TRAINING MANUAL ON

“CLIMATE SMART AGRICULTURE PRACTICES UNDER REAP PROJECTS”

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Introduction:

The purpose of this training manual is to familiarise extension officers, lead farmers, and service providers in the field of agriculture and horticulture with the content of the Climate Smart Agriculture manual. The aim is to empower them to train farmers and other stakeholders in appropriate technologies, innovations, and management practices that can help them mitigate risks posed by climate change.

The difficulties of satisfying rising food demand, particularly in developing nations, are exacerbated by factors such as population increase, increasing urbanisation, and shifting dietary habits. Climate change has an even greater impact on agricultural systems, such as crops, cattle, forests, and fisheries.

Climate change will have varying consequences depending on area, country, and location, and will disproportionately affect people based on their vulnerability and ability to adapt. Some locations may become drier and more susceptible to drought, while others may receive heavier rainfall or altered precipitation patterns. Rising temperatures will also shorten growing seasons and reduce crop output in some locations. These shifting conditions necessitate agriculture-specific methods and solutions.

Furthermore, climate change is expected to increase the frequency and severity of extreme weather events such as floods, droughts, and heatwaves, endangering food production and the livelihoods of food producers, particularly those with limited adaptability who are often located in the most vulnerable areas.

Promoting climate-smart agriculture practices demands bringing together concepts, information, and practices from various disciplines and stakeholders. This training material is intended for extension officers who are cutting-edge agricultural system reforms. It combines climate research, agricultural science, social and economic analyses, and local practices to complete a range of knowledge and solutions for achieving climate-smart outcomes. The purpose is to increase extension agents' awareness and understanding of climate change, as well as the applicability of the climate-smart approach, and to assist them in creating climate-smart agriculture training programmes in their respective nations and communities.

Purpose/Objective of the Manual:

This manual is targeted towards block-level extension officers in the agricultural and horticultural sectors and other stakeholders interested in developing training courses on climate-smart agriculture (CSA). It aims to provide answers to the following questions:

- What is climate change, and what are its causes?
- How will climate change impact agriculture?
- What can be done to support male and female agricultural producers to adapt to new conditions?
- What are practical solutions that agricultural producers and others can implement?
- What changes will other stakeholders need to make to promote climate-smart agriculture?
- How can trainers' structure participatory capacity development processes?
- How can climate change be effectively communicated to food producers?

It is important to note that agricultural production varies significantly depending on location, and climate change affects each area and farm differently. Climate-smart agricultural approaches are context-specific, and there is no one-size-fits-all solution. However, general principles and adaptable examples can be provided to suit specific circumstances.

Training Modules and Sessions:

The training courses are divided into five modules. It will be a five-day training, including a field excursion.

MODULE 1: Basics of Climate Change and Its Impacts
This module introduces the fundamental principles of climate change, its effects on natural resources and agriculture, adaption techniques, and mitigation efforts.
MODULE 2: Understanding Climate-Smart Agriculture (CSA) and its Processes
What is CSA and its Practices
MODULE 3: Uttarakhand-Related CSA Technologies, Practises, and Solutions
This training session covers several CSA technologies and practises recognised for diverse agroecosystems in the mountain, hill, and Terai eco-regions. The CSA practises, and technology will also be briefed.
MODULE 4: Integrated Gender Equality and Social Inclusion Issues in CSA Planning, Implementation, and Monitoring
This training module addresses the gender equity and social inclusion perspectives that must be included in the planning, implementation, and monitoring of CSA.
MODULE 5: Learning from the Field, Action Plan Preparation, and Closing
In this last module, participants will visit CSA demonstration sites to watch field activities and connect with farmers to leverage their learning and experiences. After the field trip, the participants will construct an action plan and present their findings and outputs.

Training Outline

Various sections have been scheduled under different modules for each day.

Time	**Day 1, 1st Half** Module 1	**Day 2, 2nd Half** Module 2	**Day 2, 1st Half** Module 3	**Day 2, 2nd Half** Module 4	**Day 3** Module 5
1st Half Time 8.00 -8.30 2nd Half Time 11.00 – 12.00	**Session 1.** Introduction of Participants and Establishment of Training Goals	**Session 1.** Introduction to climate-smart agriculture (CSA)	**Session 1.** Climate-Smart Agriculture (CSA) Technologies and Practises for Uttarakhand's Different Agro-Ecological Zones (Mountains, Hills, and Terai Region)	**Session 1.** Importance of gender and Social inclusion and its interconnection in Uttarakhand agriculture system	**Session 1.** Field visit to CSA demonstration sites
1st Half Time 08:30-09:00 2nd Half Time 12.00-01.00	**Session 2.** An introduction to climate change and important terms	**Session 2.** CSA classification based on smartness criteria	**Session 2.** Crop-Based CSA Technologies and Practises Appropriate for Uttarakhand's Mountains, Hills, and Terai Region	**Session 2.** Assessing CSA tools, technologies and practices	Continue from the previous session.
1st Half Time 09:00-10:00 2nd Half Time 02.00 – 03.00	**Session 3.** Climate threats and their consequences for Agriculture and food security	**Session 3.** Role of CSA for resilience agriculture	Continue from the previous session	**Session 3.** Gender-sensitive CSA planning, implementation, and monitoring	Continue from the previous session
Ist Half Time 10:00-10.30 2nd Half Time 03.00 – 04.00	**Session 4.** Adaptation and Mitigation strategies	**Session 4.** Assessing CSA technologies and practices	**Session 3.** Poultry and Livestock-based CSA technologies and practices suitable for Mountain, Hill and Terai regions of Uttarakhand		Session 2. Participant's reflection and facilitator's remark and feedback collection
Ist Half Time 10:30-11:00 2nd Half Time 04.00 – 05.00	Continue from the previous session	**Session 5.** Climate Risk Assessment and Risk-Based Planning	Continue from the previous session		Session 3. Closing Ceremony.

Module 1:

Basics of Climate Change and Its Impacts:

Time required	**Day 1, First Half**
Material Required	**Marker pen, whiteboard, paper and projector.**

OVERVIEW:

This module covers terminology and phrases used in climate and weather science. Its goal is to help people learn more about climate change, including its main causes affecting-term effects. It also talks about how changes in weather patterns affect food, nutrition, and economic security in farmland and the agroecosystem.

This module also shows people how to prepare for and deal with hazards and tragedies caused by climate change. This module also talks about different ways that Uttarakhand, India, and the world can deal with and adjust to climate change.

OBJECTIVES:

After the completion of this Modules, Participants will be able to:

- Become familiar with commonly used terms in climate science and explain the difference between weather and climate after completing this session.
- Explain climate change science regarding the greenhouse effect and global warming.
- Determine the primary causes of climate change.

Session 1. Introduction of Participants and Establishment of Training Goals

Participants' introductions

Participants will be introduced yourself. Participants must first discuss their names, addresses, and personal interests.

Goal of Training

The facilitator delivers the overall objectives of the training.

Collection of Expectations

Each participant is given meta cards and a marker and is asked to write down what he or she hopes to gain from this session. Limit each meta card to one expectation, and make sure the letters are clear and large enough for other participants to read from a distance. The facilitator gathers the meta cards and arranges them on the board by subject regions so that each participant may read the expectations of the other participants.

Pre-Training Evaluation/Assessment

To determine the training programme's success, an evaluation will be conducted before and after the training using a standard questionnaire.

Session 2. An introduction to climate change and essential terms

What is climate change, and how does it happen?

Changes in climate factors like temperature, rainfall, relative humidity, and wind trends over time are called "climate change." Climate change happens naturally because there are more greenhouse gases (GHGs) in the air, like carbon dioxide, methane, and nitrous oxide. Human acts or anthropogenic forces can also cause it. Human actions are the main cause of pollution in the atmosphere, which warm surface of the Earth and cause causes the change. Carbon emissions are mostly caused by burning fossil fuels, destroying forests, and setting them on fire, changing how land is used, using more agrochemicals, transportation, power, and letting trash out in cities.

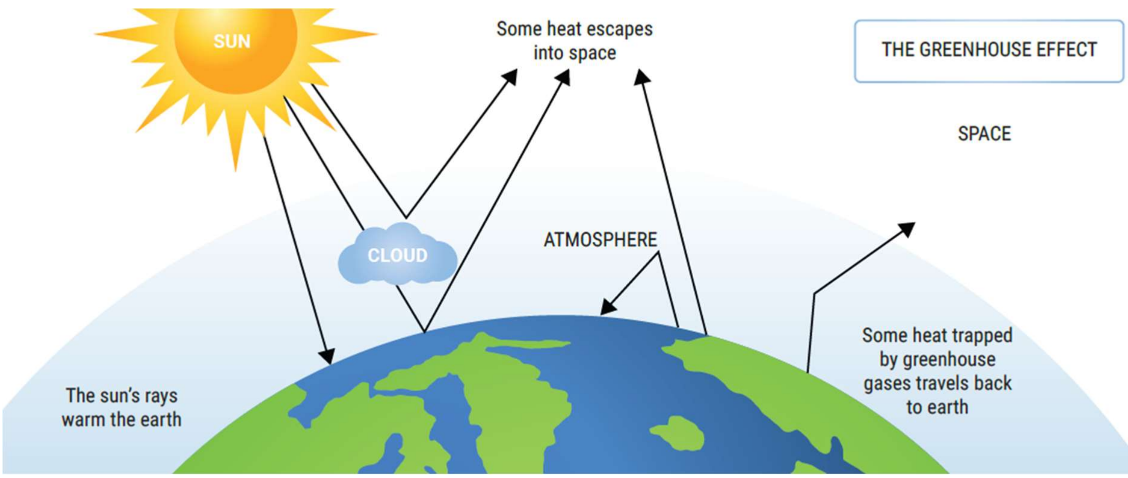


Figure 1. Climate Change Process

According to Intergovernmental Panel on Climate Change (IPCC), climate change can be referred to as "a change in the state of climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer". It refers to any change in climate over time, whether due to natural variability or as a result of human activity.
The United Nations Framework Convention on Climate Change (UNFCCC) refers climate change as "a change of climate that is attributed directly or indirectly to human activity that alters the composition of global atmosphere and that in addition to natural climate variability observed over comparable time periods".

