PART C: Sector-wise Training Modules, Curriculum and Materials

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World Wide Fund for Nature (WWF) Nepal
Managing Watersheds for Enhanced Resilience of Communities to Climate Change in Nepal (MaWRiN) Project
Sindhuli, Nepal

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1. FORESTRY SECTOR

1.1 Climate-Resilient Forestry Training

The Climate Smart Forestry (CSF) training has been designed for Community Forestry User Groups (CFUGs) and other stakeholders of the project area. The aim is to equip the users with the knowledge and skills needed to manage Community Forests (CFs) on a sustainable basis while adapting to and mitigating the impacts of climate change in the CFs. This training emphasizes practices that enhance forest productivity, increase carbon sequestration, and improve the resilience of forest ecosystems. By integrating local knowledge with appropriate techniques, the participant of the training can optimize land use, protect biodiversity, and generate sustainable livelihoods by managing their forests properly. The training also fosters user's awareness on the importance role of CFs in climate regulation, encouraging active participation in conservation and sustainable forest management practices.

Summary of community forests in the project area

Over 143 CFUGs covering more than 31,000 hectares of CFs are managing the forests for their basic forest needs such as fuelwood, fodder and timber and earning income by selling the excess of the forest products. Similarly, over 119 Leasehold Forest groups covering over 740 hectares of forest are managing their forests for poverty alleviation (Source: MaWRiN, 2022)

1.2 Proposed Training Curriculum and Materials

Modules	Training
Module 1	Climate Change Impacts in Forestry Sector of Nepal
Module 2	Role of Forests in Minimizing Climate Change Impacts
Module 3	Identification of Adaptation Options in Forestry Sector of Nepal
Module 4	Climate-resilient sustainable forest management practices
Module 5	Ecosystem-based Adaptation (EbA) in Forestry
Module 6	Low-Cost Techniques and Practices for Forest Fire Prevention, Control and Management in Changing Climate Context
Module 7	Monitoring and Evaluation of Effectiveness of CCA Actions
Module 8	Mainstreaming Gender Equality, Disability, and Social Inclusion (GEDSI) in Climate Change Adaptation Efforts in Forestry Sector of Nepal
Module 9	Integrating CCA in the Community Forest Operational Plan Revision
Module 10	harmonizing human-wildlife conflict (hwc) through adaptive strategies
Module 11	Nursery manage techniques for raising climate-resilient varieties

Module 1: Climate Change Impacts in Forestry Sector of Nepal

Climate change poses a significant and multifaceted threat to the forestry sector worldwide, including in Nepal. Its impacts are not just about a slight shift in temperature; they involve complex changes that directly affect forest health, productivity, biodiversity, and the ecosystem services they provide. Nepal's forestry sector (forests and other wooded land), which covers 44.74% of the country's geographical area[1] and supports the livelihoods of approximately 60% of the population directly[2], is highly vulnerable to the impacts of climate change. Forest resources are the second largest natural resource in Nepal after water and play a crucial role in the country's economic development. These impacts manifest in various ways, posing significant threats to forest ecosystems, biodiversity, and the communities that depend on them. The key climate change impacts on the forestry sector are described below.

1. Altered Temperature and Precipitation Regimes

a) ***Rising Temperatures:***

- Stress on tree species: Many tree species are adapted to specific temperature ranges. Rising temperatures can push them beyond their physiological limits, leading to stress, reduced growth, and increased mortality.

Weather condition in Sindhuli district

Period	Max Temp *C	Min Temp *C	Precipitation (mm)
Pre-monsoon	29.6	16.1	205.4
Monsoon	30.0	22.0	1,376.3
Post-monsoon	26.8	14.8	80.9
Winter	7.8	-	36.2
Annual	27.2	15.8	1,698.8

Source: MaWRiN project document, 2022

- Shift in species distribution: As temperatures warm, suitable habitats for certain tree species may shift northward or to higher altitudes. Species unable to migrate quickly enough, or those at their upper elevational/latitudinal limits (e.g., in mountain environments like the Himalayas), face decline or extinction in their current locations.
- Earlier phenology: Warmer temperatures can cause earlier bud burst, leafing, and flowering. This can lead to "phenological mismatch" with pollinators or other organisms that rely on specific timing, disrupting ecosystem processes. It also increases vulnerability to late spring frosts.

b) ***Changes in Precipitation Patterns***

- Increased drought frequency and intensity: More frequent and severe droughts weaken trees, making them more susceptible to pests, diseases, and fires. Prolonged droughts can lead to "carbon starvation" as trees close their stomata to conserve water, limiting photosynthesis.
- Increased extreme precipitation and flooding: Heavy rainfall events can lead to soil erosion, nutrient loss, landslides, and direct damage to trees. Flooding can stress trees and alter forest composition, particularly in riparian zones.
- Altered snowpack: Reduced snowpack due to warmer winters affects water availability in spring and summer, particularly for forests reliant on snowmelt. It can also lead to soil freezing and root damage.

2. Increased Frequency and Intensity of Disturbances

- ***Wildfires:*** Warmer temperatures, prolonged droughts, and drier vegetation create ideal conditions for more frequent, larger, and more intense wildfires. These fires can destroy vast forest areas, release significant amounts of carbon, and hinder regeneration.

[1] MoFSC, 2016. Forestry Sector Strategy (2016 – 2025), Ministry of Forests and Soil Conservation (MoFSC), Government of Nepal, Babarmahal, Kathmandu, Nepal.
[2] Forest Research and Training Centre. (2019). An Assessment of Nepal's Forestry Sector's Contribution to Sustainable Development Goals (SDGs), Forest Research and Training Centre (FRTC), Ministry of Forests and Environment, Kathmandu, Nepal.

- ***Insect outbreaks and diseases:*** Warmer winters allow more insect pests to survive, leading to larger populations and more severe outbreaks. Stressed trees (due to drought, heat) have reduced defenses, making them more vulnerable to attack by insects and pathogens. Climate change can also expand the geographical range of these pests and diseases.
- ***Storms and extreme weather events*:** Increased frequency and intensity of storms (e.g., windstorms) can cause significant physical damage to trees (uprooting, snapping trunks and branch breakage), leading to widespread tree mortality and altered forest structure.

3. Impact on Forest Ecosystem Services

- ***Biodiversity loss:*** Shifts in species ranges, increased mortality from stress and disturbances, and the spread of invasive species can lead to a decline in forest biodiversity, impacting the resilience and health of ecosystems.
- ***Water regulation:*** Forests play a crucial role in regulating water cycles, including groundwater recharge and streamflow. Climate change impacts like reduced snowpack, altered rainfall, and increased droughts can diminish this capacity, affecting water availability for human use and downstream ecosystems.
- ***Soil health and stability:*** Increased erosion from heavy rainfall and landslides, coupled with the loss of forest cover, can degrade soil quality and stability, further exacerbating the risk of natural disasters.
- ***Carbon sequestration:*** While forests are vital carbon sinks, severe disturbances (wildfires, large-scale pest outbreaks, drought-induced mortality) can turn them into carbon sources, releasing stored carbon back into the atmosphere, creating a positive feedback loop that accelerates climate change. The ability of forests to sequester carbon may also be impacted by physiological stress.
- ***Impacts on livelihoods:*** Forest-dependent communities, particularly in countries like Nepal, rely on forests for firewood, fodder, timber, non-timber forest products, and traditional medicines. Climate change impacts directly threaten these resources, affecting food security, income, and overall well-being.

Impact of floods and landslides

Heavy monsoon rains have resulted in floods and landslides in 32 districts across the country from 1 July 2019 to 1 August 2019. Specifically, a total of 222 landslides were recorded throughout the country, with Udaypur and Sindhuli districts being two of the most affected districts. The Ministry of Home Affairs (MoFA, 2019) had confirmed 117 dead, 38 people missing, and 80 people have been injured. According UNICEF (2019), over 413,572 people, with 59,565 children, have been affected. Along with the large loss of life, significant damage to assets, housing, water and sanitation, infrastructure, crops and livestock have been reported.

Source: World Vision, 2019 (Available from: *https://www.worldvision.org.sg/sites/default/files/nepal_floods_and_landslide_sit1_20190826.pdf*)

- ***Economic impacts:*** Damage to forests from climate change can reduce timber yields, increase costs for forest management and restoration, and impact industries that rely on forest products.

4. Invasive Species

- Climate change can create new opportunities for invasive plant and animal species to establish and spread, outcompeting native species and disrupting forest ecosystems.

In summary, climate change is profoundly altering the fundamental characteristics and functions of forest ecosystems. These changes are not isolated but interact in complex ways, often amplifying each other's negative effects. Understanding these impacts is the first step towards developing effective adaptation and mitigation strategies for the forestry sector.

Module 2: Role of Forests in Minimizing Climate Change Impacts

Forests play an incredibly important and multifaceted role in minimizing climate change impacts, acting as both a critical part of climate change *mitigation* (reducing the causes of climate change) and *adaptation* (adjusting to the actual or expected impacts of climate change). The importance and roles of forests in minimizing climate change impacts are described below.

I. Role of Forests in Climate Change Mitigation (Reducing Greenhouse Gases)

The primary way forests mitigate climate change is by regulating the Earth's carbon cycle. The key roles and functions of forests in reducing greenhouse gasses include:

- ***Carbon Sequestration (Carbon Sinks)***
    - Photosynthesis: Trees and other forest vegetation absorb carbon dioxide (CO_2) from the atmosphere during photosynthesis, converting it into organic matter (biomass) in their leaves, branches, trunks, and roots. This process effectively removes a major greenhouse gas from the atmosphere.
    - Long-term storage: The carbon is then stored in the living biomass (above and below ground), dead wood, litter, and forest soils. Old-growth forests, in particular, can store vast amounts of carbon over long periods.
    - Global impact: Forests currently absorb approximately 2.6 billion tons of carbon dioxide annually[3], which is about one-third of the CO_2released from burning fossil fuels. This makes them one of the most important natural carbon sinks on the planet.
    - Sustainable forest management: Practices like afforestation (planting new forests), reforestation (re-establishing forests on deforested land), and sustainable forest management (which allows for continuous carbon uptake while providing forest products) enhance forests' capacity to sequester and store carbon.

Forests fights the climate crisis

Healthy forests are powerful carbon sinks, meaning they absorb and store carbon dioxide. Estimates show that globally, between 2001-2019, forests absorbed twice as much carbon as they emitted, or 7.6 billion metric tons of CO2 per year. Therefore, forests provide a crucial capacity to remove greenhouse gases (GHG) from the atmosphere and help us avoid the worst impacts of the climate crisis. According to findings from the Intergovernmental Panel on Climate Change (IPCC), the agriculture, forestry, and other land use (AFOLU) sector can provide up to 30 percent of the GHG emissions reductions needed to limit global warming to 2°C, at a relatively low cost.

Source: UNDP (2023). Forests can help limit climate change-here is how. (Available from: https://climatepromise.undp.org/news-and-stories/forests-

Carbon trade by Nepal

Nepal has earned US$ 2.87 million from carbon trading in the Fiscal Year 2023/24. About 6 million tons of carbon has been sold through, whereas in Last year, it recorded minimization of carbon emission by 542,000 tons.
Source: https://risingnepaldaily.com/news/51164

- ***Reduced Emissions from Deforestation and Degradation (REDD+)***
    - Preventing carbon release: When forests are cleared or degraded (e.g., through unsustainable logging or forest fires), the carbon stored in their biomass is released back into the atmosphere as CO_2. Preventing deforestation and forest degradation is therefore a crucial mitigation strategy, as it avoids these emissions.
    - REDD+ initiatives: Programs like REDD+ (Reducing Emissions from Deforestation and Forest Degradation) financially incentivize developing countries to protect and sustainably manage their forests, recognizing their global value as carbon sinks.

[3] IUCN, 2021. Issues Brief: Forests and Climate Change. Available from: https://iucn.org/resources/issues-brief/forests-and-climate-change

- ***Substitution of Fossil Fuel-Intensive Products***
    - Sustainable production of forest products (timber as well as non-timber products): Wood from sustainably managed forests can be used as a renewable resource for construction, furniture, and other products, effectively storing carbon for the lifetime of the product.
    - Bioenergy: In some cases, sustainably sourced biomass can be used as a renewable energy source, replacing fossil fuels. For example, the dried leaves and litter in the forest can be utilized to make bio-briquettes, which supplies renewable energy and at the same time helps to reduce forest fire hazards. However, the carbon neutrality of bioenergy depends on the sustainability of sourcing and the overall lifecycle emissions, making it a more complex mitigation strategy.

Los of forest area in Nepal due to Climate Change

Intergovernmental Panel on Climate Change projections showed approximately 10% of species to be at an increasing high risk of extinction for every 1 °C rise in global mean temperature and recommended to limit global temperatures below 1.5 °C. To identify consequences of climate change, impacts, and implications, data collected from different sources, reviewed, assessed and analyzed, discussing dimensional impacts and mitigation strategies adopted. Nepal's 118 major ecosystems and 75 vegetation types with 44.74% forestland comprising 0.1% of global landmass harboring 3.2% flora and 1.1% fauna of the world's biodiversity critically influenced by the regional climate change and intervention of developmental projects. Since 2000, Nepal lost forest area by 2.1% including several endangered and threatened species. Nepal is highly vulnerable towards natural disasters like GLOF, Glacier retreat, flooding, landslide and global warming. Therefore, it is crucial to plan climate resilience infrastructures adopting effective environmental management tools, formulation of strong plan, policy and strategy, mitigation of greenhouse gases, climate resilient adaptation and restoration of degraded ecosystems.

Source: Bhatta, 2020. Consequences of Climate Change Impacts and Implications on Ecosystem and Biodiversity; Impacts of Developmental Projects and Mitigation Strategy in Nepal (https://www.intechopen.com/chapters/75490)

II. Role of Forests in Climate Change Adaptation (Building Resilience)

Beyond mitigating greenhouse gas emissions, forests play a vital role in helping natural and human systems adapt to the impacts of a changing climate. Some of the key roles of forests in climate change adaptation are as below.

- ***Water Cycle Regulation***
    - **Water retention and recharge:** Forest canopies intercept rainfall, slowing its descent, and their extensive root systems enhance soil infiltration, reducing surface runoff and increasing groundwater recharge. Forest soils, rich in organic matter, act like sponges, absorbing and storing large quantities of water. This helps maintain stable water supplies, particularly during dry seasons, and moderates streamflow.
    - **Flood and drought mitigation:** By regulating water flow, forests reduce the severity of floods during heavy rainfall and help maintain base flows in rivers during droughts, enhancing water security for communities and ecosystems.
    - **Improved water quality:** As water filters through forest soils, it undergoes natural purification, removing sediments and pollutants, thus providing cleaner water.
    - **Local climate regulation (Evapotranspiration):** Forests release water vapor into the atmosphere through evapotranspiration, contributing to cloud formation and local rainfall, and creating a cooling effect. This can help moderate local temperatures, particularly in hot climates, and influence regional weather patterns.

- ***Soil Conservation and Landslide Prevention***
    - Erosion control: Tree roots bind soil particles together, significantly reducing soil erosion caused by wind and water, especially on steep slopes.
    - Landslide stabilization: In mountainous regions like Nepal, forests are crucial for stabilizing slopes, preventing landslides, and reducing the risk of debris flows, which are often exacerbated by extreme rainfall events linked to climate change.

Example of Damage of floods and landslide

In September 2024, heavy rainfall triggered widespread floods and landslides across Nepal, including in the Sindhuli district, causing significant damage in Marin Rural Municipality. Specifically, 31 houses in the Bitijor area of Golanjor Rural Municipality-2 were damaged, and the harvest was also affected. The floods and landslides also buried fields prepared for paddy transplantation. The disruption of transportation networks due to landslides further complicated rescue and relief efforts.

(Source: https://myrepublica.nagariknetwork.com/news/flood-and-landslide-damage-31-houses-in-sindhuli, Republica, 2023)

- ***Biodiversity Conservation***
    - Habitat provision: Forests are home to a vast proportion of the world's terrestrial biodiversity. Conserving forest biodiversity enhances ecosystem resilience, making them better able to withstand and recover from climate change impacts like pests, diseases, and extreme weather.
    - Genetic diversity: A diverse gene pool within forest species increases the likelihood that some individuals or populations will possess traits that enable them to adapt to changing climatic conditions.
    - Ecosystem function: Healthy, biodiverse forests provide a wider range of ecosystem services, which are essential for human well-being in a changing climate.
- ***Local Climate Moderation (Microclimates)***
    - Shade and cooling: Forest canopies provide shade, reducing ground temperatures. Evapotranspiration further contributes to a cooler, more humid microclimate within and around forests, mitigating the "urban heat island" effect in cities and providing cooler refugia for wildlife and people.
    - Wind breaks: Forests can act as natural windbreaks, protecting agricultural lands and settlements from strong winds and reducing soil moisture loss.
- ***Livelihood Support and Resilience***
    - Diversified resources: For forest-dependent communities, healthy forests provide essential resources such as food, fodder, firewood, timber, and non-timber forest products (NTFPs). Maintaining these resources builds resilience against climate-induced shocks to other livelihood sources (e.g., crop failures due to drought).
    - Safety net: Forests can act as a "safety net" during periods of stress, providing alternative food and income sources when agricultural production is affected by climate change.

In conclusion, forests are not merely passive victims of climate change; they are active agents in both slowing its progression and helping human live with its effects. Protecting, restoring, and sustainably managing forests are thus indispensable strategies for a climate-resilient future.

Module 3: Identification of Adaptation Options in Forestry Sector

Nepal's forestry sector faces significant challenges from climate change, including increased temperatures, erratic rainfall, droughts, floods, landslides, forest fires, and invasive species. Given the deep reliance of many rural communities on forest resources for their livelihoods, adapting the forestry sector is crucial for both environmental sustainability and human well-being. Some key climate change adaptation options for the forestry sector in Nepal are described as below.

1. Enhancing Forest Management Practices for Resilience

- ***Sustainable Forest Management (SFM):*** Implementation of SFM principles that prioritize ecological health, biodiversity, and long-term productivity of forests. This includes practices like:
    - Reduced impact logging: Minimizing damage to remaining trees and the forest ecosystem during timber harvesting.
    - Scientific forest management: Utilizing scientific knowledge to guide decisions on species selection, planting, thinning, and harvesting to promote healthier, more resilient forests.
    - Adaptive management: Continuously monitoring forest conditions and adjusting management strategies in response to observed climate change impacts.

- ***Strengthening Community and Leasehold Forest Users:*** Empowering local communities and user groups to manage their forests effectively, incorporating climate change considerations into their operational plans. This involves:
    - Revision of Operational Plans (OPs) and Constitutions: Integrating climate change adaptation measures into the rules and practices of Community Forest User Groups (CFUGs).
    - Capacity building: Providing training and knowledge to local communities on climate change impacts, adaptation strategies, and sustainable forest management techniques.

- ***Forest Fire Management:*** Developing and implementing comprehensive forest fire prevention and control strategies, including:
    - Extension Education: Raising awareness among local communities about forest fire risks and prevention methods.
    - Firefighting Training and Equipment: Equipping and training local communities and forest personnel to effectively combat forest fires.
    - Controlled Burning: Employing controlled burning where appropriate to reduce fuel loads and prevent larger, more destructive fires.

- ***Bio-engineering and Erosion Control:*** Utilizing biological and engineering techniques to stabilize slopes, prevent landslides, and control soil erosion, especially in vulnerable hilly areas. This can involve planting specific species like bamboo.

- ***Grazing Regulation:*** Managing livestock grazing in forest areas to prevent overgrazing, which can degrade forest health and increase vulnerability to climate impacts.

- ***Pest and Disease, and Invasive Species Management:*** Monitoring and controlling outbreaks of pests and diseases, and spread of invasive species (*Banmara*) that may be exacerbated by changing climatic conditions.

- ***Conservation of Forest Biodiversity:*** Protecting and enhancing the diversity of forest species and ecosystems, as diverse ecosystems are generally more resilient to environmental changes. This includes in-situ and ex-situ conservation approaches.

2. Promoting Agroforestry and Livelihood Diversification

- Developing and Promoting Suitable Agroforestry Systems: Integrating trees with agricultural crops and livestock on the same land. This offers multiple benefits for climate change adaptation, including:
    - Soil quality improvement: Through the use of nitrogen-fixing trees and increased organic matter.
    - Microclimate regulation: Tree canopies provide shade and reduce wind, benefiting crops and livestock.
    - Diversified income sources: Providing various forest products (firewood, fodder, timber, non-timber forest products) and agricultural yields, reducing reliance on single crops.
    - Improved water retention: Trees help in water infiltration and retention.

- ***High-Value Crops and Non-Timber Forest Products (NTFPs):*** Encouraging the cultivation of climate-resilient, high-value crops like cardamom, and sustainable harvesting and marketing of NTFPs. This can provide alternative income sources and reduce pressure on traditional forest products.

- ***Alternative Energy Sources:*** Promoting the use of alternative energy sources like biogas and improved cooking stoves to reduce reliance on firewood, thereby decreasing deforestation and forest degradation pressures.

3. Policy and Institutional Frameworks

- ***National Adaptation Plans (NAPs) and Local Adaptation Plans for Action (LAPAs):*** Integrating forestry-specific adaptation strategies into national and local development planning. Nepal has already developed these frameworks, which are crucial for systematic adaptation.

- ***Reducing Emissions from Deforestation and Forest Degradation (REDD+):*** While primarily a mitigation mechanism, REDD+ initiatives in Nepal are designed to also contribute to adaptation by promoting sustainable forest management, enhancing forest carbon stocks, and providing co-benefits for local communities and livelihoods. This includes:
    - Clarifying carbon rights and benefit-sharing mechanisms: Ensuring equitable distribution of benefits from REDD+ activities to local communities.
    - Community-based REDD+: Focusing on empowering local communities in REDD+ implementation.

- ***Mainstreaming Climate Change:*** Integrating climate change considerations into all levels of forest policy, planning, and implementation, from national ministries to local forest user groups.

- ***Knowledge Management and Dissemination:*** Enhancing research, data collection, and sharing of information on climate change impacts and effective adaptation practices within the forestry sector.

- ***Capacity Building of Communities and Stakeholders:*** Providing training and resources to government officials, local communities, NGOs, and other stakeholders involved in forest management.
- ***Securing and Mobilizing Financial Resources:*** Mobilizing financial resources from national budgets, international climate funds, and private sector investments to support adaptation initiatives.

4. Research and Monitoring

- ***Vulnerability Assessment:*** Conducting detailed, field-based studies to assess the vulnerability of different forest ecosystems and forest-dependent communities to climate change.
- ***Climate-Resilient Forest Management System:*** Utilizing geospatial tools and techniques to identify "adaptation footprints" – areas highly sensitive to climate change and degradation – to prioritize intervention.
- ***Monitoring and Evaluation:*** Establishing robust systems to monitor the effectiveness of adaptation interventions and track changes in forest health, biodiversity, and ecosystem services.

Module 4: Climate-Resilient Sustainable Forest Management Practices

Climate-resilient Sustainable Forest Management (CRSFM) practices are essential for the sub-watersheds of MaWRiN project area, which is highly vulnerable to climate change impacts, yet heavily reliant on its forest resources for livelihoods and ecosystem services. CRSFM goes beyond traditional sustainable forest management by explicitly integrating strategies to adapt to and mitigate climate change.

I. Core Principles of Climate-Resilient Sustainable Forest Management

- ***Adaptive management:*** Acknowledging uncertainty, CRSFM is a continuous cycle of planning, implementation, monitoring, evaluation, and adjustment based on new climate data and the effectiveness of interventions.
- ***Ecosystem-based Approach (EbA):*** Focusing on maintaining and enhancing the health, integrity, and diversity of forest ecosystems, as healthy ecosystems are naturally more resilient to stress.
- ***Participatory governance:*** Ensuring that local communities, who are most dependent on forests and often most affected by climate change, are central to decision-making, planning, and implementation.
- ***Integration with broader landscape*****:** Recognizing that forests are part of larger social-ecological systems. CRSFM considers interactions with agriculture, water resources, and human settlements.
- ***Multi-functional forests:*** Managing forests for multiple benefits (timber, NTFPs, carbon sequestration, water regulation, biodiversity, soil stabilization, tourism) rather than a single output.

II. Key Practices for Climate-Resilience

1. Enhancing Forest Biodiversity and Genetic Diversity

- Species diversification: Moving away from monocultures to mixed forest composition. It requires planting and promoting the natural regeneration of a wide variety of native tree species, including those with different tolerances to drought, heat, pests, and diseases. This provides a "portfolio" of species, increasing the chance that some will thrive under changing conditions.
- Genetic diversity: Collecting seeds from a broad range of parent trees within a species to maintain genetic variation, which is the raw material for adaptation
- Promoting indigenous species: Prioritize native species that are well-adapted to local ecological conditions and often have traditional uses.

2. Adaptive Silvicultural Practices

- Uneven-aged management and structural diversity: Promoting mixed-age stands and varied tree sizes (uneven-aged management). This creates a more structurally diverse forest, which is often more resilient to disturbances and provides diverse habitats.
- Reduced-impact logging: If timber harvesting occurs, use techniques that minimize damage to residual trees, soil, and water quality.
- Thinning and pruning: Strategic thinning to reduce competition, improve tree vigor, and create fire breaks. Pruning can enhance timber quality and reduce ladder fuels.
- Longer rotation periods: Although forest management practices in the sub-watersheds have poorly adopted the rotation periods for planting and harvesting, in some cases

particularly in plantation forests, extending rotation periods can allow trees to grow larger, sequester more carbon, and develop stronger root systems, enhancing stability.

- Natural regeneration: Prioritizing and facilitating natural regeneration processes where possible, as naturally regenerated seedlings are often more robust. It is also important to supplement with planting when natural regeneration is insufficient, using climate-resilient seedlings from well-managed nurseries.

3. Forest Fire Management (Crucial in the Project Area)

Integrated fire management: A shift from reactive fire suppression to proactive, community-based approaches. This includes the following approaches or activities:

- Fuel load reduction: Regular collection of dry leaves, deadwood, and undergrowth, especially near human settlements. This can be combined with sustainable fuelwood collection or biomass energy initiatives.
- Fire lines: Establishing and maintaining strategic fire lines/breaks.
- Early warning systems: Implementing community-based fire detection and alert systems (e.g., using mobile apps, watchtowers, forest watchers or local volunteers).
- Community fire brigades: Training and equipping local community members (CFUGs) in basic firefighting techniques and safety.
- Controlled burning: Where ecologically appropriate and with expert supervision, using prescribed or controlled burning before the dry season to reduce fuel load.
- Awareness campaigns: Continuous public education on fire causes, prevention, and impacts.

4. Water Resource Management

- Spring source protection: Protecting forest areas around vital water sources (springs, streams) through conservation and reduced disturbance.
- Enhancing soil moisture: Practices like contour trenching, mulching, and promoting deep-rooted vegetation to increase water infiltration and retention in the soil.
- Erosion control: Implementing measures like terracing, gabions, and planting vegetation on steep slopes to prevent soil erosion and landslides, which are exacerbated by erratic rainfall.

5. Pest and Disease Management:

- Monitoring and early detection: Regular surveillance for new or escalating pest and disease outbreaks.
- Integrated pest management (IPM): Employing biological controls, promote natural predators, and maintain forest health to reduce susceptibility. Avoiding widespread chemical use that can harm beneficial organisms.
- Diversity as defense: A diverse forest is inherently more resistant to large-scale outbreaks, as pathogens are less likely to spread through a single susceptible species.

6. Integration with Livelihoods and Socio-Economic Resilience

- Sustainable Non-Timber Forest Products (NTFP) management: Promoting the sustainable harvesting and value addition of NTFPs as a diversified income source, reducing over-reliance on timber.

- Agroforestry: Integrating trees into agricultural landscapes (e.g., homegardens, alley cropping, silvopastoral systems). This diversifies farm income, improves soil fertility, provides shade, and offers microclimate regulation benefits.
- Eco-tourism: Developing community-based eco-tourism initiatives that provide alternative livelihoods and create incentives for forest conservation.
- Access to climate finance: Helping local governments and CFUGs access national and international climate finance mechanisms (e.g., REDD+, Green Climate Fund, UNDP/LoCAL) for implementing CRSFM activities.

7. Capacity Building and Knowledge Management

- Training: Providing ongoing training for CFUG members, local government officials, and forest staff on climate change science, CRSFM techniques, monitoring, and adaptive planning.
- Knowledge exchange: Facilitating sharing of best practices and lessons learned among different CFUGs and regions.
- Local and scientific knowledge integration: Combining traditional ecological knowledge with scientific research and climate modeling data for more effective strategies.
- Monitoring and data-driven adaptation: Implementing robust monitoring systems (e.g., forest health, carbon stock, HWC incidents, water availability, climate parameters) to evaluate the effectiveness of CRSFM practices and inform adaptive adjustments in the forest operational plans.

Like elsewhere in Nepal, the Community Forest User Groups (CFUGs) are the primary actors for implementing CRSFM practices in Sindhuli district. Their Operational Plans (OPs) are the key documents that need to explicitly integrate these climate-resilient strategies, moving beyond traditional resource extraction to focus on ecosystem health, climate adaptation, and diversified, resilient livelihoods. The ongoing collaborations between government agencies (e.g., DFO, BRCRN, President Chure Conservation Program), local governments, forestry related organizations (e.g., FECOFUN) and NGOs, and other development partners (e.g., Heifer, WWF Nepal) are crucial for providing technical support, training, and policy guidance for effective CRSFM implementation across the country.

Module 5: Ecosystem-based Adaptation (EbA) in Forestry

Ecosystem-based Adaptation (EbA) is a powerful and increasingly recognized approach to addressing the impacts of climate change. At its core, EbA is about working with nature to help people and ecosystems adapt to a changing climate. It leverages the inherent services and resilience of healthy ecosystems to reduce vulnerability and build adaptive capacity. Ecosystem-based adaptation (EbA) should be integrated into broader adaptation and development strategies to maintain and increase resilience and reduce vulnerability of ecosystems and people to adverse effects of climate change. The Convention on Biological Diversity (CBD) defines EbA as: "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change[4]. This definition highlights three key aspects:

- Uses biodiversity and ecosystem services: EbA recognizes the inherent value of natural systems and the benefits (services) they provide, such as clean water, fertile soil, flood regulation, and pollination.
- Part of an overall strategy: EbA is rarely a standalone solution but is integrated into broader adaptation and development plans. It complements other adaptation approaches, including technological and infrastructural solutions.
- Helps people adapt: The ultimate goal of EbA is to reduce the vulnerability of human communities to climate change impacts and enhance their ability to cope with and respond to climate-induced changes.

Key Principles of EbA

1. Holistic and integrated: EbA considers the interactions between human and natural systems, recognizing their interdependence. It goes beyond single-sector interventions.
2. Focus on resilience: Instead of merely resisting impacts, EbA aims to enhance the ability of ecosystems and human communities to absorb shocks, recover, and adapt to new conditions.
3. Sustainable management, conservation, and restoration: EbA involves proactive measures to maintain and improve the health and integrity of ecosystems. This includes protecting existing healthy ecosystems, restoring degraded ones, and managing them sustainably.
4. Provides multiple co-benefits: Beyond climate adaptation, EbA interventions often deliver a range of other benefits, such as biodiversity conservation, improved livelihoods, carbon sequestration (climate change mitigation), food security, improved water quality, and recreational opportunities. These "win-win" outcomes make EbA a highly attractive approach.
5. Context-specific and participatory: EbA solutions are tailored to local ecological and socio-economic conditions. They emphasize engaging local communities, leveraging their traditional knowledge, and ensuring equitable outcomes.
6. Adaptive management**:** Recognizing the uncertainties of climate change, EbA promotes a flexible and iterative approach, where interventions are monitored and adjusted based on new information and changing conditions.

Ecosystem-based Adaptation addresses climate change impacts by:

- Reducing exposure: For example, healthy mangrove forests act as natural barriers, reducing the impact of storm surges on coastal communities.

[4] Secretariat of the Convention of Biological Diversity, 2009. Connecting Biodiversity and Climate Change Mitigation and Adaptation. CBD technical Series No. 41 (Available from: https://www.cbd.int/doc/publications/cbd-ts-41-en.pdf)

- Reducing sensitivity: Diverse agroforestry systems can make farming communities less sensitive to drought by providing shade, improving soil moisture, and diversifying crop options.
- Increasing adaptive capacity: Empowering communities to sustainably manage their local forest resources increases their ability to make informed decisions and respond to climate risks.

Ecosystem-based Adaptation (EbA) in Forestry

Ecosystem-based Adaptation (EbA) in forestry, within the context of climate change, is a Nature-based Solution (NbS) that strategically utilizes the biodiversity and services provided by forests to help human communities and ecosystems cope with the adverse impacts of a changing climate. It's about working with nature, rather than solely relying on engineered solutions, to build resilience. The EbA in forestry involves conservation, sustainable management, and restoration of forest ecosystems to reduce vulnerability of people and the environment to climate change impacts. It recognizes that healthy, diverse forests can provide a multitude of services that directly or indirectly buffer against climate hazards, such as:

- Regulating water flows: Forests act like sponges, absorbing rainfall and releasing it slowly, which helps to mitigate floods and provide water during droughts.
- Preventing soil erosion and landslides: Tree roots stabilize soil, crucial in hilly and mountainous regions prone to extreme rainfall events.
- Providing natural barriers: Coastal forests (like mangroves, though not strictly "forestry" in the same sense as terrestrial forests, they exemplify the principle) can protect against storm surges and sea-level rise.
- Supporting livelihoods: Healthy forests provide timber, non-timber forest products (NTFPs), and opportunities for ecotourism, diversify income and reducing reliance on traditional agriculture.
- Maintaining biodiversity: Diverse forests are more resilient to pests, diseases, and climate shifts, ensuring the continued provision of ecosystem services.
- Carbon sequestration: While primarily a mitigation benefit, healthy, growing forests also sequester carbon, contributing to climate stability.

