. This is a time-consuming and labor-intensive process, and it can be difficult to detect diseases early on.	Improving yield and quality of honey production	1. Early Disease Detection and Control: A smart disease detection system for beekeeping to enable early and timely detection of diseases. Should be able to create an image recognition system that uses various algorithms to analyze images of bee colonies. Should have the ability to identify visual cues indicating disease symptoms, such as changes in bee behavior or appearance. Beekeepers should receive real-time alerts when disease-related symptoms are detected, facilitating swift intervention, and preventing disease spread.
		2. Contamination of water supplies during monsoon season	Since fishes cannot be cultivated in chlorinated water, there is a continuous requirement of fresh and flowing water, especially for trout which are susceptible to polluted water. Existing mechanism • Currently, every 10 days, 30% water is drained and re-filled with freshwater. This requires higher manual intervention. • Re- circulating aquatic system (RAS) provided under Pradhan Mantri Matsya Sampada Yojana (PMMSY). The issue with RAS is that it requires continuous electricity supply to operate.	Preservation of water quality during the monsoon season for fish farming	Beekeeping Training Platform: An online platform for comprehensive beekeeping training and resources. An interactive web-based platform that offers instructional videos, guides, and virtual simulations for beekeeping practices. Should have modules on hive management, hive building, bee care, disease prevention, and honey harvesting.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
2	Apiary	3. Insurance for bees and bee colonies	Timely and early detection of disease in beekeeping is critical because it can help save hives and prevent the spread of diseases. Currently, farmers have to manually check each box every few days to visually detect signs of any disease. This is a time-consuming and labor-intensive process, and it can be difficult to detect diseases early on.	Improving yield and quality of honey production	Precision Hive Monitoring: Need for a remote hive monitoring system to ensure optimal hive conditions; honey production and receive real-time alerts. Hive Location Optimization: Provide a location recommendation tool to help beekeepers choose optimal hive placement. A platform that considers factors such as flower availability, climate, and surrounding vegetation. Should utilize GIS data and environmental models to suggest suitable hive locations that maximize forage resources. Hive and bee insurance: Online bee and hive insurance platforms. Utilization of historical data and risk assessment models to determine premium rates based on factors like location, bee health, and climate. Should provide coverage for bee colony losses, damages, theft, or loss of beehives and equipment.

Livelihood (Product)

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
1	Horticulture	Packaging and Storage	Proper packaging and storage of lychee and malta juice for a longer period is an essential need for farmers. Currently, farmers in the region face losses due to the lack of reliable storage mechanisms. Mechanism suggested by farmers during field visit: • Centralized cold storage unit for large landholding farmers: This would allow farmers to store large quantities of juice in a single location, which would reduce the risk of spoilage. • Small cold storage unit for small landholding farmers: This would allow farmers to store smaller quantities of juice in a more affordable way.	Efficient value capture mechanisms in the supply chain of high-value horticulture/ diary/fishery/ apiary produce with a limited shelf life Reducing adulteration in horticulture/ diary/fishery/ apiary produce	. Centralized Cold Storage for Large Landholding Farmers: Need for a centralized cold storage unit to cater to the storage needs of large landholding farmers producing lychee and malta juice. A large-scale cold storage facility equipped with temperature and humidity control systems. Implementation of software to track the quantity and condition of stored juice. 2. Small Cold Storage for Small Landholding Farmers: A small-scale cold storage unit tailored for small landholding farmers producing lychee and malta juice. Creation of modular, cost-effective cold storage units with adjustable storage capacities. Integration of user-friendly controls and monitoring systems to ensure optimal storage conditions. 3. Traceability and Quality Assurance: Traceability solutions to ensure transparency and reduce adulteration risks in horticulture produce. 4. Monitoring and Alert System: A real-time monitoring and alert system to ensure optimal storage conditions and prevent spoilage. Should have the capability to monitor temperature, humidity, and other relevant parameters in storage units. A mobile app for farmers to receive real-time alerts and insights about storage conditions. Farmers can take timely actions to adjust storage conditions, preventing spoilage and preserving the quality of the juice