Some of the main causes of climate change discussed earlier are elaborated below:

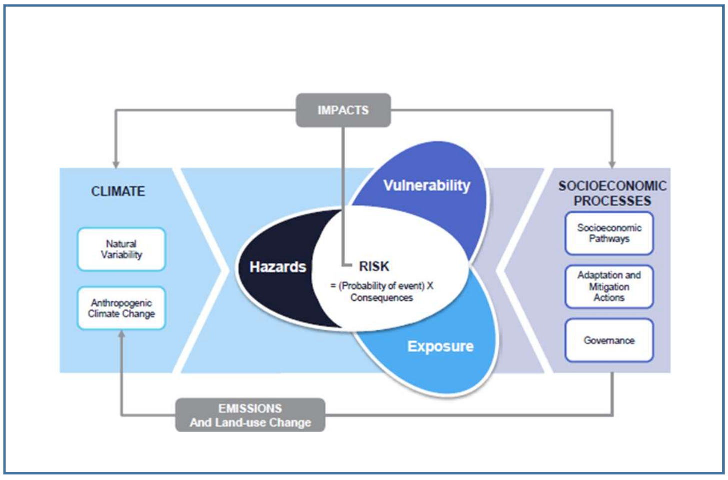
- **Burning of fossils fuels:** The burning of fossil fuels such as coal, gas and oil produces carbon dioxide and nitrous oxide which are the major GHGs in the atmosphere.
- **Agricultural practices:** The haphazard use of chemical fertilizers during crop production releases different types of greenhouse gases. Rice cultivation is the main source of methane production through anaerobic fermentation in soil when the field is continuously flooded.
- **Intensive farming/Livestock:** The animals like cattle and sheep produce a large amount of methane during their process of digestion of food (enteric fermentation). Manure management is another key source of GHGs like methane and nitrous oxide.
- **Deforestation:** Trees absorb carbon dioxide from the atmosphere mainly for photosynthesis. When trees are cut down, the carbon stored in the trees is also released into the atmosphere.

Carbon dioxide, carbon monoxide, nitrogen oxides and sulphur oxides are released when the trees are cut down.

Key Terminologies

- **Weather:** Weather can be defined as the state of an atmospheric condition at a particular place and time. Weather changes frequently in a very short period. For example, we can say it rained for an hour in Uttarakhand and then became a sunny day.
- **Climate:** Climate can be defined as the state prevailing over a long period (IPCC, 2007a). Climate is the average weather condition of a particular location for over 30 years.
  'Global Warming: Literally, global warming refers to the rise in temperature of Earth's atmosphere due to the increase in GHGs emissions.
- **Greenhouse gases (GHGs):** GHGs are those gases that absorb and emit radiant energy within the thermal infrared range. The primary GHGs in the Earths' atmosphere are water vapor, ozone (O3), carbon dioxide (CO2), methane (CH4), and nitrous oxide (N20).
- **Greenhouse effect:** The greenhouse effect is the process by which radiation from the sun is trapped in the atmosphere thus warming the planet's surface. GHGs cause greenhouse effects that results in global warming.
- **Vulnerability assessment:** Vulnerability can be defined as "the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes (IPCC, 2007). This is effective to collect baseline information from an area where a hazard occurs. This comprises of different steps and tools that can be used to assess the vulnerability of a particular site/area. However, vulnerability for farming communities towards any climatic hazard can be assessed in terms of their sensitivity and adaptive capacity.
- **Exposure:** It is a measure of the magnitude and extent of exposure of communities or systems to climate change.
- **Sensitivity:** It is a measure of how a system or community is likely to respond when exposed to climate-induced stress or disasters.
- **Adaptive capacity:** It is a measure of the potential, ability, or opportunities of a community or system to cope with the situation when they are exposed to climate-induced stress or disasters.
- **Risk:** It is the function of hazard, exposure, and vulnerability.

Climate Risks: A System View



- Risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems
- Mitigation and adaptation activities are socio-economic processes that influence both drivers and impacts of climate change.

Figure 2. Schematic of the interaction among the physical climate system, exposure and vulnerability producing risk (Illustrative Example). Source: IPCC (2014)

- **Vulnerability:** It is the function of sensitivity and adaptive capacity.

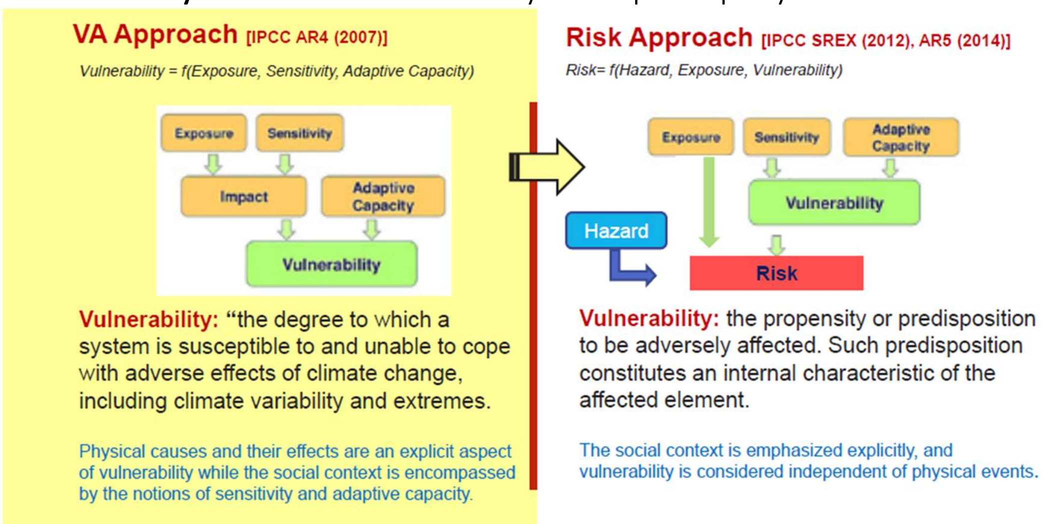


Figure 3. Conceptual framework of vulnerability and risk adopted by AR4 and AR5.

Agroecosystems: It refers to the organisms and environment of an agricultural region inside an ecosystem. Agroecosystem is a conceptual model of an agricultural system (crop, farm, or entire economy) that links its functions to its inputs and products.

Resilience: Resilience is the ability of a system to heal, absorb, withstand, and bounce back to its original state after something bad happens because of climate change. Farmers need better ways to plan so they can react to climate change and do well. The IPCC defines resilience as "the ability of social, economic, and environmental systems to deal with a dangerous event, trend, or disturbance by responding or reorganising in ways that keep their essential function, identity, and structure while also keeping the ability to adapt, learn, and change." For farming towns to do well in a changing climate, they need to find better ways to adapt. When people in rural areas plant trees, it makes them stronger.

Climate Change Adaptation (CCA): Changes in the Climate Adaptation is described as a set of efforts undertaken in response to climate change-related disasters caused by global warming. The IPCC defines climate change adaptation as "the process of adjusting to actual or expected climate and its effects." Adaptation in human systems aims to mitigate or avoid harm while also capitalising on advantageous chances. Human intervention in some natural systems, such as infrastructure, agriculture, and education, may aid adaptation to predicted climate and its effects."

Climate Change Mitigation (CCM): Climate Change Mitigation is defined as a series of actions that limit the magnitude of emission of greenhouse gases (GHGs) and increases carbon sinks through reforestation. According to the IPCC (2014), "Mitigation is a public good; climate change is a case of the 'tragedy of the commons.' Effective climate change mitigation will not be achieved if each agent (individual, institution, or country) acts independently in its selfish interest, suggesting the need for collective action. Some adaptation actions, on the other hand, have characteristics of a private good as benefits of actions may accrue more directly to the individuals, regions, or countries that undertake them, at least in the short term. Nevertheless, financing such adaptive activities remains an issue, particularly for poor individuals and countries."

Food security: Food security exists when all people, always, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (WFS, 1996).

Dimensions of food security

Food availability: Refers to the proper and adequate supply of quality food in a given area.

Food access: It refers to the social and economic aspects of how people get food. The income of an individual and the prices of food affect the accessibility of a food system.

Food utilization: It refers to the ability of an individual to utilize available food effectively.

Session 3. Climate threats and their consequences for agriculture and food security

Most of the farming in Uttarakhand is done by smallholders on land that is ecologically diverse and the most sensitive to the effects of climate change. Climate change has caused things like more severe landslides, droughts, and floods, which have hurt people's ways of making a living. The yield and productivity of agriculture have been going down for a long time. Weather trends that are hard to predict, like heat stress, long dry days, and unpredictable rain, have had a big effect on Uttarakhand's farming industry. 58–60% of the farmed land area is the only thing that can predict monsoon rain. The dry time in Uttarakhand caused the most loss of land that could be used for farming. This was followed by floods, hailstorms, rain, strong winds, and cold waves. Farmers who make their living from farming must deal with weather risks like drought, floods, landslides, and so on. This leads to less crop production and efficiency and food insecurity in some areas.

The impacts of climate change on the agricultural systems of Uttarakhand are significant. Some of the direct impacts are briefly listed and described below:

- Increasing surface runoff resulting in the decline of soil fertility.
- Loss and degradation of the agricultural field due to landslides, inundation and sand deposition.
- Frequent outbreak of crop pests and diseases.
- Loss of biodiversity especially of local origins.
- Excessive growth of weed and invasive species affecting the persistence of native biodiversity.
- Long term and frequent droughts and short rainy season's results in water scarcity during critical growth period of crops decreasing the crop production.
- Early heatwaves prevailing for an extended period affect crop growth and development thus reducing yield of crops.
- Decline of flora and fauna species.
- Unpredictable weather patterns including rainfall; Decreased availability of usable water resulting in water insecurity.
- Shifting of production zones because of an upward shifting of the snow line.

Thus, it's important to minimize the negative impacts of climate change through the promotion of climate change adaptation-related interventions.

Session IV. Adaptation and Mitigation Strategies

To deal with the bad effects of climate change, adaptation is mostly about reducing risk and vulnerability. The types of adaptation strategies depend on how vulnerable a place is to disasters caused by climate change. Research shows that adaptation is very important, especially in less-developed countries where people are more vulnerable to climate risks. Table 1 shows how to deal with the bad effects of climate change, especially in the farm sector, by adapting to and reducing the effects of climate change.