Contribution of Forests to EbA in the Climate Change Context

Forests are powerful allies in climate change adaptation due to their multi-functional nature:

1. Water regulation: As rainfall patterns become more erratic (intense downpours followed by prolonged dry spells), forests help manage water. Intact forest catchments ensure a steady supply of clean water, reduce peak flows during floods, and recharge groundwater.
2. Disaster risk reduction: For communities living in mountain valleys or on slopes, healthy forests significantly reduce the risk of landslides, soil erosion, and flash floods, which are exacerbated by extreme weather events.
3. Temperature moderation: Forest cover provides shade and contributes to local cooling through evapotranspiration, mitigating the impacts of rising temperatures and heatwaves, especially in urban or peri-urban areas.
4. Biodiversity conservation and genetic resources: Climate change threatens biodiversity. By conserving and restoring forest ecosystems, EbA helps maintain genetic diversity, crucial for species to adapt to changing conditions and for future ecosystem resilience.
5. Livelihood diversification and food security: Forest products can offer alternative income sources when climate-sensitive agriculture fails. Agroforestry systems (integrating trees

into farmlands) can provide shade, improve soil fertility, and offer diversified food sources, making livelihoods more resilient.

6. Pest and disease resistance: Diverse and healthy forest ecosystems are generally more resistant to pest outbreaks and diseases, which can become more prevalent or severe under changing climatic conditions.
7. Microclimate regulation: Forests create localized microclimates that can be more stable than surrounding open areas, providing refugia for sensitive species and habitats.

Some examples of EbA in Forestry in a Climate Change Context are:

- Afforestation and reforestation with climate-resilient species: Planting native tree species that are well-suited to projected future climatic conditions (e.g., more drought-tolerant species in areas expecting less rainfall, or species adapted to higher temperatures). In Nepal, this could mean selecting species for community forests that are more resilient to the drying trends and increased fire risk.
- Restoration of degraded forest watersheds: Restoring forests in degraded mountain slopes or critical water catchments using bioengineering techniques (e.g., planting trees and shrubs, building check dams with natural materials) to reduce landslide risk, control erosion, and improve water quality and availability for downstream communities.
- Agroforestry systems: Integrating trees into agricultural landscapes (e.g., planting fruit trees, nitrogen-fixing trees, or fodder trees) to provide shade for crops/livestock, improve soil fertility, prevent erosion, and diversify farmer incomes against climate shocks.
- Sustainable forest management (SFM): Implementing SFM practices that prioritize ecosystem health, biodiversity, and the sustained provision of ecosystem services, rather than solely timber extraction. This includes selective logging, fire-wise forestry practices (as discussed previously), and promoting natural regeneration.
- Community-based forest management (e.g., CFUGs, Leasehold forestry): Empowering local communities to manage their forests sustainably. This local ownership and traditional knowledge can be highly effective in implementing EbA measures, as communities have a direct stake in the health and resilience of their forest resources.
- Establishment of riparian buffers: Planting or restoring vegetation along rivers and streams stabilizes banks, filter pollutants, and provides shade, which helps maintain water quality and temperature for aquatic life, especially as water temperatures rise.
- Forest corridors and protected areas: Establishing or expanding protected areas and ecological corridors allows species to shift their ranges in response to climate change.

Benefits of EbA in Forestry for Climate Resilience

- Cost-effectiveness: Often more affordable than "grey" infrastructure (e.g., concrete walls, dams) and can be self-sustaining with proper management.
- Multiple co-benefits: Provides benefits beyond adaptation, including biodiversity conservation, livelihood improvements, carbon sequestration, improved air and water quality, recreational opportunities, and cultural values. This makes them "no-regrets" or "low-regrets" options.
- Sustainability: Builds on natural processes and ecological integrity, leading to more sustainable and long-lasting solutions.
- Community empowerment: Often involves local communities directly in planning and implementation, fostering ownership and strengthening local adaptive capacity.
- Flexibility and adaptability: Natural systems can adapt to some degree to changing conditions, making EbA inherently more flexible than rigid engineering solutions.

Module 6: Low-Cost Techniques and Practices for Forest Fire Prevention, Control and Management in Changing Climate Context

Forest fire management in the context of climate change is a critical and evolving challenge. The traditional approaches to fire management, while still important, must be adapted to address the amplified risks and altered fire regimes brought about by a warming planet. Climate change impacts forest fires and the strategies for managing them needs to be adapted to the changing climate context.

How Climate Change Amplifies Forest Fire Risks

Climate change directly and indirectly intensifies forest fire activity in several ways:

- ***Increased temperatures:*** Higher average temperatures lead to drier vegetation and soil, making them more flammable. This also extends the "fire season," the period when conditions are conducive to fires. Nepal, for instance, has seen prolonged dry conditions and rising temperatures contributing to a surge in forest fires, especially in the pre-monsoon season (March–May).
- ***Altered precipitation patterns****:* Climate change can lead to more frequent and severe droughts, which dry out forests and grasslands, creating vast amounts of combustible fuel. Conversely, heavier rainfall events in some areas can lead to increased vegetation growth, which then dries out and becomes fuel. Nepal has experienced reduced rainfall and drier winters, exacerbating drought severity and increasing fire vulnerability.
- ***Increased lightning strikes*****:** Warmer air holds more moisture, leading to more intense thunderstorms and a higher incidence of lightning strikes, a natural ignition source for wildfires, particularly in remote areas.
- ***Changes in weather patterns:*** Climate change can bring more extreme wind events, which fan flames, accelerate fire spread, and make fires harder to contain and predict.
- ***Pest and disease outbreaks:*** Warmer winters and altered precipitation patterns can favor the spread of forest pests (like the mountain pine beetle) that kill trees, creating vast swaths of deadwood that serve as highly flammable fuel.
- ***Carbon emission loop:*** Forest fires release massive amounts of carbon dioxide and other greenhouse gases into the atmosphere, further exacerbating global warming, creating a dangerous feedback loop. This is a significant concern for Nepal, where forest fires contribute to carbon emissions.

Incidents of forest fires in Sindhuli

Each year, an average of 3,000 forest fires incidents were recorded in Nepal from 2012 to 2024 and in Sindhuli it is around 750 incidents during the period.

Source: Shrestha et al., 2025. Forest fires in Nepal: The unseen threats of droughts, ICIMOD. Available from: https://blog.icimod.org/cryosphere-water-risks/forest-fires-in-nepal-the-unseen-threat-of-droughts/

Forest fires pose a significant threat to ecosystems, livelihoods, and infrastructure. Although large-scale, technologically advanced solutions exist, many communities in Nepal cannot afford the technology and hence require low-cost, accessible techniques and practices for effective prevention, control, and management. The low-cost approaches for forest fire prevention, control and management, focusing on community involvement and sustainable practices is described below.

I. Prevention: Stopping Fires before they start

Prevention is the most cost-effective strategy for forest fire prevention, control and management. The following measures can be adopted for prevention of forest fire.

A. Community Engagement and Awareness

- Education campaigns: Simple workshops, informational flyers, and public service announcements (e.g., through local radio or community meetings) can raise awareness about fire risks, safe burning practices, and the importance of reporting fires.
- School programs: Engaging children in fire safety education can create a culture of fire awareness from a young age.
- Traditional knowledge integration: Many indigenous and local communities have long-standing practices for living with fire. Integrating this traditional ecological knowledge into modern prevention efforts can be highly effective and culturally appropriate.
- Volunteer networks: Establishing and supporting local volunteer groups for fire prevention activities (e.g., clearing brush, maintaining firebreaks) leverages community labor and strengthens local capacity.

B. Fuel Management (Reducing Flammable Material)

- ***Manual Fuel Reduction***
  - Underbrush clearing: Removing dry grasses, shrubs, and dead leaves from the forest floor. This can be done with simple hand tools like rakes, hoes, and machetes.
  - Thinning: Selectively removing smaller, unhealthy, or crowded trees to create more space between tree crowns, reducing the chance of a surface fire escalating into a crown fire. This can be done with hand saws or small chainsaws.
  - Pruning: Removing lower branches from trees to increase the "ladder fuel break" (the distance from the ground to the lowest branches), making it harder for fire to climb into the canopy.

- ***Creation of Fire Lines or Firebreaks***
  - Manual clearing of fire hazards: Fire line or firebreaks are the barriers constructed to slow or stop the progress of a wildfire by removing combustible material (fuel) from its path. Establishing strips of land where all flammable vegetation is cleared down to mineral soil is one of the best forest fire prevention measures. The core principle behind a fire line is to break the "fire triangle" – the three elements necessary for a fire to burn: fuel, oxygen, and heat. A fire line primarily works by removing the fuel element. The fire lines can follow natural features (natural firebreaks) like ridges or streams, or utilize existing roads and trails. Man-made fire lines can also be created specifically for fire management.
  - Grazing: Controlled grazing by livestock can help reduce fine fuels like grasses and weeds in specific areas.
- ***Controlled/Prescribed Burning***
  - Under strict conditions and with trained personnel, intentionally setting small, low-intensity fires can reduce accumulated fuel loads, mimicking natural fire cycles. This is a highly effective, though potentially risky, prevention tool when done correctly.

C. Safe Practices for Human Activities

- Campfire safety: Educating campers and visitors on how to build, maintain, and fully extinguish campfires (drown, stir, and feel method).
- Responsible debris burning: Providing guidelines and, if necessary, permits for burning agricultural or garden waste, emphasizing safe distances from flammable materials and favorable weather conditions.

- Equipment maintenance: Encouraging proper maintenance of vehicles, chainsaws, and other equipment to ensure spark arrestors are functional and to prevent hot exhausts from igniting dry vegetation.
- No smoking zones: Designating areas where smoking is prohibited, especially during dry seasons.

II. Control

Control means suppressing fires when they occur. Prompt and effective initial attack is crucial for low-cost control. The following measures can be adopted for fire control.

A. Early Detection and Reporting

- Local lookout towers/observation posts: Strategically placed vantage points where trained individuals can spot smoke. Volunteers can be manned during high-risk seasons.
- Community patrols: Organized groups of local residents who patrol high-risk areas, especially during dry periods, to identify and report fires quickly.
- Mobile phone networks: Establishing clear communication channels and encouraging community to report fires immediately via mobile phones to a designated authority.

B. Initial Attack/Response and Suppression

- Hand tools: Equipping local communities and first responders with basic tools like shovels, rakes, axes, and fire swatters. These are effective for suppressing small fires and creating fire lines.
- Water buckets and pumps: Utilizing readily available water sources (rivers, ponds) with buckets or small, portable pumps for direct application on small fires.
- Dirt/soil application: Smothering small fires with dirt to cut off oxygen.
- Back burning/back fire: It is the process of lighting vegetation in such a way that it has to burn against the prevailing wind. This produces a slower moving and more controllable fire. In certain situations, intentionally burning small areas ahead of a wildfire to create a firebreak, removing fuel in the path of the main fire. This is a more advanced technique that requires training and careful management.
- Community fire brigades: Training and organizing local community members into volunteer fire brigades with basic fire suppression skills and equipment.

III. Fire Management with Integrated and Long-Term Strategies

Effective management of forest fire involves a holistic approach that integrates prevention and control. The following measures can be adopted for effective management of forest fires.

A. Integrated Fire Management Plans

- Risk mapping: Simple mapping exercises using local knowledge to identify high-risk areas, potential ignition sources, and vulnerable assets.
- Seasonal preparedness: Developing and communicating seasonal fire plans, including designated fire-fighting teams, communication protocols, and evacuation routes.
- Resource inventory: Knowing what resources (water sources, tools, trained personnel) are available within the community.

B. Post-Fire Recovery and Rehabilitation

- Erosion control: Implementing simple measures like contour trenching or planting fast-growing groundcover to prevent soil erosion after a fire.

- Reforestation with fire-resistant species: When replanting, prioritizing native tree species that are more resistant to fire.
- Learning and adapting: Conducting post-fire assessments to learn from each event and adapt future prevention and management strategies.

C. Policy and Governance

- Local policy development: Encouraging local communities to develop their own fire management rules and regulations, building on traditional practices and local needs.
- Partnerships: Fostering collaboration between local communities, forest departments, NGOs, and other stakeholders to share resources, knowledge, and responsibilities.
- Incentives: Exploring ways to incentivize fire-wise practices, such as providing small grants for fuel reduction or recognizing communities with strong fire prevention records.

IV. Adapting Forest Fire Management to Climate Change

Effective forest fire management in a changing climate requires a shift from reactive suppression to proactive, integrated, and adaptive strategies. Some of the climate-informed prevention and fuel management approaches include:

A. Proactive Fuel Reduction

- Strategic thinning and pruning: More aggressive and targeted removal of underbrush, small trees, and lower branches to reduce fuel continuity and prevent crown fires. This needs to consider future climate scenarios and promote fire-resistant species.
- Expanded use of prescribed burns: Carefully planned and executed prescribed burns are essential for reducing accumulated fuel loads under controlled conditions, mimicking natural fire regimes and reducing the risk of catastrophic wildfires. However, this requires greater expertise and more precise weather forecasting given the increased variability.
- Creation of "fire-smart" landscapes: Designing and managing landscapes to be less fire-prone, including strategic placement of firebreaks, utilizing natural barriers (rivers, wetlands), and encouraging fire-resistant vegetation around settlements.

B. Promoting Fire-Adapted Ecosystems

- Species selection: When undertaking reforestation or afforestation, prioritize native tree species and genotypes that are better adapted to future warmer and drier conditions and are naturally more fire-resistant. This could involve "assisted migration" where suitable species are introduced to areas where their current range is predicted to shift.
- Increasing biodiversity: Diverse ecosystems, in terms of species, age, and structure, are often more resilient to disturbances, including fire.

C. Water Resource Management: Given increased drought risk, securing and managing water sources for firefighting becomes paramount. This could involve building artificial ponds or maintaining existing water bodies.

D. Enhanced Early Detection and Monitoring

- ***Advanced technologies:*** While low-cost methods remain vital, integrating them with more advanced, though still accessible, technologies can significantly improve detection.
    - Satellite imagery and remote sensing: Utilizing platforms like MODIS and VIIRS (as implemented in Nepal) for near real-time fire detection, monitoring fire spread, and assessing burned areas.

- Drones: Drones can provide detailed information on fire location, dimension, and evolution, aiding suppression efforts and identifying areas for evacuation.
- Early warning systems: Developing and strengthening sophisticated fire danger rating systems that incorporate real-time weather data (temperature, humidity, wind speed, precipitation) and drought indicators to predict fire risk.

- ***Community-based surveillance:*** Even with technology, well-organized community patrols and a robust reporting system (e.g., via mobile phones) remain crucial for ground-level verification and rapid response, especially in remote areas of Nepal.

In conclusion, forest fire management in a climate-change context demands a paradigm shift. It's no longer just about putting out fires, but about building long-term resilience in ecosystems and communities, understanding the evolving nature of fire, and embracing an integrated, adaptive, and collaborative approach that puts climate change at its core.

Module 7: Monitoring and Evaluation of Effectiveness of CCA Actions

Monitoring and Evaluation (M&E) of Climate Change Adaptation (CCA) actions is crucial for ensuring that interventions are effective, efficient, and truly build resilience in a changing climate. However, it presents unique challenges compared to traditional development M&E.

Challenges of M&E for CCA

The key challenges of M&E for CCA actions are as below:

1. Long timeframes: Adaptation is a continuous process, not a fixed endpoint. The full impacts of adaptation actions may only become evident over decades, far exceeding typical project cycles. This makes it hard to measure long-term success.
2. Moving baselines: Climate change itself is altering the baseline conditions (e.g., rainfall patterns, temperature, sea levels). What constitutes "successful adaptation" can shift as the climate changes, making it difficult to compare "before" and "after" scenarios.
3. Attribution gap: It's hard to definitively attribute observed changes solely to an adaptation intervention, as numerous other social, economic, and environmental factors are simultaneously at play. It's difficult to answer: "What would have happened in the absence of the intervention?"
4. Uncertainty: Climate change projections inherently carry uncertainty. Adaptation plans must be flexible and adaptive, which complicates fixed M&E frameworks.
5. Context-specific: Adaptation is highly localized and context-dependent. What works in one community or ecosystem may not work elsewhere, making standardized indicators difficult to apply universally.
6. Defining "Success": There's no universal consensus on what "successful adaptation" looks like. Is it reducing vulnerability? Increasing adaptive capacity? Avoiding impacts? All of these are relevant but hard to quantify.
7. Data availability and quality: Especially in low-income and remote settings (like many parts of Nepal), baseline data may be limited or non-existent, and data collection capacity can be weak.
8. Measuring "avoided impacts": A key goal of adaptation is to prevent negative impacts. Measuring what *didn't* happen (e.g., how many lives were saved from a flood due to early warning systems) is inherently difficult.
9. Integration with development: Adaptation is often intertwined with sustainable development. Separating adaptation outcomes from broader development outcomes can be complex.

II. Key Principles and Best Practices for Effective Monitoring and Evaluation of CCA

Given the above challenges, M&E for CCA requires a flexible, iterative, and learning-oriented approach as described below.

A. Focus on Learning and Adaptive Management

- M&E for learning: Shift from purely accountability-driven M&E to a "Monitoring, Evaluation, and Learning" (MEL) framework. This emphasizes continuous learning, feedback loops, and adjustments to interventions as new information emerges or conditions change.
- Adaptive management: M&E findings should directly inform adjustments to adaptation strategies, recognizing that plans may need to evolve.

B. Theory of Change (ToC) Approach

- **Clearly articulated pathways:** Developing a clear Theory of Change (ToC) for each adaptation intervention is important. The TOC maps out the assumed causal pathways from inputs and activities to outputs, outcomes, and long-term impacts, explicitly linking them to climate change vulnerabilities and desired resilience. The ToC also helps to identify critical assumptions that need to be monitored and tested.

C. Mixed-Methods Approach (Quantitative and Qualitative)

- Triangulation: Combine quantitative data (e.g., number of hectares reforested, cost of damages avoided, and increase in household income) with qualitative data (e.g., perceptions of vulnerability, changes in community coping strategies, and satisfaction with interventions).
- Participatory M&E: Actively involve local communities, vulnerable groups, and stakeholders in the M&E process. Their local knowledge and lived experiences are invaluable for understanding effectiveness and relevance. This also builds local capacity and ownership.

D. Focus on Indicators across Different Levels

- Impact indicators: Attempt to capture the long-term, fundamental changes in resilience and avoided losses, even if these are difficult to measure directly (e.g., reduced mortality from heatwaves, maintained agricultural productivity despite climate shocks).
- Outcome indicators: Assess the short-to-medium-term changes in adaptive capacity or reduced vulnerability (e.g., increased awareness of climate risks, changes in farming practices, improved access to water during droughts).
- Output indicators: Measure the direct products of the intervention (e.g., kilometers of early warning system installed, number of drought-resistant seeds distributed).
- Process indicators: Track whether the adaptation actions are being implemented as planned (e.g., number of training sessions held, policies formulated, firebreaks created).
- Proxy indicators: Use measurable proxies for hard-to-quantify impacts (e.g., changes in insurance uptake as a proxy for reduced risk perception).

E. Baseline Data and Regular Monitoring

- Establish baselines: Wherever possible, collect robust baseline data *before* intervention implementation to provide a reference point for measuring change.
- Regular data collection: Implement systematic and regular data collection to track progress against indicators.
- Vulnerability reduction: Measure how interventions are reducing the specific vulnerabilities of people and systems to climate impacts.
- Disaggregated Data with equity lens: Collect and analyze data disaggregated by gender, age, ethnicity, socio-economic status, and other relevant factors. This helps understand if adaptation benefits are reaching the most vulnerable and if unintended negative consequences are emerging for specific groups.

Module 8: Mainstreaming Gender Equality, Disability, Social Inclusion in Climate Change Adaptation Efforts in Forestry Sector

Mainstreaming GEDSI in climate change adaptation efforts within Nepal's forestry sector is not just a matter of social justice; it is crucial for ensuring the effectiveness, sustainability, and equity of adaptation interventions. Nepal, with its diverse geography, high climate vulnerability, and significant dependence on forest resources, experiences climate change impacts disproportionately across different social groups. Therefore, mainstreaming GEDSI in climate change adaptation in forestry sector is vital, and it can be achieved through the following measures.

A. Why Mainstream GEDSI in Forestry Climate Adaptation?

1. Differentiated Vulnerabilities and Impacts

- Women: Often bear the primary responsibility for collecting firewood, fodder, and water. Climate change-induced impacts like forest degradation, water scarcity, and increased forest fires amplify their workload, expose them to greater risks (e.g., violence during long treks for resources), and affect their health.
- Dalits, Indigenous Peoples, and other marginalized groups: These groups often live in the most climate-vulnerable areas (e.g., steep slopes, flood plains) with limited access to resources, information, and decision-making power. Their traditional livelihoods, which are often forest-dependent, are highly susceptible to climate shocks.
- People with disabilities: Face significant barriers in accessing information, participating in community discussions, and physically engaging in adaptation activities (e.g., tree planting, forest fire control). They are also at higher risk during climate-induced disasters due to limited mobility and inadequate accessible infrastructure.
- Youth and elderly: Young people may lack experience and resources, while the elderly may have reduced mobility and be more vulnerable to health impacts from climate change.

2. Unique Knowledge and Capacities

- Traditional ecological knowledge: Women, Indigenous Peoples, and local communities possess invaluable traditional knowledge about local ecosystems, weather patterns, and sustainable resource management, which can be crucial for effective adaptation strategies.
- Agents of change: These groups are not merely vulnerable; they are often active agents of change with innovative solutions. Empowering them can unlock significant potential for effective and locally appropriate adaptation.

3. Enhanced Effectiveness and Sustainability

- Inclusive planning: When adaptation strategies are designed with the active participation and specific needs of all groups, they are more likely to be relevant, effective, and adopted by the community.
- Equitable benefit sharing: Ensuring that benefits from adaptation interventions (e.g., income from NTFPs, access to resilient forest products) are distributed equitably prevents exacerbating existing inequalities and promotes social cohesion.
- Reduced conflicts: Ignoring the needs of marginalized groups can lead to resentment, conflicts over resources, and undermine the long-term sustainability of projects.

4. Policy Compliance and Human Rights

- Nepal has national policies and international commitments (e.g., UN Framework Convention on Climate Change, Convention on Biological Diversity) that mandate gender equality and social inclusion in climate action. Mainstreaming GEDSI aligns with human rights principles, ensuring that adaptation efforts "do no harm" and actively promote equity.

B. How to Mainstream GEDSI Climate Change Adaptation in Forestry Sector in Nepal

Mainstreaming GEDSI requires a systematic and transformative approach across all stages of policy, planning, and implementation. Here are some approaches for GEDSI mainstreaming.

1. Policy and Institutional Level

- Policy integration: Ensure that national and sub-national forest policies, climate change policies, and adaptation plans explicitly recognize GEDSI principles and mandate their integration. Nepal's Climate Change Policy of 2019 and updated NDCs already identify GESI as a cross-cutting thematic area, which is a good starting point.
- Resource allocation: Allocate dedicated budgets for GEDSI-responsive activities within forestry and climate change programs. Track gender-responsive budgets to ensure funds reach the intended beneficiaries.
- Institutional capacity building: Provide comprehensive training and capacity building to government officials (federal, provincial, and local), forestry personnel, and community leaders on GEDSI concepts, analysis, and mainstreaming tools.
- Clear roles and responsibilities: Define clear roles and responsibilities for GEDSI integration across different levels of government and within forestry institutions to avoid ambiguities.
- Monitoring and evaluation frameworks: Develop robust GEDSI-sensitive monitoring and evaluation frameworks with disaggregated data (by gender, caste, ethnicity, disability, age, etc.) to track progress, identify gaps, and ensure accountability.
- Functional linkages: Establish strong functional linkages and coordination mechanisms between federal, provincial, and local levels, and across different sectoral ministries (e.g., Forests and Environment, Agriculture, Women, Children and Senior Citizens) to ensure coherent GEDSI mainstreaming.

2. Program and Project Level

- ***Targeted Interventions***
  - Skill building: Provide specific training and capacity-building programs tailored to the needs of different groups (e.g., women's groups on nursery management, people with disabilities on accessible forest product processing).
  - Livelihood diversification: Promote climate-resilient livelihood options that are accessible and beneficial to all groups, considering their unique skills and needs (e.g., mushroom farming, beekeeping, medicinal plant cultivation, ecotourism).
  - Technology access: Ensure equitable access to climate-resilient technologies and practices, addressing any barriers related to gender, disability, or social status.
  - Leadership and empowerment: Support the leadership development of women and marginalized groups in Community Forest User Groups (CFUGs) and other forest

governance bodies. This involves not just representation but also genuine empowerment in decision-making.

- ***Participatory Needs Assessment and Planning***
  - Disaggregated data collection: Conduct gender, disability, and social inclusion analyses at the outset of any project to understand the specific vulnerabilities, roles, knowledge, and needs of different groups.
  - Inclusive consultations: Ensure meaningful participation of women, people with disabilities, Dalits, Indigenous Nationalities, and other marginalized groups in all planning and decision-making processes. This may require:
    - Flexible meeting times and locations.
    - Providing accessible information (e.g., in local languages, Braille, sign language).
    - Childcare support to enable women's participation.
    - Separate consultation groups for marginalized voices if needed to create safe spaces.
    - Respecting Free, Prior, and Informed Consent (FPIC) where Indigenous Peoples are involved.

3. Community and Local Level

- Raising awareness: Conduct awareness campaigns on climate change impacts and adaptation options, explicitly addressing how these affect different GEDSI groups. Use accessible communication methods.
- Challenging social norms: Address traditional social norms and stereotypes that limit the participation and leadership of women and marginalized groups in forest management and climate action.
- Strengthening local institutions: Support CFUGs and other local forest management bodies to adopt GEDSI-responsive operational plans and constitutions. Encourage quotas or specific provisions for marginalized groups in their executive committees.
- Conflict resolution: Develop inclusive conflict resolution mechanisms within communities to address disputes over forest resources, particularly those exacerbated by climate change and potentially impacting marginalized groups.

C. Challenges in GEDSI Mainstreaming in Forestry Sector in Nepal

Despite policy commitments, challenges remain in Nepal:

- Implementation gap: Policies and guidelines exist, but effective implementation at the local level is often hampered by a lack of capacity, resources, and accountability.
- Perception of vulnerability: Marginalized groups, especially women, are often viewed solely as vulnerable, overlooking their knowledge and potential as agents of change.
- Patriarchal structures: Deeply embedded patriarchal social norms and power structures limit women's participation and decision-making in many spheres, including natural resource management.
- Limited disaggregated data: A lack of consistent collection and analysis of gender and socially disaggregated data makes it difficult to assess specific impacts and track progress.
- Geographical barriers and remote areas: Reaching and engaging marginalized communities in remote and geographically challenging areas can be difficult.
- Donor-driven priorities: Sometimes, donor priorities can overshadow genuine, locally-led GEDSI integration.

Module 9: Integrating CCA in the Community Forest Operational Plan Revision

Nepal's community forestry model, which empowers local communities (Community Forest User Groups - CFUGs) to protect, manage and utilize their forests, is recognized globally. However, these forests, and the livelihoods dependent on them, are increasingly vulnerable to climate change impacts. Integrating climate change adaptation (CCA) into community forest operational plans (CFOPs) is therefore not just a good practice, but a necessity. Here are the steps of how CFOP revision can effectively incorporate CCA in the project area, drawing on existing frameworks and current understanding.

The Imperative for CCA Integration in CFOPs

Nepal's forests face direct impacts from climate change, including:

- Increased frequency and intensity of forest fires: Prolonged dry seasons and higher temperatures exacerbate fire risk.
- Floods and landslides due to changes in precipitation patterns: More erratic rainfall, leading to both droughts and intense rain events causing floods and landslides.
- Pest and disease outbreaks: Warmer temperatures can facilitate the spread of pests and diseases.
- Shifts in species distribution: Some tree species may struggle in their current ranges, while others may migrate upwards or to different areas.
- Impacts on Non-Timber Forest Products (NTFPs): Changes in climate can affect the availability and yield of crucial NTFPs.

These impacts directly threaten the ecological health of community forests and the socio-economic well-being of CFUG members. Revising CFOPs to embed CCA strategies is a proactive step to build resilience.

Key Steps for Integrating CCA in CFOP Revision

The revision of a CFOP is a participatory process involving the CFUG, technical experts from the Division Forest Office (DFO), and potentially supporting NGOs. Integrating CCA means adding specific climate change adaptation related considerations and activities throughout this established process. The key steps for CFOP revision with CCA integration are as below:

1. Initiation and Sensitization

- Awareness workshops: The process begins with workshops for CFUG members on local climate change impacts. It will focus on observed changes in the climatic factors, such as "Have you noticed changes in rainfall patterns?", "Are there more fires?", "Are certain plants flowering at different times?". This links the climate change issues to local realities.
- Participatory vulnerability and risk assessment: Facilitate discussions to identify which forest resources, areas, and livelihood activities are most vulnerable to climate change within their specific community forest. Use participatory climate vulnerability and risk mapping tools.
- Forming a multi-stakeholder CFOP revision team: In the initiation phase, form multi-stakeholder CFOP revision teams. Ensure the revision committee includes diverse CFUG members (including women, poor, marginalized, and youth) and technical

personnel (from DFO, local government, or NGOs) who have some understanding of climate change.

2. Information Collection (Climate-Informed) and Analysis

- Forest inventory: Beyond traditional inventory, assess tree health, regeneration success of different species under changing conditions, and indicators of stress (e.g., dead branches, insect damage). Identify climate-sensitive species and other climate change related impacts.
- Hydrological assessment: Map water sources within or around the forest. Assess changes in spring water flow or stream levels.
- Socio-economic survey (climate focus): Understand how climate-related changes in forest resources impact different households' livelihoods, food security, and energy needs. Identify existing traditional coping strategies.
- Data from external sources: Integrate climate projections for the region, fire risk maps, and information on emerging pests/diseases from government agencies or research institutions.

3. Formulating Objectives and Activities (Adaptation Strategies)

The core of the revised CFOP will be the specific actions to enhance climate resilience. These actions should be localized and practical. The following specific CCA actions need to be considered while deciding adaptation strategies during objectives and activities formulation. The following ecosystem0based adaptation (EbA) principles need to be considered and adopted in this step.

- **Biodiversity Enhancement**
  - Species diversification: Promote planting and natural regeneration of a wide variety of native tree species, including those known for drought tolerance, pest resistance, or adaptability to changing conditions. Avoid monocultures.
  - Genetic diversity: Promote the use of seeds from diverse sources within the local region or from areas with slightly warmer/drier climates (assisted migration, carefully considered with technical guidance).
  - NTFP diversification: Encourage the cultivation of climate-resilient NTFP species.
- **Water Resource Management**
  - Spring source protection: Protect forest areas around water sources to maintain water quality and quantity.
  - Water harvesting: Implement techniques like contour trenches, check dams, and small ponds within the forest to improve soil moisture and groundwater recharge.
  - Promote water-efficient practices: Within the CFUG and their agricultural land.
- **Soil Health and Erosion Control**
  - Implement anti-erosion measures like terracing, hedgerows, and minimum soil disturbance during forest operations.
  - Promote mulching to retain soil moisture.
- **Forest Fire Prevention and Management:**
  - Fuel load reduction: Regular thinning, pruning, and removal of dry leaves and debris to reduce combustible material.
  - Fire lines or fire breaks: Maintain and expand effective fire lines.
  - Early warning systems: Establish community-based fire detection and warning systems.
  - Community fire brigades: Train CFUG members in fire suppression techniques, and make provision to equip them with at least basic firefighting tools and equipment.

- Controlled burns: Where appropriate and with expert supervision, use controlled burns to reduce fuel load.

- **Pest and Disease Management:**
  - Regular monitoring for signs of new or escalating pest/disease outbreaks.
  - Promote natural predators or biological control methods.
  - Diversify species to reduce susceptibility to widespread outbreaks.

- **Sustainable Harvesting and Livelihoods:**
  - Adjust harvesting schedules and quotas based on forest health and climate stress.
  - Promote value addition to forest products to reduce pressure on raw material extraction.
  - Diversify livelihoods away from sole reliance on climate-sensitive forest products (e.g., beekeeping, mushroom cultivation, ecotourism).
  - Promote energy alternatives (improved cooking stoves, biogas, solar) to reduce fuelwood pressure.