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
2	Agro-forestry	Lack of value capture mechanisms in the supply chain of high forestry/agro-forestry products hindering rural income generating opportunities	Lack of value capture mechanisms in the supply chain of high forestry/ agro-forestry products hindering rural income generating opportunities	Efficient value capture mechanisms in the supply chain of high-value agro-forestry produce such as pine needles	1. Value capture mechanisms in the supply chain of high forestry/agro-forestry products to enhance rural income-generating opportunities 2. Platforms that connect local producers with buyers and provide transparency in pricing. 3. Increase profitability for communities engaged in agroforestry by creating reliable markets for their products. 4. Stimulate economic growth in the region while encouraging sustainable resource management.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
3	Dairy	1. High adulteration of milk that is sold in the market.	The milk sold in the market is frequently adulterated, compromising its quality and safety. Adulteration may involve adding water, synthetic milk, or other substances to increase volume or extend shelf life. Adulterated milk poses health risks to consumers and reduces its nutritional value.		. Milk Quality Assurance: A milk quality testing and verification system to combat adulteration in the market. A portable milk testing device that can quickly analyze milk samples for quality parameters such as fat content, protein levels, and contaminants. Consumers should be able to verify the quality and authenticity of purchased milk, deterring adulteration, and ensuring safer consumption.
		2. Lack of milk processing units in the region	Limited availability of milk processing units hinders the conversion of raw milk into value-added dairy products such as butter, cheese, yogurt, and powdered milk. Without processing units, dairy farmers are unable to diversify their product range, leading to limited market opportunities and lower profitability.		2. Milk Processing Units Establishment: Facilitation of the establishment of milk processing units to diversify dairy products and increase market opportunities. Financial support and technical guidance to establish small-scale milk processing units. Equipment of these units with essential processing equipment such as pasteurizers, separators, and packaging machinery.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
3	Dairy	3. Lack of storage facility for milk and milk products	Inadequate storage facilities for milk and milk products result in spoilage, wastage, and limited shelf life, particularly in Champawat region with insufficient refrigeration or cold chain infrastructure.		3. Cold Storage and Preservation Facilities: Cold storage facilities for milk and dairy products to extend shelf life and reduce wastage. Cold storage units should be equipped with temperature and humidity control systems. Efficient inventory management software for tracking product quantities and expiry dates.
		4. Market linkages	Lack of effective market linkages prevents dairy farmers from accessing wider markets, limiting their potential for growth and profitability. Farmers face challenges in selling their produce at fair prices, while buyers struggle to find reliable sources for quality dairy products.		4. Market Linkages Enhancement: Creation of an online platform to connect dairy farmers and processors with a wider market. A user-friendly online marketplace where dairy products can be listed and accessed by potential buyers, including retailers, restaurants, and consumers. Features such as order management and secure payment options.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
4	Fisheries	1. Market linkage	Tourist footfall in the Champawat region is low, which leads to a lack of local demand for fish. Although local demand is high during the festive season, farmers are not able to get the right market or price for their fish.		1. Market Linkage Enhancement: An online marketplace and distribution platform to facilitate efficient market linkage for fishery produce. A user-friendly e-commerce platform that connects fish farmers with potential buyers, including local markets, restaurants, and processing units. Needs features such as order tracking, real-time inventory management, and secure payment options.
		2. Lack of infrastructure for preservation of fishes for longer period	Since the demand in the region is low due to low tourist footfall, there is a high need to preserve fish for a longer period. The department currently provides ice boxes (at a 50% subsidy). Additionally, the breeding and selling cycle lasts for 6-9 months, making storage of fish even more essential to ensure maximum profits for farmers.		2. Fish Preservation Infrastructure: A fish preservation infrastructure to extend the shelf life of fishery produce and reduce wastage. Establish community-based fish storage facilities equipped with cold storage, ice, and proper hygiene measures. Need to integrate temperature and humidity monitoring systems to ensure optimal storage conditions. 3. Traceability and Quality Assurance: A traceability system to ensure product authenticity and reduce adulteration in fishery produce. Need for a blockchain-based system to track the journey of fishery produce from farm to consumer. Consumers gain confidence in the quality and authenticity of the purchased fish, while farmers deter potential adulteration through enhanced transparency. 4. Market Intelligence and Demand Forecasting: A platform to assist fish farmers in understanding demand trends and making informed production decisions. Data analytics tools that analyze historical consumption patterns, tourism forecasts, and local demand. Predictive models to guide fish farmers in aligning production cycles with market needs.