Table 1. Climate change adaptation and mitigation strategies (Examples)

Adaptation Strategies	Mitigation Strategies
• Increasing crop diversity in agricultural/farming systems • Cropping pattern changes, crop cycle and planting time adjustments • Water harvesting and water management efficiency. • Construction and restoration of irrigation infrastructure • promotion of climate-resilient technology, including agricultural varieties that are disease/pest/drought resistant, especially in stress-prone areas. • promotion of regional and indigenous practises and knowledge • empowering local communities economically. • Increasing community awareness through instruction, information sharing, and • increasing the communities'/organizations' institutional capacity and efficiency.	• reduction in the use of chemical fertilisers and pesticides and promotion of ecological and organic farming. • promoting reforestation while reducing deforestation. • increasing the use of renewable energy sources like solar energy, electrifying vehicles, reducing the usage of those powered by fossil fuels, and promoting the use of electrical energy

Exercise: List the main climatic risks to agriculture, along with the solutions.

Steps

- Groups of participants will be assigned to the exercise, which must be finished in the allotted 10 minutes.
- The group will be tasked with identifying the various climate threats that regularly affect the agriculture industry.
- The effects of climate hazards and the steps taken to counter them will be listed by participants.
- Participants will finally present the topics of their group discussions, and the facilitator will offer their opinions and recommendations.

Module 2.

MODULE 2: Understanding Climate-Smart Agriculture (CSA) and its processes	
Time required	**Day 1, 2nd Half**
Material Required	**Marker pen, white board, paper and projector.**

Overview:

The concept of CSA is explained in this session, along with its salient features and many instances of CSA technologies, practises, and planning strategies. The courses provide a brief explanation of the three pillars—adaptation, mitigation, and food security—before describing CSA and its models. Additionally, this module gives participants the chance to discuss and evaluate the possibilities of various CSA technologies and practises that are supported and/or used in their region.

Objectives

The following will be possible for the participants after completing this module:

- Understand and describe CSA and its practices.
- Differentiate between CSA technologies and practices based on their smartness criteria and conventional practices.
- Suggest and Identify CSA technologies and practices appropriate for different agro ecosystem across mountain, hills and Terai, and for their locality in particular.

Session 1. Introduction to climate-smart agriculture (CSA)

CSA has been emerged to address the challenges in the agriculture sector caused by climate-induced disasters and stresses. It is defined as a strategic approach that aims to sustainably improve agricultural productivity and enhance food security, increase farmers' resilience and adaptation to climate change, and reduce and/or remove GHGs emission where possible (FAO, 2013). CSA helps guide actions needed to transform and reorient agricultural systems to effectively support the development and ensure food security in a changing climate.

In Uttarakhand, CSA has come into practice recently, and various government and non-government organizations are promoting CSA technologies and practices. Some of these organizations include the Ministry of Agriculture, Department of Agriculture, Rural Enterprise Acceleration Project (REAP) and so on. However, investment in the research and development of CSA related capacity building is not adequate to generate and promote technologies and practices appropriate for different agro-ecological zones ranging from high hill to Terai.

Three Pillars of Climate-Smart Agriculture (CSA)

CSA consists of three pillars which are described below:

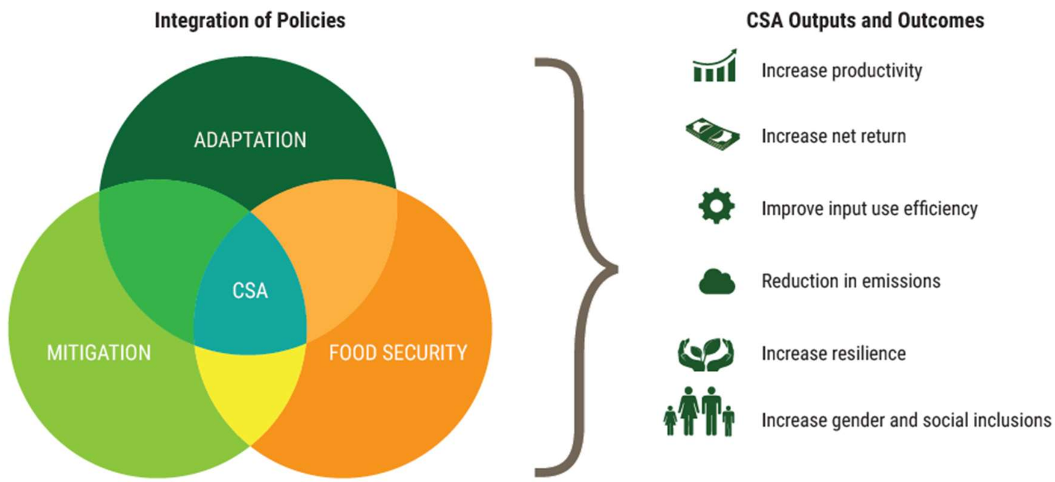


Figure 5. FAO conceptual framework of Climate-Smart Agriculture

Adaptation

The term "adaptation" refers to changing exposure, lowering sensitivity, and boosting adaptive capability to lessen vulnerability to disasters brought on by climate change. Examples:

- Use of drought-tolerant crop types is one of the adaptation strategies that can be used if a given place experiences drought conditions. Additionally, promoting various water-efficient technologies, such as drip irrigation, may be maybe way to grow crops in water-restricted areas.
- Similarly, farming communities in flood-prone locations might set up raised nursery beds to save seedlings from flooding.

Mitigation:

Mitigation refers to lowering greenhouse gas emissions and boosting carbon sequestration to store atmospheric carbon dioxide over an extended period. Examples:

- Using zero tillage/minimum tillage technology can reduce GHG emissions from the volatilisation of organic soil carbon.
- Through the application precision farming techniques, integrated nutrient management can decrease emissions by minimising the overuse and loss of chemical fertilisers.
- The use of a leaf colour chart decreases the overuse of fertilisers by making it easier to determine the precise quantity of nitrogen that plants need.
- Use of cover crops and incorporation of crop residues into the soil can generate higher inputs.
- The use of a solar-powered irrigation system can take the place of a diesel pump-powered irrigation system, significantly reducing GHG emissions.

Productivity

The CSA seeks to sustain and enhance agricultural production and productivity under challenging climatic conditions by promoting various technologies and practises relevant to climate change adaptation.

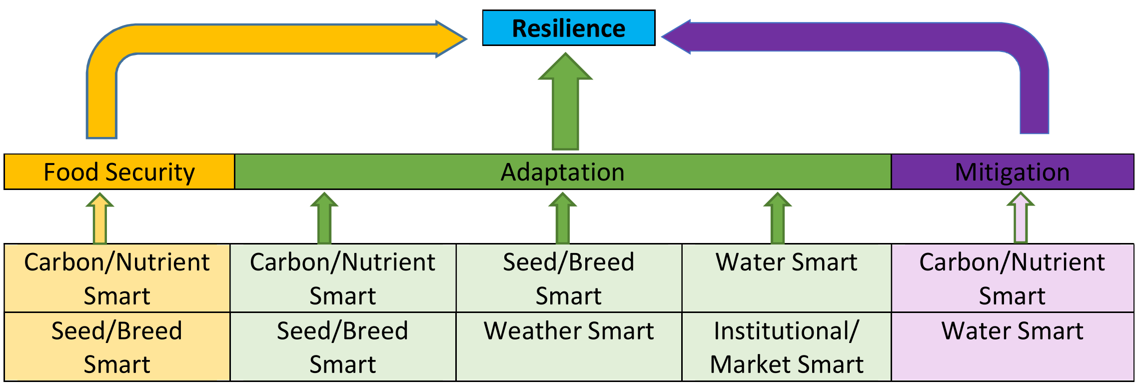
Session 2. CSA classification based on smartness criteria.

The CGIAR Research Programme on Climate, Change, Agriculture and Food Security (CCAFS) has created a framework for climate-smart alternatives and categorised CSA technologies and practises under them.

Technologies and practices marketed for climate change adaptation and mitigation are classified under many smart criteria, such as weather and knowledge-smart, water-smart nutrient/carbon-smart, seed/breed-smart, and institution/market-smart (CCAFS, 2016). One CSA technology or practice an also support many smartness criteria. A weather-smart technology that can also be regarded as water-smart technology is the use of drought-tolerant varieties, for instance. Like how solar-powered irrigation systems are thought of as water-smart technologies, they can also be categorised as carbon-smart technologies due to their contribution to reducing GHG emissions.

Types of Climate Smart Options				
Weather and Knowledge Smart	Water Smart	Seed/Breed Smart	Carbon/Nutrient Smart	Institutional/Market Smart

All these climate-smart options ultimately contribute to the three pillars of CSA as illustrated in the figure below.



(Source: Adopted and modified from Pudasaini et al., 2018)

CSA technologies and practices are site-specific. For instance, some technologies and practices appropriate for the hilly region may not be useful in the Terai region. CSA is aimed at identifying practices that are most adaptable to a localized condition or widely across multiple agro ecosystems.

Categorization of CSA technologies and practices based on five smart options.

Water Smart: The variation in rainfall caused by climate change, which leads to dry periods and drought, is one of the effects. The production and productivity of agriculture are decreased because of erratic rainfall and persistent drought.

As a result, water-efficient technologies and practises are available for this situation, and they can be regarded as water-smart since water-smart technologies are those that utilise water effectively and efficiently. Extreme weather-related yield loss is reduced thanks to this practise. Examples include the collection of rainwater, drip irrigation, solar-based irrigation, water harvesting/collection tanks, drainage management, cover crops, mulching, direct-seeded rice, alternate soaking and drying, spray irrigation, etc.

Weather and Knowledge Smart: Agricultural difficulties are increasing because of the changing and increasingly unpredictable weather patterns. Reduced agriculture production, particularly in rainfed farming systems, is being caused by increased variability in rainfall patterns. Changing weather conditions raise risks and unpredictability, which reduces agriculture's profitability even further. To properly plan agricultural operations, farmers must have access to and receive meteorological and weather information.