4. Monitoring and Evaluation (Adaptive Management)

a) Identification of Climate-Specific Indicators: Evaluation and monitoring of adaptive management requires identifying and defining climate-specific indicators, which are the indicators in the OP to track the effectiveness of CCA measures. Some examples of the climate-specific indicators are:
- Number of fire incidents and area burnt.
- Changes in water flow from key springs.
- Survival rate and health of climate-resilient species planted.
- Changes in phenology (flowering/fruiting times).
- Incidence of new pests/diseases.
- Household income diversification.

b) Regular review and learning: The OP should explicitly state that it's a "living document" that will be periodically reviewed (e.g., annually, mid-term) and adapted based on monitoring results and new climate information. This embodies the principle of adaptive management.

c) Financial planning and resource mobilization
- Budget for CCA activities (e.g., purchasing fire-fighting equipment, seedlings for diversified planting, training materials).
- Actively seek funding from local government (municipal/rural municipal climate funds), provincial government, national climate funds (like the Local Climate Adaptive Living Facility - LoCAL), and NGOs.
- Explore potential for Payment for Ecosystem Services (PES) or carbon financing mechanisms (like REDD+ activities) where the CFUG can generate income from their forest's carbon sequestration or other services.

d) Formal approval
- The revised OP, with its integrated CCA components, must be approved by the CFUG General Assembly.
- It is then submitted to the respective Division Forest Office (DFO) for formal approval. The DFO's role is crucial for technical endorsement and ensuring alignment with national forest and climate change policies.

Module 10: Harmonizing Human-Wildlife Conflict (HWC) through Adaptive Strategies

Although human-wildlife conflict is not a big issue in Sindhuli district, few cases of wildlife attack (mainly local leopard, monkey, parrot and wild boar) have been reported in the MaWRiN project area. Harmonizing human-wildlife conflict (HWC) through adaptive strategies is a dynamic and essential approach, especially in a context like community forests along the sub-watersheds where people and wildlife often share landscapes in close proximity. The goal isn't to eliminate all interactions, but to manage negative ones to foster coexistence and prevent harm to both humans and wildlife. Adaptive strategies are key because HWC situations are constantly evolving due to changes in human demographics, land use, climate, and wildlife behavior. The concepts and approaches for harmonizing HWC through adaptive strategies is given below:

Example of human and wildlife conflict in Sindhuli

Elephant attacks are a recurring issue in the district, with wild elephants frequently causing significant damage to settlements in Sindhuli. Around two weeks before 7 March 2023, a wild elephant killed one person and damaged several houses in Ranibas, Kamalamai Municipality-13. highlighting the growing human-wildlife conflict in the area. Around 30 households were damaged by elephant in Sindhuli in 2023 (*Source: Republica, 7 March 2023)*

What is Harmonizing HWC through Adaptive Strategies?

At its heart, harmonizing HWC is about managing the dynamic interface between human and wildlife populations to reduce negative impacts (conflict) and promote positive interactions (coexistence) by continuously learning, adjusting, and improving interventions based on monitoring and feedback. Key principles include:

1. Shift from conflict to coexistence: Moving beyond seeing wildlife as simply a "problem" to be controlled, towards understanding how humans and wildlife can share the landscape sustainably.
2. Holistic and multi-faceted approach: Recognizing that HWC is complex and requires a combination of ecological, social, economic, and policy interventions. There's no "one-size-fits-all" solution.
3. Adaptive management: This is the cornerstone. It's a structured approach to decision-making in the face of uncertainty. It involves:
    - Planning: Setting clear goals and designing interventions.
    - Implementing: Putting strategies into action.
    - Monitoring: Collecting data on the effectiveness of interventions and HWC incidents.
    - Evaluating: Analyzing data to understand what works and what doesn't.
    - Adjusting: Modifying strategies based on evaluation results. This creates a continuous learning cycle.
4. Community participation: Empowering local communities to be central to problem identification, solution design, implementation, and monitoring. Their traditional knowledge, local context, and buy-in are vital.
5. Understanding human dimensions: Recognizing that human attitudes, perceptions, and tolerance levels are as important as wildlife behavior. Strategies must address the social and psychological impacts of HWC.
6. Landscape-level thinking: HWC often occurs across landscapes, not just within a single village or forest patch. Solutions need to consider connectivity, migration routes, and broader land-use planning.

Adaptive Strategies in Action (Examples from other part of the country)

Nepal has a rich experience in community-based conservation and HWC management. Adaptive strategies often involve a blend of traditional wisdom and modern scientific approaches as below:

1. Direct Mitigation Measures (Preventive and Responsive)

These are the "front-line" actions, often adapted based on local experience:

- **Improved Fencing**
  - Electric fences: Continuously monitored and maintained (e.g., through CFUG committees or Buffer Zone User Committees - BZUCs, as seen in areas around Chitwan National Park). Adaptive management here involves adjusting fence design, power, and placement based on how wildlife learns to circumvent them.
  - Live fences: Planting unpalatable or thorny vegetation (e.g., *Simal, Sisnu*) as natural barriers, often combined with other deterrents.
  - Mesh wire fencing: Partially buried to deter burrowing animals like wild boars.

- **Acoustic/olfactory deterrents:** Using noise makers (traditional drums, modern alarm systems), light alarms (solar-powered lights), or pungent substances (chilli fences) that are rotated to prevent habituation.

- **Improved Livestock Management**
  - Predator-proof shed/enclosures: Strengthening night enclosures with reinforced walls and roofs.
  - Herding practices: Increasing vigilance, using guard dogs.
  - Carcass management: Proper disposal of livestock carcasses to avoid attracting predators.

- **Crop Protection**
  - Crop diversification: Exploring less palatable or economically viable alternatives to highly conflict-prone crops (e.g., cultivating ginger, turmeric, or cash crops not favored by wild boars).
  - Synchronized cropping: Encouraging communities to plant and harvest at the same time to reduce the period of crop vulnerability.
  - Field Patrolling: Organizing community patrolling during peak conflict times.

- **Human Safety Measures**
  - Awareness campaigns: Educating communities on safe behavior around wildlife, especially for dangerous species like elephants and bears (e.g., not provoking animals, avoiding solitary movement in certain areas/times).
  - Early warning systems: Using mobile phones or specific alarm systems to alert villagers of approaching dangerous animals.

2. Habitat Management and Ecological Interventions

These aim to reduce wildlife's need to foray into human settlements:

- Forest restoration and enrichment: Improving the quality of habitat *within* the forest/protected area to ensure adequate food, water, and shelter for wildlife. This includes planting native fruit-bearing trees.
- Waterhole creation/maintenance: Developing alternative water sources inside the forest, especially crucial during dry seasons, to prevent animals from seeking water in villages.

- Corridor management: Protecting and enhancing forest corridors to facilitate safe movement of wildlife between protected areas and forest patches, reducing encounters in human-dominated areas.
- Waste management: Proper disposal of household and agricultural waste around human settlements to reduce attractants for animals like bears and wild boars.

3. Community and Social Strategies

These address the human dimension and build tolerance:

- Compensation and relief schemes: Nepal has a government compensation policy for HWC incidents (human death/injury, livestock/crop loss). Adaptive strategies focus on making these schemes more efficient, timely, and accessible. Recently revised guidelines include more species and better coverage for certain losses. Community-based relief funds or insurance schemes can supplement this.
- Community rapid response teams: Training and equipping local volunteers (often from CFUGs) to respond quickly and non-lethally to HWC incidents.
- Conflict resolution and dialogue platforms: Creating spaces for affected communities, conservation authorities, and local government to discuss grievances, share ideas, and find solutions collaboratively.
- Livelihood diversification: Promoting alternative income-generating activities that reduce reliance on conflict-prone agriculture or resource extraction (e.g., ecotourism, sustainable NTFP value chains, beekeeping, improved agriculture not affected by wildlife). This builds economic resilience and tolerance.
- Conservation education and awareness: Ongoing programs to increase understanding of wildlife behavior, the importance of conservation, and best practices for coexistence.
- Empowering local institutions: Strengthening the capacity of CFUGs, BZUCs, and local governments to manage HWC independently and adaptively.

4. Policy and Institutional Strengthening

- Integrating HWC into CFOPs: As discussed above, ensuring that community forest operational plans explicitly include HWC assessment, mitigation strategies, and monitoring.
- Multi-stakeholder coordination: Enhancing collaboration between DNPWC, DFO, local governments, NGOs, research institutions, and local communities for promoting HWC and minimizing human-wildlife conflicts.
- Data collection and monitoring: Establishing robust, standardized systems for reporting HWC incidents, tracking the effectiveness of interventions, and sharing this data to inform adaptive management decisions.
- Research and innovation: Supporting studies on wildlife behavior, effectiveness of deterrents, and climate change impacts on HWC to develop new, adaptive solutions.

Module 11: Nursery Management Techniques for Raising Climate-Resilient Plant Varieties

Raising climate-resilient tree varieties in nurseries is a critical step in sustainable forest management and reforestation efforts, especially in the MaWRiN project area diverse agro-climatic zones and high vulnerability to climate change. The goal is to produce robust, healthy seedlings that have a higher chance of survival and growth in future, potentially more challenging, environmental conditions. The key nursery management techniques for raising climate-resilient varieties include:

I. Strategic Planning and Site Selection

1. Species and Provenance Selection

- Climate-adapted species: Prioritizing native tree species that are naturally adapted to the local climatic conditions (temperature, rainfall patterns, drought tolerance) and are projected to remain suitable under future climate scenarios. Consultation to local climate projections and species distribution models is vital for identifying site-specific climate-adapted species.
- Diversity: Planting a diverse range of species rather than monocultures. Biodiversity enhances overall ecosystem resilience.
- Stress-tolerant varieties: Within a species, selecting provenances (seed sources from a specific geographic location) that exhibit tolerance to stresses like drought, heat, specific pests, or diseases prevalent in the future planting site.
- Assisted migration (cautious approach): For some species, considering introducing germplasm from slightly warmer/drier regions if it's projected that the local climate will shift to resemble those conditions. This must be done carefully with expert guidance to avoid unintended ecological consequences.
- Multi-purpose species: Favor species that provide multiple benefits (timber, fodder, NTFPs, soil stabilization, carbon sequestration) to enhance community resilience.

2. Nursery Site Selection

- Water availability: Ensure a reliable and sufficient water source, especially crucial for future drought conditions. Consider rainwater harvesting or boreholes.
- Drainage: Good drainage is essential to prevent waterlogging, which can stress seedlings.
- Sunlight: Adequate sunlight for healthy seedling growth.
- Accessibility: Easy access for transportation of materials and seedlings.
- Protection: Site should be protected from strong winds, floods, and grazing animals.

II. Seed Collection and Pre-Treatment

1. Source Selection

- Collect seeds from healthy, vigorous 'plus trees' that show natural resilience in challenging environments.
- Ensure genetic diversity by collecting from a sufficient number of parent trees across a population, not just a few individuals.
- Document the precise geographic origin (provenance) of the seeds, including altitude, aspect, and ecological conditions.

2. **Seed Quality:** Only use viable, high-quality seeds. Conduct germination tests.
3. **Pre-Treatment:** Employing appropriate pre-treatment methods (scarification, stratification, soaking) to break dormancy and ensure uniform germination, especially for hardy species.

III. Nursery Infrastructure and Environmental Control

1. **Shade Houses/Nets:** Provide adjustable shade to protect young seedlings from intense sun, especially during heatwaves or for shade-loving species. This helps reduce water stress.
2. **Water Management Systems**
   - Efficient irrigation: Implement water-efficient irrigation techniques like drip irrigation, micro-sprinklers, or hand-watering with watering cans (for small community nurseries) to minimize water loss.
   - Water storage: Invest in tanks or small ponds for water storage to ensure supply during dry periods.
   - Water quality: Ensure water used for irrigation is free from pathogens or excessive salts.
3. **Potting Media**
   - Well-drained and nutrient-rich: Use a potting mix that provides good drainage, aeration, and essential nutrients.
   - Organic matter: Incorporate compost, well-rotted manure, or other organic matter to improve water retention, nutrient availability, and soil structure, reducing reliance on synthetic fertilizers.
   - Local sourcing: Prioritize locally available, sustainable materials for potting mix.
4. **Containers**
   - Appropriate size: Select container sizes that allow for good root development and sufficient growth before out-planting.
   - Root training: Consider root-training containers (e.g., root trainers, polybags with holes) to prevent root coiling and promote a healthier root system, which is crucial for establishment in harsh sites.
   - Eco-friendly alternatives: Explore alternatives to plastic polybags like leaf bags (as pioneered by ICIMOD in Nepal), newspaper pots, or biodegradable pots to reduce plastic pollution and improve root penetration post-planting.

IV. Cultivation and Tending Practices

1. **Sowing and Pricking Out**
   - Sow seeds at optimal density to avoid overcrowding.
   - Prick out seedlings carefully and transplant them into individual containers once they have a few true leaves, minimizing root damage.
2. **Watering Regimes**
   - Strategic watering: Watering deeply and less frequently to encourage roots to grow downwards, mimicking natural drought conditions and making seedlings more drought-tolerant. Superficial watering needs to be avoided.
   - Adjust to weather: Adapt watering schedules based on daily weather conditions (temperature, humidity, rainfall).

3. **Pest and Disease Management (IPM):**
    - ***Integrated pest management (IPM):*** Employ an IPM approach to minimize chemical use. This includes:
        - Hygiene: Maintain strict nursery hygiene to prevent disease spread.
        - Monitoring: Regular inspection for pests and diseases.
        - Biological control: Encourage beneficial insects or use bio-pesticides (e.g., Trichoderma for soil-borne diseases).
        - Cultural practices: Ensure proper spacing, aeration, and watering to reduce disease susceptibility.
        - Quarantine**:** Isolate infected seedlings.
    - ***Stress reduction*****:** Healthy, non-stressed seedlings are naturally more resistant to pests and diseases.

4. **Nutrient Management:**
    - Balanced fertilization: Provide balanced nutrients, often through organic amendments. If using chemical fertilizers, apply them sparingly and according to seedling needs. Over-fertilization can make seedlings soft and vulnerable.
    - Mycorrhizal inoculation: Consider inoculating seedlings with beneficial mycorrhizal fungi, which enhance nutrient and water uptake, significantly improving drought tolerance and overall resilience.

5. **Hardening Off**
    - Gradual acclimatization: Before out-planting, gradually expose seedlings to harsher conditions (reduced watering, increased sunlight, less protection) over several weeks. This prepares them for the rigors of the planting site.
    - Root pruning: For bare-root seedlings, root pruning might be done to encourage a more fibrous root system.

V. Post-Nursery Considerations

1. Transportation: Transporting seedlings carefully to minimize stress and damage to roots and foliage.

2. Site Preparation and Planting: Even the best nursery techniques are wasted if site preparation and planting techniques are poor. So, it needs to be ensured that proper spacing, pit preparation, and planting depth at the out-planting site.

3. Monitoring and Evaluation: Tracking the survival and growth rates of different varieties from the nursery. This feedback loop is crucial for adaptive management – learning which techniques and species/provenances are most successful in particular climates and adjusting future nursery practices accordingly.

2. Soil Conservation and Watershed Management

2.1 Climate SMART Soil Conservation and Watershed Management training

Example of risk of landslides

The mean change in precipitation and temperature in the medium-term and the long- term for different regions of Nepal shows that the increase in temperature would be highest in Chure and Terai regions of the country. The maximum temperature between the period 1971 to1994 increased by less than 0.03°C per year in the Siwaliks. For the project district Sindhuli, the number of very wet days and extreme wet days is projected to rise significantly in the mid-term period whereas the number of rainy days is expected to decrease which increases the risk of flooding and landslides in Marin watershed.

(Source: MaWRiN Project Document, 2020)

Climate-resilient Soil Conservation and Watershed Management Trainings have been designed for the farmers, CFUG members and other stakeholders of the project area. This training aims to increase the understanding level of participants on climate smart soil conservation practices in the watershed areas. This training promotes integrated, ecosystem-based approaches that enhance land productivity, reduce erosion, improve water availability, and build resilience against extreme weather events. After the training, the participants will understand how to improve soil fertility, how to control landslides and floods with low cost or natural based solutions, and how to retain water in the sources in the catchment.

2.2 Training Curriculum and Material

Modules	Training
Module 1	Climate change impacts on watershed management
Module 2	Climate-smart watershed management techniques
Module 3	Sustainable land management and monitoring of land degradation
Module 4	Nature-based solutions for soil conservation and watershed management

Module 1: Climate Change Impacts on Watershed Management

Climate change profoundly impacts watershed management in Nepal, a country highly vulnerable to its effects due to its fragile mountainous terrain, steep topography, and heavy reliance on climate-sensitive sectors like agriculture and water resources. Watersheds, as integrated biophysical and socio-economic units, are particularly susceptible to changes in temperature and precipitation patterns. The key climate change impacts on watershed management in the project area are as below.

I. Hydrological Impacts

a) Altered Precipitation Patterns

- Increased intensity of rainfall: More frequent and intense heavy rainfall events, particularly during the monsoon, lead to increased surface runoff, higher peak flows, and reduced infiltration. This overwhelms the natural capacity of watersheds to absorb water.
- Decreased winter precipitation and prolonged dry spells: Reduced snowfall in the Himalayas and less winter rain can lead to drying up of springs and perennial streams, causing water scarcity during the dry season. This exacerbates drought conditions.
- Unpredictable monsoon: Changes in the onset, duration, and intensity of the monsoon make water availability unpredictable, impacting agricultural cycles and water supply.

b) Changes in Streamflow Regimes

- Increased floods and flash floods: More intense rainfall leads to a higher frequency and severity of floods, especially flash floods in smaller, steep watersheds, causing damage to infrastructure, agricultural land, and loss of lives.
- Reduced baseflow: Decreased groundwater recharge due to less infiltration (from intense rainfall or prolonged droughts) results in lower baseflow in rivers and streams during the dry season, impacting water availability for domestic use, irrigation, and hydropower.
- Glacial melt and GLOFs: While initially contributing to increased glacial-fed river flows, the long-term impact of glacier retreat is reduced water availability. Glacial Lake Outburst Floods (GLOFs) pose a significant threat to downstream communities and infrastructure.

c) Groundwater Depletion: Reduced recharge from inconsistent rainfall and increased abstraction for irrigation and domestic use during dry periods lead to falling groundwater tables and drying up of traditional water sources like springs.

II. Geo-physical Impacts

a) Increased Soil Erosion and Landslides

- Intense rainfall: Heavy rainfall on steep, deforested, or degraded slopes significantly increases soil erosion, leading to loss of fertile topsoil.
- Landslides and debris flows: Water-saturated slopes become unstable, leading to an increase in landslides and debris flows, blocking rivers, destroying infrastructure, and posing threats to settlements.
- Sedimentation: Increased erosion results in higher sediment loads in rivers, leading to siltation of reservoirs, irrigation canals, and hydropower facilities, reducing their lifespan and efficiency.

b) Riverbank Erosion: Higher flow velocities and increased flood events cause severe riverbank erosion, altering river courses and damaging riparian land.

III. Ecological Impacts

a) Forest and Biodiversity Degradation
   - Forest fires: Prolonged dry spells and higher temperatures increase the risk and intensity of forest fires, leading to loss of forest cover, which in turn exacerbates erosion and impacts water retention in watersheds.
   - Changes in species composition: Altered hydrological regimes and increased temperatures can stress native plant and animal species, leading to changes in biodiversity and the potential loss of sensitive aquatic and terrestrial ecosystems within watersheds.

b) Impact on Aquatic Ecosystems: Changes in water temperature, flow regimes, and sediment loads affect water quality, aquatic habitats, and fish populations.

c) Degradation of Watershed Health: Overall, the combination of these impacts degrades the health and functionality of the watershed, diminishing its capacity to regulate water flow, filter pollutants, and support diverse ecosystems.

IV. Socio-economic Impacts

a) Water Scarcity and Food Insecurity
   - Drying water sources and inconsistent rainfall directly threaten drinking water supply and irrigation for agriculture, leading to water scarcity for communities and impacting crop yields.
   - This exacerbates food insecurity and poverty, particularly for marginalized and vulnerable communities who are highly dependent on natural resources.

b) Damage to Infrastructure: Floods, landslides, and erosion damage roads, bridges, hydropower plants, irrigation systems, and human settlements, incurring huge economic losses and disrupting development.

c) Increased Health Risks: Contaminated water sources due to heavy runoff and reduced water quality during droughts increase the incidence of waterborne diseases.

d) Livelihood Displacement: Extreme events can displace communities, forcing them to seek alternative livelihoods or migrate.

e) Increased Disaster Risk: Communities within watersheds face heightened risks from water-induced disasters, leading to loss of life, property, and agricultural land.

V. Implications for Watershed Management in Nepal

These impacts necessitate a shift towards more climate-adaptive and integrated watershed management strategies in Nepal. This includes:

- Springshed management: Protecting and recharging groundwater sources and springs, which are vital for rural water supply.
- Rainwater harvesting: Promoting rainwater harvesting at household and community levels for domestic use and supplemental irrigation.

- Erosion control: Implementing bio-engineering techniques, terracing, contour farming, and reforestation to stabilize slopes and control soil erosion.
- Community-based adaptation: Empowering local communities with knowledge and resources to identify risks and implement adaptation measures.
- Early warning systems: Developing and improving early warning systems for floods and landslides.
- Climate-resilient infrastructure: Designing and constructing infrastructure that can withstand climate impacts.
- Integrated land use planning: Developing land use plans that consider climate risks and promote sustainable resource management within watershed boundaries.
- Policy integration: Mainstreaming climate change considerations into all levels of watershed management planning and implementation.

Module 2: Climate-Smart Watershed Management Techniques

Climate-smart watershed management technologies are crucial for a country like Nepal which is highly vulnerable to climate change impacts, such as erratic rainfall, increased floods, landslides, droughts, and glacial lake outburst floods. Climate-smart watershed management integrates climate change considerations into the holistic management of land, water, and related resources within a watershed, aiming to enhance resilience, ensure water security, and support sustainable livelihoods.

The "5 Ja" concept in the watershed management (*Jal* - water, *Jamin* - land, *Jangal* - forest, *Jaibik Bibidhata* - Biodiversity, and *Janata* - People) perfectly aligns with the integrated approach of cliamte-smart watershed management. Some of the key climate-smart watershed management techniques, with a focus on their application and relevance in Nepal is discussed as below.

I. Ecosystem-Based Adaptation (EbA) and Nature-Based Solutions (NbS)

Ecosystem based adaptation and Nature-based solutions are foundational to climate-smart water management, leveraging natural processes for resilience. The EbS/NbS for watershed management includes:

1. Forest Restoration and Sustainable Management

- ***Afforestation/reforestation with climate-resilient species:*** Planting native tree species (e.g., *Alnus nepalensis, Schima wallichii, Pinus roxburghii, Salix spp.* in appropriate zones) that are more tolerant to drought, higher temperatures, or increased rainfall intensity. This improves soil stability, enhances water infiltration, and reduces erosion.

Example of NbS for soil conservation (Source: SWN, 2025)

- **Community forest management for water security:** Empowering Community Forest User Groups (CFUGs) to manage forests specifically for watershed protection, including planting water-retaining species, controlling grazing, and managing undergrowth to prevent rapid runoff and enhance groundwater recharge.
- **Fire-wise forestry:** Implementing practices like fuel break creation, controlled burning (where appropriate and with strict safety protocols), and community fire awareness campaigns to reduce the risk of catastrophic wildfires, which are exacerbated by climate-induced droughts. Healthy forests are less susceptible to large, intense fires.

2. Springshed Management and Recharge

- ***Spring protection and rejuvenation:*** Identifying critical springsheds (recharge zones for springs), protecting them from degradation, and implementing measures like contour trenching, rainwater harvesting ponds, and tree plantations to enhance groundwater recharge and ensure perennial spring flow, vital for drinking water in hills.

- ***Water source conservation:*** Protecting existing water sources (rivers, streams, ponds) from pollution and degradation through riparian buffer zone management (planting vegetation along water bodies) and community-led conservation efforts.

3. Agroforestry and Climate-Smart Agriculture

- ***Integrating trees on farmlands:*** Planting multi-purpose trees (e.g., fruit trees, fodder trees, nitrogen-fixing trees) within agricultural fields or around boundaries. This provides shade for crops, improves soil moisture retention, reduces erosion, diversifies income sources, and provides fodder/food during dry spells.
- ***Conservation farming:*** Practices like minimum tillage, direct seeding, and residue retention to improve soil health, increase organic matter, and enhance water infiltration, making agricultural lands more resilient to drought and heavy rainfall.
- ***Drought-tolerant and flood-resistant crops:*** Promoting the cultivation of local landraces and new varieties of crops that are better adapted to changing climatic conditions.
- ***Integrated Pest Management (IPM):*** Reducing reliance on chemical pesticides, as pest outbreaks can be influenced by changing climate patterns.

II. Water Infrastructure and Management

Climate-smart water infrastructure and water resource management in the context of changing climate context are important for watershed management. These techniques focus on managing water resources more efficiently and robustly, and include:

1. Rainwater Harvesting

- Household and community ponds: Constructing small ponds at household or community levels to collect rainwater for irrigation, livestock, or domestic use during dry periods.
- Rainwater harvesting: Collecting rainwater from rooftops for drinking and domestic use, especially in areas with water scarcity or contaminated groundwater.
- Recharge ponds and percolation tanks: Building structures that allow collected rainwater to slowly infiltrate into the ground, recharging groundwater aquifers.

2. Efficient Irrigation Systems

- Drip and sprinkler irrigation: Promoting water-efficient irrigation methods that deliver water directly to plant roots, significantly reducing water waste, particularly for high-value crops. Literature suggests that drip irrigation saved up to 60% water compared to open channel irrigation system[5].
- System of rice intensification (SRI): An agronomic practice for rice cultivation that uses less water, seeds, and labor while increasing yields, highly relevant for Nepal's rice-dependent agriculture. Research suggests that SRI can save 50-75% water to traditional rice cultivation[6].
- Rehabilitation of traditional irrigation channels (Kulos): Restoring and upgrading traditional irrigation systems, often with more resilient materials (e.g., HDPE pipes, PCC), to ensure water delivery even after flash floods or landslides.

[5] Jain, Bhatt and Singh, 2022. A study on saving water using drip irrigation technologies in paddy and enhancing yield, International Journal of Research in Agronomy, 5(1): 13-18 (Available from: https://www.agronomyjournals.com/archives/2022/vol5issue1/PartA/4-2-21-424.pdf)

[6] Dhakal, M. P. 2005. Farmers' Evaluation of the System of Rice Intensification in the Middle Mountains of Nepal, Internatioanl Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, pp 39

3. Small-Scale Water Storage

- Check dams and gabion structures: constructing small check dams (using local materials like stones, logs) and gabion structures in gullies and streams to slow down water flow, reduce erosion, and trap sediment, while also allowing water to infiltrate and recharge groundwater.
- Multi-purpose ponds: designing ponds that serve multiple functions – water storage, fish farming, groundwater recharge, and even small-scale hydro-power as appropriate and feasible.

III. Disaster Risk Reduction (DRR) Integration

Climate-smart watershed management is inherently linked to DRR in a climate change context, and it includes the following key measures:

1. Early Warning Systems (EWS)

- Community-based EWS: Developing and implementing simple, locally managed early warning systems for floods, landslides, and forest fires. This includes simple, understandable, and accessible warning dissemination systems (e.g., sirens, mobile alerts, community networks) that enable communities to disseminate alerts to downstream or vulnerable communities and take timely action. It also supports communities in developing and implementing response plans, including evacuation strategies and resource allocation.
- **Hydrological and meteorological monitoring:** Establishing and maintaining networks of rain gauges, river level sensors, and weather stations within the watershed to monitor conditions and provide real-time data.
- **Local capacity building:** Training local volunteers and committees to manage EWS, interpret warnings, and coordinate evacuation or protective measures.

2. Landslide and Erosion Control

Landslides and erosion are major natural hazards, particularly in the ecosystem of the project area, exacerbated by steep slopes, heavy monsoon rains, and often unsustainable land use practices. Common landslide and erosion control measures within watershed management include:

- Vegetative/bio-engineering measures: These are often the most cost-effective and environmentally friendly solutions, especially for surface erosion and shallow landslides. They work by enhancing soil cohesion, reducing the erosive power of rainfall, and improving water infiltration. It uses a combination of vegetative (e.g., planting fast-growing grasses, shrubs, trees) and civil engineering (e.g., gabion walls, retaining structures) techniques to stabilize unstable slopes and control erosion, critical in Nepal's fragile mountainous terrain.

Example of landslide status in Sindhuli District

In 2016, Sindhuli district accounted for 469 landslides where 27 out of 32 VDCs were found to be affected by landslide occurrence. Thirteen VDCs possessed landslide number less than 10 and 12 VDCs possessed landslide number between 10 and 50. Dadigurase VDC (now in Marin RM) and Kamalamai Municipality occupied higher number of landslides between 50 and 100 in this district. They possessed 75 and 100 landslides respectively. The size distribution showed 133 small, 284 medium and 52 large landslides. Thirty large landslides of 52 were located in four VDCs namely Pipalmadhi, Mahendrajhyadi and Kyaneshor (now three in Hariharpurgadhi RM) and Mahadevsthan (now Marin RM) and Ten large landslides were situated in Kamalamai Municipality and Kapilakot VDC (now in Marin RM) possessing 5 in each VDC.

Source: TU-CDES (2016). Landslide Inventory Characterization and Engineering Design for Mitigation Works of Chure Area in Ten Districts (Available from: https://chureboard.gov.np/storage/files/chure-landslide-ten-districts1697725591.pdf)

- Structural/engineering measures: These are used for more severe erosion problems, deep-seated landslides, or to protect critical infrastructure. They often work in conjunction with vegetative measures (bio-engineering). It includes drainage management, retaining walls, check dams and gully plugs, soil nailing and rock bolting, and slope grading and benching.
- Contour trenching/bunding: Digging trenches or building small earthen bunds along contours to intercept runoff, promote infiltration, and reduce soil erosion on slopes.

3. DRR Integration into Policies

- DRR and long-term watershed health may not always receive the necessary political prioritization. Hence, effective watershed management requires ensuring that DRR principles are explicitly integrated into national and sub-national policies, strategies, and plans for integrated watershed management.
- Coordination and upstream-downstream linkages: It is also important to establish effective coordination platforms among various government departments (e.g., water, forestry, agriculture, and disaster management), local governments, NGOs, and communities. This addresses the challenge of fragmented institutional structures. Likewise, promoting a clear understanding and coordinated action between upstream and downstream communities, recognizing that actions in one part of the watershed affect others is also equally important.

IV. Land Use Planning, Policy, Governance, and Capacity Building

Effective climate-smart watershed management requires robust institutional and community frameworks.

1. Integrated Watershed Management Plans

An Integrated Watershed Management Plan (IWMP) is a comprehensive strategy for sustainably managing a watershed's natural resources, including water, soil, vegetation, and biodiversity, while considering the socio-economic needs of the communities within it. It aims to address interconnected issues holistically, moving beyond sector-specific approaches. The following three key approaches will underpin the IWMP:

- Risk-based planning: Developing comprehensive watershed management plans that are informed by multi-hazard risk assessments (floods, droughts, landslides, fires) at the landscape scale and participatory vulnerability mapping at the community level.
- Participatory approach: Ensuring meaningful involvement of all stakeholders, especially women and marginalized groups (GEDSI mainstreaming), in planning, implementation, and monitoring of watershed activities.
- Local level integration: Aligning watershed plans with local government development plans, leveraging local government resources and mandates.

2. Land Use Planning and Policy Measures

These are crucial for preventing future hazards and ensuring the long-term sustainability of the watershed. It includes the following measures:

- Hazard mapping and risk assessment: Identifying landslide-prone areas and erosion hotspots through geological surveys, historical data, and GIS mapping. This guides land use planning and informs where development should be restricted or specific mitigation measures are needed.

- Integrated land use planning: Developing watershed-level land use plans that designate appropriate areas for agriculture, forestry, settlements, and infrastructure, considering slope stability, soil type, and hydrological characteristics.
- Regulation and enforcement: Implementing and enforcing regulations that restrict or prohibit construction, deforestation, or certain agricultural practices on highly unstable slopes.
- Community Participation and Awareness: Engaging local communities in planning, implementing, and maintaining erosion and landslide control measures. Their traditional knowledge is invaluable, and their active participation ensures the sustainability of interventions.

3. Capacity Building and Awareness:

- Training for local communities and institutions: Providing technical training to CFUGs, water user groups, local disaster management committees, and local government officials on CSWM techniques, climate risk assessment, and M&E.
- Knowledge sharing: Facilitating exchange visits and platforms for communities to share successful CSWM practices and learn from each other.
- Climate information services: Improving access to and understanding of localized climate forecasts and advisories for farmers and forest managers to make informed decisions.

4. Policy and Institutional Coordination

- Multi-sectoral collaboration: Fostering strong coordination among different government ministries (Forests and Environment, Water Resources, Agriculture, Federal Affairs and General Administration), local governments, NGOs, and community organizations.
- Legal and policy frameworks: Ensuring national and local policies (e.g., National Adaptation Plan, Forest Sector Strategy, Watershed Management Guidelines) support and incentivize CSWM approaches and adequately address climate change adaptation.

Module 3: Sustainable Land Management and Monitoring of Land Degradation

Sustainable Land Management (SLM) and the effective monitoring of land degradation are critical for sustainable watershed management in the project area, given its fragile mountain ecosystems, high population pressure on land, and increasing vulnerability to climate change impacts.

I. Sustainable Land Management (SLM) Techniques in Nepal

Sustainable land management encompasses a holistic approach to land use and management that aims to maintain or enhance land productivity, ecological integrity, and the provision of ecosystem services, while adapting to and mitigating climate change. Key techniques relevant for the project area include:

1. **Agroforestry** (Integration of trees and crops): Planting multi-purpose trees (fruit, fodder, timber, nitrogen-fixing) within agricultural fields or on farm boundaries. This improves soil fertility, reduces erosion, provides shade for crops and livestock (critical in warming climates), diversifies income, and enhances biodiversity. Agroforestry is widely adopted in various forms, from scattered trees on farmlands to intensive home gardens. It provides fodder for livestock, reduces reliance on forest collection, and offers diversified food and income sources, making farming systems more resilient to climate shocks like droughts.