S.No.	Livelihood sub-category	Pain Point	Operational Scenarios	Use Cases	Functional Requirements
5	Apiary	Use of cheap packaging alternatives hampering the quality appeal of honey sold	Honey is sold in alcohol bottles because they are cheap, but this is hampering the marketing and quality appeal of the product.		. Premium Packaging Solutions: Premium packaging solutions to enhance the quality appeal and marketing of honey products. Aesthetically pleasing and eco-friendly packaging options specifically tailored for honey. Incorporation of materials that preserve honey quality and prevent contamination, such as glass or food-grade plastic. 2. Tamper-Proof Packaging: Need for tamper-proof packaging measures to ensure the integrity and authenticity of honey products. Need for seals, labels, or packaging designs that clearly indicate if the container has been tampered with. 3. Collaborative Marketing Platform: An online platform to facilitate collaborative marketing efforts for honey producers Should have features for joint promotional campaigns, sharing resources, and reaching wider audiences. 4. Quality Assurance Certification: A quality assurance certification program for honey products. A certification process that verifies the quality, purity, and authenticity of honey products. Third-party testing and auditing to ensure compliance with industry standards.

Annexure 2

Follow Through Operationalisation and Scale Up

As we conclude this comprehensive exploration of the strategies for technological procurement and implementation in IHR, we stand at the threshold of a new era. This era is defined not just by the challenges we face but more importantly, by the innovative solutions we embrace to overcome them. The journey mapped out for both the district and state administrations part of IHR is ambitious yet achievable, setting the stage for a transformative impact that extends beyond mere technological advancement to foster sustainable development and improved quality of life.

District Administration

Innovation Fund Creation and Management

1. Resource Allocation Model:

a) Diverse Funding Sources: Explore various funding sources, including government grants, private sector contributions, and international aid, to diversify and strengthen the fund's financial base.

b) Sustainability Measures: Implement strategies to ensure the long-term sustainability of the fund, such as establishing endowments or partnerships with financial institutions.

c) Funding Mechanism: District administration should create a District Innovation Fund under the annual district development plan to enable pilot procurement of the innovative technologies. The creation of this fund will ensure continuity of the innovation ecosystem.

2. Project Lifecycle Management:

a) Technology Centred Proposals: Draft technology-centered procurement proposals by clearly articulating the technological specifications and advantages as it not only demonstrates a forward-thinking approach but also ensures that the selected technology aligns seamlessly with project requirements. This strategy contributes to the overall efficiency, effectiveness, and sustainability of the proposed project. Moreover, explicitly stating the technological components and their benefits provides transparency to stakeholders, fostering trust and understanding.

b) Proposal Submission and Review: Create a transparent and efficient system for submitting and

reviewing proposals, ensuring that the process is accessible to all potential contributors, including local entrepreneurs and grassroots organizations.

c) Pilot and Scale: Develop a phased approach for project implementation, starting with small-scale pilots and based on success and learning, scaling them to a broader level.

Integration With District Development Plan

1. Strategic Alignment:

a) Integration: Seamlessly integrate technology projects with the district's broader development initiatives in key areas for improving rural livelihood opportunities.

b) Long-term Vision: Align these initiatives with the district's long-term goals, ensuring that technological advancements contribute to sustainable development.

2. Inclusive Development Focus:

a) Accessibility and Inclusivity: Ensure that technological solutions are accessible to and inclusive of all segments of society, including marginalized and remote communities.

b) Cultural Sensitivity: Respect and incorporate local cultural norms and practices in the development and deployment of technological solutions.

State Administration

State Innovation Fund Establishment:

1. Vision for Technological Advancement:

a) Technology as a Development Enabler: Position technology not just as a tool but as a core component of the state's development strategy, aiming to boost economic growth, environmental sustainability, and social welfare. For example: Creating the State Innovation Fund aligned to the broader objectives of the Uttarakhand@25 mission.

b) Focus on Green Technologies: Prioritize technologies that promote environmental sustainability, addressing issues like climate change.

State-Wide Deployment And Scaling:

1. Cross-District Learning and Adaptation:

a) Inter-District Collaboration: Facilitate collaboration and knowledge exchange among districts to share experiences, challenges, and successes in implementing technological solutions.

b) Customization for Local Contexts: Customize and adapt technology solutions to fit the specific needs and contexts of different districts, considering their unique geographical, cultural, and socio-economic characteristics.

Leveraging Partnerships

1. Global Partnerships for Local Benefit:

a) International Collaboration: Forge partnerships with international organizations and governments to bring global5 best practices, expertise, and technologies to IHR.

b) Global Funding Opportunities: Tap into global funding sources, such as international development funds and climate change mitigation funds, to support technology initiatives.

Capacity Building And Knowledge Transfer

1. Comprehensive Training Ecosystem:

a) Skill Development Centers: Establish dedicated skill development centers focused on emerging technologies and their applications in various sectors.

b) Continuous Learning and Development: Promote a culture of continuous learning and professional development among government officials and community leaders to keep pace with technological advancements.