Additionally, sharing knowledge regarding the presence of pests and diseases brought on by shifting climatic conditions and its management techniques aids in improved planning and prompt response. Agro-advisory services and other weather-smart technologies distributed via mobile, FM, radio, and television assist prevent crop damage. An individual can access the information through a different mobile-based application that can be downloaded on android mobile phones. Examples: Meghdoot (IMD), IFFCO Kisan Agriculture, Krishi Jagran, Bijak App, Crop Insurance, Kheti-Badi etc.

Institutional and Market Smart: The institutional linkages need strengthening for enhanced agriculture production. Examples of institutional/market-smart practices include Inter-sectoral linkage, capacity building programs, financial services, market information, etc. These practices help farmers in accessing resources, information, and market outlets and address gender related issues.

Carbon and Nutrient Smart: Global warming is caused by an increase in the amount of greenhouse gases (GHGs) released into the atmosphere because of burning different fossil fuels, using chemicals, and altering agricultural practises. To preserve a healthy environment, it is crucial to implement technology and practises that lower GHG emissions and boost carbon sequestration. Over the next 25 years, it is predicted that 12% less food would be produced globally due to declining soil fertility, which might result in a 30% increase in global food costs (UNCCD, 2015).

Soil erosion, poor organic matter recycling, and uneven fertilisation are the primary causes of soil fertility reduction in Uttarakhand. Farmers use chemical fertilisers randomly to boost output. Overuse and improper application of chemical fertilisers degrades soil quality, resulting in decreased crop yield and increased GHG emissions. Furthermore, the burning of fossil fuels, agricultural leftovers, cow dung, a prevalent practise throughout Uttarakhand's Terai area, and the growing of low productive livestock species under inadequate management all contribute to GHG emissions.

It is important to reduce GHGs emissions through the implementation of different carbon-smart technologies. Proper soil nutrition management by organic manure, integration of legume in the cropping system, site-specific nutrition management, use of leaf colour chart (LCC), Green Seeker and residue retention, farmyard manure management, zero-tillage/minimum tillage are some examples of carbon/nutrient-smart technologies and practices.

Seed and Breed Smart: Quality seeds of regionally adapted types, as well as better livestock breeds, are critical to total agricultural and livestock production. Community seed banks, the adoption of drought, flood, and disease tolerant crop varieties, and cross-bred high yielding livestock breeds are examples of seed-smart/breed-smart technologies and practises supported in Uttarakhand. Elevated temperatures and changing weather patterns have also increased the incidence and occurrence of novel insect/pests and disease in agricultural crops. To overcome this issue, pest and disease resistance cultivars are required. Furthermore, nutrient efficient crop cultivars aid in reducing the use of chemical fertiliser in the soil.

Session 3. Role of CSA for resilience agriculture

Agricultural resilience can be described as the ability of farming communities to absorb and recover from shocks and strains caused by climate hazards in their agricultural productivity and livelihoods.

Smallholder farmers practise subsistence agriculture in Uttarakhand. Only a limited percentage of farmers have adopted new technologies, particularly in areas with significant output potential. In this context, CSA could be a viable option for increasing gross agricultural production while making the best use of finite inputs and resources, particularly in low input agriculture systems. CSA technology and practises also help to lower production costs and may be feasible solutions for smallholders.

CSA technologies accept the use of the practices that are adapted to local conditions. CSA approaches principally build on sustainable agriculture as they promote the judicious management of water, land, and other resources and optimize the benefits from the food systems.

A comparison of current farming practises versus climate-smart agriculture.

	Current Agriculture Practices	Climate-Smart Agriculture
Natural resources	Make the best use of natural resources - the land, water, forests, and soils needed in production - while giving little concern to their long-term sustainability.	Restore, conserve, and use natural resources sustainably.
Land	Increase agricultural land by deforesting and turning grasslands to farmland/cropland	Increases land utilisation by converting degraded land to cultivable land (e.g., by solar-powered irrigation) and minimises soil degradation caused by intensive tilling (by utilising zero or minimal tillage) or similar practises.
Varieties	Rely on a few crops, as well as a few high yielding upgraded and hybrid crop types and improved breeds.	To preserve output, enhance yields, and ensure stability in the face of climatic change, use a mix of old and modern, regionally suited types and breeds.
Inputs	Relentless use of fertilizer, pesticides, and herbicides.	• Improve the efficiency of agrochemical use. • Control pests, diseases and weeds using integrated management approaches. • Priority is given to the application of compost manure and green manure. • Crop rotation with legumes helps to fix nitrogen and reduces the usage of chemical fertilisers.
Energy	Use farm machinery that usually relies on fossil fuels – such as tractors and diesel pumps.	Use energy-saving methods such as solar irrigation and biofuels.
Production and marketing	Specialize in production and marketing to achieve greater efficiency.	Diversify production and marketing to add stability and reduce risk.

(Source: FAO, 2013a)

Session 4. Assessing CSA technologies and practices

In CSA, careful assessments of the technologies and practices are of utmost importance. The pool of CSA technologies which are most relevant to different agro ecosystems i.e., high hill, mid hill and Terai region can be evaluated against four qualifying criteria: in) the technical appropriateness in the local context, ii) economic benefits, iii) farmer's acceptance, iv) climate sensitivity and scalability (Paudel et al., 2017). The technologies and practices are identified based on the literature reviews, consultation with the stakeholders and subject experts, field piloting and screening based on which final selection can be done.

CSA practices can be assessed upon various indicators representing the three pillars CSA. The indicators to assess the CSA technologies and practices can be grouped in four different categories; in) changes in the agronomic practices, ii) increase in the energy/water use efficiency, iii) use of ICT services for the dissemination of information related services, and iv) various methods that can either reduce or transfer the risks associated with farming systems. The reduction in the greenhouse gas emission and the use of clean energy can be counted as indicators to assess the mitigation pillar of CSA. CSA can be further assessed based on the indicators such as timesaving and drudgery reduction, access to information and knowledge, capacity building, leadership roles and skills development, increment in the income, asset and nutrition diets. The indicators set can be used to monitor the progress and assess the CSA technologies and practices as suitable technologies play a key role in the different agro-ecological regions.

Exercise: List several CSA technologies and practises and categorise them based on smartness criteria.

- Participants are divided into many groups. Each group has 4-5 people.
- The participants are provided with a list of different CSA practices.
- The participants are asked to group practices and technologies based on the smartness criteria discussed in the earlier.
- The outputs of the group work will be shared in the plenary for discussion.

Session 5. Climate Risk Assessment and Risk-Based Planning

Agricultural production, processing, marketing, and financing all involve climatic and non-climatic hazards. To minimise risk and maximise profits, it is critical to thoroughly understand all the risks associated with a specific site and crop commodity, beginning with planning, which includes identifying actions and interventions and allocating resources to implement them. We will only discuss understanding and assessing climate hazards in agriculture in this section. From defining the threat to implementing appropriate solutions and evaluating them in the existing environment, risk-based planning involves several processes. To properly comprehend climate threats, the following phrases/terms must be understood:

Vulnerability Assessment: This method is helpful for gathering baseline information from a hazardous environment. To analyse the vulnerability of a certain site/area, various methods and technologies can be employed. Farming communities' vulnerability to any climate hazard can be quantified in terms of their sensitivity and adaptive capability to respond to the risks to which they are exposed.

Understanding and mapping commonly occurring climate hazards and disasters:

i. **Historical Timeline:** In this process, the information on the climate-induced disaster over years i.e., last 20-30 years is collected. The event that has occurred along with the qualitative and quantitative information will be collected.

Procedures:

- Organise Focus Group Discussions with members of all ages, from the elderly to the young, because they have lived through various periods and can readily talk about the past and contemporary problems.
- For time duration, information can be taken in 5 years' interval depending upon the situation.

Table 3 is an example of a historical timeline.

Climate Related major hazards/ disasters	Time interval and the degree of effects/impacts					
	1975-1980 AD	1980-1985 AD	1985-1990 AD	1990-1995 AD	1995-2000 AD	2000-2005 AD
Floods	Huge floods in 1976 washed way 50 households and 10 hectares of land.					
Drought					Drought reduced the production of paddy field.	
Landslide		Landslide has washed 5 hectares of paddy field.				

ii. **Ranking of Climate Hazards/Disasters:** The hazards/dangers derived from the historical chronology are categorised and prioritised in this procedure based on their incidence in the specific location and community.

Procedures:

- Make a list of the hazards that are more likely to occur in that area.
- List out the climatic hazards in rows and columns in a table.
- Compare both the hazards vertically and horizontally and select the one which has more impact in terms of loss.
- Put the number in the hazards based on their frequency and score them which has the greatest priority.

Table 4 shows an example of a ranking of climate Hazards/dangers.

Hazards	Landslide	Drought	Flood	Hailstone	Pest	Fire	Diseases	Total
Landslide		Landslide	Flood	Landslide	Landslide	Landslide	Landslide	5
Drought			Flood	Hailstone	pest	Fire	Diseases	0
Flood				Flood	Flood	Flood	Flood	6
Hailstone					Pest	Hailstone	Diseases	2
Pest						Pest	Diseases	3
Fire							Diseases	1
Diseases								4

iii. **Preparation of Seasonal Calendars:** This is yet another technique for assessing a community's Vulnerability. This tool lists the climate threats that the community faces over time and compares past and present conditions.

Procedure:

- Prepare a seasonal calendar format in brown paper or chart paper.
- List the climatic hazards in the first row and first column.
- Then discuss the time duration in the past like when the drought used to occur in that specific community and what is the scenario at present.
- If the occurrence of the hazards varies, then discuss with the community what they have been doing to overcome the specific hazard.

Table 5. Sample of a seasonal calendar

Seasons		**Rabi**		**Kharif Season**					**Rabi Season**				
Hazards		**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep t**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Drought	**Before**												
	Now												
Flood	**Before**												
	Now												
Leaf Miner	**Before**												
	Now												
hailstone	**Before**												
	Now												

iv. **Preparation of Crop Calendars:** This tool is like a seasonal calendar. This tool lists changes in crops and agricultural operations by the community through time and compares past and present conditions.