2. **Conservation Agriculture**
   Conservation agriculture is another widely used sustainable land management technology in Nepal. Conservation agriculture practices include minimum tillage or no-tillage, maintaining permanent soil cover, and crop rotation or crop diversification. Conservation agriculture is relevant for both Terai and hills of Nepal for improving soil health in increasingly degraded agriculture lands. For example, System of Rice Intensification (SRI) and zero-tillage for wheat are gaining traction in Nepal.
   - **Minimum tillage/no-till:** Reducing soil disturbance to maintain soil structure, organic matter, and beneficial organisms. This improves water infiltration, reduces erosion, and saves labor and other costs for agriculture.
   - **Permanent soil cover:** Maintaining crop residues or growing cover crops to protect the soil surface from erosion, retain moisture, and suppress weeds.
   - **Crop rotation/diversification:** Growing a variety of crops in sequence to improve soil health, break pest cycles, and enhance overall farm resilience.

3. **Bioengineering and Slope Stabilization**
   Bioengineering is one of the effective sustainable land management practices for slope stabilization. It combines vegetation and civil works using live plants (grasses, shrubs, trees) in combination with minor civil engineering structures (e.g., gabion walls, brushwood check dams) to stabilize unstable slopes, prevent landslides, and control soil erosion, especially crucial along roads and in fragile mountainous areas. Bioengineering practices are widely practiced and highly effective in Nepal's steep and tectonically active terrain, reducing disaster risk and increasing slope stabilization.

4. **Watershed Management**
   Integrated watershed management is another effective land management technique. This approach involves managing land and water resources across an entire watershed to reduce erosion, regulate water flow, enhance groundwater recharge, and mitigate floods

and droughts. The techniques for integrated watershed management include reforestation, springshed management, terracing, contour farming, rainwater harvesting, and small-scale check dams. Integrated watershed management is essential for water security, disaster risk reduction, and maintaining ecosystem services from mountains to plains. The Churia range is a prime example where integrated watershed management is vital.

5. Sustainable Forest Management (SFM)

Sustainable Forest Management (SFM) is not just about managing trees; it's a holistic approach to land management that recognizes forests as vital ecosystems providing a multitude of benefits essential for human well-being and the health of the planet. It aims to maintain and enhance the ecological, economic, and social values of forests for present and future generations. The link between SFM and sustainable land management is intrinsic, as forests play a critical role in shaping the broader landscape and influencing other land uses. SFM operates on several key principles that directly contribute to sustainable land management, such as (a) maintaining forest health and vitality, (b) conserving forest biological diversity, (c) maintaining productive functions of forests, (d) protecting soil and water resources (watershed functions), and (e) maintaining socio-economic functions. Thus SFM directly contributes to sustainable land management through:

- Preventing land degradation: By maintaining forest cover, SFM is a primary tool for preventing soil erosion, desertification, and land degradation, especially in vulnerable landscapes.
- Enhancing land productivity: Healthy forests contribute to the productivity of adjacent agricultural lands by regulating water, protecting soil, providing shade, and supporting biodiversity (e.g., pollinators).
- Biodiversity conservation: Forests are biodiversity hotspots. SFM helps preserve this biodiversity across the landscape, which is essential for ecosystem services.
- Disaster Risk Reduction (DRR): SFM is a fundamental component of nature-based DRR strategies. Forests act as natural barriers against landslides, stabilize slopes, regulate water flow to prevent floods, and can even influence local microclimates.
- Integrated land use planning: SFM provides a framework for integrating forest management with other land uses (agriculture, settlements, infrastructure) within a holistic land use plan, ensuring that all uses are sustainable and mutually supportive.
- Climate change resilience: By promoting healthy and diverse forest ecosystems, SFM enhances the resilience of the entire landscape to the impacts of climate change, while also contributing to mitigation.
- Water security: SFM ensures the long-term health of watersheds, which are critical for providing clean and sufficient water for human consumption, agriculture, and industry.
- Community empowerment through community forest management: SFM empowers local communities (CFUGs) to sustainably manage and utilize forest resources.
- Fire management: By implementing controlled burns, creating firebreaks, and promoting community-based fire prevention to reduce forest fire risk, effective fire management leads to control severe land degradation.

6. Sustainable Grazing Land Management

Sustainable grazing land management is a crucial component of sustainable land management, particularly in the project watersheds where a significant portion of land is used to grazing, and where livestock is central to rural livelihoods. It focuses on practices that maintain or enhance the health and productivity of grasslands/grazing lands while

sustaining their ecological functions and providing economic benefits. Sustainable grazing land management contributes to sustainable land management through:

- Soil health improvement and erosion control
- Water cycle regulation by promoting greater water infiltration into the soil, reducing surface runoff and increasing groundwater recharge
- Biodiversity conservation
- Increased forage production and livestock productivity
- Disaster risk reduction, and
- Livelihood sustainability

Key Principles and Practices of Sustainable Grazing Land Management

- Grazing monitoring strategies: It includes rotational grazing, rest periods and seasonal grazing. This can be achieved by implementing controlled grazing practices to prevent overgrazing, allowing vegetation to recover and maintain soil cover.
- Fodder and forage development: Sustainable grazing management includes promoting the cultivation of fodder trees and improved pasture species to reduce pressure on natural rangelands. Where appropriate, it involves introduction of high-yielding, nutritious and adaptable grasses and legumes to enhance pasture productivity.
- Weed and invasive species control: It involves manual removal, biological control or integrated pest management for removing and controlling weeds, invasive species and prioritizing ecological approaches.

7. Terracing and Contour Farming

Terracing and contour farming are traditional and highly effective practices in Nepal's hilly agricultural landscapes.

- Terracing: Constructing level or nearly level platforms on slopes to reduce the gradient, slow down water flow, and prevent soil erosion.
- Contour farming: Plowing and planting crops along the contours of a slope rather than up and down, creating small ridges that trap water and reduce runoff.
- Gully stabilization: Using bio-engineering or small check dams to prevent gully formation and stabilize existing gullies within rangelands.

II. Monitoring of Land Degradation in Nepal

Effective monitoring of land degradation is crucial to understand the extent, type, and drivers of degradation, assess the effectiveness of sustainable land management interventions, and inform policy.

A. Key Indicators of Land Degradation

Monitoring land degradation involves tracking changes in various indicators across biophysical, socio-economic, and land management domains. These indicators help to identify the type, extent, severity, and causes of degradation, which is crucial for effective sustainable land management (SLM) interventions. Land degradation monitoring typically focuses on changes in various indicators related to:

1. Biophysical Indicators

The biophysical indicators directly reflect changes in the physical, chemical, and biological properties of the land, and include:

- Vegetation cover and productivity
- Reduced vegetation cover: Decrease in the density, type, and extent of plant life (e.g., bare ground becoming more prevalent, less canopy cover in forests).
- Decreased biomass: lower overall plant mass, indicating reduced productivity.
- Changes in Species Composition: Shift from desirable, productive species to pioneer, invasive, or less palatable species (e.g., *Imperata cylindrica or Saccharum munja* are found in degraded lands of the project area).
- Land use/land cover (LULC) change: Conversion of forests to other land use types such as agriculture, settlements, construction; or agricultural land to barren land, or shrubland expansion.
- Forest canopy density: A decrease indicates forest degradation (e.g., due to unsustainable logging, fuelwood collection, or overgrazing).
- Biomass: Reduction in above-ground biomass, indicating loss of vegetative cover and productivity.
- Species composition: Shift from perennial, diverse, and native species to annual, invasive, or pioneer species (e.g., *Imperata cylindrica*, *Saccharum munja* often indicate degraded lands).

2. Soil Health and Quality Indicators

The following indicators are used to monitor soil health and quality:

- Soil erosion (by water and wind): Visual signs (rills, gullies, sheet erosion, exposed tree roots), sediment load in rivers, and direct measurements using erosion plots.
- Soil organic carbon: A key indicator of soil health and fertility. Declining soil organic carbon indicates degradation. Nepal has committed to increasing soil organic carbon stock as part of its Land Degradation Neutrality (LDN) targets[7].
- Soil structure: Indicators like bulk density (compaction), infiltration rates, and aggregate stability.
- Sediment deposition: Accumulation of eroded soil in lower slopes, riverbeds, or reservoirs (e.g., silting of rivers in the project area)
- Soil nutrients: Depletion of essential macronutrients (N, P, K) and micronutrients.
- Salinization/acidification: Chemical degradation processes (less common as primary driver in Nepal, but can occur in specific pockets or with poor irrigation practices).
- Physical soil degradation or soil compaction: Increased bulk density, reduced porosity, hindering root penetration and water infiltration (often due to heavy machinery or overgrazing).
- Waterlogging: Persistent saturation of soil due to poor drainage, often leading to anaerobic conditions and crop stress.

3. Water Resource Degradation Indicators

- Decreased water quality: Increased turbidity (siltation), changes in pH, or pollution levels, indicating soil erosion and poor land management.

[7] https://www.unccd.int/sites/default/files/ldn_targets/Nepal%20LDN%20Country%20Commitments.pdf

- Reduced water availability: Drying up of springs and wells, reduced streamflow, or lowering of groundwater tables. Changes in spring yield, groundwater levels, or perennial stream flow, often linked to watershed degradation.
- Changes in hydrological regimes: More frequent or severe floods and droughts, indicating a disruption in the natural water balance of the watershed.

4. Socio-Economic-Cultural Indicators (Impact on People)

These indicators reflect the human dimension and impacts of land degradation on communities.

- Decreased crop yields: Decline in agricultural productivity despite same or higher inputs.
- Decline in livestock productivity: reduced fodder availability, leading to lower milk, meat, or wool production, and poorer animal health.
- Abandonment of agricultural land: Farmers leaving degraded land due to its unproductiveness.
- Livelihood diversification: Decreased access to forest products, forcing people to seek alternative, potentially less sustainable livelihoods.
- Livelihood impacts:
    - Increased poverty: Reduced income from farming and livestock, forcing communities into deeper poverty
    - Food insecurity: Lower food production leading to food shortage and malnutrition
    - Out-migration: Higher out-migration, particularly from the degraded areas due to declining land productivity and lack of economic opportunities
    - Increased labour for production on degraded land to get the same or lower yields.
- Loss of traditional knowledge: Erosion of indigenous practices for sustainable land management as land degrades and livelihoods shift.
- Increased conflict over resources: Greater competition for scarce resources like water, grazing land, or fertile soil.

B. Monitoring Methods

Monitoring of land degradation can be done through a combination of various methods as below.

1. Remote Sensing and GIS

- Satellite imagery: Analyzing time-series satellite data (e.g., Landsat, Sentinel, Google Earth Engine) to detect changes in LULC, NDVI, forest cover, and other biophysical parameters over time. This is increasingly used for large-scale and cost-effective monitoring in Nepal (e.g., for REDD+ Measurement, Reporting and Verification (MRV) of emission reductions).
- Drone technology: High-resolution imagery from drones provides detailed information for localized degradation assessments and monitoring of sustainable land management interventions.

- GIS mapping: Integrating various layers of data (e.g., slope, rainfall, soil type, LULC) to create land degradation risk maps, identify hotspots, and visualize changes.

2. Ground-Based Field Surveys and Measurements

- Transect walks and plot establishment and measurements: Systematic ground surveys to collect data on vegetation cover, soil erosion features, soil samples, and specific sustainable land management intervention performance.
- Soil sample analysis: Laboratory analysis of soil samples for chemical properties (soil organic carbon, nutrients, pH, salinity) and physical properties (texture, bulk density, organic matter).
- GPS and drones for verification: Ground-truthing of remote sensing data with actual field observations (visual assessments).

2. Community-Based Monitoring

This type of monitoring can be conducted by involving local communities, especially sub-watershed committee and CFUGs, in collecting and interpreting data, leveraging their traditional knowledge and detailed understanding of local changes. Participatory tools and methods such as community mapping, photo monitoring, and seasonal calendars will be used to capture local perceptions of degradation and SLM effectiveness. The community based monitoring strengthens local ownership, builds capacity, and provides ground-level data that complements remote sensing. It's particularly effective for tracking subtle changes or highly localized degradation patterns.

3. Household Surveys and Participatory Rural Appraisal (PRA)

Using PRA tools for land degradation monitoring captures local knowledge, develops a sense of ownerships, is cost-effective, and gives context specific solutions. This method involves:

- Community mapping to visually represent the community's understanding of their land, including areas affected by degradation, land use patterns, water sources, forest cover, and infrastructure.
- Transact walks to systematically observe and discuss land degradation issues along a defined line (transect) that cuts across different land use types or ecological zones. This method is usually used to collect socio-economic data related to land use, livelihood impacts, and local perceptions of degradation and the effectiveness of SLM practices.
- Historical timelines/trend analysis to understand how land quality and environmental conditions have changed over a longer period, often through the recall of older community members.
- Direct observation and discussion, which can include focus group discussions, key informant interviews, and wealth ranking to understand differential impacts across social groups (GEDSI).

Module 4: Nature-based Solutions (NbS) for Soil Conservation and Watershed Management

In recent days, the Nature-Based Solutions (NbS) are increasingly recognized in Nepal as a cost-effective, sustainable, and holistic approach to address challenges in soil conservation and watershed management, particularly in the face of climate change. NbS involve protecting, sustainably managing, and restoring natural or modified ecosystems to address societal challenges (like erosion, floods, and water scarcity) while simultaneously providing human well-being and biodiversity benefits.

The MaWRiN project area, with its fragile mountainous ecosystems and high vulnerability to climate impacts, has a strong rationale for adopting NbS. The watershed's traditional ecological knowledge and community-based resource management practices often align well with NbS principles. Some of the key Nature-Based Solutions for soil conservation and watershed management being implemented and promoted in Nepal for soil conservation and watershed management are described here.

I. For Soil Conservation (Erosion Control and Land Stabilization)

These solutions primarily focus on stabilizing slopes, reducing surface runoff, enhancing soil structure, and preventing land degradation, and include:

1. Bioengineering (Soil and Water Bioengineering)

This is a core NbS that uses living plant materials (grasses, shrubs, trees) alone or in combination with simple civil engineering structures (like gabions, brushwood check dams) to stabilize slopes, control erosion, and protect land. Some of the key techniques of bioengineering practices are:

- Live staking: Inserting live woody cuttings (e.g., willow, poplar, bamboo) into slopes to root and stabilize the soil.
- Brush layering: Placing layers of live branches horizontally into trenches along the contour of slopes, which root and act as living contour barriers.
- Vegetated gabions: Steel wire mesh cages filled with stones, and then planted with vegetation (e.g., grasses, shrubs) to provide structural support while allowing vegetation to root and grow through, reinforcing the structure.
- Live crib walls: Interlocking wooden structures filled with soil and live plants, used to stabilize steep slopes.
- Contour terracing and bunding: Creating level or gently sloping terraces along contours, often reinforced with vegetation, to reduce runoff velocity, increase water infiltration, and control erosion on agricultural lands.
- Grass seeding/turfing: Establishing dense grass cover on bare or degraded slopes to protect the soil surface from splash erosion and improve infiltration.

These bioengineering practices are highly effective, especially when combined with small civil structures. Vegetation provides immediate surface protection and long-term deep root reinforcement. It's often more cost-effective and environmentally friendly than purely "grey" infrastructure.

2. **Afforestation and Reforestation:** It is the planting trees on degraded lands, barren slopes, and within watersheds to restore forest cover. The key benefits of afforestation and reforestation are that tree roots bind the soil, preventing erosion; canopy intercepts rainfall, reducing splash erosion; forest litter improves soil organic matter and water infiltration; and restored forests enhance biodiversity and sequester carbon. Nepal's successful community forestry program can be seen is a prime example of an NbS, where local communities manage forests, leading to increased forest cover, reduced soil erosion, and improved livelihoods.
3. **Agroforestry:** Agroforestry integrates trees and shrubs into agricultural landscapes (e.g., planting fodder trees on farm boundaries, alley cropping). Trees help stabilize soil on farmland, improve soil fertility through nitrogen fixation (leguminous trees), provide fodder for livestock, reduce wind erosion, and offer shade.
4. **Cover Cropping and Conservation Tillage:** Planting non-cash crops (cover crops) between main cropping seasons or maintaining crop residues on the soil surface (conservation tillage) is an example of NbS. It protects the soil from direct rainfall impact, reduces runoff velocity, increases organic matter, improves soil structure, and reduces erosion on agricultural fields.

II. For Watershed Management (Water Regulation, Quality, and Disaster Risk Reduction)

These solutions aim to improve the hydrological functions of the watershed, enhance water quality, and reduce risks from floods and droughts.

1. **Springshed Management:** Springshed management is about protecting and recharging natural springs, which are vital water sources for many rural communities. This involves understanding the geology and hydrology of the spring's recharge zone and implementing conservation measures within that area. It involves reforestation around spring sources, contour trenches, recharge ponds, and check dams upstream of the spring to enhance groundwater infiltration. This method ensures perennial water supply, improves water quality, and builds climate resilience against drying springs due to erratic rainfall.
2. **Rainwater Harvesting and Recharge Ponds:** It is collecting and storing rainwater (from rooftops, impermeable surfaces) for direct use or for recharging groundwater. It involves construction of household or community-level rainwater harvesting tanks, small earthen ponds, or infiltration trenches in strategic locations to capture runoff and allow it to percolate into the ground. The technique augments water supply during dry seasons, reduces surface runoff and erosion, and contributes to groundwater replenishment.
3. **Wetland Restoration and Creation:** It is about protecting, restoring, or creating natural or semi-natural wetlands within the watershed. Wetlands act as natural sponges, absorbing excess water during floods and slowly releasing it during droughts, thus regulating streamflow. They also filter pollutants, improve water quality, and provide crucial habitats for biodiversity.
4. **Riparian Buffer Zones:** Establishing vegetated strips along rivers, streams, and lakes. It stabilizes riverbanks, reduces erosion, filters agricultural runoff (preventing nutrient and sediment pollution of water bodies), provides shade, and creates wildlife corridors.
5. **Bio-dykes and Living Dikes:** Bio-dykes are prepared using strategic planting of locally available trees and plants along riverbanks to form natural barriers against floods and erosion, as successfully demonstrated on the Karnali River in Nepal. It is an environmentally friendly alternative to concrete structures, binds soil, prevents erosion, maintains natural water flow, and reduces flood impacts on homes and agricultural land.

3. Agriculture Sector

3.1 Climate-Smart Agriculture Training

This Climate-Smart Agriculture (CSA) training has been designed to equip the farmers and other community level stakeholders in the project area on how the climate change has affected the agricultural production, degradation of soil fertility, and food security affecting the livelihoods, particularly of women and marginalized communities. The training, therefore, aims to empower the training participants with the knowledge and skills to address climate change impacts, enhance food security, and promote sustainable practices. This training also promotes integrated approaches such as improved crop varieties, efficient water and soil management, agroforestry, and sustainable livestock practices. By adopting CSA practices, farmers can increase productivity, safeguard their livelihoods[8] by building resilience to climate change, and contribute to national food security in a changing climate.

3.2 Training Curriculum and Materials for Climate Change Adaptation

Modules	Training Content/Subject
Module 1	Climate change impacts in Agriculture Sector
Module 2	Climate change related policies in Nepal (Related to agriculture sector of Nepal)
Module 3	Identification of adaptation options in Agriculture Sector of Nepal
Module 4	Examples of adaptation options that can be mainstreamed in agriculture sector
Module 5	Climate smart agriculture framework
Module 6	Challenges of mainstreaming CCA options in agriculture sector
Module 7	Climate resilient agriculture practices and technologies (including NbS)
Module 8	Promotion of indigenous crops and seed production
Module 9	Promotion of riverbed farming in flood damaged agriculture farms
Module 10	Monitoring and evaluation of effectiveness of CCA actions
Module 11	Agricultural Value Chain Development and Market Linkages

[8] Seventy to eighty percent of the local population relies on subsistence agriculture, forest, and fish farming for their livelihood with a significantly higher percentage (85%) of the female population depending on it as compared to male population (73%). While agriculture is the main source of livelihood for people living in the sub-watersheds, the average landholding capacity of each household is 0.92 hectares (*Source: MaWRiN project document, 2022)*.

Module 1: Climate Change Impacts in Agriculture Sector

Climate change poses significant challenges to the agriculture sector, affecting crop yields, disrupting food production, and ultimately threatening food security. Key drivers of these impacts include soil degradation, increased pest and disease outbreaks, and growing water scarcity. These climate-related stresses not only undermine local food systems but also jeopardize the overall economic stability of agrarian communities. The effects are particularly severe for resource-poor and marginalized farmers, who have limited capacity to adapt. This training module is designed to help participants understand the diverse impacts of climate change on agriculture and their livelihoods,

1. Decrease in Crop Production and Yields

- Rising temperatures can negatively affect crop yields, especially for staple crops like corn, rice, wheat, and soybeans. High temperatures can lead to reduced photosynthesis, slower growth, and even plant death (e.g., temperature higher than 36^0C can kill soybean seedlings[9]). While some regions at higher altitudes might experience longer growing season, the overall effect often leads to reduced yields in already warm areas.
- Climate change contributes to changes in CO_2 levels. Increased atmospheric CO_2 can have a mixed effect. It can enhance photosynthesis and water use efficiency in some plants, potentially boosting yields for certain crops like wheat, rice, potatoes, and lettuce. However, this "CO_2 fertilization effect" might not fully compensate for the negative impacts of rising temperatures and altered precipitation patterns, and for some crops like maize and soybeans, the overall impact can be negative.
- Climate change alters precipitation patterns. Climate change leads to more unpredictable rainfall, resulting in both increased frequency and intensity of droughts and floods. Prolonged periods of low precipitation cause water scarcity, limiting irrigation, stressing crops, and leading to reduced yields or crop failure. Similarly, heave rainfalls can cause soil erosion, waterlogging, and damage to crops and agricultural infrastructure, leading to significant losses.

> ***Example of Climate Change Impact on Agriculture in the project area***
>
> Prolonged drought, increasing sedimentation in the agriculture field, on-going crop damage caused by pests, deteriorating of soil moisture due to excess heat, irregularity in the rainfall, are the climate-change related key issues and challenges that the communities are currently facing. These challenges and issues have resulted in low production of agricultural crops leading to hardship to farmers. During the FGDs and KIIs, over 60% have expressed that they have enough to feed the family year-round and about 25% said the production is enough for about six months and the remaining said it is not enough even for six months, particularly Hayu communities (*Government has been providing 4000 per person and per month as allowance*). Almost all respondents (95%) consistently expressed their concern that if the current agriculture patterns and declining production trends continue, food shortage could occur in coming years. These concerns were consistently expressed across all sub-watershed areas. (Source: TNA Field Study, April-May 2025)

- Warmer temperatures can expand the geographical range and accelerate the life cycles of agricultural pests and diseases, leading to greater crop damage and increased need for interventions.
- Changes in temperature and precipitation can affect pollinator populations and their activity, impacting the reproduction of many crops.

2. Soil Degradation

Climate change also degrades soil and hence impacts on crop production and yield through:

[9]Front Plant Sci, 2024 Jul 31;15:1427086. doi: 10.3389/fpls.2024.1427086 https://pmc.ncbi.nlm.nih.gov/articles/PMC11322351/

- Erosion: Intense rainfall and strong winds, exacerbated by climate change, can lead to increased soil erosion, washing away nutrient-rich topsoil crucial for crop growth.
- Loss of organic matter: Higher temperatures can accelerate the decomposition of soil organic matter, reducing soil fertility, water retention capacity, and overall soil health.
- Desertification: Prolonged droughts and reduced precipitation can lead to desertification, rendering land unproductive.
- Salinization: Changes in rainfall patterns and increased evaporation can lead to the accumulation of salts in the soil, making it unsuitable for many crops.

3. Overall Impact on Food Security

Climate change is one of the most significant and rapidly escalating threats to global food security. Its impacts are far-reaching, affecting every pillar of food security: availability, access, utilization, and stability.

- **Impact on Food Availability**: Climate change affects food availability through production disruptions through:
    - Decreased crop yields**:** Rising temperatures, altered precipitation patterns (more droughts and floods), and increased frequency of extreme weather events (heatwaves, storms) directly reduce agricultural productivity. While some regions at higher latitudes might see temporary benefits from longer growing seasons, the overall trend points to lower yields for major staple crops like corn, rice, wheat, and soybeans, especially in already warm and vulnerable regions.

Loss of agricultural land and crops as a result of climate-related extreme events in Nepal (1971- 2007)

Events	Loss (in hectares)
Droughts	329,332
Floods	196,977
Hailstorms	117,518
Rains	54,895
Strong winds	23,239
Cold waves	21,794
Others (forest fires, storms, epidemics, fires, etc.)	83,336

Source: MOFE- *Sectoral Report: Agriculture and Food Security*, 2025

    - Reduced arable land: Climate change contributes to soil degradation through erosion, desertification, and salinization, making land unsuitable for farming. Sea-level rise also inundates coastal agricultural areas.
    - Livestock and fisheries decline: Heat stress reduces livestock productivity (milk, meat, eggs). Changes in ocean temperature and acidification impact fish populations, their distribution, and the health of marine ecosystems, threatening a crucial protein source for many.
    - Increased pests and diseases: Warmer temperatures expand the range and accelerate the life cycles of agricultural pests, weeds, and diseases for both crops and livestock, leading to greater losses.
    - Water scarcity: Agriculture is the largest consumer of freshwater. Climate change-induced droughts and unpredictable rainfall lead to water scarcity, limiting irrigation and directly impacting crop and livestock production.

- **Impact on Food Access (affordability and distribution)**
    - Rising food prices: Reduced agricultural output due to climate impacts leads to scarcity, which drives up food prices. This makes nutritious food less affordable, particularly for low-income households and vulnerable populations who spend a larger proportion of their income on food. Studies suggest climate change could add significant percentage points to annual food inflation.

- Disrupted supply chains: Extreme weather events (floods, hurricanes, heatwaves) can damage infrastructure (roads, bridges, storage facilities), disrupting transportation and distribution of food from farms to markets. This can lead to localized shortages and further price spikes.
- Loss of livelihoods: For millions of smallholder farmers, fishers, and pastoralists, climate change directly threatens their ability to produce food and earn income. Crop failures, livestock deaths, and depleted fish stocks mean lost income, pushing more people into poverty and making it harder to access food.
- Increased Conflict and Displacement: Resource scarcity, exacerbated by climate change, can fuel social unrest and conflict, leading to displacement of populations. Displaced people often face severe food insecurity due to lack of access to land, markets, and basic services.

- **Impact on Food Utilization (Nutrition and Safety)**
  - Decreased Nutritional Quality: While increased CO2 can sometimes boost crop yields, it can also reduce the nutritional content of staple crops, leading to lower levels of essential vitamins and minerals (e.g., iron, zinc). This can worsen "hidden hunger" where people consume enough calories but lack micronutrients.
  - Increased Food Contamination: Warmer temperatures can promote the growth of foodborne pathogens and toxins (like aflatoxins) in crops and stored food. Floods can contaminate water sources and agricultural land, increasing the risk of waterborne diseases.
  - Health impacts: Climate change-related health issues, such as heat stress, vector-borne diseases (e.g., malaria, dengue), and waterborne illnesses, can reduce individuals' ability to properly absorb and utilize nutrients, further contributing to malnutrition. Pregnant women and young children are particularly vulnerable.

- **Impact on Food System Stability**
  - Increased volatility: Climate change introduces greater volatility and unpredictability into food systems. Erratic weather patterns make it harder for farmers to plan, leading to more frequent and severe episodes of food shortages and surpluses, causing price fluctuations.
  - Reduced resilience: Current food systems are often optimized for efficiency rather than resilience. Climate shocks expose these vulnerabilities, leading to widespread disruptions. Over-reliance on a few staple crops and limited geographic sources for production also increases systemic risk.
  - Weakened institutions: Climate change can strain governance structures and emergency response systems, making it harder for governments and organizations to respond effectively to food crises.

Module 2: Agriculture Sector related Climate Change Policies in Nepal

Nepal, being highly vulnerable to climate change due to its diverse topography and heavy reliance on climate-sensitive sectors like agriculture, has developed several policies and plans to address these challenges. The key climate change-related policies relevant to the agriculture sector in Nepal are described below:

1. National Climate Change Policy (2019): This is Nepal's overarching policy document on climate change. It aims to build a climate-resilient society and contribute to socio-economic prosperity. Key aspects relevant to agriculture include:

- Enhancing adaptation capacity: A primary objective is to enhance the climate change adaptation capacity of vulnerable persons, families, groups, and communities. This directly applies to farmers.
- Climate-friendly agriculture: The policy explicitly states strategies to promote a "climate-friendly agriculture system."
- Targeting vulnerable groups: It mandates conducting agriculture-based adaptation programs specifically targeting poor, marginalized, landless, indigenous people, vulnerable households, women, and persons with disability.
- Promoting resilient crops: It emphasizes identifying and promoting agricultural crops suitable for dry and waterlogged areas and developing technologies that protect crops from climate-induced disasters like drought and cold waves.
- Mainstreaming climate change: The policy aims to integrate climate change issues into policies, strategies, plans, and programs at all levels of the state and across sectoral areas, including agriculture.
- Green economy: It promotes the concept of low-carbon emission development, which has implications for sustainable agricultural practices.

2. National Adaptation Plan (NAP), 2023: The NAP is a comprehensive strategy that outlines Nepal's mid and long-term adaptation needs and strategies. Agriculture and Food Security is identified as one of the most urgent priority sectors.

- Sector-specific interventions: The NAP outlines 64 specific adaptation interventions across eight key economic sectors, with agriculture and food security being a primary focus.
- Integrating adaptation: It aims to systematically integrate climate change adaptation into policies, planning, and programs across all sectors and levels of government.
- Strategic goals for agriculture (until 2050): The NAP includes an ambitious blueprint for the agriculture and food security sector, with nine prioritized adaptation programs amounting to a significant budget. These programs aim to bolster agro-ecosystems, elevate productivity, conserve genetic resources, enhance capacities, embrace clean energy, and introduce farmer-friendly climate risk-sharing models.
- Focus on resilience: The NAP emphasizes building adaptive capacity and resilience to reduce vulnerability to climate change impacts.

3. Agriculture Development Strategy (ADS) 2015-2035: While not solely a climate change policy, the ADS is the guiding framework for Nepal's agricultural sector development and incorporates climate change considerations.

- Vision for sustainability: Its vision includes "a self-reliant, sustainable, competitive, and inclusive agricultural sector." sustainability inherently involves climate resilience.
- Addressing climate challenges: The ADS acknowledges emerging climate change challenges to the agriculture sector and suggests actions to address them.
- Promoting climate-smart agriculture: The ADS facilitates mechanisms to support the adoption and scaling up of CSA practices and technologies. CSA aims to sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change, and reduce/remove greenhouse gas emissions.

4. Local Adaptation Plans for Action (LAPA): Developed in 2011, LAPAs serve as crucial blueprints for implementing adaptation initiatives at the grassroots level. They translate national climate change policies into local actions, often focusing on:

- Community-based adaptation: Promoting context-specific adaptation measures identified by local communities, including those related to agriculture (e.g., drought-resistant crops, improved irrigation, changed planting calendars).
- Integrating climate change into local development: Ensuring that climate change considerations are factored into local development planning and budgeting processes.

5. Other Relevant Initiatives and Policies

- ***National Framework on Local Adaptation Plans for Action (LAPA Framework):*** Provides guidance for integrating climate change adaptation into local planning processes.
- ***Promoting Climate Resilient Agriculture (CRA) Projects:*** Various projects supported by international partners (like FAO, UNDP, CIF, GCF) focus on building climate resilience in Nepal's agriculture sector. These often involve:
  - Capacity building for farmers and agricultural institutions.
  - Improving access to weather and climate information and early warning systems.
  - Introducing stress-tolerant crop varieties and livestock breeds.
  - Promoting efficient irrigation technologies and water management.
  - Developing and disseminating climate-smart farming practices (e.g., integrated pest management, organic fertilization, agroforestry).
  - Facilitating access to finance and insurance for climate adaptation.
- ***Forestry and Biodiversity Policies:*** While focused on forests, these policies often intersect with agriculture through agroforestry, watershed management, and biodiversity conservation, which contribute to climate resilience in agricultural landscapes.

Module 3: Identification of Climate Change Adaptation Options in Agriculture Sector of Nepal

Nepal's agriculture sector, being highly vulnerable to climate change, requires a multi-pronged approach to climate change adaptation. The identification of effective adaptation options considers both traditional knowledge and modern scientific advancements, aiming to build resilience across diverse agro-ecological zones. The key adaptation options in the agriculture sector of Nepal include:

1. Climate-Smart Agriculture (CSA) Practices: CSA is a holistic approach that seeks to achieve food security and broader development goals under a changing climate. It focuses on three pillars: sustainably increasing productivity and incomes, adapting and building resilience to climate change, and reducing/removing greenhouse gas emissions. Some of the CSA practices are described below.

- **Improved Crop Varieties**
  - Drought-tolerant crops: Introducing and promoting varieties of maize, rice, millet, and other staples that can withstand prolonged dry spells.
  - Flood-tolerant crops: Cultivating paddy varieties that can tolerate submergence for extended periods.
  - Short-duration varieties: Using early-maturing crops to avoid late-season droughts or unseasonal heavy rainfall.
  - Pest and disease-resistant varieties: Breeding and deploying crops with inherent resistance to common pests and diseases whose prevalence might increase with changing climate.
  - Heat-tolerant varieties: Developing or introducing crops that can maintain yields under higher temperatures.