2. Knowledge Dissemination and Public Engagement:

a) Public Awareness Campaigns: Conduct extensive public awareness campaigns to educate the populace about the benefits and opportunities presented by new technologies.

b) Community Innovation Hubs: Set up community innovation hubs or centers where locals can learn about, interact with, and contribute to technological advancements.

These expanded strategies offer a comprehensive roadmap for the IHR such as Uttarakhand district and state administrations to not only procure and implement technology but also ensure that it becomes a catalyst for sustainable development, economic growth, and improved quality of life across the region.

Way Forward

Integrating advanced technologies in the Indian Himalayan Region (IHR) is expected to drive significant economic transformations. Adoption of AI, precision agriculture, blockchain, and renewable energy is set to enhance operational efficiency and reduce costs in various sectors. AI can streamline agricultural processes, saving labor and resources. Transitioning to renewable energy sources like solar and wind is likely to cut energy expenses, benefiting rural areas. Technological advancements in agriculture, livestock management, and digital platforms can boost productivity, income, and market access for local producers. Moreover, these innovations will create job opportunities and promote entrepreneurship. Environmentally sustainable technologies will contribute to a balanced and resilient economic model, safeguarding against climate-related impacts. While specific numerical projections are challenging, the overall direction points towards improved efficiency, productivity, sustainability, and resilience. Achieving these benefits requires careful planning and adaptation to evolving needs.

Scalability And Replication Model

1. Criteria for Selection:

a) Effectiveness in Pilot Projects: Technologies that have shown tangible benefits in initial deployments, like AI in dairy management for health monitoring or digital platforms for market access, should be scaled up. Metrics for effectiveness would include yield improvement, cost reduction, and user satisfaction.

b) Adaptability to Local Contexts: Selected technologies must be adaptable to diverse environmental and cultural settings of the Himalayan region. This includes customizing user interfaces for local languages and ensuring suitability for varying agricultural practices and climatic conditions.

c) Cost-Effectiveness: Prioritize technologies that provide maximum impact with minimal investment, essential for widespread adoption in economically diverse regions.

2. Processes for Adaptation:

a) Customization for Local Needs: Modify technologies to align with local practices and environments. For example, adjusting digital platforms to local agricultural cycles and providing local language support.

b) Community-Centric Design: Involve local communities, farmers, and stakeholders in the design process to ensure that the technologies meet their specific needs and preferences.

3. Overcoming Potential Challenges:

a) Infrastructure Development: Address gaps in infrastructure, such as reliable internet access and electricity, which are prerequisites for technology deployment.

b) Training and Capacity Building: Implement comprehensive training programs targeting various community segments to ensure effective use and maintenance of the technologies.

c)Policy Framework and Government Support: Collaborate with local authorities to establish supportive policies, subsidies, and incentives to encourage technology adoption and scaling.

Future Roadmap

1. Short-term Goals (1-2 Years):

a) Expand Successful Pilot Projects: Scale technologies that have shown success in pilot phases, adapting based on feedback and results. This could include expanding blockchain use in product traceability across more districts.

b) Initiate Community Training Programs: Launch targeted training and capacity-building initiatives focusing on new technologies, aiming to reach a broad segment of the population, including farmers, local entrepreneurs, and youth.

2. Mid-term Goals (3-5 Years):

a) Sector-Wide Integration: Aim for the integration of technologies across various sectors. For example, using AI for predictive analytics in agriculture and resource management across multiple districts.

b) Enhanced Market Connectivity: Leverage digital platforms to improve market access for rural producers, potentially linking them to national and international markets.

3. Long-term Vision (5+ Years):

a) Establishment of Sustainable and Resilient Livelihoods: Strive for the complete integration of these technologies to create sustainable and resilient livelihoods, making them integral to the region's economic fabric.

b) Continuous Innovation and Adaptation: Foster an environment of ongoing research and development, ensuring that the region remains adaptive to new technological advancements and climate challenges.

Monitoring And Evaluation

a) Regular Assessment for Impact and Improvement: Develop and implement a robust monitoring and evaluation framework to continually assess the impact of these technologies and refine strategies based on data and feedback.

By following this detailed and comprehensive roadmap, the IHR can harness the transformative potential of modern technologies to create a more resilient, sustainable, and prosperous future for its communities, aligning with the unique challenges and opportunities of this diverse and dynamic region.

Annexure 3

Innovators Shortlisted by Pioneer Agency, UCOST for Field Technology Showcase

UTTARAKHAND STATE COUNCIL FOR SCIENCE & TECHNOLOGY

Department of Science & Technology
(Govt. of Uttarakhand)

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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)

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