Procedure:

- Create a crop calendar format on brown paper or chart paper.
- List crops in the first column and months in the first row.
- Then discuss the time duration in the past when the community used to cultivate and harvest the crops and what is the scenario in the present.

Beside these tools, an individual need to consider the intensity and behaviour of the precipitation and monitoring of the weather measurements such as installation of the weather forecasting system, record keeping of the climatic parameters in the climate diary.

Action Planning

The selection of potential CSA practices can be done through the participation of various stakeholders including farming communities. The farming communities implementing the technologies for years can also help in the climatic risk management and need to be considered during the risk-based planning. However, the new technologies and practices that are advance and that need advanced research and planning can be taken from researchers as they need to be validated with the facts and figures through research. The focus group discussion with the participation of the local communities and stakeholders plays an indispensable role in the prioritization of the technologies and practices suitable for a specific agro-ecological region. The technologies can be identified and prioritized through consultation workshops and in a participatory manner with the participants. The importance of the respective technologies is assessed by the experts during the consultation workshop. The team then identifies some technologies and practices for implementation in specific location.

Implementation

Based on various agro-ecological zones, the identified technologies can be immediately deployed. However, those that need to be validated through the production of evidence must be put into practise as action research, and pertinent data must be gathered to evaluate the overall performance and suitability of the technology to successfully address the identified climate risk of the region.

Monitoring

To determine whether CSA technologies are being used correctly and effectively in each area, monitoring is necessary. Data can be generated to evaluate the indicators' performance after comparing them to the baseline. Regular and collaborative monitoring field visits should be organised in the presence of communities, important stakeholders, and organisations working in the CSA, including government officials.

MODULE 3:

Uttarakhand-Related CSA Technologies, Practises, and Solutions

Time required	**Day 2, Ist Half**
Material Required	**Marker pen, white board, paper and projector.**
Method	**Presentation, discussion and group work**

Overview

This module includes information on various climate-smart technologies and practises applicable to distinct ecological zones of Uttarakhand, as well as their contribution to the three pillars of CSA. Agriculture is extremely vulnerable to climate-change-induced disasters, but there are numerous solutions for dealing with them. Several CSA technologies and practises have been found and recommended for the agriculture and livestock sectors in Uttarakhand. However, research is essential to develop new applicable CSA technology to handle severe climatic threats imposed on agriculture. By the end of this workshop, participants will be able to categorise various climate-smart technology and practises that are appropriate for their locality.

Objectives

Participants will be able to do the following after completing this module:

- List various/numerous CSA technologies and practises that are appropriate for diverse agro-ecological zones.
- Distinguish how these technologies and practises contribute to the CSA pillars.

Session 1. Climate-Smart Agriculture (CSA) Technologies and Practises for Uttarakhand's Different Agro-Ecological Zones (Mountains, Hills, and Terai Region)

Uttarakhand is a state with diversified geography, separated into three natural zones: mountains/hills (high and low hills), and Terai. They account for 86% (hills) and 14% (plain/terai) of the state's total land area, respectively. Even within the same location, different agro-ecological zones/niches have distinct micro-climatic conditions. As a result, agricultural technology and practises that work in one place may not work in another. Some technologies are suitable for all regions in some instances. This session focuses on the many climate change adaption technologies and practises for distinct agro-ecological zones, as well as strategies for categorising them based on various smartness criteria, as shown in Table 7 below.

Table 7. CSA option for high hills, low hills and terai.

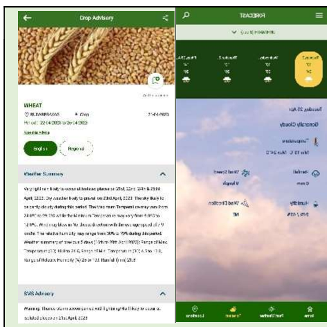
CSA Options	High-Hills & VHH	Mid-Hills	Terai/ Bhabr	Smartness
Introduction of new crops, seeds, varieties, seedlings, etc.	✓	✓	✓	Weather and knowledge smart
Home garden	✓	✓	✓	Weather and knowledge smart
Mixed farming (legume integration)	✓	✓	✓	Nutrient and weather smart
Community seed banks	✓	✓	✓	Knowledge smart
Small hand-tools, machines	✓	✓	✓	labour/energy smart
Agriculture insurance (particularly index based)	✓	✓	✓	Weather smart
ICT-based agro-advisory	✓	✓	✓	Knowledge and weather smart
Cattle-shed improvement	✓	✓		Nutrient and carbon smart
Package of plastic pond, plastic house, drip irrigation and improved cattle-shed	✓	✓		Water, weather and nutrient smart
Plantation and agroforestry	✓	✓		Carbon smart
Plastic house	✓			Weather and water smart
Plastic pond		✓		Water smart
Water-harvesting ponds, multiple-use and water source protection		✓		Water smart
Drip irrigation		✓		Water smart
Solar-based irrigation			✓	Water and energy smart
Conservation agriculture (zéro tillage, residue rétention)			✓	Carbon, water, and weather smart
System of rice intensification			✓	Water smart

Session 2. Crop-Based CSA Technologies and Practises Appropriate for Uttarakhand's Mountains, Hills, and Terai Region

Weather and Knowledge Smart technology and practices

Agro-met advisory services: Changes in temperature and rainfall, climate extremes (e.g., extremely rainy days, lengthy dry spells, very cold nights, intense heatwave), and climate-induced hazards such as drought, flood, and increased pest and disease incidence are the principal impacts of climate change. However, due to a lack of sufficient understanding and advance information on weather conditions and their potential impact on agriculture, farmers are encountering difficulty in protecting their crops and/or minimising agricultural damage. As a result, agro-met advice service is one of the critical practises that offers farmers with knowledge, information, and predictions about weather conditions, agronomic practises, and the risk of pest and disease infestation. This enables farmers to adopt suitable mitigating measures on time. Furthermore, this service disseminates crop market information, particularly for vegetable crops, which assists farmers in making better harvesting and marketing plans. There are numerous methods for conveying weather and other information to farmers, including delivering information from the IMD (meghdhoot), Mausam, IITM bulletin to farmers in person, by radio, FM, television, and text message. This agro-met advisory service is available throughout Uttarakhand.

The agro-met advisory services contributes to CSA pillars in the following ways.

	Adaptation	Mitigation	Food Security
 Weather and Market information through mobile	Farmers receive timely weather information, allowing them to be better prepared to deal with harsh weather. Farmers also receive knowledge on the finest agricultural practises, allowing them to adopt appropriate practises in the face of a changing environment.		Reduced crop loss owing to poor weather conditions as a result of timely meteorological information. Farmers can boost crop production by implementing the bulletin's recommended climate-resilient varieties, technology, and cultural practises.

Crop and livestock insurance: Climate change has varied degrees of impact on agriculture. Crop loss has grown because of extreme weather events, particularly protracted drought, floods, and the occurrence of pests and diseases. Farmers may potentially lose animals because of climate-related disasters. Crop and livestock insurance has been implemented as a risk reduction measure to ensure farmers are compensated when crops and livestock are lost due to harsh weather conditions and disasters. The Uttarakhand government has approved and implemented crop and livestock insurance policies.

The agriculture and livestock insurance contributes to CSA pillars in the following ways.

Adaptation	Mitigation	Food Security
Farmers can bear the risk of cultivating crops and raising livestock because of crop and livestock insurance.	Not Applicable	Farmers receive payments from insurance companies when their crops and livestock are destroyed by harsh weather.

Plastic House: Precipitation fluctuation is one of the primary effects of climate change, resulting in long-term drought and flood conditions that reduce crop productivity. Excessive rainfall at inconvenient times makes cultivating high-value crops challenging. Plastic houses, particularly in mid-hill and mountain areas, can be one of the methods used to address the problem. A plastic house is a greenhouse-like building in which plants, particularly high-value crops, are grown under semi-controlled conditions, thereby creating a favourable environment for crop cultivation. This technology is well recognised and has the potential for Uttarakhand's mid and high hills since it protects plants from frost and cold injury. In contrast to open fields, disease and pest concerns are projected to be relatively minimal under the plastic house, enhancing crop output and quality. The plastic house can be more successful and advantageous in terms of producing crops in drought-prone locations when combined with drip irrigation. Under the plastic house, high-value crops such as off-season vegetables such as tomato, Cole crops, and cucurbits, particularly cucumber, are typically grown. Farmers benefit more from adopting it because it allows them to cultivate crops throughout the year.

Adaptation	Mitigation	Food Security
Farmers can cultivate crops. throughout the year.	Not Applicable	Farmers can benefit more from plastic tunnels than from traditional farming practises due to increased output, longer season harvesting, and the option of planting high-value crops.

Climate-Resilient home garden: The home garden is an integrated agricultural approach in which vegetables, fruits, fodders, medicinal plants, and other crops are grown in a small plot of ground surrounding the homestead, maximising spatial and temporal aspects primarily to meet the family's daily needs. Aside from crops, livestock are also included in the home garden. Because of its diversity, knowledge intensiveness, and use of many climate-smart technologies and practises integrated into the home garden production system, home gardening is regarded as one of the climate-resilient practises. Home gardens are considered as the domain of women farmers because family members tend them. Aside from getting healthy and fresh vegetables for everyday usage, homeowners can also generate some surplus and potentially earn money. The home garden is appropriate for all three agro-ecological zones, but crop selection may differ depending on the zone. The size of the house garden will depend on the amount of land available.

The climate-resilient home garden contributes to CSA pillars in the following ways:

Adaptation	Mitigation	Food Security
Make the best use of space, time, variety, knowledge systems, and farmer-friendly CSA technologies and practises for women. Crop/agricultural diversity in the home garden ensures agricultural yield even in the event of a natural calamity.	Farmers primarily utilise organic manure and bio-pesticides in their home gardens, which reduces GHG emissions.	Farmers can grow a variety of crops in their backyard, ensuring food and nutrition security. Farmers save money for their families while also earning some money from their home gardens.

Water Smart technologies and practices

Solar-based irrigation system: The solar-powered irrigation system is a significant CSA technology that allows rural communities to irrigate crop fields even during the dry season. Solar irrigation has assisted smallholder farmers in transitioning from conventional rain-fed subsistence agriculture to high-value crops and marketing by organising them in groups and cooperatives. This is regarded as one of the best CSA technologies for elevating water in Terai and foothill river basins.