- **Water Management Technologies**
  - Efficient irrigation systems: Implementing drip irrigation, sprinkler systems, and micro-irrigation to maximize water use efficiency, especially in water-scarce regions.
  - Rainwater harvesting: Constructing ponds, tanks, and check dams to collect and store rainwater for irrigation during dry periods.
  - Alternate wetting and drying (AWD) for rice: A water-saving technology that involves intermittently irrigating rice fields instead of continuous flooding, reducing water consumption and methane emissions.
  - Groundwater recharge: Promoting practices that allow rainwater to infiltrate and replenish groundwater tables.

- **Soil Health Management**
  - Conservation agriculture: Practices like minimum tillage/zero tillage to reduce soil disturbance, retain soil moisture, and prevent erosion.
  - Crop rotation and diversification: Rotating different crops to improve soil fertility, break pest cycles, and enhance overall farm resilience.
  - Cover cropping: Planting non-cash crops between main crop cycles to protect soil from erosion, suppress weeds, and add organic matter.

- Organic fertilization and green manure: Utilizing compost, farmyard manure, and green manure crops (e.g., sun hemp) to improve soil structure, fertility, and water retention.
- Terracing and contour farming: Traditional and effective methods, particularly in hilly regions, to prevent soil erosion and conserve water.

- **Agroforestry:** Integrating trees into farming systems (e.g., planting fodder trees, fruit trees, or timber trees alongside crops or pastures). This provides shade, reduces soil erosion, enhances biodiversity, sequesters carbon, and offers alternative income sources.

2. Diversification and Livelihood Strategies

- Crop diversification: Shifting from monoculture to growing a variety of crops, including short-duration vegetables, legumes, and high-value crops, to reduce risk and improve food security. This also helps improve soil fertility.
- Livestock integration: Raising small ruminants (goats, poultry) alongside crop farming. Livestock provide manure for fertilizer, and their sales offer diversified income streams. Promoting fodder and zero grazing can also contribute to reducing deforestation and land degradation.
- High-value crops and niche products: Promoting cultivation of high-value crops (e.g., ginger, turmeric, cardamom, off-season vegetables) suitable for specific agro-climatic zones, which can provide higher income even with smaller landholdings.
- Off-farm income generation: Supporting farmers in developing non-agricultural skills and enterprises to diversify household income, reducing their sole reliance on agriculture and increasing their adaptive capacity.

3. Climate Information Services and Early Warning Systems:

- Weather forecasts: Providing timely and localized weather forecasts (temperature, rainfall, extreme events) through various channels (mobile alerts, radio, and community groups) to help farmers make informed decisions about planting, harvesting, and other farm operations.
- Pest and disease surveillance: Establishing systems to monitor and provide early warnings about pest and disease outbreaks, allowing for timely interventions.
- Agro-advisory services: Offering expert advice to farmers on appropriate climate-smart practices based on local conditions and forecasts.

4. Institutional and Policy Support

- Access to finance and insurance: Facilitating access to agricultural loans, microfinance, and crop/livestock insurance schemes to help farmers cope with climate-induced losses and invest in adaptation measures.
- Research and development: Investing in agricultural research to develop new climate-resilient crop varieties, livestock breeds, and farming technologies specifically suited for Nepal's diverse agro-ecological conditions.
- Capacity building and extension services: Providing training, demonstrations, and farmer-to-farmer learning platforms to enhance farmers' knowledge and skills in climate-smart agriculture.
- Community-based adaptation (CBA): Empowering local communities to identify their specific climate risks and design and implement localized adaptation solutions, often

drawing on indigenous knowledge (e.g., community-managed irrigation systems, farmer-managed seed banks).

- Strengthening value chains: Building resilient value chains that can withstand climate shocks, ensuring market access for farmers' products.

5. Ecosystem-Based Adaptation (EbA)

- Watershed management: Protecting and restoring degraded watersheds to ensure consistent water supply for agriculture and reduce the risk of floods and landslides.
- Forestry and agroforestry: Restoring forests and promoting agroforestry practices to enhance ecosystem services, improve soil health, and regulate local climate.
- Biodiversity conservation: Conserving agricultural biodiversity (traditional crop varieties, local livestock breeds) as a crucial genetic resource for future adaptation.

Module 4: Examples of Climate Change Adaptation Options that can be Mainstreamed in Agriculture Sector

Mainstreaming adaptation options in the agriculture sector means integrating climate change considerations into the routine planning, policies, programs, and practices of agricultural development. It's about making climate resilience a core element of how agriculture operates, rather than a separate, add-on activity. Some examples of adaptation options that can be mainstreamed, with an emphasis on how they become integrated into normal agricultural operations, include:

I. Integrating into National/Sub-National Agricultural Policies and Strategies

- ***Mainstreaming in policy for climate-resilient crop varieties and breeds*:** Government agricultural research institutions (e.g., NARC in Nepal) routinely prioritize breeding and releasing drought-tolerant, flood-tolerant, heat-tolerant, and pest/disease-resistant crop varieties (e.g., submergence-tolerant rice, early-maturing maize). Similarly, livestock breeding programs focus on indigenous breeds known for their resilience or developing new resilient breeds. For example, providing incentives for seed companies to produce and distribute these varieties, subsidizing their purchase by farmers, and integrating them into national seed plans. Research funding is specifically allocated for these traits.

- ***Mainstreaming in water-smart agricultural practices promotion:*** National irrigation policies and programs shift from large-scale, open-canal systems to promoting water-efficient technologies like drip irrigation, sprinkler systems, and rainwater harvesting at the farm and community levels. Extension services actively demonstrate and train farmers on these techniques. For example, subsidies for farmers to adopt micro-irrigation, inclusion of rainwater harvesting structures in community agricultural infrastructure projects, and curricula for agricultural technicians including water-use efficiency modules.

- ***Mainstreaming in soil health and conservation agriculture policies:*** Agricultural policies promote practices that enhance soil organic matter, reduce erosion, and improve water retention. This includes conservation tillage (minimum or zero tillage), crop rotation, intercropping, and the use of cover crops. For example, inclusion of conservation agriculture principles in national agricultural extension manuals, payment for ecosystem services schemes that reward farmers for adopting soil-friendly practices, and research on local context-specific conservation tillage methods.

- ***Mainstreaming in agroforestry as a standard practice:*** Policies and programs encourage the integration of trees into farming systems, recognizing their multiple benefits (shade, soil stabilization, fodder, timber, carbon sequestration). For example, forestry departments and agriculture departments collaborate on agroforestry extension packages. Subsidies for planting multi-purpose tree species on farm boundaries or within fields. Inclusion of agroforestry models in land-use planning documents.

II. Integrating into Agricultural Programs and Projects (Development and Extension)

- ***Mainstreaming in Climate Information Services (CIS) as a Core Component:*** Instead of being standalone projects, climate information and agro-advisory services become an inherent part of regular agricultural extension. For example, daily weather forecasts and seasonal outlooks are integrated into agricultural radio programs, mobile SMS services for farmers, and local government agricultural meetings. Extension workers are trained to interpret and disseminate climate information effectively.

- ***Diversification of Farming Systems:*** Development projects and extension efforts actively promote crop, livestock, and livelihood diversification rather than encouraging monoculture. For example, providing technical support and market linkages for farmers to grow diverse high-value crops (e.g., off-season vegetables, herbs) alongside staples. Training farmers on integrated farming systems that combine crops, livestock, and aquaculture.

- ***Risk Transfer Mechanisms (Agricultural Insurance):*** Agricultural insurance schemes (e.g., crop insurance, livestock insurance) are developed and made accessible to farmers as a regular tool for managing climate-related risks. For example, Government or private sector insurance products tailored to specific climate risks (e.g., drought index insurance), with partial premium subsidies for smallholder farmers. Awareness campaigns on the benefits and workings of agricultural insurance.

- ***Farmer Field Schools (FFS) and Capacity Building:*** Training programs for farmers through FFS or similar extension methodologies consistently incorporate climate change adaptation strategies into their curriculum. For example, FFS sessions demonstrating how to apply water-saving irrigation, identify new climate-induced pests, or select appropriate drought-resistant crop varieties. Training to farmers to conduct their own risk assessments and develop local adaptation plans.

III. Integrating into Local Governance and Community Planning

- ***Local Adaptation Plans of Action (LAPAs)[10] with Agricultural Focus:*** Local governments (municipalities, rural municipalities) are mandated and supported to develop LAPAs that specifically identify and budget for agricultural adaptation actions. For example, community meetings led by local government officials to prioritize climate risks in agriculture (e.g., increased landslides, erratic rainfall) and allocate funds for solutions like check dams, improved drainage, or resilient seed banks.

- ***Disaster Risk Reduction (DRR) in Agricultural Planning:*** DRR strategies and early warning systems are integrated into agricultural development plans at the local level. Example of DRR in agriculture planning include community-level disaster preparedness plans include measures for protecting crops and livestock during floods or landslides. Early warning systems provide specific agricultural advice (e.g., "heavy rain expected, harvest ripe crops early").

IV. Integrating into Research and Development

- ***Applied Research on Local Adaptation*****:** Agricultural research institutions conduct demand-driven research on adaptation options that are context-specific, socially acceptable, and economically viable for different agro-ecological zones and farming systems. Scope of research include researching the performance of traditional crop varieties under new climate scenarios, developing appropriate technologies for small-scale farmers in rain-fed areas, and studying the effectiveness of different agroforestry models.

[10] http://climate.mohp.gov.np/downloads/National_Framework_Local_Adaptation_Plan.pdf

Module 5: Climate Smart Agriculture Framework

A Climate-Smart Agriculture (CSA) framework is a comprehensive approach to managing agricultural landscapes that aims to achieve three interconnected objectives, often referred to as the "triple-win":

1. Sustainably increasing agricultural productivity and incomes: This involves enhancing yields, improving efficiency in resource use (land, water, nutrients), and strengthening food security, ultimately contributing to better livelihoods for farmers.
2. Adapting and building resilience to climate change: This means helping agricultural systems and communities cope with the current and future impacts of climate change, such as droughts, floods, extreme temperatures, and new pests and diseases. It focuses on reducing vulnerability and strengthening the capacity to absorb shocks.
3. Reducing and/or removing greenhouse gas (GHG) emissions: Where possible, CSA seeks to mitigate agriculture's contribution to climate change by reducing emissions from farming practices (e.g., improved livestock management, optimized fertilizer use) and enhancing carbon sequestration in soils and biomass (e.g., agroforestry, conservation agriculture).

I. Key Components of a CSA Framework

While the specific practices and interventions within a CSA framework are highly context-specific, the overarching framework typically involves:

1. **Evidence Base and Situation Analysis**
   - Assessing current and projected climate change impacts on specific agricultural systems.
   - Identifying vulnerabilities and risks.
   - Analyzing existing traditional and innovative CSA practices and their potential for productivity, adaptation, and mitigation.
   - Understanding socio-economic, environmental, and institutional contexts.
2. **Policy and Enabling Environment**
   - Developing supportive national and local policies, strategies, and regulations that encourage CSA adoption.
   - Ensuring coherence and coordination across different sectors (agriculture, environment, finance, etc.).
   - Addressing issues like land tenure, market access, and gender equity, which can significantly influence CSA adoption.
3. **Institutional Strengthening and Capacity Building**
   - Building the capacity of farmers, extension services, researchers, and other stakeholders to understand, implement, and monitor CSA practices.
   - Strengthening research and development institutions to generate context-specific CSA innovations.
   - Fostering farmer organizations and community-based initiatives.
4. **Financing and Investment**
   - Mobilizing public and private finance for CSA investments.

- Exploring innovative financing mechanisms, including climate finance, carbon markets, and risk insurance.
- Providing financial incentives for farmers to adopt CSA practices.

5. **Technology and Practices**
   - Promoting a diverse range of climate-smart practices, which can include:
     - Crop management: Drought-tolerant and heat-tolerant varieties, improved seeds, integrated pest management, precision agriculture, diversified cropping systems.
     - Water management: Efficient irrigation (e.g., drip irrigation), rainwater harvesting, water-saving technologies.
     - Soil management: Conservation agriculture (minimum tillage, cover cropping, crop rotation), improved nutrient management, organic matter enhancement, carbon farming.
     - Livestock management: Improved feeding strategies, manure management, improved breeds.
     - Agroforestry: Integrating trees into farming systems for multiple benefits (shade, soil improvement, carbon sequestration, diversified income).
     - Post-harvest management: Climate-smart storage structures, reducing food loss and waste.

6. **Monitoring, Evaluation, and Learning (MEL)**
   - Establishing robust MEL systems to track progress, assess impacts, and learn from experiences.
   - Documenting successful CSA practices and their benefits.
   - Facilitating knowledge sharing and peer-to-peer learning among farmers and stakeholders.

II. Examples of CSA Frameworks in Practice

Many countries and organizations have adopted CSA frameworks, often tailored to their specific needs. Some examples include:

- ***Nepal National Adaptation Programme of Action*** (NAPA, 2010) of Nepal identifies immediate and urgent needs for climate change adaptation in the most vulnerable sectors, including agriculture and food security. Nine projects aligned with the NAPA are currently being implemented. It has described national CSA policies and frameworks, identifying priority practices and investment areas based on their unique contexts. (The document is available from: https://unfccc.int/resource/docs/napa/npl01.pdf)
- ***The Local Adaptation Plan of Action (LAPA) Framework, 2019*** of Nepal provides guidelines for local adaptation planning and implementation, creating opportunities for integrating CSA practices into local development plans as well as annual agricultural extension plans (The document is available from: http://climate.mohp.gov.np/downloads/National_Framework_Local_Adaptation_Plan.pdf)
- ***FAO's Climate-Smart Agriculture (CSA) Guide:*** Provides a comprehensive approach to planning, implementing, and assessing CSA projects and programs, emphasizing situation analysis, targeting and prioritization, program support, and MEL. (Reference materials is available on: https://www.fao.org/climate-smart-agriculture-sourcebook/en/)

- ***The World Bank's CSA Approach:*** Focuses on diagnostics to inform and accelerate climate action in the agriculture and food sector, turning analytics into action through financing and advice, and developing country-level CSA Investment Plans. (Resource material is available on: https://www.worldbank.org/en/topic/climate-smart-agriculture#:~:text=Climate%2Dsmart%20agriculture%20(CSA),food%20security%20and%20climate%20change).

Challenges in Implementing CSA Frameworks in the Project area

Despite the clear benefits, implementing CSA frameworks faces several challenges in the MaWRiN project area. The key challenges identified during field consultations are as below:

- Lack of investment: Insufficient funding for research, development, and scaling up of CSA practices, particularly at the local government level.
- Knowledge gaps and awareness: Limited awareness among farmers and stakeholders (both district line agencies and local governments) about CSA practices and their benefits, as well as a lack of context-specific knowledge.
- Policy and institutional barriers: Fragmented policies, poor inter-ministerial coordination, weak institutional capacity, and inadequate extension services.
- Tenure insecurity: Farmers are less likely to invest in long-term CSA practices due to the they lack secure land tenure.
- Access to finance: Smallholder farmers often face difficulties accessing credit and financial incentives for adopting new technologies.
- Trade-offs and synergies: Identifying and managing the potential trade-offs and maximizing synergies between the three CSA pillars (productivity, adaptation, mitigation) can be complex.
- Data and monitoring: Challenges in collecting robust data to measure the impact of CSA interventions and inform future decisions.
- Behavioral change: Shifting traditional farming practices requires overcoming inertia, cultural norms, and risk aversion among farmers.

The MaWRiN project, therefore, needs to focus on addressing these challenges. Overcoming these challenges requires a concerted effort involving governments, international organizations, civil society, the private sector, and farmers themselves, focusing on integrated approaches, capacity building, and innovative financing mechanisms.

Module 6: Challenges of Mainstreaming Climate Change Adaptation Options in Agriculture Sector

Mainstreaming Climate Change Adaptation (CCA) options in the project area's agriculture sector is crucial given its high vulnerability, but it faces numerous challenges. These challenges are often interconnected, spanning institutional, financial, technical, social, and informational domains. The key challenges include:

I. Institutional and Governance Challenges

- ***Weak coordination and fragmented approaches:*** Numerous government ministries, departments, NGOs, and international organizations are involved in agriculture and climate change, often working in silos. This leads to duplication of efforts, inefficient resource allocation, and a lack of coherent policy implementation. In Nepal, the shift to a federal structure has added complexity, requiring effective coordination between federal, provincial, and local governments, which is still evolving.

- ***Limited institutional capacity****:* Government agencies at all levels often lack sufficient human resources, technical expertise, and institutional mandates to effectively plan, implement, and monitor CCA initiatives. There's a particular need to enhance the capacity of local government staff and agricultural extension workers on climate change, vulnerability assessment, and the selection and integration of adaptation options.

- ***Policy-practice gap:*** Nepal has strong climate change policies (e.g., National Climate Change Policy, NAP, ADS) on paper, but their effective translation into concrete, on-the-ground action is often lacking. Studies show that while policies are coherent for targeting highly affected areas, they may deviate in discerning appropriate planning and implementing units at the local level.

- ***Inadequate mainstreaming into regular planning:*** Climate change adaptation is often treated as a separate, project-based activity rather than being fully integrated into core agricultural development planning and budgeting processes. While LAPAs exist, their full institutionalization and integration into regular local development plans remain a challenge. Some local authorities may implement "climate-friendly" programs without explicitly declaring them as climate actions.

II. Financial Challenges

- ***Limited financial resources:*** Implementing widespread CCA options, especially those requiring significant investment (e.g., large-scale irrigation infrastructure, research into new crop varieties), requires substantial funding, which is often scarce. Reliance on external funding for many CCA initiatives makes them vulnerable to funding cycles and donor priorities. Domestic resource mobilization for climate action needs to be strengthened.

- ***Lack of access to finance for farmers:*** Smallholder farmers, who constitute the majority in Nepal, often lack access to credit, loans, or affordable agricultural insurance schemes to invest in adaptation technologies or cope with climate-induced losses. High transaction costs, lack of collateral, and limited financial literacy can be barriers for farmers trying to access formal financial services.

III. Technical and Technological Challenges

- ***Lack of context-specific technologies and knowledge:*** Adaptation options need to be tailored to specific agro-ecological zones and local contexts. "One-size-fits-all" solutions are often ineffective. Research and development of appropriate, locally relevant technologies are often insufficient. Nepal's vast agro-ecological diversity (Terai, Hills, Mountains) means

that an adaptation option effective in one region might not work in another. Scientific evidence for many climate-smart techniques is not always well-documented or disseminated.

- ***Weak agricultural extension services:*** The reach and effectiveness of agricultural extension services in disseminating climate-smart agriculture (CSA) knowledge and practices to farmers are often limited. Farmers have limited access to weather and climate information and early warning systems. Weak extension services mean farmers lack knowledge of improved soil fertility practices, disease-resistant crop care, and efficient irrigation techniques.

- ***Availability and affordability of inputs:*** Even if farmers are aware of adaptation options, the necessary inputs (e.g., drought-tolerant seeds, new machinery, quality fertilizers, and pesticides for new pests) may not be readily available or affordable at the local level. The supply chain for climate-resilient inputs can be weak, and the cost of some advanced CSA technologies (e.g., solar-pump irrigation, machine-based zero-tillage) can be prohibitive for smallholder farmers.

IV. Socio-Economic and Cultural Challenges

- ***Low adaptive capacity of farmers:*** Many farmers, particularly smallholder and subsistence farmers have limited financial, social, and technical resources, making it difficult for them to adopt new practices or absorb climate shocks. The high incidence of poverty in rural areas exacerbates vulnerability. Many farmers practice autonomous adaptation based on limited understanding, which can sometimes lead to maladaptive practices.

- ***Land fragmentation and small landholdings:*** Extremely fragmented landholdings in Nepal limit the adoption of modern machinery or larger-scale adaptation interventions that require contiguous land. The average farm size is small (around 0.68 ha), making commercialization difficult and increasing production costs.

- ***Out-migration and feminization of agriculture:*** Significant male out-migration from rural areas for economic opportunities means that women, the elderly, and marginalized groups are increasingly responsible for farming. These groups often face structural inequalities, limited access to resources, information, and decision-making power. Women farmers, while crucial, may have less access to land ownership, credit, and extension services, hindering their ability to adapt.

Dependency of people on out-migration

The findings revealed that nearly 95% of households of Marin Rural Municipality primarily depend on remittances for their income, with 96.9% using the sum for debt repayment and 78.6% for their children's education. Furthermore, the findings indicated that remittances significantly impact various aspects of individuals' lives in the research area, including food sufficiency, healthcare access, and community involvement. With a substantial impact on debt repayment, savings, and children's education, remittances significantly contribute to the socio-economic landscape, positively affecting food sufficiency, healthcare access, and overall consumption for families in the agricultural communities of Sindhuli district of Nepal.

***Source**: Thapaliya, et. al., 2025. Impacts of remittance on migrants' households in Agrarian societies of Sindhuli, Nepal. Journal of Agriculture and Forestry University, 6(1):31 - 44*

- ***Lack of awareness and understanding:*** Farmers and even some local officials may have a limited understanding of long-term climate change impacts versus seasonal variability, leading to reactive rather than proactive adaptation. There is a need for more field-based demonstrative understanding and awareness campaigns for smallholder farmers.

- ***Perception and risk aversion:*** Farmers, particularly those operating at subsistence levels, can be risk-averse. Adopting new practices involves uncertainty, labor changes, and potential initial yield reductions, which can deter adoption. If the benefits of new adaptation

practices are not immediately obvious or guaranteed, farmers may stick to traditional, albeit less resilient, methods.

V. Data and Information Gaps

- ***Limited Localized Climate Data:*** Lack of granular, localized climate data and projections makes it difficult to design precisely targeted adaptation interventions. While national-level data exists, micro-spatial climate variability is significant, requiring detailed regional and local data for effective planning.
- ***Poor Documentation and Sharing of Best Practices:*** Successful adaptation strategies and lessons learned are not always well-documented, disseminated, or integrated into wider knowledge management systems. This hinders the scaling up of successful interventions and prevents others from learning from past experiences.

Module 7: Climate Resilient Agriculture Practices and Technologies

Climate-resilient agriculture encompasses a range of practices and technologies that enable agricultural systems to withstand and adapt to the impacts of climate change, such as rising temperatures, changing precipitation patterns, and increased frequency of extreme weather events (droughts, floods, hail, frost). The goal is to ensure food security, improve livelihoods, and contribute to environmental sustainability. The key climate-resilient agriculture practices and technologies are described below.

I. Practices (Nature-Based Solutions and Traditional Knowledge)

These practices often involve integrating ecological principles and traditional knowledge:

1. **Diversification of Crops and Livestock:**
    - Mixed farming/intercropping: Growing multiple crops together or integrating livestock and crops. This spreads risk, enhances biodiversity, improves nutrient cycling, and provides varied income streams. For example, planting drought-tolerant millets alongside more water-intensive crops.
    - Climate-smart varieties: Cultivating local, indigenous, and improved crop varieties that are inherently more tolerant to drought, heat, cold, floods, or specific pests and diseases. This includes short-duration varieties, stress-tolerant rice, and improved breeds of goats or poultry.
    - Agroforestry: Integrating trees and shrubs into agricultural landscapes. Trees provide shade for crops and livestock, improve soil health (through leaf litter and root systems), fix nitrogen (leguminous trees), offer fodder and fuel, act as windbreaks, and sequester carbon.

2. **Soil Health and Fertility Management (Conservation Agriculture):**
    - No-till/reduced tillage: Minimizing soil disturbance helps maintain soil structure, increase organic matter, improve water infiltration, and reduce erosion.
    - Cover cropping: Planting non-cash crops (e.g., legumes) to cover the soil during fallow periods. This protects against erosion, suppresses weeds, improves soil fertility, and retains moisture.
    - Crop rotation: Alternating different types of crops on the same land over time to improve soil health, break pest and disease cycles, and optimize nutrient use.
    - Organic fertilizers/composting: Using farmyard manure, compost, and green manures to replenish soil organic matter and nutrients, enhancing soil's water-holding capacity and resilience.
    - Vermiculture: Using worms to break down organic matter into nutrient-rich compost that improves soil fertility.

3. **Efficient Water Management:**
    - Rainwater harvesting: Collecting and storing rainwater (e.g., in ponds, tanks, or through contour bunding) for irrigation during dry periods, reducing reliance on groundwater.
    - Efficient irrigation techniques: Practices like drip irrigation and sprinkler irrigation deliver water directly to plant roots, minimizing waste.
    - Mulching: Covering the soil surface with organic materials (crop residues, straw) or plastic sheets to reduce evaporation, conserve soil moisture, and suppress weeds.

- Springshed management: Protecting and restoring the recharge areas of natural springs to ensure continuous water flow, which is crucial for many rural communities.

4. Integrated Pest and Disease Management (IPM):

- Biological control: Using natural predators, parasites, or pathogens to control pests instead of relying solely on chemical pesticides.
- Cultural practices: Employing techniques like appropriate planting dates, crop rotation, and timely weeding to prevent pest and disease outbreaks.
- Resistant varieties: Using crop varieties that have natural resistance or tolerance to common pests and diseases.
- Bio-pesticides: Utilizing extracts from local plants (e.g., neem, *Titepati*) with insecticidal properties.

5. Optimized Crop Calendars and Seasonal Adjustments

- Adjusting planting and harvesting dates based on changing climate patterns and seasonal forecasts to avoid periods of extreme heat, drought, or heavy rainfall.
- Cultivating crops with shorter growing cycles to reduce exposure to prolonged stress.

6. Farmer Education and Training

- Knowledge sharing platforms**:** Access to information on new techniques, climate forecasts, and sustainable practices can help farmers adapt more quickly.
- Training programs: Educating farmers on how to adopt new technologies and practices can improve resilience at the grassroots level.

II. Technologies (Modern Tools and Innovations)

The climate resilient agriculture technologies, usually modern tools and innovations, often complement and enhance traditional practices. The common climate-resilient technologies used in Nepal are as below.

1. Improved Irrigation Technologies

- Smart irrigation systems: Smart irrigation systems are advanced, technology-driven solutions that optimize water usage in agriculture by delivering the right amount of water at the right time. These systems enhance water-use efficiency, reduce waste, and help crops withstand climate-related stress such as droughts or irregular rainfall. These technologies move beyond traditional flood irrigation methods to more precise and efficient water delivery systems. Some of the examples of improved irrigation technologies are: Drip irrigation (micro-irrigation), sprinkler irrigation, smart/precision irrigation systems (data driven) and subsurface drip irrigation.
- Solar-powered irrigation: Utilizing solar energy to power pumps for irrigation, reducing reliance on fossil fuels and providing a sustainable energy source.
- General benefits of improved irrigation technologies include: water conservation, increased crop yields and quality, reduced production costs, environmental sustainability, improved soil health, adaptation to climate change, and higher cropping intensity.

2. **Resilient Crop and Livestock Technologies**
   - Stress-tolerant crop varieties: Development and promotion of genetically improved crop varieties and livestock breeds that perform well under adverse climatic conditions. Stress-tolerant crop varieties include drought-tolerant varieties, flood-tolerant varieties, heat-tolerant varieties, salinity-tolerant varieties, pest and disease resistant varieties, etc. In Nepal, several drought-tolerant maize, and flood-tolerant rice varieties have been developed to cultivate under adverse climatic conditions.
   - Protected cultivation: Use of greenhouses, poly-houses, or net houses to protect crops from extreme weather events (hail, frost, strong winds) and manage microclimates.
   - Hydroponics/aeroponics: Soilless farming techniques that can significantly reduce water consumption and allow for controlled environments, though often more capital-intensive.

3. **Agro-Biodiversity and Crop Diversification**
   - Revival of local landraces: Promoting and conserving traditional, locally adapted crop varieties (landraces) that have evolved resilience to local stresses over generations. Nepal has rich diversity in rice, maize, and millet landraces.
   - Diversified cropping systems: Implementing multi-cropping, intercropping, and crop rotation to enhance resilience against a single crop failure and improve soil health.
   - Agroforestry systems: Integrating trees and shrubs into crop and livestock farming systems. Trees provide shade, improve soil fertility, act as windbreaks, offer fodder, fuel, and timber, and sequester carbon, creating a more resilient and diverse farm ecosystem.

4. **Seed Banks and Community Seed Systems**
   - Community seed banks: Local initiatives where farmers conserve, exchange, and manage diverse seeds of traditional and improved varieties, ensuring access to climate-resilient seeds even after climate shocks.
   - Formal seed systems: Development and distribution of certified climate-resilient seeds through research institutions (e.g., NARC) and private companies.

5. **Post-Harvest Technologies**
   - Improved storage facilities: Technologies like hermetic bags or improved silos to prevent post-harvest losses due to moisture, pests, and mold, enhancing food security.
   - Value addition/processing: Technologies for drying, processing, and preserving agricultural products to reduce waste and create new income opportunities, particularly for off-season markets.

6. **Digital Climate Services and Agro-Advisories**
   - Weather forecasting tools: Mobile applications and online platforms providing localized, real-time weather forecasts, early warnings for extreme events (floods, droughts, hailstorms), and agro-advisories (e.g., optimal planting times, pest alerts).
   - Remote sensing and GIS: Using satellite imagery and Geographic Information Systems to monitor crop health, soil moisture, vegetation cover, and identify degraded areas, helping farmers make informed decisions.
   - Precision agriculture: Using sensors, drones, and GPS-enabled equipment to precisely apply water, fertilizers, and pesticides based on real-time needs, optimizing resource use and reducing waste.

Benefits of Adopting Climate-Resilient Agriculture Practices and Technologies

- Improved crop yields and productivity: Helps farmers maintain or even increase yields despite climate variability.
- Enhanced food security: Ensures more stable food production and availability, reducing hunger and malnutrition.
- Increased livelihoods and income: Provides farmers with more reliable income sources and diversified opportunities.
- Reduced vulnerability to shocks: Makes farming systems more resilient to droughts, floods, and other extreme weather events.
- Environmental protection: Promotes soil health, conserves water, reduces deforestation, and mitigates greenhouse gas emissions (carbon sequestration).
- Efficient resource use: Optimizes the use of water, fertilizers, and energy, leading to cost savings.
- Data-driven decision making: Empowers farmers with information to make better choices for their farms.
- Gender equality: Many climate-resilient agriculture initiatives, particularly in Nepal, involve and empower women farmers who are often at the forefront of agricultural labor.

Module 8: Promotion of Indigenous Crops and Seed Production

Promoting indigenous crops and seed production is a crucial strategy for enhancing food security, improving livelihoods, conserving biodiversity, and building climate resilience in the ecologically fragile and socio-economically vulnerable area. Particularly, the Chure region, characterized by fragile geology, steep slopes, active erosion, and a mix of diverse ethnic communities, stands to benefit immensely from such initiatives.

Importance of Promotion of Indigenous Crops and Seeds Production

1. ***Climate resilience:*** Indigenous crops are inherently adapted to local agro-climatic conditions, including erratic rainfall (droughts and floods), heat stress, and varying soil types prevalent in the Chure. They often perform better than exotic varieties under stress.
2. ***Ecological appropriateness:*** Many indigenous varieties are less demanding on external inputs (fertilizers, pesticides), aligning with sustainable land management and minimizing environmental degradation in a sensitive ecosystem.
3. ***Nutritional security:*** Indigenous crops often have superior nutritional value (e.g., millets, local pulses) compared to staple crops, contributing to dietary diversity and addressing malnutrition.
4. ***Biodiversity conservation:*** Promoting indigenous crops helps conserve agricultural biodiversity, which is vital for the long-term adaptability of farming systems.
5. ***Reduced dependency:*** Local seed production reduces farmers' reliance on external, often expensive, seed markets and enhances seed sovereignty.
6. ***Cultural significance:*** Many indigenous crops are deeply intertwined with local cultural practices, festivals, and traditional food systems, strengthening cultural identity.
7. ***Soil health and erosion control:*** Practices associated with indigenous crops (e.g., diverse cropping, less intensive tillage) often contribute to better soil cover and reduced erosion, critical in the Chure's fragile slopes.

Strategies for Promotion of Indigenous Crops and Seed Production

1. Awareness and Valuation Campaigns

- Highlight benefits: Conduct workshops, farmer field days, and community meetings to raise awareness about the nutritional, economic, and ecological benefits of indigenous crops.
- Cooking demonstrations: Showcasing diverse and tasty recipes using indigenous crops to increase their consumption and market demand.
- Success stories: Feature farmers who have successfully cultivated indigenous crops and benefited from them.

2. Research, Documentation, and Selection

- Ethnobotanical surveys: Documenting existing indigenous crop varieties, their characteristics, uses, and associated traditional knowledge in the Eastern Chure.
- On-farm research: Collaborating with farmers to test the performance of various indigenous landraces under changing climatic conditions.
- Participatory varietal selection: Empowering farmers to select preferred varieties based on their criteria (yield, taste, drought tolerance, pest resistance).

- Germplasm collection and conservation: Establishing local conservation centers or collaborating with national gene banks (e.g., National Agricultural Genetic Resources Centre - NAGRC) to preserve valuable genetic material.

3. Strengthening Community Seed Systems

- Community seed banks: Establish and support farmer-managed community seed banks (CSBs) at the local level. These CSBs serve as local repositories for diverse indigenous seeds, facilitate seed exchange, and ensure seed availability after disasters.
- Farmer field schools (FFS): Conduct FFS focusing on improved seed production techniques for indigenous varieties, quality control, storage, and seed health.
- Seed producer groups/cooperatives: Organize and train farmer groups specifically for the production of quality seeds of indigenous crops, connecting them to local markets.
- Quality seed certification (informal/formal): Support farmers in informal seed quality assurance or link them to formal certification processes where applicable.

4. Promoting Sustainable Cultivation Practices:

- Conservation agriculture: Encourage practices like reduced tillage, mulching with crop residues, and cover cropping to improve soil health, conserve moisture, and reduce erosion in the fragile Chure slopes.
- Intercropping and mixed cropping: Promote the traditional practice of growing multiple indigenous crops together to maximize land use, enhance biodiversity, and reduce risks.
- Organic farming: Encourage the use of farmyard manure, compost, and bio-pesticides, aligning with the low-input nature of many indigenous crops.
- Climate-smart irrigation: Promote small-scale, efficient irrigation methods appropriate for indigenous crops and Chure topography (e.g., micro-irrigation, rainwater harvesting).

5. Market Linkages and Value Addition

- Niche markets: Identify and develop niche markets for indigenous crops, emphasizing their unique nutritional value, organic nature, or cultural significance.
- Value addition: Support small-scale processing and value addition (e.g., flour from millets, healthy snacks, traditional beverages) to increase farmers' income.
- Fair pricing: Advocate for fair pricing mechanisms that reflect the ecological and nutritional value of indigenous crops, moving away from volume-based pricing alone.
- Farmer-producer organizations or cooperatives: Support the formation of FPOs to collectivize production, improve bargaining power, and streamline market access.

6. Policy and Institutional Support

- Integration into local plans: Advocate for the inclusion of indigenous crop promotion and seed production in local government (Rural Municipalities/Municipalities) agricultural and development plans.
- Subsidies and incentives: Provide targeted subsidies or incentives for farmers adopting indigenous crops and engaging in local seed production.
- Government research and extension: Encourage government agricultural research institutions (NARC) and extension services to prioritize research and extension on indigenous crops in the Chure region.

- Chure-Terai Madhesh Conservation and Development Board (CTMCDP): Collaborate with the CTMCDP to integrate indigenous crop promotion within their broader conservation and livelihood initiatives in the Eastern Chure.

7. Capacity Building and Knowledge Exchange

- Training programs: Organize comprehensive training on all aspects from seed selection, cultivation, pest management, harvesting, to post-harvest handling and seed storage.
- Farmer-to-farmer learning: Facilitate peer-to-peer knowledge exchange platforms, where experienced local farmers share their practices and insights.
- Youth engagement: Involve youth in agricultural activities, leveraging technology to promote indigenous knowledge and creating new opportunities in rural areas.

Module 9: Promotion of Riverbed Farming in Flood Damaged Agriculture Farms

Floods are a recurring disaster in Nepal, particularly in the Terai region, often leading to widespread deposition of sand, silt, and debris on previously fertile agricultural lands. This devastates farmers' livelihoods by making traditional cultivation impossible. In this context, promoting riverbed farming techniques on these flood-damaged lands becomes a highly relevant and adaptive strategy. This technology also helps reclaiming and utilizing land that was otherwise rendered unproductive due to flooding and sedimentation deposits.

I. The Opportunity in Flood-Damaged Farms

When rivers flood, they often deposit sand and gravel, transforming fertile fields into barren riverbeds. However, these lands, damaged by floods and sedimentation, once the floodwaters recede in the post-monsoon dry season, can become prime locations for riverbed farming. The underlying moisture content in the sandy substrate, coupled with the seasonal availability of the land, creates a unique opportunity for:

- Reclaiming productive capacity: Turning what appears to be "lost" land into a source of income.
- Rapid livelihood recovery: Providing immediate economic relief to farmers who have lost their standing crops and topsoil.
- Natural fertilization: Floodwaters often deposit nutrient-rich silt along with sand, which, when properly managed with organic matter, can enhance fertility.
- Climate resilience: It offers a flexible farming system that anticipates and adapts to the annual cycle of flooding and recession.

II. Why to Promote Riverbed Farming?

Riverbed farming offers a practical, low-cost, and effective solution for many flood-affected farmers, enabling them to turn a destructive force into a productive opportunity. Here are the justifications or key importance of riverbed farming in the project areas affected by flooding and sedimentation, and the cost of reclaiming the land is high.

1. Livelihood diversification and poverty reduction: It provides a crucial source of income and employment for marginalized communities, including landless farmers, who lack access to conventional agricultural land. This can be a stepping stone out of poverty, allowing families to earn significant income from off-season vegetable sales.
2. Food and nutrition security: Riverbed farming primarily focuses on high-value vegetables and cucurbits, which not only generate income but also provide nutritious food for families, contributing to improved dietary diversity and health outcomes, particularly for women and children.
3. Utilization of marginal land: It transforms otherwise fallow or "waste" riverbed land into productive agricultural areas, maximizing land use efficiency.
4. Off-season production and market access: Crops grown on riverbeds mature earlier than conventional field crops due to the unique microclimate of riverbeds, allowing farmers to fetch better prices in local and regional markets when supplies are low.
5. Climate change adaptation: As climate change leads to erratic rainfall, increased floods, and the deposition of sand on fertile lands, riverbed farming offers a flexible and adaptive

strategy. The rapid drying of riverbeds after monsoon allows for cultivation, while the risk is limited to a single season.

6. Low input requirements: Often requires minimal tillage and can utilize the conserved moisture from the receding river, reducing the need for extensive irrigation infrastructure. Farmers often use minimal chemical fertilizers, relying more on organic inputs, leading to environmentally friendlier practices.
7. Community empowerment: Many successful riverbed farming initiatives involve community groups, fostering collaboration, knowledge sharing, and collective bargaining power.

III. Key Techniques and Practices of Riverbed Farming

While the general principles of riverbed farming apply, there are specific considerations when dealing with flood-damaged agricultural land:

1. Site Assessment and Stability

Before starting the farming, the site identified for riverbed farming needs to be assesses for its suitability and stability. The following aspects need to be considered during the assessment:

- Post-flood topography: Carefully assess the new topography, sediment type (sand, silt, gravel), and depth of deposition. Some areas might be too gravely or unstable for cultivation.
- Erosion risk: Identify areas prone to further erosion or shifting river courses during the next monsoon. Plots should ideally be allocated perpendicular to the river flow to give farmers access to varying moisture levels and minimize the impact of future shifts.
- Water table depth: The presence of a water table not deeper than 1-1.5 meters is ideal to reduce the labor required for watering.

2. ***Site selection:*** Identifying suitable riverbed areas that are relatively stable, less prone to sudden floods, and retain some sub-surface moisture after the monsoon recedes.

3. Debris Clearance and Land Preparation

- Removal of large debris: Farmers will need to clear large boulders, logs, and other debris deposited by the flood. This can be labor-intensive or require machinery.
- Trench/Pit Preparation: Digging trenches (e.g., 50-100 cm deep and wide) or pits into the sandy substrate. These structures help to concentrate organic matter and access deeper moisture. The East-West orientation of trenches is crucial for maximizing sun exposure and minimizing sand collection by prevailing winds.
    - Trench system: Trench system of riverbed farming is usually practiced in western part of Nepal. It involves digging long, shallow trenches (e.g., 50-70 cm deep, 30-40 cm wide) in the sandy riverbed, often in an East-West direction to maximize sunshine and minimize sand collection. These trenches are filled with a mixture of sand and organic matter (compost, farmyard manure).
    - Pits system: Pits system of riverbed farming is usually practiced in the Eastern Nepal: For areas with shallower water tables, circular pits are dug, similarly filled with organic matter.

4. ***Soil improvement/Organic matter application:*** Flood-deposited sand is often low in organic matter. Massive incorporation of compost, farmyard manure (FYM), and other organic amendments into the trenches/pits are paramount. This improves:
    - Water holding capacity: Sandy soils drain quickly; organic matter acts like a sponge.
    - Nutrient retention: Organic matter provides a slow release of essential nutrients and prevents their leaching.
    - Microbial activity: Essential for healthy plant growth.

    Alternatively, bio-fertilizers can also be used in the farm. Promotion of local bio-fertilizers like *Jholmal* (a liquid bio-fertilizer from cow dung, urine, and plant extracts) can further enhance soil fertility and reduce reliance on external inputs.

5. ***Crop and Variety Selection:*** The common crops cultivated in riverbed farming are:
    - Drought-tolerant, deep-rooted crops: Cucurbits are the most common and successful crops grown in riverbed farming due to their long taproots, which can reach the deeper, moist subsoil layers. Examples include watermelon, muskmelon, cucumber, bottle gourd, bitter gourd, sponge gourd, pumpkin, and pointed gourd.
    - Other fast growing varieties: Given the limited dry season window, selecting varieties with shorter maturity periods is beneficial.
    - High-value crops or vegetables: Some farmers also cultivate tomatoes, chilies, beans, and certain leafy greens, depending on soil conditions and market demand. Focus should be on the crops that provide significant income given the labor invested, leveraging off-season market advantage.

6. ***Water management***
    - Initial hand watering: In the initial stages, young plants may require hand watering from the remaining river water until their roots grow deep enough to access the subsoil moisture.
    - Mulching: A layer of organic material (crop residues, dry grass) or plastic sheets are applied over the planting area helps conserve soil moisture, suppress weeds, and regulate soil temperature.
    - Mini-ponds/water harvesting: in some cases, digging small temporary ponds nearby to store residual river water for irrigation can be beneficial.

7. ***Protection measures***
    - Windbreaks/sand barriers: In some areas, temporary fences or windbreaks structures (e.g., woven bamboo mats, crop stalks) can also be constructed to protect young plants from strong winds and shifting sand to avoid physical damage and further sand deposition.
    - Animal fencing: Riverbeds are often frequented by stray animals. Simple fencing or community guarding can protect crops.

8. ***Pest and disease management:*** Pest and diseases are often managed through cultural practices, manual removal, and the use of bio-pesticides or integrated pest management (IPM) approaches, as chemical use near water bodies is discouraged.

9. ***Harvesting:*** Crops are typically harvested before the onset of the next monsoon season (May/June).

10. ***Shelters:*** Farmers may construct temporary shelters near their plots for security and to protect against wild animals. The shelters can also be used for storage purposes. However, the farmers need to be careful that the shelters are not affected by during flooding.

IV. Promotion Strategies and Support

1. Technical Training and Capacity Building

- Farmer Field Schools (FFS): Conducting hands-on training sessions focused on site selection, trench/pit preparation, organic matter application, specific crop cultivation techniques, pest management, and post-harvest handling.
- Local Resource Persons (LRPs): Identifying and training local farmers who are experienced in riverbed farming to act as mentors and provide ongoing support to new practitioners.

2. Facilitating Access to Resources

- Quality seeds: Provide access to suitable, high-quality seeds of cucurbits and other appropriate vegetables.
- Organic inputs: Promote and facilitate access to compost, farmyard manure, and bio-fertilizers.
- Basic tools: Support access to simple tools for digging and cultivation.
- Small-scale irrigation: While less intensive than field farming, small, portable pumps or micro-sprinklers might be useful for initial establishment or during dry spells.

3. Market Linkages

- Value chain development: Connect riverbed farmers directly to local and regional markets, wholesalers, and consumers to ensure fair prices.
- Collective marketing: Encourage the formation of farmer groups or cooperatives for collective bargaining and transportation of produce.
- Off-season advantage: Emphasize the unique selling proposition of off-season vegetables from riverbeds.

4. Policy and Institutional Support

- Land access: Advocate for clear and secure access to riverbed land for landless and marginalized communities, potentially through lease agreements with local authorities (municipalities/rural municipalities).
- Government schemes: Encourage local and provincial governments to integrate riverbed farming into their agricultural development plans and allocate budgets for its promotion (e.g., providing seed subsidies, technical support).
- Inter-agency coordination: Foster collaboration between government agencies (agriculture, irrigation, land management), I/NGOs, and community-based organizations.

5. Documentation and Knowledge Sharing

- Case studies: Document successful riverbed farming models and their socio-economic and environmental impacts.
- Knowledge platforms: Create platforms for farmers and practitioners to share experiences and learn from each other.

- Research: Conduct further research on optimal varieties, sustainable input management, and climate change impacts specific to riverbed farming.

Organizations like Helvetas Swiss Intercooperation, ICIMOD, and various local NGOs have been instrumental in promoting riverbed farming in Nepal's Terai and Madhesh regions, demonstrating its significant potential to transform the lives of vulnerable communities. This practice represents a remarkable example of adapting traditional wisdom to contemporary challenges, particularly for climate resilience and poverty alleviation.

Module 10: Monitoring and Evaluation of Effectiveness of Climate Change Adaptation Actions

Monitoring and Evaluation (M&E) of Climate Change Adaptation (CCA) actions is crucial for ensuring that interventions are effective, efficient, and truly build resilience in a changing climate. However, it presents unique challenges compared to traditional development M&E.

Challenges of M&E for CCA

The key challenges of M&E for CCA actions are as below:

1. Long timeframes: Adaptation is a continuous process, not a fixed endpoint. The full impacts of adaptation actions may only become evident over decades, far exceeding typical project cycles. This makes it hard to measure long-term success.
2. Moving baselines: Climate change itself is altering the baseline conditions (e.g., rainfall patterns, temperature, sea levels). What constitutes "successful adaptation" can shift as the climate changes, making it difficult to compare "before" and "after" scenarios.
3. Attribution gap: It's hard to definitively attribute observed changes solely to an adaptation intervention, as numerous other social, economic, and environmental factors are simultaneously at play. It's difficult to answer: "What would have happened in the absence of the intervention?"
4. Uncertainty: Climate change projections inherently carry uncertainty. Adaptation plans must be flexible and adaptive, which complicates fixed M&E frameworks.
5. Context-specific: Adaptation is highly localized and context-dependent. What works in one community or ecosystem may not work elsewhere, making standardized indicators difficult to apply universally.
6. Defining "Success": There's no universal consensus on what "successful adaptation" looks like. Is it reducing vulnerability? Increasing adaptive capacity? Avoiding impacts? All of these are relevant but hard to quantify.
7. Data availability and quality: Especially in low-income and remote settings (like many parts of Nepal), baseline data may be limited or non-existent, and data collection capacity can be weak.
8. Measuring "avoided impacts": A key goal of adaptation is to prevent negative impacts. Measuring what didn't happen (e.g., how many lives were saved from a flood due to early warning systems) is inherently difficult.
9. Integration with development: Adaptation is often intertwined with sustainable development. Separating adaptation outcomes from broader development outcomes can be complex.

II. Key Principles and Best Practices for Effective Monitoring and Evaluation of CCA

Given the above challenges, M&E for CCA requires a flexible, iterative, and learning-oriented approach as described below.

A. Focus on Learning and Adaptive Management

- M&E for learning: Shift from purely accountability-driven M&E to a "Monitoring, Evaluation, and Learning" (MEL) framework. This emphasizes continuous learning, feedback loops, and adjustments to interventions as new information emerges or conditions change.

- Adaptive management: M&E findings should directly inform adjustments to adaptation strategies, recognizing that plans may need to evolve.

B. Theory of Change (ToC) Approach

- **Clearly articulated pathways:** Developing a clear Theory of Change (ToC) for each adaptation intervention is important. The TOC maps out the assumed causal pathways from inputs and activities to outputs, outcomes, and long-term impacts, explicitly linking them to climate change vulnerabilities and desired resilience. The ToC also helps to identify critical assumptions that need to be monitored and tested.

C. Mixed-Methods Approach (Quantitative and Qualitative)

- Triangulation: Combine quantitative data (e.g., number of hectares reforested, cost of damages avoided, and increase in household income) with qualitative data (e.g., perceptions of vulnerability, changes in community coping strategies, and satisfaction with interventions).
- Participatory M&E: Actively involve local communities, vulnerable groups, and stakeholders in the M&E process. Their local knowledge and lived experiences are invaluable for understanding effectiveness and relevance. This also builds local capacity and ownership.

D. Focus on Indicators across Different Levels

- Impact indicators: Attempt to capture the long-term, fundamental changes in resilience and avoided losses, even if these are difficult to measure directly (e.g., reduced mortality from heatwaves, maintained agricultural productivity despite climate shocks).
- Outcome indicators: Assess the short-to-medium-term changes in adaptive capacity or reduced vulnerability (e.g., increased awareness of climate risks, changes in farming practices, improved access to water during droughts).
- Output indicators: Measure the direct products of the intervention (e.g., kilometers of early warning system installed, number of drought-resistant seeds distributed).
- Process indicators: Track whether the adaptation actions are being implemented as planned (e.g., number of training sessions held, policies formulated, firebreaks created).
- Proxy indicators: Use measurable proxies for hard-to-quantify impacts (e.g., changes in insurance uptake as a proxy for reduced risk perception).

E. Baseline Data and Regular Monitoring

- Establish baselines: Wherever possible, collect robust baseline data *before* intervention implementation to provide a reference point for measuring change.
- Regular data collection: Implement systematic and regular data collection to track progress against indicators.
- Vulnerability reduction: Measure how interventions are reducing the specific vulnerabilities of people and systems to climate impacts.
- Disaggregated Data with equity lens: Collect and analyze data disaggregated by gender, age, ethnicity, socio-economic status, and other relevant factors. This helps understand if adaptation benefits are reaching the most vulnerable and if unintended negative consequences are emerging for specific groups.

Module 11: Agriculture Value Chain Development and Market Linkages

Agriculture Value Chain Management and Market Linkages are crucial for transforming subsistence farming into a more commercial, profitable, and climate-resilient sector, especially in regions like Sindhuli, Nepal which has huge agriculture commercialization potential. These concepts encompass all activities that bring a product from the farm to the final consumer, adding value at each stage. By adopting a comprehensive and collaborative approach to agriculture value chain development, MaWRin project can empower the farmers in the project area, enhance their economic opportunities, and build a more resilient and sustainable agricultural sector for the local communities.

1. Understanding the Agricultural Value Chain

Agricultural value chain development is a strategic approach to improve the efficiency, profitability, and sustainability of the entire process of bringing agricultural products from the farm to the consumer. For a region like Sindhuli, where subsistence farming is prevalent and climate change poses significant threats, value chain development is not just about making more money, but also about building resilience and ensuring food security.

An agricultural value chain includes all the actors and activities involved in the production, processing, and distribution of an agricultural product. It typically involves:

- Input suppliers: Providing seeds, fertilizers, animal feed, veterinary services, tools, and machinery.
- Producers (Farmers): Cultivating crops or raising livestock.
- Aggregators/collectors: Gathering produce from multiple smallholder farmers.
- Processors: Transforming raw produce into value-added products (e.g., milk to cheese, fruits to jam, meat processing).
- Wholesalers: Distributing products to retailers.
- Retailers: Selling products to consumers (e.g., local shops, supermarkets, restaurants).
- Consumers: The end-users of the product.
- Enabling environment: This includes supporting services like financial institutions, extension services, research organizations, transportation, and government policies.

2. Importance of Effective Value Chain Development

Effective agricultural value chain management has several benefits. The major importance of value chain management is as below:

- *Increased farmer income*: By streamlining processes, reducing post-harvest losses, and connecting farmers directly to better markets, farmers can receive fairer prices for their produce.
- *Improved product quality:* Better handling, storage, and processing throughout the chain lead to higher quality products.
- *Enhanced efficiency:* Efficient value chains minimize waste, optimize resource use, and reduce costs.
- *Market responsiveness:* A well-managed value chain can quickly respond to market demands and consumer preferences.

- *Value addition:* Processing and packaging can transform raw commodities into higher-value products, creating more jobs and income opportunities.
- *Food security:* By making agricultural systems more efficient and resilient, value chain management contributes to overall food security.

3. Core Principles of Value Chain Development

The core principles of value chain development are as below:

- Market-driven approach: Value chain development starts with what the market demands (consumer preferences, quality standards, quantity needed, price points) rather than simply what farmers produce.
- Inclusivity: It ensures that smallholder farmers, women, and marginalized groups are actively included and benefit from value chain improvements.
- Value addition: It focuses on increasing the value of products at each stage, through processing, packaging, branding, and quality improvement.
- Collaboration and partnerships: It fosters strong linkages and trust among all actors in the chain (farmers, input suppliers, traders, processors, retailers, financial institutions, government).
- Sustainability and resilience: It integrates climate-smart agricultural practices, resource efficiency, and environmental protection into the value chain.
- Information flow: It ensures that timely and accurate market information, technical knowledge, and weather advisories reach farmers and other chain actors.

4. Key Stages and Interventions in Value Chain Development

i) Upstream (Input Supply and Production)

- ***Improved Input Access***
    - Quality seeds/breeds: Facilitate access to climate-resilient, high-yielding crop varieties and improved livestock breeds suitable for Sindhuli's agro-climatic conditions.
    - Fertilizers and pesticides: Ensure availability of quality and appropriate agro-chemicals, along with training on their safe and efficient use.
    - Credit and finance: Link farmers to microfinance institutions, cooperatives, and commercial banks for loans to purchase inputs, adopt new technologies, and make on-farm investments.

- **Enhanced Production Practices**
    - Climate-smart agriculture (CSA): Promote practices like drought-resistant crops, water-efficient irrigation (drip, sprinkler), soil health management, rainwater harvesting, and integrated pest management (IPM).
    - Training and extension: Provide hands-on training to farmers on modern farming techniques, animal health, nutrition, and disease prevention, tailored to local conditions. Digital extension services can play a key role.
    - Mechanization: Introduce small-scale, appropriate farm machinery to reduce labor intensity and improve efficiency, especially for post-harvest operations.

- **Farmer Mobilization and Organization**: Formation/strengthening of farmer producer organizations and cooperatives. These act as vital hubs for collective action, enabling farmers to:
    - Aggregate produce for better market access and bargaining power.
    - Access inputs and services at lower costs.
    - Share knowledge and resources.
    - Jointly invest in post-harvest infrastructure.

ii) Midstream (Post-Harvest, Processing, and Logistics)

- **Post-Harvest Management**
    - Reduced losses: Implementing proper harvesting techniques, on-farm storage solutions, and improved packaging to minimize post-harvest losses.
    - Grading and sorting: Training farmers and aggregators on quality standards to ensure consistency and fetch better prices.

- **Processing and Value Addition**
    - Local processing units: Supporting the establishment of small to medium-scale processing units for products like fruit (Junar) pulp, dried vegetables, dairy products (cheese, ghee), meat products, etc.
    - Product diversification: Exploring opportunities for new products based on local resources and market demand.
    - Branding and packaging: Developing attractive branding and packaging to enhance market appeal and command higher prices. This can include "Sindhuli Organic" or similar labels.

- **Logistics and Transportation**
    - Improved road connectivity: Advocating for better rural road infrastructure to connect production areas with markets.
    - Efficient transport solutions: Promoting the use of appropriate vehicles for agricultural produce (e.g., small trucks, insulated vans for perishables).
    - Collection centers: Establishing well-equipped collection centers with basic sorting, grading, and temporary storage facilities in key production clusters.

iii) Downstream (Marketing and Distribution)

- **Market Intelligence**
    - Information systems: Developing systems to provide farmers with real-time market prices, demand trends, and buyer information via mobile apps, SMS, or community radio.
    - Market studies: Conducting studies to identify new market opportunities and consumer preferences.

- **Diverse Marketing Channels**
    - Direct sales: Promoting farmers' markets, farm-gate sales, and direct sales to consumers (e.g., through community-supported agriculture models).
    - Contract farming: Facilitating contract farming arrangements between farmers and larger buyers (e.g., supermarkets, hotels, food processors) for assured markets and fair prices.

- Digital platforms: Leveraging e-commerce platforms and mobile applications to connect farmers with urban markets.
- Wholesale and retail linkages: Building stronger relationships with traditional wholesalers and retailers, ensuring transparent pricing and fair practices.

- **Quality Assurance and Certification**
  - Good agricultural practices (GAP): Encourage adoption of GAP standards to ensure food safety and quality, which can open up higher-value markets.
  - Organic certification: Support farmers in achieving organic certification for niche markets.

5. Enabling Environment and Cross-Cutting Factors for Value Chain Development

- **Policy and Regulatory Framework**
  - Supportive policies: Advocate for government policies that encourage agricultural investment, provide incentives for value chain actors, and streamline regulations.
  - Land use policies: Address issues related to land fragmentation and tenure security.

- **Access to Finance and Investment**
  - Tailored financial products: develop specific financial products for agricultural value chain actors (e.g., working capital loans, investment loans for machinery or processing units).
  - Risk mitigation: Explore crop insurance and livestock insurance schemes to reduce financial risks for farmers.

- **Research and Development**
  - Adaptive research: Conduct research on local crop varieties, livestock breeds, and farming techniques that are best suited to Sindhuli's specific environmental conditions and market needs.
  - Technology transfer: Facilitate the adoption of appropriate technologies throughout the value chain.

- **Public-Private Partnerships (PPPs):** Encourage collaboration between government, private sector, and civil society organizations to leverage resources, expertise, and innovation for value chain development.

6. Key Challenges in Agricultural Value Chain Development and Management

- Multiple intermediaries: A long chain of middlemen often means farmers receive a very small share of the final consumer price, while intermediaries pocket significant profits without adding substantial value.
- Poor infrastructure: Inadequate road networks, especially in hilly and remote areas like parts of Sindhuli, make transportation costly and lead to significant post-harvest losses. Lack of proper storage facilities (cold storage) is also a major issue.
- Lack of information: Farmers often lack access to timely and accurate market information (prices, demand, trends), which puts them at a disadvantage during negotiations.

- Low productivity and quality control: Traditional farming practices, limited access to quality inputs (seeds, breeds, feed), and insufficient knowledge of modern techniques lead to lower yields and inconsistent product quality.
- Limited access to finance: Farmers struggle to access formal credit for investments in improved technologies, inputs, or value addition activities.
- Weak farmer organizations: While cooperatives exist, their capacity for collective bargaining, quality control, and market engagement is often limited.
- Post-harvest losses: Significant losses occur due to improper harvesting, handling, storage, and transportation.
- Limited processing and value addition: Most agricultural products are sold in raw form, missing opportunities for higher returns through processing, grading, and packaging.
- Policy and institutional gaps: Despite various policies, their effective implementation and coordination across different levels of government (federal, provincial, local) remain a challenge.
- Climate change impacts: As discussed previously, climate change adds another layer of complexity, affecting production and thus the entire value chain.

7. Market Linkages

Agricultural market linkage refers to the process of connecting farmers (producers) to various market actors and ultimately to consumers. It's about ensuring that agricultural products can efficiently move from where they are produced to where they are demanded, fetching fair prices for farmers and ensuring quality products for consumers. In the context of MaWRiN project area in Sindhuli district, strengthening agricultural market linkages is critical for several reasons:

- Poverty reduction: Better market access leads to higher and more stable incomes for smallholder farmers, lifting them out of poverty.
- Commercialization of agriculture: Shifts farming from subsistence to a market-oriented approach, encouraging farmers to produce what the market demands.
- Food security and nutrition: Efficient markets ensure food availability and can encourage diversification into more nutritious crops.
- Reduced post-harvest losses: Improved market linkages often come with better post-harvest handling, storage, and transportation, reducing waste.
- Economic growth: A thriving agricultural sector, supported by strong market linkages, contributes significantly to national and local GDP.
- Climate vulnerabilities and risk: Strengthening market linkages is critical for reducing climate risk vulnerabilities through easy access to inputs, knowledge transfer, new market opportunities, and building resilience by connecting producers to resources, information, finance, and diverse opportunities, enabling them to better anticipate, absorb, and adapt to the inevitable impacts of a changing climate.

8. Strategies for Improving Agricultural Market Linkage

Effective market linkages are about connecting farmers more directly and efficiently with consumers and buyers, bypassing unnecessary intermediaries.

i) Strengthening Farmer Producer Organizations (FPOs) and Cooperatives

- Collective action: Encouraging the formation and strengthening of Farmer Producer Organizations (FPOs), cooperatives, and self-help groups. These groups enable farmers to aggregate their produce, negotiate better prices, access inputs collectively, and share resources and knowledge.
- Collective bargaining: Empowering FPOs to negotiate better prices for inputs and outputs.
- Pooled production: Facilitating collective production, grading, and packaging for economies of scale.
- Shared infrastructure: Investing in common facilities like collection centers, small-scale processing units, and storage.
- Business planning and management: Training FPOs in business development, financial management, and market intelligence.
- Training: Providing training on market requirements (quality standards, packaging), basic business management, record-keeping, and negotiation skills.

ii) Direct Marketing Channels

- Farmers' markets (Haat Bazaars): Regular local markets where farmers can sell directly to consumers.
- Contract farming: Agreements between farmers and buyers (processors, retailers) for assured supply at pre-agreed prices.
- E-commerce platforms: Digital platforms connecting farmers/cooperatives directly with consumers, especially in urban areas.

iii) Developing Market Infrastructure

- Cold storage and warehouses: To reduce post-harvest losses and allow farmers to sell when prices are favorable.
- Collection centers: Establishing well-equipped collection centers in production hubs where farmers can bring their produce for sorting, grading, temporary storage, and onward transport.
- Storage facilities: Developing cold storage facilities for perishable goods (fruits, vegetables, dairy) and dry warehouses for grains to reduce post-harvest losses and enable farmers to store products until prices are favorable.
- Wholesale markets: Improving existing wholesale markets and establish new ones with proper facilities for efficient trade.
- Rural roads for improved transportation**:** Investing in and maintain all-weather rural roads to reduce transportation costs and time, making it easier for farmers to reach markets.

iv) Value Addition and Processing

- Support for small-scale processing units: Encouraging and supporting local processing of agricultural products (e.g., dried fruits, spices, dairy products) to increase their value and shelf life.
- Branding and packaging: Encouraging farmers/farmer groups to brand and package their products to differentiate them in the market and potentially fetch premium prices.

- Quality standards and certification: Promote Good Agricultural Practices (GAP) and facilitate access to quality certifications (e.g., organic certification) to meet the demands of higher-value markets.

v) Market Information Systems (MIS)

- Real-time data: Establishing systems (e.g., mobile apps, SMS services, community radio) that provide farmers with up-to-date information on market prices, demand trends, weather forecasts, and available buyers. This reduces information asymmetry and empowers farmers.
- Market intelligence: Conducting regular market surveys and analyses to identify profitable crops, niche markets, and value-addition opportunities.

vi) Diverse Marketing Channels:

- Direct marketing: Facilitating farmers' access to urban farmers' markets ("Haat Bazaars"), roadside stalls, and direct sales to consumers, hotels, and restaurants.
- Contract farming: Promoting contract farming arrangements where farmers agree to supply specific quantities and qualities of produce to buyers (processors, exporters, large retailers) at pre-agreed prices. This provides assured markets and reduces price volatility.
- E-commerce/digital platforms: Developing and promoting online platforms that connect farmers directly with buyers, particularly for high-value or specialty products.
- Linkages with supermarkets/retail chains: Establishing formal linkages between farmer groups and organized retail chains, which often demand consistent quality and quantity.

vii) Access to Finance

- Agricultural credit: Ensure easier access to affordable credit for farmers for inputs, farm improvements, post-harvest equipment, and value addition activities.
- Crop and livestock insurance: Implement and promote insurance schemes to protect farmers from climate-related risks and market price fluctuations.

viii) Capacity Building and Extension Services

- Training farmers in improved production techniques, post-harvest management, quality standards, and marketing skills.
- **Extension Services:** Strengthening agricultural extension services to provide technical guidance and market-related information to farmers. Facilitating access to appropriate technologies.

ix) Policy Support and Regulation

- Formulating and implementing policies that promote fair trade practices, reduce market distortions, and provide incentives for value chain development.
- Encouraging private sector investment in agricultural value chains.

9. Market Linkages Challenges

- Geographical isolation: Hilly terrain and poor road infrastructure in many parts of Sindhuli make transportation difficult and costly.
- Small production volumes: Most farmers are smallholders, producing in small, fragmented quantities, making it difficult to meet bulk buyer demands.

- Lack of post-harvest facilities: Insufficient cold storage, warehouses, and processing units lead to significant losses, especially for perishable products like fruits (e.g., sweet oranges, a key product in Sindhuli).
- Dominance of middlemen: A long chain of intermediaries often exploits farmers by offering low farm-gate prices and taking a large share of the consumer price.
- Limited market information: Farmers often lack timely and accurate information on market prices and demand, leading to suboptimal selling decisions.
- Weak farmer organizations: While cooperatives exist, their capacity to effectively manage collection, quality control, and market negotiations is often limited.
- Quality inconsistency: Lack of standardized grading and quality control practices can deter potential buyers.

4. Livestock Sector

4.1 Climate-Resilient Livestock Training

Livestock Status in Sindhuli

Year	Cattle	Buffalo	Sheep	Goat	Pig	Fowl	Duck
2019/20	135963	69178	76399	285114	12152	1224353	4570
2020/21	138344	68816	462	290345	12556	1123651	51
2021/22	NA	NA	NA	NA	NA	NA	NA
2022/23	93239	47309	1693	318415	21867	903701	11815

Source: Department of Livestock Services, 2023

Climate Smart Livestock Training has been designed for farmers, livestock holders and other stakeholders. It aims to build the capacity of training participants with the knowledge and skills to adopt sustainable and resilient livestock management practices that address climate change. The training integrates approaches that reduce greenhouse gas emissions, enhance animal productivity, improve feed and water management, and promote animal health and welfare in changing climatic conditions. After the training, it is expected that this training contributes to increase understanding of climate-smart livestock practices; reduce environmental footprint of livestock farming through sustainable practices; and strengthen livelihoods and food security of rural livestock-dependent communities.