The solar-based irrigation system contributes to CSA pillars in the following ways:

Adaptation	Mitigation	Food Security
Water must be available all year so that farmers may cultivate rice and vegetable crops on time, regardless of the weather.	This system emits no GHGs and has the potential to dramatically reduce GHG emissions produced by diesel pumps.	Increase in productivity of crops and vegetables due to assured irrigation facilities. Increased cropping intensity by growing multiple crops in a year rather than keeping land fallow after the summer crop.

Rainwater Harvesting: Rainwater harvesting is one of the appropriate practises in which naturally existing rainwater is gathered either in big community-managed ponds like Terai or in smaller ponds or tanks like those found in the mid and high hill districts. Rainwater harvesting lowers surface runoff and collects water for irrigation during the dry season. Furthermore, collecting water from the top of the home in the water collection tank during the rainy season is a typical practise, particularly in Uttarakhand's high and mid hills. In the following methods, rainwater collection systems help to adaptation, mitigation, and production (food security).

Adaptation	Mitigation	Food Security
Improve water availability for farmers during dry period to cultivate high value (vegetable) crops. It also helps to decrease/reduce soil erosion. The construction of larger ponds for collecting rainwater minimises societal responses to climate change such as population displacement, habitat abandonment, and so on.	Crops can be grown all year long, which aids in carbon sequestration and lowers GHG emissions.	Increase and secure agricultural yield, especially for vegetable crops. Farmers may earn more money and protect their food supply.

Drip irrigation: Drip irrigation is a water-saving technology that is regarded as one of the most critical technologies for climate change adaptation. It is made up of plastic pipes with outlets through which water slowly drips from the system. Because drip irrigation irrigates plants solely in the root zone, it promotes water consumption efficiency while also reducing weed infestation in the field, providing in cost savings for intercultural operations. It also decreases soil erosion, especially on sloped land. Furthermore, disease incidence is low because most of the soil and foliage remain dry. This approach is suitable for high-value vegetables and fruits, as well as crop cultivation in the mid hills, high hills, and Terai.

The drip irrigation contributes to three pillars of CSA in the following ways:

Adaptation	Mitigation	Food Security
Water efficiency and minimal water loss. Weed infestation in the field is minimal.	Weed reduction reduces the use of weedicides, which reduces greenhouse gas emissions.	Increased yield of high-value crops (vegetables) results in more income, allowing farmers to better secure their food and livelihood.

System of rice intensification (SRI): The System of Rice Intensification (SRI) is an agricultural practise that tries to increase rice yield. This method of cultivating rice uses less water since younger seedlings (approximately 15 days old as compared to a month old) are transplanted individually in wider spacing (25-40 cm) that allows for easier hand weeding with tools. This is an important adaptive practise for rice production because it uses less water. This practise is better appropriate in Uttarakhand's Terai region. This farming practise contributes to three CSA pillars, as illustrated in the table below:

Adaptation	Mitigation	Food security
Rice cultivation requires 30-40% less water than traditional methods. Healthy and strong plants with long roots even in minimum water application.	High carbon storage in plants due to increased biomass. Reduced use of chemical fertilisers. Reduced water logging and flooding of the land reduces methane gas emissions.	Increase rice productivity when compared to traditional methods. lower production costs as a result of lower irrigation and input utilisation.

Carbon/Nutrient-Smart technologies and practices:

Minimum Tillage and Zero Tillage: Zero tillage and minimum tillage are farming practises in which the soil is disturbed as little as possible during crop production. This practise is suitable for wheat and other compatible crops in the Terai region. This practise reduces the cost of manpower, seed and fertiliser, and irrigation (since the soil remains moist). When using zero tillage in wheat, seeds are sown in rows where fertilisers can be applied simultaneously with the help of a machine. Because the soil is less disturbed, there is more carbon storage in the soil, which contributes to a reduction in CO_2 emissions. This practise helps CSA in the following ways.

Adaptation	Mitigation	Food Security
Wheat and other crops must be sown on time. Maintain soil moisture due to less disturbance.	Increase soil organic matter and carbon storage in the soil. Reduce the use of fuels for tillage operations in comparison to standard farming.	Reduce the cost of production. Higher cost: benefit ratio.

Mulching: Mulching is a method of covering soil with straw, compost, plant materials, or plastic sheets to reduce water loss from evaporation and erosion, enrich the soil with organic matter, and limit weed development. Furthermore, this practise contributes significantly to the reduction of CO_2 emissions from the soil. Mulching is popular in the mid hills and may be appropriate in the Terai region as well. Plastic mulch helps to conserve water, solarize soil, and discourage weed development. Plastic mulch has recently been widely employed for vegetable cultivation beneath greenhouses or plastic houses, as well as in open fields of commercial pocket areas. Mulching helps with CSA in the following ways.

Adaptation	Mitigation	Food Security
Increase the organic matter in the soil. Serve as a soil cover to keep the soil moist.	Reduce soil exposure to produce less carbon emissions from the soil. Minimise the use of weedicide	Increase the crop yield in dry. areas.

Agro-forestry: Agro-forestry is an agricultural practise or system that integrates agriculture, forestry, and livestock operations to maximise land productivity and reap the benefits of various crop yields. It is a community-based adaptation practise that helps to strengthen community resilience to climate change while simultaneously contributing to mitigation by lowering greenhouse gas (GHG) emissions. Furthermore, this practise helps to reduce soil erosion, especially in sloppy areas, because it provides a dense canopy and proper use of soil nutrients due to plants with different root systems, which improve organic matter in soil, reduce flood loss, and increase water availability (Nuryati et al., 2019). This farming style is suitable for mid and high hill settings, although it can also be used in the Terai region, particularly for plantation crops. Agroforestry contributes to the following CSA pillars.

Adaptation	Mitigation	Food Security
Proper use and recycling of nutrients in the soil. Increase soil organic matter and minimise soil erosion.	Improve carbon sequestration through sustainable land use management.	Integrated farming of varied crop plants and livestock allows for several crop harvests and increases the overall productivity of the farming system.

Leaf Colour Chart (LCC): Leaf Colour Chart (LCC) is one of the CSA technologies used to predict nitrogen fertiliser requirements for cereal crops, particularly rice, wheat, and maize, based on the greenness of the plant leaf. LCC is a decision-making tool for estimating the optimal amount of nitrogen fertiliser to employ, particularly in cereal crops. LCC is made up of six green stripes that vary in hue from yellow green to dark green according on the amount of nitrogen (amino acids) in the leaves. This technology is applicable in all places where cereal crops are grown (Terai, hills, and mountains). This is a woman-friendly tool because it is easy to use and comes with straightforward instructions.

The use of LCC contributes to CSA pillars in the following ways.

Adaptation	Mitigation	Food Security
Reduce the occurrence of disease and pests caused by overuse of nitrogen fertiliser in crops and climate change.	Reduce the emission of nitrous oxide gas due to optimum use of nitrogen fertilizer.	Reduce Production cost. Increase crop productivity by using fertiliser correctly and minimising crop loss from lodging caused by excessive nitrogen fertiliser application.

Seed/Breed-smart technologies and practices

Climate-Resilient crops and Crop varieties: Climate-resilient crops and crop types are significant in climate change adaptation because they can be grown under unfavourable climatic circumstances. Drought is one of the most serious consequences of climate change. Variation in rainfall patterns causes long-term drought during the summer season and flooding during the rainy season. To deal with this condition, drought and flood-tolerant crops and cultivars are required. Drought and flood-tolerant rice varieties/cultivars are now available in Uttarakhand. Planting those cultivars in drought and flood-prone locations can help reduce crop loss under harsh weather conditions. In Uttarakhand, several have lately advocated enhanced climate-resilient maize and wheat varieties. Aside from these primary grains, climate-resilient crops include amaranth, millet, foxtail millet, finger millet, barley, buckwheat, and others. These crops can be grown in drought-prone areas and produce a high yield. Climate-resilient crops and cultivars are one of the practical ways for mitigating the effects of climate change and are suited for all three agro-ecological zones of Uttarakhand. Climate-resilient crops and crop types contribute to the following CSA pillars.

Adaptation	Mitigation	Food Security
Climate resilient crop varieties are better adapted under drought and flood conditions. Pest and disease resistant cultivars can mitigate the spread of pests and illnesses caused by climate change.	Crop cultivation during the dry season can also help with carbon sequestration. Pesticides are used less when disease-resistant crops are grown.	Cultivation of climate tolerant crop varieties increases yield even under stress conditions and helps to promote food and nutrition security.

Community Seed Banks: A Community Seed Bank (CSB) is a method of protecting plant genetic resources, boosting farming communities' access to local germplasms, and producing and distributing quality seeds on a local scale. Through the production and distribution of high-quality seeds, CSBs can be a feasible means of generating agro-biodiversity-based income for farming communities (Joshi et al., 2018). CSBs protect and promote local and farmer-preferred improved varieties for food security, while also improving the lives of smallholder farming communities in marginal and risky locations. CSB is now a farmer's institution where farmers' seeds are gathered, stored, and sold to seed businesses and other farmers. In the context of climate change, CSBs play an important role. Seed conservation and promotion of local and improved varieties are critical for providing seeds amid crop losses due to drought, flood, disease, and pests. CSBs have also been generating and disseminating enhanced seeds of drought and flood-tolerant rice varieties (Sahbaghi series and DRR 42, 43, 44), which are crucial in climate change adaptation. CSBs can be constructed in Uttarakhand's three agroecological zones. In the following ways, CSBs contribute to the CSA pillars.

Adaptation	Mitigation	Food Security
CSB can supply seeds even in extreme climatic condition and disasters. CSB may manufacture and distribute a wide range of crop variety seeds, including local and climate adaptable enhanced varieties.	Not Applicable	Improved seeds provided from CSB increase crops yield. During a crisis, locally tailored seed provided by CSB can reduce crop loss and help to food security.

Exercise: List several CSA technologies and practises appropriate for various agro-ecological locations.

- Participants are divided into groups as per geographical region and one group leader is selected in each group.
- They will be asked to list out different CSA technologies and practices that are useful for their regions.
- They categorize the list of technologies and practices as per their geographical location.