B.4.2 Training Curriculum and Material

Modules	Training Content/Subject
Module 1	Climate resilient livestock management practices
Module 2	Livestock shed improvement and management
Module 3	Fodder and feed management
Module 4	Manure/waste management for GHG emission reduction

Module 1: Climate Resilient Livestock Management Practices

Climate-resilient livestock management practices are essential for ensuring the sustainability and productivity of animal agriculture in the face of climate change challenges like extreme heat, droughts, floods, and new disease patterns. These practices aim to reduce livestock's vulnerability to climate impacts while also contributing to climate change mitigation (e.g., by reducing greenhouse gas emissions). Climate-resilient livestock management practices in Nepal are critical for safeguarding the livelihoods of millions of smallholder farmers who rely on livestock. The changing climate poses significant threats, including increased heat stress, reduced availability and quality of feed and fodder, higher incidence of diseases, and impacts on water resources. Key climate-smart livestock management practices include:

I. Breed Selection (Improved Breeds) and Genetic Improvement

This involves choosing and developing animal breeds that are inherently better suited to changing climatic conditions and the local context. The following approaches can be adopted for breed selection and genetic improvement.

- ***Promoting indigenous and locally adapted breeds***: Local breeds (e.g., some goat, cattle, and poultry breeds in various parts of Nepal) often possess natural resilience to local environmental stresses like heat, disease, and sparse feed resources due to generations of natural selection. They are typically hardier, require fewer external inputs, and are less susceptible to certain diseases.

  For example, Khari goat is the most widespread and popular indigenous goat breed in Nepal, particularly prevalent in the mid-hills and inner Terai regions. It is highly valued by smallholder farmers precisely because of its hardiness and adaptability to the diverse and often challenging local conditions. Similarly, Yak and Nak in the high Himalayas are adapted to extreme cold and high altitudes.

- ***Strategic cross-breeding:*** Combining the resilience of indigenous breeds with the higher productivity (e.g., milk yield, growth rate) of exotic or improved breeds is the strategic cross-breeding. This aims to create animals that are both productive and hardy. For example, cross-bred cows and buffaloes (like cross-Murrah buffaloes) are promoted for increased milk production while maintaining some level of local adaptability.

- ***Artificial Insemination (AI):*** Artificial Insemination involves the collection of semen from a genetically superior male animal (sire) and its manual deposition into the reproductive tract of a female animal (dam) at the appropriate time for conception. This technology has been in use in Nepal for decades and is crucial for enhancing the productivity and genetic potential of the country's livestock. It is a widely adopted and crucial practice in Nepal's livestock sector, serving as a primary tool for genetic improvement and increased productivity, particularly in cattle and buffaloes. Despite its established presence, the practice faces unique challenges given Nepal's diverse geography, socio-economic conditions, and traditional farming systems. For example, Murrah buffalo semen is widely used for AI to improve the milk yield and growth rate of local buffalo populations. AI in goats, particularly using semen from breeds like Boer, is gaining traction to improve meat production and growth rates in local goat breeds. Jersey and Holstein-Friesian are the most common exotic breeds whose semen is used for upgrading.

- ***Breeding for Specific Traits:*** Selecting breeding enhance productivity while reducing resource use. It involves selecting animals for traits that enhance resilience, such as:

- Heat tolerance: Breeds that can dissipate heat more efficiently or maintain productivity at higher temperatures.
- Drought tolerance: Animals that can survive and produce on less water or lower-quality feed.
- Disease resistance: Breeds with natural immunity or higher resistance to prevalent diseases, reducing reliance on antibiotics and veterinary interventions.
- Feed efficiency: Animals that convert feed into products more efficiently, reducing resource use and potentially methane emissions per unit of product.

II. Climate-Smart Feed and Fodder Management

Ensuring a consistent supply of nutritious feed is crucial, especially during periods of drought or floods that impact forage availability. Climate-smart feed and fodder management includes the below measures:

- **Cultivation of Resilient Forage Species**
  - Drought-tolerant forages: Planting fodder crops (e.g., Napier grass, Guinea grass, various legumes like *Berseem clover*, certain tree fodders) that can thrive under dry conditions or require less water.
  - Flood-tolerant forages: Utilizing fodder varieties that can withstand temporary waterlogging.
  - Multi-purpose trees and shrubs (Agroforestry/Silvopastoral Systems): Integrating fodder trees (e.g., *Ipil-ipil, Koiralo, Tanki*) into pastures and farmlands. These provide nutritious fodder, especially during dry seasons, offer shade for animals, improve soil fertility, and sequester carbon.
- **Fodder Conservation Techniques**
  - Silage making: Fermenting green fodder (e.g., maize, Napier grass) in anaerobic conditions to preserve its nutritional value for extended periods, providing feed during lean seasons.
  - Hay making: Drying green fodder to reduce moisture content for long-term storage. *P*roper chopping, compaction, and sealing for silage; appropriate drying and storage is important to prevent mold for hay.
- **Balanced Feeding and Nutritional Supplementation**
  - Optimizing diets: Formulating balanced rations using available feed resources, including crop residues (e.g., rice straw, maize stovers), agro-industrial by-products (e.g., rice bran, oil cakes), and green fodder. This improves digestibility, reduces methane emissions from enteric fermentation, and enhances animal health and productivity.
  - Mineral and vitamin supplements: Providing area-specific mineral mixtures, urea-molasses blocks, or other supplements to address nutritional deficiencies, which can compromise immunity and productivity.
  - Urea treatment of straw: Treating low-quality crop residues (like rice straw) with urea to improve their digestibility and nutritional value.
- **Pasture Management**
  - Rotational grazing: Rotational grazing is the systematically moving livestock across different sections of pasture to allow vegetation to recover, preventing overgrazing, improving forage quality, and enhancing soil health.

- Pasture improvement: Over-seeding degraded pastures with resilient forage species and implementing appropriate fertilization improves pasture.

III. Animal Health and Disease Management

Climate change can alter the distribution and intensity of animal diseases. The following measures are necessary for improving animal health and disease management.

- Enhanced disease surveillance and early warning systems: Rapid detection and reporting of unusual disease outbreaks, allowing for quick isolation and intervention.
- Regular vaccination programs: Robust and timely vaccination campaigns against endemic and emerging diseases.
- Bio-security measures: Implementing strict hygiene protocols, proper waste disposal, and controlled animal movements to prevent disease introduction and spread on farms.
- Parasite control: Effective deworming programs and external parasite control strategies, as warmer temperatures can increase parasite loads.
- Stress reduction: Measures to minimize heat stress (e.g., cooling animals with water, providing ample shade and water) as stressed animals are more susceptible to disease.
- Integrated pest and vector control: Managing insect vectors (e.g., mosquitoes, ticks) that transmit diseases.
- Ethno-veterinary practices: Integrating traditional knowledge of herbal remedies and local treatments for common animal ailments, where appropriate.

IV. Climate-Smart Housing and Infrastructure

Protecting livestock from extreme weather events is an effective climate-resilient livestock management practice. This includes:

- **Construction of improved animal sheds:** Designing and constructing well-ventilated sheds that provide adequate shade and protection from extreme heat, cold, heavy rain, and strong winds. This includes features like proper roofing materials, elevated floors (in flood-prone areas), and good drainage.
- **Improved water availability and access:** Ensuring continuous and easy access to clean drinking water, especially during hot periods. This may involve protected water sources, water harvesting tanks, or reliable pumping systems.
- **Shade structures:** Providing natural or artificial shade in grazing areas to reduce heat stress.

V. Manure Management and Methane Mitigation

Livestock manure is a source of greenhouse gas emissions (methane and nitrous oxide). Manure management is, therefore, important to reduce the greenhouse gas emission. Composting manure reduces methane and nitrous oxide emissions, and treated manure can be used as organic fertilizer, which improves soil fertility. The following methods are used for manure management:

- **Biogas digesters:** Utilizing anaerobic digesters to convert animal manure into biogas (a clean cooking fuel) and nutrient-rich organic fertilizer (slurry). This significantly reduces methane emissions from stored manure and provides renewable energy, while the slurry improves soil fertility.
- **Composting:** Proper composting of manure reduces methane emissions compared to open dumping and produces high-quality organic fertilizer for crops.

- **Improved feed quality:** As mentioned, better-quality feed and digestion can reduce methane emissions from enteric fermentation in ruminants.

VI. Water Management for Livestock

Water management ensuring water availability for both animals and fodder production is vital for climate-resilient livestock management. Some of the methods for water management for livestock are:

- Rainwater harvesting: Collecting and storing rainwater in ponds or tanks for livestock drinking and fodder irrigation.
- Efficient water use: Implementing efficient watering systems for animals to minimize waste.
- Springshed management: Protecting and enhancing natural spring sources crucial for water supply in hilly regions.

Overarching Principles for Implementation of Climate-Resilient Livestock Practices

- Participatory approach: Engaging farmers in the planning and implementation of practices to ensure relevance and ownership.
- Integration: Combining livestock management with other climate-smart agricultural practices (e.g., agroforestry, resilient crop varieties) for a holistic approach.
- Capacity building: Providing technical training, farmer field schools, and access to extension services.
- Policy support: Government policies that incentivize the adoption of climate-resilient practices, provide access to finance, and support research and development.
- Inclusive and gender responsiveness: Recognizing and supporting the critical role of women in livestock management and ensuring their access to training, resources, and decision-making.

VII. Key Challenges in Implementing Climate-Resilient Livestock Management Practices

Sindhuli district faces significant challenges in implementing climate-resilient livestock management practices. These challenges are often interconnected and exacerbated by the overarching impacts of climate change. Here are some key issues to consider:

1. Water Scarcity and Availability

- *Drought conditions:* Sindhuli is experiencing increasingly erratic rainfall patterns and prolonged dry spells, leading to drying up of water sources and reduced availability of water for livestock, particularly during critical periods. This directly impacts animal health, productivity, and can force farmers to reduce herd sizes.
- *Impact on fodder and feed:* Water scarcity directly affects the growth of fodder crops and natural pastures, leading to feed shortages. This forces farmers to spend more on purchasing feed, which can be a significant financial burden.

2. Feed and Fodder Shortages and Quality

- *Reduced pasture availability:* Climate change impacts, such as droughts and changes in precipitation, lead to degradation of grazing lands and reduced availability of natural fodder.

- *Low quality feed:* The available feed might be of lower nutritional value, impacting animal health, growth, and milk production.
- *Limited adoption of improved fodder technologies:* Farmers may lack knowledge, resources, or access to climate-resilient fodder varieties and cultivation techniques (e.g., silage making).

3. Increased Incidence of Diseases and Pests

- *Emergence of new diseases:* Changes in temperature and humidity create favorable conditions for the spread of existing diseases and the emergence of new ones.
- *Parasitic infestations:* Increased prevalence of parasites due to altered environmental conditions.
- *Limited veterinary services:* Remote areas in Sindhuli may have inadequate access to veterinary services, diagnostic facilities, and affordable medicines, making it difficult to control disease outbreaks effectively.

4. Lack of Knowledge and Awareness

- *Limited understanding of climate change impacts*: Many farmers may not fully grasp the long-term implications of climate change on their livestock or the benefits of adopting climate-resilient practices.
- *Insufficient training and extension services:* There's a need for more targeted training programs and effective extension services to equip farmers with the knowledge and skills required for climate-resilient livestock management. This includes topics like improved animal housing, disease prevention, feed management, and breeding strategies.

5. Financial Constraints and Access to Credit

- *Limited capital for investment:* Smallholder farmers often lack the financial resources to invest in improved animal breeds, climate-resilient infrastructure (e.g., improved animal sheds, rainwater harvesting systems), or feed supplements.
- *Lack of access to finance:* Many farmers in rural areas face difficulties in accessing loans from financial institutions due to collateral requirements or complex procedures.

6. Traditional Practices and Resistance to Change

- *Reliance on traditional methods*: Farmers may be hesitant to adopt new practices due to ingrained traditional methods, lack of trust in new technologies, or fear of failure.
- *Dominance of indigenous breeds:* While indigenous breeds have certain adaptability, there might be a lack of scientific breeding programs to enhance their climate resilience and productivity.

7. Market Access and Value Chain Issues

- *Unorganized marketing channels:* Poor market linkages and unorganized marketing channels can limit farmers' income, making it difficult to recover costs and invest in resilient practices.
- *Lack of processing facilities:* Insufficient processing and chilling centers for milk and meat can lead to post-harvest losses and limit opportunities for value addition.

8. Institutional and Policy Gaps

- *Weak institutional capacity:* Government agencies and local institutions may have limited capacity to implement and monitor climate-resilient livestock programs effectively.
- *Inadequate policy frameworks:* While efforts are being made, there might still be gaps in policies and legal frameworks to fully support climate-resilient livestock development, especially at the local level.
- *Coordination issues:* Lack of effective coordination among different stakeholders (government, NGOs, research institutions, farmers' cooperatives) can hinder integrated approaches.

Addressing these challenges in Sindhuli requires a multi-faceted approach, including capacity building, technological interventions, improved access to finance and services, and strong policy support that is tailored to the local context and addresses the specific vulnerabilities of livestock farmers in the district.

Module 2: Livestock Shed Improvement and Management

Livestock shed improvement and management are crucial aspects of enhancing livestock productivity, animal health, and overall agricultural sustainability in Nepal. Given that a significant portion of Nepal's population relies on agriculture and livestock for their livelihoods, and the challenges posed by climate change, there's a growing emphasis on adopting modern and resilient shed management practices. In the context of changing climate, there is a need of climate-smart livestock shed management, which goes beyond basic shelter to incorporate practices that enhance animal welfare and productivity while simultaneously building resilience to climate change impacts and reducing greenhouse gas (GHG) emissions. In Nepal, where livestock are integral to livelihoods and highly vulnerable to climate shifts, adopting these climate-smart management practices is crucial.

I. Importance of Improved Livestock Sheds

- Animal health and welfare: Proper sheds provide shelter from extreme weather (heat, cold, rain, wind), reduce stress, and minimize the risk of diseases by ensuring good ventilation, drainage, and hygiene.
- Productivity enhancement: Healthy and comfortable animals are more productive (higher milk yield, faster weight gain, better reproductive performance).
- Manure management: Well-designed sheds facilitate efficient collection and management of animal waste, which can be used for organic fertilizer or biogas production, reducing environmental pollution and greenhouse gas emissions.
- Labor efficiency: Improved shed design can make daily management tasks (feeding, watering, cleaning) easier and less time-consuming for farmers.
- Climate change adaptation: Climate-resilient sheds can protect livestock from increasing extreme weather events, which are becoming more frequent in Nepal.

II. Core Principles of Climate-Smart Livestock Shed Management

- **Adaptation**
  - Protecting animals from extreme weather: Designing sheds to shield animals from increasing heat stress, cold waves, heavy rainfall, and strong winds.
  - Disease prevention: Reducing the incidence and spread of climate-sensitive diseases (e.g., vector-borne diseases that spread with warmer temperatures, or respiratory issues from poor ventilation during cold snaps).
  - Resource efficiency: Optimizing the use of water and feed within the shed environment.
- **Mitigation**
  - Reducing GHG emissions: Primarily focusing on efficient manure management to minimize methane (CH_4) and nitrous oxide (N_2O) emissions.
  - Sustainable resource use: Using locally sourced, environmentally friendly construction materials and promoting energy efficiency.
- **Productivity and Livelihoods**
  - Increased output: Ensuring optimal animal health and comfort to boost milk, meat, and egg production.

- Cost-effectiveness: Designing sheds that are durable, require less maintenance, and allow for efficient use of labor and resources, ultimately improving farmer income.

III. Key Components of Climate-Smart Livestock Shed Management in Nepal

1. Climate-Resilient Shed Design and Construction

- *Ventilation:* Crucial for managing heat stress. This includes:
  - Natural ventilation: High roofs, open sides (with adjustable curtains for cold/rain), and proper orientation to prevailing winds.
  - Ridge vents: To allow hot air to escape from the top.
  - Tree plantation: Planting trees around the shed for natural shade and cooling.
- *Insulation:* Using materials that provide good insulation against both heat and cold extremes. Local materials like mud, bamboo, and thatch can be surprisingly effective when properly utilized.
- *Roofing:* Light-colored or reflective roofing materials to reduce heat absorption during summer. Proper roof overhangs to provide shade and protection from rain.
- *Flooring:* Easy-to-clean, non-slippery, well-drained floors (e.g., slatted floors or concrete with a slight slope) to prevent water stagnation and facilitate manure collection.
- *Space allocation*: Adequate space per animal to prevent overcrowding, reduce stress, and improve air quality.
- *Orientation:* Orienting the shed to maximize sunlight in winter for warmth and disinfection, while minimizing direct sun exposure during hot summer afternoons.

2. Efficient Manure Management for GHG Reduction

- *Integrated collection systems:* Designing sheds with integrated channels or sloped floors to efficiently collect both solid dung and liquid urine. This prevents nutrients from leaching into the soil and water, and reduces methane emissions from anaerobic decomposition in uncontrolled piles.
- *Biogas digesters:* Promoting the installation of biogas plants connected to animal sheds. This is a highly effective climate-smart practice in Nepal:
  - Mitigation: Captures methane from manure, preventing its release into the atmosphere, and converts it into clean cooking fuel.
  - Adaptation/productivity: Provides renewable energy for cooking/lighting, reducing reliance on firewood (deforestation) and fossil fuels. The digested slurry from the biogas plant is a high-quality organic fertilizer, improving soil health and crop yields.
- *Improved composting:* For farms without biogas, promoting aerobic composting of manure in covered pits or heaps to reduce methane emissions compared to open piling.
- *Urine collection and use:* Collecting urine separately (it's rich in nitrogen) for direct application as liquid fertilizer, reducing the need for synthetic fertilizers.

3. Water Management

- *Efficient watering systems:* Using nipple drinkers or trough designs that minimize water wastage and ensure constant access to clean water.

- *Rainwater harvesting:* Collecting rainwater from shed roofs for animal drinking or cleaning purposes, reducing reliance on groundwater or other sources, especially during dry seasons.

4. Feed and Fodder Management

- *Improved fodder cultivation*: Promoting the cultivation of high-quality, nutritious, and climate-resilient fodder crops (e.g., Napier grass, Berseem) near the sheds to ensure year-round availability and reduce the need for external feed.
- *Silage/hay making*: Encouraging farmers to preserve surplus green fodder through silage or hay making for use during feed-scarce periods.
- *Balanced rations:* Providing a balanced diet to animals, as improved digestion can reduce enteric methane emissions.

5. Health Management and Biosecurity

- *Disease surveillance and prevention*: Well-designed sheds facilitate better hygiene, which is critical for preventing diseases, including those sensitive to changing climatic conditions.
- *Isolation facilities*: Having separate areas to isolate sick animals or new introductions to prevent disease spread.

IV. Key Aspects of Livestock Shed Improvement and Management

1. Site Selection

- Drainage: High ground, well-drained soil, away from flood-prone areas.
- Ventilation: Good airflow to prevent heat stress and accumulation of harmful gases.
- Sunlight: Adequate sunlight for warmth in winter and disinfection, but shade in summer.
- Accessibility: Easy access for animals, feed, water, and manure removal.

2. Shed Design and Construction:

- Material: Emphasis on using locally available, cost-effective, and durable materials (e.g., bamboo, wood, corrugated iron sheets, bricks).
- Space: Adequate space per animal to prevent overcrowding, which leads to stress and disease spread.
- Flooring: Non-slippery, easy-to-clean, and well-drained floors (e.g., concrete with proper slope).
- Roofing: Provides shade and protection from rain and direct sun. Consider materials that keep the shed cool.
- Ventilation: Open sides (with curtains for protection), ridge ventilation, and proper height to allow air circulation.
- Feeders and waterers: Easily accessible, cleanable, and designed to minimize feed/water wastage and contamination.
- Manure pit/collection system: Integrated system for collecting dung and urine to convert into compost or biogas.

3. Hygienic Practices

- Regular Cleaning: Daily removal of dung and urine.
- Disinfection: Regular disinfection of the shed to control pathogens, especially between batches of animals or after disease outbreaks.
- Waste management: Proper disposal or utilization of animal waste.

- Pest and vector control: Measures to control flies, mosquitoes, and rodents that can transmit diseases.

4. Feeding Management:

- Nutritious diet: Providing balanced feed and fodder to meet the nutritional requirements of different animal species and production stages.
- Fodder cultivation: Promotion of year-round green fodder cultivation (e.g., Napier grass, *Berseem*, etc.) to reduce reliance on expensive concentrates.
- Silage/hay making: Techniques for preserving green fodder for lean seasons.
- Water availability: Constant access to clean and fresh drinking water.

5. Health Management

- Vaccination and deworming: Regular vaccination and deworming programs.
- Disease surveillance: Early detection and reporting of disease symptoms.
- Isolation facilities: Provision for isolating sick animals to prevent disease spread.
- Biosecurity measures: Limiting access of unauthorized persons and animals to the shed.

V. Initiatives and Policies for Climate-Smart Shed Management in Nepal

- Government Programs: The Ministry of Agriculture and Livestock Development (MoALD) and its Department of Livestock Services (DLS) are responsible for formulating and implementing policies and programs related to livestock development. These often include components for shed improvement, breed improvement, feed management, and animal health.
- Nepal Livestock Sector Innovation Project (NLSIP): A World Bank-financed project that supports smallholder farmers and agro-processing enterprises to enhance productivity, resilience, and value addition in selected livestock value chains. NLSIP has actively promoted climate-smart livestock technologies, including improved shed and manure management. It offers matching grants to farmers for building modern sheds and provides training.
- Heifer Project Nepal: A prominent NGO working to empower smallholder farmers. It promotes Climate-Resilient Agriculture and Climate-Resilient Livestock approaches, which include improved manure management, animal shed improvements, composting, and fodder plantations.
- Local Government Initiatives: Municipalities and rural municipalities (like Waling Municipality, as seen in recent news) are increasingly providing subsidies and technical support to farmers for constructing modern and improved livestock sheds, particularly for goats and dairy animals. These initiatives often involve women farmer groups to promote economic empowerment.
- Training and Capacity Building: Various government, non-government, and international organizations conduct training and orientation programs for farmers on proper goat shed management, dairy shed hygiene, feed formulation, and disease prevention.
- Animal Welfare Directive, 2073 (2016 AD): While not exclusively on sheds, this directive provides guidelines on animal welfare, including provisions for proper housing, ventilation, light, and protection from extreme weather for working animals, which can be applied to livestock sheds generally.
- National Animal Health Policy, 2078 (2021 AD): This policy, along with the National Livestock Breeding Policy, 2078, provides a broader framework for animal health and

productivity, implicitly encouraging better shed management as a part of overall animal husbandry.

VI. Key Challenges of Promoting Climate-Resilient Livestock Shed Management

- Financial constraints: Many smallholder farmers lack the capital to invest in modern shed construction. While subsidies exist, they may not be sufficient or accessible to all.
- Lack of awareness and knowledge: Traditional farming practices are deeply ingrained, and there's a need for continued awareness campaigns and technical education on the benefits and methods of improved shed management.
- Technical capacity: Limited availability of skilled animal husbandry technicians and veterinarians in rural areas to provide guidance and support.
- Feed and fodder scarcity: Even with improved sheds, the persistent challenge of providing year-round quality feed and fodder impacts livestock productivity.
- Climate change impacts: While improved sheds are a mitigation strategy, increasing temperatures, erratic rainfall, and new disease patterns pose ongoing challenges to shed design and management.
- Limited access to quality inputs: Difficulty in accessing quality construction materials, improved breeds, and veterinary medicines, especially in remote areas.
- Cultural and social factors: In some communities, traditional beliefs or practices might hinder the adoption of new shed management techniques.

Despite these challenges, there's a strong drive in Nepal to modernize the livestock sector, with shed improvement and management being a critical component of achieving sustainable and profitable livestock farming.

VII. Role of Local Governments and Organizations in Nepal

Local governments, often in partnership with national and international NGOs (like Heifer International Nepal, WWF Nepal, LI-BIRD, and projects like NLSIP), have been playing a crucial role in promoting climate-smart livestock shed management, and the major interventions include:

- Awareness and training: Conducting workshops and demonstrations for farmers on climate-smart shed designs, manure management, and sustainable feeding practices.
- Technical support: Providing access to expert advice for shed design, construction, and management.
- Subsidies and financial incentives: Offering financial assistance or matching grants for farmers to invest in improved sheds, biogas plants, and other climate-smart technologies.
- Demonstration farms: Establishing model climate-smart livestock farms at the municipal level to showcase best practices.
- Integration into LAPA/local plans: Mainstreaming climate-smart livestock practices into local adaptation plans and broader development strategies.

Module 3: Livestock Fodder and Feed Management

Fodder and feed management are critical components of successful livestock management, directly impacting animal health, productivity, and the overall economic viability of livestock operations. Livestock fodder and feed management in the context of climate change is a critical area for Nepal's agricultural sector. Climate change directly impacts the availability, quality, and accessibility of feed resources, which in turn affects animal health, productivity, and the livelihoods of millions of smallholder farmers. Therefore, adopting "climate-smart" approaches to fodder and feed management is essential for building resilient livestock management and ensuring food security through improved livestock productivity.

I. Benefits of Fodder and Feed Management in Livestock management

The major importance of fodder and feed management in livestock management are as below:

1. Improved Nutrition

- Meeting nutrient requirements: Animals, like humans, require a balanced diet of carbohydrates, proteins, fats, vitamins, and minerals for maintenance, growth, reproduction, and milk/meat production. Proper fodder and feed management ensures these specific nutritional needs are met at different life stages (e.g., young, lactating, pregnant).
- Enhanced digestibility and nutrient absorption: Processing techniques like chopping, grinding, and pelleting break down complex feed components, making them easier for animals to digest and absorb nutrients. This maximizes the utilization of feed, reducing waste and improving feed conversion ratios.
- Increased palatability and intake: Processed and well-managed feed is often more appealing to livestock, encouraging consistent consumption. This directly translates to better weight gain, higher milk yields, and improved overall performance.
- Elimination of anti-nutritional factors: Some raw feed materials contain anti-nutritional factors that can hinder nutrient absorption or cause digestive issues. Proper processing can eliminate or reduce these harmful substances, ensuring animals get the full benefit of their diet.

2. Improved Animal Health

- Reduced digestive disorders: Unprocessed or poorly managed feed can lead to digestive problems like bloat or indigestion. Appropriate processing and feeding practices minimize these risks and improve digestive systems.
- Stronger immune system: A balanced and nutritious diet is fundamental for a robust immune system, making animals more resilient to diseases and infections.
- Prevention of deficiencies and toxins: Good feed management prevents nutrient deficiencies that can lead to various health issues. It also minimizes the risk of consuming contaminated feed (e.g., mold, mycotoxins, poisonous weeds), which can cause sickness, reduced productivity, or even death.
- Better reproductive performance: Adequate nutrition is crucial for successful reproduction, leading to improved fertility rates and healthy offspring.

3. Increased Productivity and Economic Benefits

- Higher yields: For dairy animals, optimized feeding leads to increased milk production. For meat animals, it results in better weight gain and meat quality. In poultry, it means improved egg production.

- Cost-effectiveness: Feed often constitutes a significant portion (60-70%) of livestock production costs. Efficient fodder and feed management, including proper storage and minimizing waste, helps reduce these costs. Utilizing locally available fodder resources can also decrease reliance on expensive imported feeds.
- Sustainable practices: Practices like rotational grazing in pasture management not only provide fresh feed but also contribute to soil conservation and health. Growing fodder crops can also help in nitrogen fixation and erosion control.
- Reduced environmental impact: Balanced feeding can reduce methane emissions from ruminants and minimize nitrogen and phosphorus release into the environment, contributing to a lower carbon footprint for livestock production.

II. Impacts of Climate Change on Fodder and Feed

Nepal is highly vulnerable to climate change, and as in other sectors, the climate change has greatly impacted livestock sector by affecting fodder and feed availability and quality. These impacts collectively lead to a significant feed deficit in the project area, particularly during the dry winter and early summer months, forcing farmers to rely on expensive concentrates or less nutritious crop residues. This has also forced farmers to reduce the number of livestock and shifting to small livestock than keeping large livestock like cow and buffaloes. The major climatic factors and their impacts on fodder and feed for livestock management in the project area are as below.

- Erratic rainfall patterns: More frequent droughts (leading to fodder scarcity) and intense rainfall (causing floods that damage fodder crops and pastureland).
- Rising temperatures: Affects the growth and quality of fodder crops, potentially reducing their nutritional value. It can also lead to heat stress in livestock, reducing their feed intake and conversion efficiency.
- Changes in seasonality: Altered growing seasons can disrupt traditional fodder production cycles.
- Increased pests and diseases: Warmer temperatures can favor the proliferation of pests and diseases that affect fodder crops, and also lead to new livestock diseases that impact their ability to utilize feed.
- Degradation of pasturelands: Overgrazing combined with changing climate patterns can lead to pasture degradation, reduced biodiversity of forage species, and desertification, especially in mountain and hill regions.
- Water scarcity: Reduced water availability due to changing precipitation patterns directly impacts irrigation for fodder crops.

III. Climate-Smart Fodder and Feed Management Strategies

In order to address the above challenges, the following climate-smart approaches have been increasingly promoted, or need to be promoted, to the farmers:

1. Diversification of Fodder Species (Climate-Resilient Varieties)

- Drought-tolerant fodder crops: Promoting varieties of grasses and legumes (e.g., Napier grass, Guinea grass, various legumes like *Berseem, Stylo*) that can withstand longer dry spells.
- Flood-tolerant varieties: Identifying and promoting fodder species that can tolerate waterlogging in flood-prone areas.
- Heat-tolerant varieties: Selecting and breeding fodder crops that maintain productivity and nutritional value under higher temperatures.

- Fodder trees: Promoting the planting of multi-purpose fodder trees (e.g., *Leucaena, Calliandra, Ficus, Bauhinia*) on farm boundaries, degraded lands, and terraces. These trees provide green fodder during lean seasons, contribute to soil fertility, reduce erosion, and offer shade.

2. Fodder Conservation Techniques

- Silage making: Encouraging farmers to make silage from surplus green fodder (especially during the monsoon) to preserve its nutritional value for the dry season. This involves anaerobic fermentation of chopped green fodder.
- Hay making: Promoting proper hay-making techniques (drying fodder to low moisture content) to store dry roughage for periods of scarcity. This is particularly relevant for monsoon grasses that would otherwise go to waste.

3. Improved Pasture and Grazing Management

- Rotational grazing: Implementing rotational grazing systems to prevent overgrazing, allow pastures to regenerate, and maintain vegetation cover.
- Pasture rejuvenation: Introducing improved and climate-resilient grass and legume species to degraded pastures.
- Enclosure and fencing: Protecting degraded areas to allow natural regeneration and facilitate controlled grazing.
- Water harvesting and irrigation: Developing small-scale irrigation systems (e.g., drip irrigation, rainwater harvesting ponds) for fodder plots to ensure water availability during dry spells.

4. Optimizing Feed Utilization and Quality

- Balanced ration formulation: Educating farmers on providing balanced diets to livestock using available fodder, feed supplements, and concentrates to meet nutritional requirements. Better nutrition improves digestion, which can potentially reduce enteric methane emissions.
- Urea-molasses mineral blocks (UMMB): Promoting the use of UMMB, which provide essential nutrients and improve the digestibility of low-quality roughages (like crop residues).
- Enrichment of crop residues: Treating crop residues (e.g., rice straw, maize stover) with urea or other additives to improve their palatability and nutritional value.
- Hydroponic fodder: Exploring and demonstrating hydroponic fodder production, especially in areas with limited land or water. This soilless cultivation can provide fresh green fodder year-round using minimal water.
- Feed additives: Investigating and promoting feed additives that can reduce enteric methane emissions in ruminants, though this is often more feasible in commercial farming systems.

5. Agroforestry Systems

- Integrating fodder trees and shrubs into farming systems (agroforestry) provides multiple benefits: fodder, fuel wood, timber, soil fertility improvement, carbon sequestration, and microclimate regulation (shade for animals).

6. Capacity Building and Awareness

- Farmer training: Providing comprehensive training to smallholder farmers on climate-smart fodder production, conservation, and feeding strategies.
- Demonstration farms: Establishing model farms to showcase successful climate-smart fodder management practices.
- Extension services: Strengthening the reach and effectiveness of livestock extension services to disseminate knowledge and provide technical support.

Module 4: Farm Manure/Waste Management for GHG Emission Reduction

Farm manure and waste management play a crucial role in reducing greenhouse gas (GHG) emissions, particularly methane (CH_4) and nitrous oxide (N_2O). These gases are potent contributors to climate change, and their release from decomposing manure can be significant. Effective management strategies aim to minimize their escape into the atmosphere while often providing co-benefits like nutrient recovery and renewable energy generation.

The key strategies for farm manure/waste management involves: (a) Composting, (b) Biogas production through anaerobic digestion, and (c) Improved manure storage and handling. The strategies are described as below.

1. Composting

Composting is the aerobic decomposition of manure or other organic material by microorganisms in a managed system. It requires air, moisture, and appropriate carbon and nitrogen ratios. By promoting aerobic decomposition, composting reduces methane emissions (which are typically produced in anaerobic conditions). While some N_2O can be emitted during composting, proper management (e.g., regular turning for aeration) can minimize this. The key benefits of composting are that it:

- Produces nutrient-rich compost, a valuable soil amendment.
- Reduces manure volume.
- Minimizes odors compared to open storage.
- Improves soil health and fertility, reducing the need for synthetic fertilizers.