Session 3. Poultry and Livestock-based CSA technologies and practices suitable for Mountain, Hill, and Terai region of Uttarakhand.

In Uttarakhand, livestock accounts for around 29.3% of total agricultural GDP contribution. Milk and milk products account for 17.6% of livestock gross domestic product, meat for 2.5%, and eggs for 0.5% (Ministry of Agriculture and Farmers Welfare, Government of India, fiscal year 2019-20). Climate change has a negative impact on water availability, fodder production, rangeland and pasture quality, agricultural output, creating hunger and worsening animal health. Climate change is projected to exacerbate livestock systems' vulnerability and amplify current factors affecting livestock production systems, such as rapid population and economic growth, increased demand for food and food products, and conflict over finite resources. By the end of this session, participants will know and will be able to categorize various livestock and poultry-based climate-smart technologies and practices suitable for their location.

Poultry based Climate Smart Technologies in Uttarakhand

Climate Smart Housing for Poultry: To cope with extremely hot and cold climatic conditions, commercial chicken farming requires climate-smart housing with enough drinking and feeding facilities. Climate-smart housing not only reduces the risk of adverse weather conditions, but it also reduces labour requirements. In terms of poultry shed orientation, south-east facing is preferred for tropical climates and northwest facing for alpine climates since it minimises excessive hot and cold conditions in hotter and colder places. A cemented floor with dry rice husk bedding material is required for poultry farming to protect birds from cold and moist circumstances, whereas unplasticized Polyvinyl Chloride (UPVC) is excellent for roofing to protect poultry from extremely hot and cold weather. Furthermore, an automatic cooling and heating system is required to protect chickens from extreme heat and cold. The regular flow of fresh air under the shed through the exhaust fan, the removal of the roofing, and strict adherence to the procedures serve to reduce the occurrence of disease and parasites in the poultry.

Stress tolerant high – yielding breeds of poultry: The adaptation of breeds to different climates is critical to reducing poultry losses caused by climate change. The adaptive capacity of chicken to increased water and temperature stress is already low and is rapidly deteriorating. Because poultry requires a short to medium production period, there is always a high danger of failure owing to climatic stress. There are several stress-tolerant high-yielding breeds of poultry in Uttarakhand, including Kadaknath, Vanaraja, Aseel, Rhode Island Red, and Plymouth Rock. These breeds are well-adapted to the local climate and farming conditions, and are known for their fast growth rates, high egg production, and good meat quality. By selecting these breeds, farmers can maximize their production and profitability while minimizing the impact of climate stressors on their flocks.

Feed Management of Poultry: Commercial chicken farming relies on concentrate feeding, which accounts for 60 to 70% of overall production costs. Poultry farming is becoming more expensive as the price of concentrate feed rises. Scientific feed formulation is required to ensure that all nutrients are well integrated, including vital amino acids and probiotics that aid bird digestion in poor climatic circumstances. The amount and timing of concentrate ration feeding is particularly important for protecting poultry from unfavourable weather conditions and increasing meat/egg production. To cope with the situation, more protein-rich feed is required during the cold season and less during the warm and hot seasons. Aside from concentrate feeding, some low fibre green leafy grass and insect larvae must also be included in chicken diet. Improved breeds can produce more meat/eggs when supplemented with 20% green grasses and insect larvae. Local breeds can be grown by supplying 50% concentrate diet and the remaining 50% from scavenging.

Livestock based CSA technologies in Uttarakhand:

Climate wise livestock management should prioritise the research and deployment of technologies that contribute to the triple-win goal of increased productivity, climate change adaptation and resilience, and climate change mitigation through decreased GHG emissions. Food security is improved by increased animal output. Adaptation tactics can boost livestock productivity's resilience to climate change, while mitigation efforts can greatly minimise livestock's influence on climate change. Some of the smart livestock strategies that contribute to the triple win aim are listed below.

Breed management: Low producing ruminants, particularly indigenous (local or less producing) breeds, consume a substantial proportion of their feed intake for maintenance, resulting in a greater level of emission per unit of product. However, more productive animals emit less methane per unit of product. On the contrary, it is well recognised that increased milk output and lean tissue accretion increase basal/metabolic heat generation. having high-producing animals for increased output also implies having animals that are more susceptible to heat stress. Furthermore, indigenous (local or less productive) breeds are better adaptable to climatic threats. Thus, increasing the production capacity of indigenous breeds that are better able to deal with climate hazards results in reduced emissions per unit of product without compromising adaptability capabilities. Breed improvement of indigenous breeds could be accomplished through genetic selection, in which the finest ones are chosen for breeding based on desirable features, or through crossbreeding with high producing breeds. Breed improvement eventually leads to the production of the same number of products with fewer animals, lowering overall GHG emissions.

Feed Management: Proper feed management is essential for the health and productivity of livestock. In Uttarakhand, farmers can adopt feed management practices such as silage making and stall feeding. Silage making involves storing green fodder in airtight conditions, which can help farmers to provide quality fodder to their livestock even during the lean season. Stall feeding involves feeding animals in a confined space, which can help in reducing wastage of fodder and improving the quality of feed.

Crop Residues Treatment: Climate Smart Crop Residues Treatment refers to the sustainable management of crop residues after harvest that can help to reduce greenhouse gas emissions, improve soil health and fertility, and increase agricultural productivity. This includes practices such as incorporation, mulching, composting, controlled burning, and using crop residues as animal feed. By adopting climate-smart crop residues treatment practices, farmers can reduce their environmental footprint, improve soil quality, and contribute to climate change mitigation and adaptation efforts.

Silage Feeding: Following a scarcity of feed supplies and their quality, especially during times of seasonal feed scarcity, is critical to maintaining productivity and metabolic activity. Silage production is an efficient method of preserving fodder. Silage could be made from maize, sorghum, Napier, and other grains. Crops are collected about 50% flowering stage, chopped, wilted to reduce moisture content to 65-70%, and stored in a silo pit under anaerobic conditions for approximately 2 months. Silage can be fed at a rate of 5kg per animal at first for adjustment, and then fed like green fodder afterwards. This indicates that while silage can be used as a substitute for green grass during the lean season, it is preferable to feed green grass during the abundant season.

Pasture Management/ Control of pasture grazing:

Higher quality pasture feed promotes higher feed efficiency, increased nutrient absorption, and lower GHG emissions. Furthermore, forages with broad root systems aid in carbon sequestration in soil, boosting soil water holding capacity, enhancing grassland biodiversity, and protecting against erosion. Pasture can be effectively managed by sustainable grazing management practises such as reducing grazing pressure on overstocked sites, seeding improved pastures, and rotational grazing. Promoting adaptable pasture species will also be critical in minimising grazing land vulnerability to climate change. The agricultural system produces about 70% of worldwide N_2O emissions, which are caused by soil biological processes such as nitrification (the oxidation of NH_3^+ to NO_2^- and NO_3^-) and denitrification (the reduction of NO_3^- to N_2). Denitrification requires the substrate NO_3^- generated by nitrification. Controlling nitrification is thus the most efficient way to reduce N_2O emissions. To restrict nitrifying activity, several plants naturally synthesise and release nitrification inhibitors from their roots. Perennial grasses such as Brachiaria decumbens (Signal grass), Brachiaria brizantha (bread grass), and Brachiaria mutica (Para grass), as well as the annual forage Sorghum bicolour (Sorghum or big millet), have previously been planted in Uttarakhand's mid hills and Terai region. These organisms have the ability to suppress biological nitrification.

1. **Biogas Management:** Manure's gas emissions and leaching of nutrients, organic materials, and odour have negative environmental consequences. Efficient manure treatment can minimise GHG emissions while increasing agricultural yield. Small biogas plants based on animal faeces are built at the Village level in Uttarakhand. The biogas technique creates manure energy while reducing GHG emissions by replacing firewood, kerosene, and various chemical fertilisers.
2. **Control of animal diseases related to climate change (Vector-borne diseases):** The intensity and distribution of infections and their vectors are indirectly correlated with climate change's impact. The rise and reemergence of vector-borne diseases is more evidence of the interplay between human and animal health and climate change. In addition, zoonotic infections account for 75% of developing animal diseases. Therefore, surveillance, early diagnosis, treatment, and control of such diseases are increasingly crucial.
3. **Shed improvement and Manure Management:** Shed improvement and management are essential to sustainable livestock production. Shed improvement refers to upgrading animal housing facilities to provide a comfortable and safe environment. Manure management involves properly appropriately storing and disposing of animal waste to prevent environmental pollution and promote soil health. Here is a brief overview of these two practices:

Shed Improvement:

- **Adequate space and ventilation:** Proper ventilation and adequate space are crucial for maintaining healthy animals. This can be achieved by installing fans, windows, and proper ventilation systems in the shed.
- **Flooring and bedding:** The type of flooring and bedding used in the shed can affect the animal's health and comfort. Materials such as straw, sawdust, and sand can be used for bedding, while concrete or other sturdy materials can be used for flooring.
- **Lighting**: Proper lighting is essential for animal health and productivity. This can be achieved by installing artificial lighting or using natural light sources.

Manure Management:

- **Collection and storage:** Manure should be collected and stored in a designated area away from water sources and human habitation. This can be achieved by constructing a separate manure pit or composting facility.
- **Composting:** Composting is a natural process that breaks down manure into a nutrient-rich fertilizer that can be used for crop production. This can be achieved by piling the manure in a designated area and allowing it to decompose naturally or by using a compost bin or tumbler to speed up the process.
- **Nutrient management planning:** Nutrient management planning involves using manure and other organic materials to improve soil fertility while minimizing the risk of environmental pollution. This can be achieved by developing a nutrient management plan that outlines the appropriate amount and timing of manure application.

In conclusion, shed improvement and manure management are crucial components of sustainable livestock production. By adopting practices that provide a comfortable and safe environment for animals while managing manure in a way that promotes soil health and reduces environmental pollution, farmers can improve the productivity of their livestock while minimizing their environmental impact.

Module 4.

Integrated Gender Equality and Social Inclusion issues in CSA Planning Implementation and Monitoring.

Time required	**Day 2, 2nd Half**
Material Required	**Marker pen, white board, paper and projector.**

Overview

Women play a vital part in agriculture since they are more interested in farming outside of household tasks. Women account for 43 percent of agricultural labour force in developing nations, with significant variance among regions and countries (FAO, 2011). It is critical that women farmers have access to information, services, resources, and technologies in order to boost workload efficiency and bring about transformational changes in the agricultural sector.

This module informs learners about how climate change affects women and provides an overview of women's interdependence with agriculture and climate change. It also introduces participants to significant national policies concerning climate change and agriculture, gender-responsive budgeting, and women-friendly strategies for reducing women's drudgery in agriculture.

Objectives

At the end of the module, participants will be able to:

- identify the relationship between women, agriculture, and climate change.
- internalise the importance of gender integration in CSA.
- learn about women-friendly CSA practises.
- Recognise gender policy provisions in agriculture and climate change.

Session 1. Importance of gender and social inclusion and its interconnection in Uttarakhand agriculture system.

Women, agriculture, and Climate change in Uttarakhand

Uttarakhand, a hilly state in northern India, heavily relies on agriculture, which employs about 70% of its population. Women farmers play a crucial role in this sector, representing about 70% of the agricultural workforce. However, they face significant challenges due to climate change. Over the past three decades, Uttarakhand has experienced a temperature increase of about 0.6°C, leading to changes in rainfall patterns and more frequent extreme weather events such as floods and landslides. These changes have also affected cropping patterns, with some crops becoming less viable and others more suitable. Unfortunately, women farmers in Uttarakhand face multiple gender-based barriers such as limited access to credit, information, and technology, as well as cultural and social norms that restrict their decision-making power and mobility. Nonetheless, adopting climate-resilient agriculture practices and supporting women-led initiatives such as self-help groups and women-led cooperatives can help women farmers in Uttarakhand adapt to the impacts of climate change and empower them.One of the main challenges that women farmers in Uttarakhand face is erratic weather patterns. Extreme weather events such as droughts, floods, and landslides have become more frequent, resulting in crop failures, reduced yields, and losses. This affects the income of women farmers who often depend on agriculture for their livelihoods.

To support women farmers in Uttarakhand, there is a need for policies that address the specific challenges that they face. This includes increasing access to credit, inputs, and technology. There is also a need for policies that support the adoption of climate-resilient farming practices and promote sustainable agriculture. Finally, there is a need to promote gender equality in agriculture and ensure that women farmers have equal access to resources and opportunities.

Climate Change and women workload.

According to Bhatta (2015), climate vulnerability has a greater impact on women than on men, as women are not only directly exposed to nature but also affected by migration and the feminization of agriculture, especially in rural areas. Women's vulnerability is further compounded by their involvement in daily farming activities and their limited ability to respond to risks. Climate change has led to prolonged drought periods, resulting in an increase in weeds that must be removed, which is primarily the responsibility of women. As a result, women's workload has increased due to the effects of climate change. The impact of climate change on women is also influenced by changes in rainfall patterns, such as decreased frequency and intensity, which can lead to drying up of water sources, erratic rainfall or drought, and an increase in pests, diseases, and weeds. These changes affect women's ability to adapt to their environment. The migration of men from rural areas also directly affects women's daily lives and agricultural workload. Women face several constraints, such as poverty, lack of education, skills, and income, which limit their access to information and opportunities to explore alternative livelihood options within agriculture and off-farm sectors. These factors contribute to the challenges that women face in adapting to climate change.

Session 2. Assessing CSA Tools, Technologies, and Practices

The use of tools and technologies that reduce the workload and save time can encourage women to participate in farming and increase agricultural productivity. There are several low-cost innovations available that can help reduce women's physical strain and increase farm productivity, making women more resilient to climate change. By utilizing such tools and technologies, women can effectively manage their agricultural work and contribute to the overall growth of agriculture.

While implementing Climate-Smart Agriculture (CSA), it is essential to consider that not all practices may be gender-friendly, and some innovative technologies identified by research may not be adopted by farmers. Thus, the initial step for the implementation of CSA should involve a need assessment to search and select appropriate tools and technologies. Women-friendly tools and practices that are suitable for a particular context are more easily adopted by the community. Two important criteria for selecting CSA technologies and practices are: they should either contribute to or improve the conditions of women and poor farmers, or at the very least, not harm them. It is crucial to consider the potential impact of CSA practices and technologies on different groups of farmers and ensure that they are inclusive and equitable.

Table 8. The pool of technologies/tools and practises is further refined based on how these practises improve or do not hurt women's situations and positions. For context and location-specific gender-friendly CSA, additional indicators for each of the criteria are being developed.

Criteria I. Condition of Women	**Criteria II. Position of Women**
Time Saving and Drudgery	Leadership skill and role
Access to Knowledge	Influencing decision making
Income	Recognition
Nutrition	
Health	

Here are few examples of women friendly time saving tools to reduce the women workload	
	**Jab Planter:** Jab planter is a seed showing tool. This machine can reduce people and livestock requirements for land preparation and seed showing. It is a lightweight and single women can easily handle it for showing in line.
	**Millet thresher:** Traditionally millet threshing is time consuming and labour intensive. Millet thresher is time saving.
	**Corn sheller:** Electric Small corn sheller is a simple tool to separate maize seed from the cob. It is portable, inexpensive, easy to operate and available in the market. This machine is timesaving and reduces injuries and blisters for women farmers.
	**Farm rake:** Women are mostly responsible for cleaning animal shed, removing and cutting weeds. Farm rake is one of the tools for women to cut or remove weeds. This tool is equally useful in collecting cow/buffalo dung in animal shed leaving women's hand clean and unwounded.

Session 3. Gender Sensitive CSA planning, implementation, and monitoring:

Women's increased workload due to climate change has resulted in adverse effects on their health, income, safety, nutrition, and empowerment. Climate challenges have exacerbated their existing marginalization and limited their access to knowledge, technologies, climate finance, and infrastructure. Integrating gender in CSA requires considering the status of gender inequality in project sites and communities to plan, implement, and monitor interventions. Basic information on gender disparities should be used to guide the selection of appropriate interventions that address the unique challenges faced by women in agriculture.

Consideration while planning CSA:

- Gender analysis and mapping of roles: It is important to understand the engagement of men and women in farming activities and also analyse the differential impact of climate change in the local context. This analysis will give a background of the vulnerability status of women based on which CSA interventions can be identified/developed.
- Identification of CSA actions and interventions that improve the condition and position of women: Identification of women responsive technologies, practices suitable at the local context will help to improve the condition of the women.
- Identification of targeted communication materials and specific training and capacity building needs.

Consideration while implementing CSA:

- Production of simple but effective communication means to reach women as males and females have different capacities to understand the information. Even the capacity of women to understand and read knowledge products are not homogenous in Uttarakhand. Hence, attention should be paid while generating knowledge products targeting women in different parts of Uttarakhand.
- Consider how the identified interventions benefit women and men equally also make sure the identified interventions for CSA do no harm to women.
- Women and men may not access information from the same place or same way. Hence, it is important to make sure suitable time, locations and right resource person is selected for training to benefit men and women equally.
- Eliminate any kind of discrimination between men and women while implementing the CSA intervention. Consider that women equally participate in the planning, design, testing and implementation of CSA interventions.

Consideration while monitoring and evaluating CSV:

- Monitoring and evaluation for the effectiveness of CSA tools for women: After the selection and promotion of CSA tools and technologies, it is necessary to carefully monitor the effectiveness of the technologies and practices before we go for large-scale promotion.
- To assure if climate-smart agriculture technologies and interventions implemented are gender-responsive, the following additional criteria and indicators can be used in CSA framework.

Criteria	Indicators	Positive	Neutral	Negative
Condition of women	Time saving and drudgery reduction			
	Access to knowledge			
	Income			
	Assets			
	Nutrition			
	Health			
Position of women	Leadership Skill and role			
	Influencing decision making			
	Recognition			

Module 5.

Learning from the field, Action Plan Preparation, and Closing

Time required	**One Day**
Material Required	**Marker pen, white board, paper and projector.**

Overview

During this practical session, participants are separated into different mixed groups based on the number of participants and given orientation and information about the farming communities as well as the tasks they are expected to complete in groups. A field trip will be organised for groups in a community where CSA practises have been put in place. Each group interacts with farmers and their institutions, raising concerns about the strategy and specific initiatives. Participants can also make ideas to individual farmers and farmer groups on the site for improving the technology they use in their operations.

After the field visit, participants are asked to identify the communities' climate vulnerability and suggest appropriate CSA technologies and practises to better address the problems while taking agro ecology, technical feasibility, and farmer affordability into account. Each group is tasked with developing a CSA action plan to recommend agricultural communities for implementation in the visited place.

Objectives

At the end of this module, participants will be able to:

- Develop action plan to reduce climatic risk of a specific area.

Session 1. Field visit to CSA demonstration sites

Procedure:

- The participants are divided into mixed groups each comprising of 5-6 members and a group leader is selected.
- Prior to the field trip, the group will be given information about the visiting communities as well as the tasks that must be completed.
- Participants go to CSA demonstration sites.
- Based on field observations and community involvement, each group is required to identify climate vulnerability and develop their own CSA action plans.
- Each group will also identify prospective CSA technologies and practises, as well as diverse stakeholders who will play roles in their implementation.
- The facilitators will provide the necessary assistance for the group exercise; and
- The group leader from each group is asked to make the presentation and feedback and suggestions are provided by facilitator.

Session 2. Participant’s reflection and facilitator’s remark and feedback collection

After completing the regular sessions, the facilitator hands over the session to the organiser for reflection, evaluation, and closure. The organiser will ask participants to provide honest feedback on the training outcome, session delivery, venue, and logistics so that it can be used to improve future training sessions. Similarly, available facilitators will be asked to share their thoughts and comments with the participants and organisers.

Participatory evaluation

An assessment of the participant’s level of technical knowledge acquisition and comprehension can be used to gauge the effectiveness of the training. The organiser can create a questionnaire in advance with the help of the facilitators, which will be used to evaluate the participants before and after the training.

Session 3. Closing Ceremony.

At the end of the session, certificates are distributed to the participants. At the programme’s closing is done by the organizer by thanking all the participants for their active participation and for making the training programme successful.

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