Common composting methods for farmyard manure management include:

- ***Cold Composting (Passive composting):*** This composting method involves simply piling organic materials and letting them decompose naturally over time without active management. It's advantages are that it requires very low effort and minimal attention, while its disadvantages include slow process (can take a year or more), may not reach high enough temperatures to kill pathogens or weed seeds, can attract pests if not managed well.
- ***Hot composting (Active composting):*** It is a more managed approach involving specific ratios of "greens" and "browns," regular turning, and moisture monitoring to maintain high temperatures. Its benefits are: it produces finished compost much faster (weeks to a few months), kills pathogens and weed seeds, minimizes odors. Its disadvantage is that it requires more active management and attention.
- **Vermicomposting (Worm composting):** This method uses specific species of worms (e.g., red wigglers, *Eisenia fetida*) to break down organic waste in a contained bin or compost pit. The worms consume the waste and excrete nutrient-rich "worm castings" (vermicast). Adoption of this method is increasing in the recent days due to the quality of vermicompost produced through this method. It is excellent for food scraps, it can be done indoors or in small spaces, and it produces highly potent compost and "compost tea" (liquid leachate). However it requires specific worms, which can be sensitive to overfeeding or improper moisture/ temperature, and hence certain materials (meat, dairy, citrus) should be avoided while composting.

Choosing the right composting method depends on the type and quantity of waste, available space, desired speed of decomposition, and level of effort willing to be invested. Regardless of

the method, composting is a powerful tool for sustainable waste management and environmental health.

2. Anaerobic Digestion (AD):

Anaerobic digestion is one of the most effective methods of manure management. In this process, microorganisms break down organic matter in manure in the absence of oxygen, producing biogas (a mixture of methane and carbon dioxide). Flexi-biogas systems or smaller-scale digesters are being developed for smallholder farmers with fewer animals, making AD more accessible. By capturing the methane that would otherwise be released into the atmosphere, AD significantly reduces CH_4 emissions. The captured methane can then be flared (oxidizing it to less potent CO_2) or, more beneficially, used as a renewable energy source for electricity, heat, or vehicle fuel. Beyond GHG reduction, AD offers numerous advantages as below:

- Generates renewable energy, offsetting fossil fuel use.
- Reduces odors from manure.
- Decreases pathogens and weed seeds in the digestate.
- Improves nutrient management, as the digestate (the liquid and solid remains after digestion) is a nutrient-rich fertilizer.
- Can co-digest with other organic wastes (like food waste) for enhanced benefits.

3. Improved Manure Storage and Handling

This strategy helps to reduce the emission of GHG, though it is a practice than a technology. Some of the improved manure storage and handling techniques and practices include:

- Covered lagoons/tanks: Placing impermeable covers over manure storage facilities captures methane. This captured methane can then be flared or utilized for energy. This alone can significantly reduce methane emissions.
- Decreased storage time: Applying manure to land as soon as possible after collection can reduce the time it spends in anaerobic storage, thereby decreasing methane emissions.
- Solid-liquid separation**:** Separating solids from liquids in manure can alter the conditions for decomposition, potentially reducing emissions depending on the subsequent handling of each fraction. Solid manure typically emits less methane than liquid manure in anaerobic conditions.
- Aeration: Introducing oxygen to liquid manure storage (aeration) can convert anaerobic conditions to aerobic, reducing methane production. However, this needs careful management to avoid increasing N_2O emissions through nitrification-denitrification.

4. Nutrient Management and Application

This method increases the nutrition value of manure, and this process helps to reduce the GHG emission. Major nutrition management and application strategies are as below:

- Optimized application timing and rate: Applying manure to fields at the right time (when crops need nutrients) and at the right rate minimizes nutrient loss through runoff or volatilization of N_2O.
- Soil and manure testing: Regularly testing both soil and manure ensures proper nutrient balance for plant needs, reducing the risk of excess nutrient application and associated GHG emissions.
- Injection of liquid manure: Injecting liquid manure directly into the soil rather than surface application can reduce ammonia volatilization and subsequent N_2O emissions.

- Precision application technologies: GPS-guided spreaders and variable-rate application systems ensure manure is spread evenly and precisely, delivering the right amount of nutrients to different parts of the field, reducing waste and emissions. However, this technology difficult to adopt by the smallholder farmers due to its higher costs and the technological skills required.

5. Dietary Manipulation for Livestock

Dietary manipulation for livestock is an approach to reduce the amount of nitrogen excreted in urine and feces and thereby reducing GHG emission. The methods include:

- Reduced dietary protein: Lowering crude protein levels in animal feed, while ensuring adequate amino acid balance, can reduce the amount of nitrogen excreted in urine and feces, thereby decreasing ammonia volatilization and subsequent N_2O emissions from manure.
- Improved feed quality: Enhancing the digestibility of feed can lead to more efficient nutrient utilization by animals, resulting in less manure produced and potentially lower emissions per unit of product.

Challenges and Considerations

Although farm manure/waste management can significantly reduce GHG emissions into the atmosphere, there are some challenges that need to be considered. Some of the key challenges include:

- **Cost and infrastructure:** Many effective mitigation strategies, such as anaerobic digesters, require significant upfront investment and infrastructure, posing challenges for smaller farms.
- **Variability:** Manure characteristics and climatic conditions vary widely, meaning a "one-size-fits-all" solution is often not feasible. Mitigation practices need to be tailored to specific farm systems.
- **Pollution swapping:** It's important to consider potential "pollution swapping" effects, where reducing one GHG might inadvertently increase another, or shift pollution to a different environmental compartment (e.g., water). Therefore, an integrated approach is necessary.
- **Measurement and monitoring:** More accurate and granular methods for quantifying GHG emissions from manure management are needed to verify the effectiveness of different practices.

By implementing a combination of these strategies and embracing innovative technologies, the agricultural sector can significantly reduce its GHG footprint from manure and waste management, contributing to broader climate change mitigation efforts.

5. Water Sector

5.1 Climate SMART Water Resource Management Training

Climate Smart Water Resource Management Training which is designed for farmers-including women and marginalized communities and other stakeholders, aims to strengthen the capacity of training participants in managing water resources in a way that is both resilient to and mitigates the effects of climate change. This training focuses on efficient, adaptive, and integrated approaches to water use that enhance agricultural productivity, protect water ecosystems, and build resilience to climate-induced water stress such as droughts, floods, and irregular rainfall. After the training, the participant will learn how to improve water use efficiency in household consumption and achieve water security by ensuring access to sufficient, safe, and reliable water resources for various uses, including agriculture.

Example of decrease in water source in Chure

The settlement of Bhalkhada in Hariharpurgadhi Rural Municipality-5, Sindhuli, had plenty of natural water springs until 20 years back, remembers Sukhmaya Rai Danuwar, who's in her late fifties. The community people ascribe the water shortage to rampant deforestation of the Chure region. As reported by Sukhmaya, the land use map from 1995 to 2014 showed significant decrease in water sources in Sindhuli district. The land use map shows that the pond area also decreased by 20% during the same period in the district. The decrease in pond area might be due to increase in temperature and decrease in rainfall. The temperature trends along the Chure area on different stations are increasing and shrinkage of pond area is observed. (*Source: MaWRiN project document, 2022)*

5.2 Training Curriculum and Materials

Modules	Training
Module 1	Climate Change Impacts in Water Sector
Module 2	Integrated Water Resource Management for Climate Change Adaptation
Module 3	Water scarcity, demand management and water quality management in a changing climate
Module 4	Water source and spring source protection and management
Module 5	Nature-Based Solutions for Water Resource Management
Module 6	Mainstreaming Gender Equality, Disability, and Social Inclusion (GEDSI) in climate change adaptation for water resource management
Module 7	Challenges of mainstreaming CCA options in Water sector in Nepal

Module 1: Climate Change Impacts in Water Sector

Climate change poses significant and multifaceted impacts on the water sector, affecting both water quantity and quality, and leading to severe socio-economic consequences. These impacts are already being observed globally, with particular vulnerabilities in regions like the MaWRiN project area. The key impacts of climate change in water sector are described below.

1. Impacts on Water Quantity

- ***Changes in precipitation patterns:*** Climate change disrupts the hydrological cycle, leading to more unpredictable rainfall. Some regions experience more frequent and intense heavy rainfall events, increasing flood risks and runoff, while others face prolonged and severe droughts. This makes water availability less reliable.
- ***Reduced Water Supplies***
    - Decreased Snowpack and Glacier Melt: Many regions rely on snowpack and glaciers for their freshwater supply. Rising temperatures cause snow to melt earlier or precipitate as rain instead of snow, leading to reduced snowpack and accelerated glacier retreat. This initially increases river flow in some glacier-fed rivers but is projected to lead to a gradual decrease in the long term, impacting water availability for drinking, agriculture, and hydropower.
    - Groundwater depletion: Increased demand for water, especially for irrigation, combined with reduced natural replenishment from rainfall, exacerbates groundwater depletion. Droughts intensify this problem.
    - Increased evaporation: Higher temperatures lead to increased evaporation from surface water bodies and soil, further reducing available water.
- ***Extreme Weather Events***
    - Floods: More intense rainfall events increase the frequency and severity of river floods and flash floods, damaging water infrastructure, contaminating water sources, and making waterpoints inaccessible.
    - Droughts: Extended dry periods reduce water levels in rivers and groundwater, leading to water scarcity for various uses.

2. Impacts on Water Quality

- *Contamination from flooding*: Floodwaters can carry a variety of harmful contaminants, including sewage, agricultural runoff (pesticides, fertilizers), and other pollutants. This can overwhelm drainage and wastewater treatment systems, contaminating drinking water sources and crops.
- *Warmer water temperatures:* Rising surface water temperatures in lakes and oceans create favorable conditions for harmful algal blooms and other microbes. Some algae produce toxins that are detrimental to human health and aquatic life. Warmer water also reduces oxygen levels, affecting aquatic ecosystems.
- *Increased pollution concentration during droughts:* during dry periods, lower water levels reduce the dilution of pollutants, leading to higher concentrations of toxins, pathogens, and chemicals in water bodies.
- *Salinization:* Rising sea levels and coastal flooding can lead to saltwater intrusion into freshwater aquifers and surface water bodies, compromising water quality for drinking and irrigation.

3. Socio-Economic Consequences

- *Water scarcity and insecurity:* Over two billion people worldwide already lack access to safe drinking water, and climate change is expected to exacerbate this. Reduced water availability impacts basic human needs, sanitation, and food production.
- *Food insecurity:* Agriculture is the largest user of freshwater. Water scarcity and unpredictable rainfall directly impact crop yields and livestock, threatening food security and increasing food prices, disproportionately affecting low-income households.
- *Health impacts:* Contaminated water sources lead to an increase in waterborne diseases (e.g., diarrheal diseases), fever, and other infections. Vulnerable populations, such as children and the elderly, are particularly susceptible.
- *Infrastructure damage:* Extreme weather events like floods and landslides damage water supply and sanitation infrastructure (e.g., pipelines, wells, treatment facilities, dams), leading to disruptions in services and costly repairs.
- *Economic losses:* Droughts cause significant economic losses in agriculture, energy (hydropower), and public water supply. Overall economic productivity can be hindered by water-related issues.
- *Displacement and migration:* Water scarcity and water-related disasters can destabilize communities, triggering civil unrest and forced migration.
- *Increased burden on women and girls:* In many regions, women and girls are primarily responsible for water collection. Climate-induced water scarcity and longer distances to water points increase their physical and mental burden, impacting their education and well-being.
- *Challenges to Water, Sanitation, and Hygiene (WASH) services:* Climate hazards are already disrupting water supply systems, damaging sanitation infrastructure, and contaminating water sources in rural Nepal.

4. Adaptation Strategies in the Water Sector

Addressing these impacts requires comprehensive adaptation strategies, and some of the key adaptation strategies are discussed here:

- ***Water Resource Management***
  - Improved water use efficiency: Promoting sustainable water use, pricing mechanisms, and water-saving agricultural techniques (e.g., drip irrigation).
  - Increased storage capacity: Constructing new infrastructure like ponds, wells, and reservoirs, and promoting rainwater harvesting.
  - Groundwater recharge: Implementing measures to enhance natural and artificial groundwater recharge.
  - Sustainable river basin management: Strengthening climate resilience through integrated management of river basins.
- ***Infrastructure Resilience***
  - Climate-smart infrastructure: Designing and building water and sanitation infrastructure that can withstand climate change impacts (e.g., raised handpumps, flood-resilient designs).
  - Repair and retrofit facilities: Upgrading existing infrastructure to be more resilient.

- Protecting natural buffers: Conserving and restoring coastal mangroves and wetlands as natural barriers against flooding and erosion.

- ***Early Warning Systems and Preparedness***
  - Monitoring and modeling climate risk: Developing robust monitoring networks and climate models to predict changes in water availability and extreme events.
  - Planning for climate change: Integrating climate change considerations into water resource planning and policy development.

- ***Water Quality Protection***
  - Controlling runoff and erosion: Implementing measures like building swales and rain gardens, controlling stormwater runoff, and planting trees to reduce sediment and pollutant loads in waterways.
  - Wastewater treatment: Ensuring robust wastewater treatment systems to prevent contamination.

- ***Demand-side management***
  - Water conservation: Promoting water conservation practices in all sectors.
  - Water recycling and reuse: Implementing technologies for water recycling.

- ***Capacity building and policy***
  - Research and data: Investing in research and maintaining strong databases on water resources and climate impacts.
  - Inclusive policies: Developing policies that address the water needs of all communities, particularly marginalized groups.
  - Cross-sectoral collaboration: Fostering collaboration among government agencies, civil society, and researchers.

Module 2: Integrated Water Resource Management for Climate Change Adaptation

Integrated Water Resource Management (IWRM) is widely recognized as the most effective framework for managing water resources in the face of complex challenges, particularly climate change adaptation (CCA). IWRM is not just a theoretical concept but a practical necessity for ensuring water security and building resilience.

What is IWRM for Climate Change Adaptation?

IWRM is a process that promotes the coordinated development and management of water, land, and related resources, in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. When applied to Climate Change Adaptation (CCA), it explicitly integrates climate risks and vulnerabilities into all aspects of water planning and management. Essentially, it's about shifting from a fragmented, sectoral approach to a holistic one that considers:

- All water users: Domestic, agricultural, industrial, environmental, energy.
- All water sources: Surface water (rivers, lakes), groundwater (aquifers, springs), rainwater.
- All impacts: Water scarcity, floods, pollution, ecosystem degradation.
- All scales: From household to local, municipal, and potentially river basin levels.
- All stakeholders: Government, communities, private sector, NGOs, academia.

Core Principles of IWRM for CCA

- Water is a finite and vulnerable resource, essential to sustain life, development and the environment: This principle highlights the preciousness of water and the need for its careful management, especially under climate stress.
- Water management should be based on a participatory approach, involving all stakeholders: Crucial for CCA, as local communities (often most vulnerable) possess invaluable traditional knowledge and are key to implementing effective adaptation measures. This includes GEDSI mainstreaming.
- Women play a central part in the provision, management and safeguarding of water: Recognizing women's roles, often as primary water providers, is fundamental for effective and equitable IWRM and CCA. Their insights and participation are vital.
- Water has an economic value in all its competing uses and should be recognized as an economic good: This principle encourages efficient water use and investment in water infrastructure, while ensuring equitable access for basic needs.

Key Components of IWRM for CCA

1. **Climate-Informed Water Resource Assessment**
   - Vulnerability assessment: Identify which communities and sectors are most vulnerable to specific climate impacts on water (e.g., communities relying on drying springs, farmers affected by droughts/floods). This must be GEDSI-disaggregated.
   - Water Balance Analysis: Develop current and future water balances (demand vs. supply) under different climate scenarios to understand potential deficits or surpluses.
   - Data collection and analysis: Go beyond historical data to project future climate scenarios (rainfall, temperature, extreme events) and their impacts on water availability (spring discharge, river flows, groundwater levels).

2. **Watershed/Springshed-Based Planning and Management**
   - Scale of intervention: Recognizing that water flows across administrative boundaries, planning should ideally happen at the watershed or sub-watershed level. For the project prioritized sub-watershed area, this means managing the *springsheds* and local catchments comprehensively.
   - Upstream-downstream linkages: Promote collaboration between communities and actors in upstream and downstream areas, acknowledging their interdependence for water resources. Upstream protection benefits downstream users.
   - Nature-based solutions (NbS): Integrate NbS (as discussed previously) like springshed recharge, reforestation, wetland restoration, and riparian zone management into watershed plans. These build natural resilience to climate impacts.

3. **Demand Management and Water Use Efficiency**
   - Sustainable water use practices: Promote and incentivize water-efficient practices in domestic (low-flow fixtures, greywater reuse), agricultural (drip irrigation, climate-smart agriculture), and other sectors.
   - Water conservation: Implement programs for reducing water losses in distribution systems (leak detection and repair) and promote water recycling and reuse where feasible.
   - Rainwater Harvesting: Promote household and community-level rainwater harvesting to supplement water supply and reduce reliance on vulnerable sources.

4. **Supply Enhancement and Diversification (Climate-Resilient Infrastructure)**
   - Source diversification: Reduce over-reliance on single sources (like a few springs) by developing alternative sources, such as rainwater harvesting, well development (with sustainable abstraction), or inter-basin transfers if feasible and environmentally sound.
   - Climate-resilient infrastructure: Design and construct water infrastructure (tanks, pipelines, irrigation canals) to withstand projected climate impacts (e.g., increased flood intensity, landslides).
   - Groundwater management: Develop strategies for sustainable groundwater use and artificial recharge, especially crucial for spring-fed areas.

5. **Multi-Hazard Risk Management**
   - Integrated flood and drought management: Develop plans that address both extremes. This includes early warning systems, flood protection measures (e.g., bioengineering), and drought contingency plans (e.g., emergency water supplies, crop insurance).
   - Water quality protection: Implement measures to protect water sources from contamination, which can be exacerbated by extreme weather events (e.g., floods washing pollutants into sources).

6. **Institutional and Governance Strengthening**
   - Legal and policy frameworks: Review and update local policies and bylaws to support IWRM principles and climate change adaptation (e.g., mandating source protection zones, water-efficient building codes).
   - Cross-sectoral coordination: Establish mechanisms for effective coordination among different government departments (Water, Agriculture, Forestry, Health) and other stakeholders at municipal and district levels.
   - Decentralization and local capacity: Empower local governments and Water User Committees (WUCs) with the necessary authority, technical capacity, and financial resources to implement IWRM.

- Conflict resolution: Develop mechanisms to resolve water-related conflicts, which may increase with climate-induced scarcity.

7. Gender Equality, Disability, and Social Inclusion (GEDSI) as a Cross-Cutting Theme

- Participatory planning: Ensure meaningful involvement of women, people with disabilities, Dalits, and other marginalized groups in all decision-making processes, from assessment to implementation and monitoring.
- Equitable access and benefit sharing: Design water schemes and adaptation measures that ensure equitable access to water and benefits for all, addressing specific needs (e.g., accessible tap stands, reduced water collection burden for women).
- Knowledge integration: Recognize and value the traditional ecological knowledge and adaptation strategies of diverse groups.
- Capacity building: Provide targeted training and empowerment programs for women and marginalized groups in water management and climate resilience.

8. Monitoring, Evaluation, and Learning:

- Climate-sensitive indicators: Develop indicators that track not only water availability and quality but also climate resilience and equity outcomes (e.g., number of springs with increased dry season flow, reduction in time spent collecting water by women, number of households with improved access during drought).
- Adaptive management: Establish systems for continuous learning and adjustment of IWRM plans based on monitoring data, new climate information, and changing local conditions.

Challenges in Implementing IWRM for CCA

- Institutional fragmentation: Overlapping mandates and lack of coordination among different government agencies.
- Data gaps: Insufficient hydro-meteorological data, especially disaggregated data on climate impacts and vulnerabilities.
- Limited technical capacity: Shortage of trained personnel at the local level for hydro-geological surveys, climate modeling, and NbS implementation.
- Financial constraints: Limited financial resources for large-scale IWRM and CCA interventions.
- Political economy: Power dynamics and vested interests can hinder equitable water allocation and management.
- Lack of awareness: Low understanding among some communities and decision-makers about the strong links between climate change, water, and sustainable development.
- Top-down vs. bottom-up: Bridging the gap between national policies and local-level implementation.

Module 3: Water Scarcity, Demand Management and Water Quality Management in a Changing Climate Context

Water scarcity, demand management, and water quality management are three interconnected and critical challenges for watershed management in the context of a changing climate. As climate change intensifies, these issues will become more pronounced, requiring integrated and adaptive strategies. By integrating adaptive strategies across water scarcity, demand, and quality management, a more secure, resilient, and healthy water future can proactively be built for the communities residing in the watershed in the challenging context of climate change.

1. Water Scarcity in a Changing Climate Context

The key impacts of climate change on water scarcity are:

- Erratic rainfall patterns: More intense, shorter downpours lead to high runoff and less infiltration, meaning less water recharges groundwater and springs. Longer dry spells between rainfall events exacerbate dry season scarcity.
- Drying springs: Many spring sources, crucial for both upstream and downstream communities are experiencing reduced flows or completely drying up due to altered recharge patterns, deforestation in catchment areas, and potentially increased evapotranspiration.
- Reduced groundwater recharge: Changes in precipitation, increased surface runoff, and land-use changes (e.g., urbanization, concrete surfaces) can significantly reduce the replenishment of underground aquifers that feed springs and wells.
- Increased evapotranspiration: Higher temperatures lead to increased evaporation from surface water bodies and transpiration from plants, reducing available water.
- Snow/glacier melt (indirect impact): While the MaWRiN project area itself is not be directly glacier-fed, broader regional changes in glacial melt patterns in the Himalayas can affect major river systems that might be considered for large-scale inter-basin transfers in the long term, or influence regional weather patterns.

The strategies for addressing water scarcity include:

- Comprehensive water source assessment: Regular monitoring of spring discharge rates (especially in dry season) and groundwater levels. Understanding the hydrological connections between rainfall, land cover, and spring yield.
- Springshed management and recharge enhancement (Nature-Based Solutions): This is paramount for spring-dependent areas, and includes:
    - Reforestation/afforestation: Planting native, water-friendly trees and shrubs in spring recharge areas to increase infiltration.
    - Contour trenches and pits: Digging structures on slopes to slow down runoff and promote water percolation.
    - Pond construction/rehabilitation: Creating small ponds to capture rainwater for localized recharge.
- Rainwater harvesting: Promoting widespread adoption of household and community-level rainwater harvesting for both direct use and groundwater recharge. This supplements supply during dry periods.

- Diversification of water sources: Reducing over-reliance on a single source. Explore additional, sustainably managed groundwater sources (e.g., tube wells in suitable geological areas) or consider inter-basin transfers as a last resort, if larger regional plans allow and impacts are mitigated.
- Water storage solutions: Constructing climate-resilient storage tanks at community and household levels to store water during periods of availability for use during scarcity.

2. Demand Management

Demand management focuses on influencing water use patterns to optimize existing supplies, rather than solely seeking new sources. It's often the most sustainable and cost-effective approach of water management. Strategies for water demand management include:

- Water use efficiency and conservation**:** At household level, water use efficiency can be promoted by using low-flow fixtures, educate on behavioral changes (shorter showers, turning off taps), prompt leak detection and repair within household systems, and encourage greywater reuse for non-potable purposes (e.g., gardening, toilet flushing) where safe.
- At agricultural level, climate smart agriculture practices with efficient irrigation technologies like drip irrigation or micro-sprinklers are the important strategies. Promoting mulching to reduce evaporation, conservation tillage to improve soil moisture, and cultivate drought-tolerant crop varieties are other strategies for demand management.
- Water audits and leakage reduction by conducting regular audits of the entire water supply network (from source to tap) to identify and fix leaks in pipes, tanks, and connections is another strategy. Non-revenue water (water lost before reaching the consumer) is a significant issue in many drinking water systems in Nepal. Moreover, optimizing water pressure in distribution networks to reduce leakages and pipe bursts can also help in water conservation.
- Public awareness and education is another important strategy for water conservation. Conducting campaigns to educate communities on the economic and environmental value of water, the implications of climate change on water availability, and the importance of conservation is essential. Likewise, the communities need to be encouraged for behavioural change on water-saving habits through schools, community meetings, and local media.
- Water pricing and incentives can also contribute to demand management leading to efficient water use and water conservation. Implementing progressive tariffs that charge higher rates for increased consumption incentivizes conservation for non-essential uses, while ensuring a basic affordable lifeline tariff for all. Similarly, providing subsidies for efficient technologies or financing schemes for water-efficient appliances, irrigation systems, and rainwater harvesting infrastructure can also manage water demand.
- Community-led planning is another important strategy, which involves formation of Water User Committees (WUCs) and engagement of local communities in water allocation decisions, fostering local ownership and responsible use. This includes developing and enforcing local bylaws on water use.
- Demand forecasting by utilize population growth projections, socio-economic factors, and climate change scenarios helps to forecast future water demand accurately. This informs planning and avoids over- or under-sizing infrastructure.

3. Water Quality Management in a Changing Climate Context

Climate change significantly impacts water quality, making management more complex. Impacts of climate change on water quality include:

- Increased turbidity: Intense rainfall and floods lead to increased soil erosion and sediment runoff, making spring and river water highly turbid, requiring more treatment.
- Contamination from runoff: Heavy rainfall washes pollutants (agricultural chemicals, animal waste, pathogens from unmanaged sanitation) from land surfaces into water sources.
- Reduced dilution during droughts: Lower water levels during droughts mean pollutants are less diluted, leading to higher concentrations of contaminants.
- Increased water temperature: Higher ambient temperatures can promote the growth of pathogens and algae in stagnant water bodies.
- Damage to infrastructure: Floods and landslides can damage water supply infrastructure, leading to contamination (e.g., pipes breaking and allowing ingress of polluted water).
- Changes in groundwater quality: Altered recharge patterns can affect groundwater chemistry, potentially mobilizing naturally occurring contaminants (e.g., arsenic in some parts of Nepal, though less common in hills).

4. Strategies for Water Quality Management

- ***Source Protection (NbS focus):***
    - *Springshed/catchment protection*: Re-emphasizing protection of the immediate spring vicinity and its entire recharge area through afforestation, fencing, and sustainable land use to minimize contamination risk.
    - *Riparian zone management:* Protecting and restoring vegetation along streams and rivers to filter runoff before it enters water bodies.

- ***Regular water quality monitoring***
    - *Routine testing:* Implementing a regular water quality testing program for key parameters (e.g., E. coli, turbidity, pH, chlorine residual) at the source, storage, and tap stands. The community can be trained for such routine testing of water quality.
    - *Community-based testing:* Training Water User Committee members and local health volunteers in basic field testing methods using simple kits. This empowers communities to monitor their own water.

- ***Water treatment at point of use/supply***
    - *Household water treatment and safe storage**:*** Promotion of simple, effective household treatment methods like boiling, solar disinfection (SODIS), use of ceramic filters, or water purification tablets, especially during monsoon or when source contamination is suspected.
    - *Community/system-level treatment:* For larger schemes, exploring appropriate treatment technologies like slow sand filters, chlorination, or sedimentation tanks, designed with climate resilience in mind to handle higher turbidity.

- ***Integrated Sanitation Management:***
    - WASH integration: It is important to make the community and stakeholders recognize that safe water quality depends heavily on good sanitation and hygiene, and promoting proper waste disposal, construction of improved latrines, and handwashing practices to prevent fecal contamination of water sources.
    - Fecal sludge management: Integrated sanitation management includes developing plans for the safe collection, treatment, and disposal of fecal sludge, especially in more densely populated areas.

- ***Early Warning Systems for Water Quality:*** Developing simple community-level early warning systems for periods of high risk of contamination (e.g., during intense rainfall or after landslides) prompting communities to take precautions.

Module 4: Water Source and Spring Source Protection and Management

Water source and spring source protection and management is vital, especially for a fragile geography and ecosystem of the sub-watersheds in MaWRiN Project area, where communities heavily rely on these natural water supplies for the livelihoods. The challenges are amplified by climate change, which affects precipitation patterns, glacial melt, and the overall hydrological cycle.

Understanding the Importance of Water Sources and Springs

- Primary Water Supply: Springs are often the most reliable and accessible source of drinking water for a significant portion of Nepal's rural and even semi-urban population, particularly in the hills and mountains.
- Ecosystem Services: Healthy watersheds and spring sources provide crucial ecosystem services, including regulating water flow, filtering pollutants, maintaining biodiversity, and supporting livelihoods.
- Climate Resilience: Protecting these sources enhances community resilience to climate change impacts, such as increased frequency of droughts, erratic rainfall, and reduced dry-season flows.
- Economic Value: Reliable water sources reduce the time and effort spent on water collection (often by women and girls), freeing up time for education, economic activities, and other productive endeavors.

Key Challenges in Water Source and Spring Protection and Management

1. **Climate Change Impacts**
   - *Drying Springs*: Erratic rainfall patterns, longer dry spells, and reduced infiltration due to land-use changes are leading to the drying up of many springs or a significant decrease in their discharge, especially during the dry season.
   - *Increased Runoff and Erosion:* High-intensity rainfall events cause increased surface runoff, soil erosion, and landslides, which can contaminate water sources and damage infrastructure.
   - *Water Quality Degradation*: Changes in precipitation and temperature can impact water quality, increasing the risk of waterborne diseases.

2. **Anthropogenic Pressures**
   - *Deforestation and Land-Use Change:* Unplanned development, deforestation, and conversion of forests to agricultural land or settlements reduce infiltration and recharge of groundwater, directly affecting spring yields.
   - *Unplanned Infrastructure Development*: Road construction and other infrastructure projects can disrupt natural water flow paths, damage spring sources, and contribute to erosion.
   - *Pollution:* Improper waste disposal, agricultural runoff (pesticides, fertilizers), and unmanaged sanitation systems can contaminate water sources.
   - *Over-extraction:* Growing population and increased water demand for various uses (domestic, agriculture) can lead to over-extraction, depleting groundwater levels and reducing spring flows.

3. **Governance and Institutional Gaps**
   - Fragmented Governance: Water resource management in Nepal is fragmented, with different government agencies having overlapping or unclear mandates. This calls for the need of watershed management approach in management of natural resources like water.
   - Limited Capacity: Local governments and communities may lack the technical capacity, financial resources, and awareness to effectively manage and protect water sources.
   - Lack of Integrated Planning: A lack of integrated water resource management (IWRM) that considers the entire watershed often leads to uncoordinated efforts and unsustainable practices.
   - Inadequate Enforcement: Existing policies and regulations for source protection may not be adequately enforced.

4. **Socio-Cultural Factors**
   - Lack of Awareness: Communities may not be fully aware of the link between land use, watershed health, and water availability and quality.
   - Equity Issues: Vulnerable and marginalized groups (including women, Dalits, and Indigenous Peoples) may have limited access to decision-making processes and equitable benefits from water management initiatives.

Strategies for Water Source and Spring Source Protection and Management

Effective management requires a multi-pronged, integrated, and community-centric approach with multi-stakeholder engagement in managing the resources. The key strategies and approaches are as below:

1. Springshed Management and Revival

This is a critical strategy the Chure Hills. It focuses on the entire hydrological unit that feeds a spring. The key interventions for springshed management and revival include:

- ***Springs Inventory and Mapping*****:** Identify all existing and dried-up springs, map their locations using GIS, and assess their discharge rates (especially in dry seasons).
- ***Hydrogeological Studies***: Understand the geological formations and groundwater flow paths that feed the springs to delineate the springshed area accurately.
- ***Catchment Area Treatment (Recharge Enhancement)***
  - Afforestation/Reforestation: Plant indigenous trees and shrubs in the springshed to increase soil infiltration and reduce surface runoff.
  - Contour Trenches and Eyebrow Terraces: Dig small trenches along contours to slow down water flow, increase infiltration, and reduce erosion.
  - Recharge Pits/Ponds: Construct small ponds or pits to capture rainwater and allow it to percolate into the ground, recharging aquifers.
  - Gully Plugs and Check Dams: Build structures to prevent gully formation and control erosion in degraded areas.
  - Regulation of Land Use: Implement zoning regulations or community agreements to restrict activities that can negatively impact water infiltration (e.g., unsustainable farming practices, construction).

- ***Source Protection Structures***
    - Source Protection Chambers: Construct masonry or concrete chambers around the spring outlet to protect it from contamination (human and animal waste, debris).
    - Fencing: Erect fences (live or dead) around the immediate spring area to prevent human and livestock intrusion.
    - Diversion Ditches: Create ditches to divert surface runoff away from the spring source.
- ***Water Quality Monitoring:*** Regularly test the water quality of springs to identify potential contamination and ensure it's safe for consumption.

2. Community-Based Water Resource Management (CBWRM):

Given Nepal's strong tradition of community-managed water systems, CBWRM is fundamental.

- *Formation of Water User Committees (WUCs):* Empower local communities to form and strengthen WUCs with diverse representation (including women, marginalized groups, and people with disabilities).
- *Capacity Building*: Provide WUCs and local communities with training on technical aspects of water management, water quality testing, financial management, conflict resolution, and GEDSI integration.
- *Participatory Planning*: Engage communities in identifying their water needs, assessing local sources, designing protection measures, and developing water management plans.
- *Local Ownership:* Foster a sense of ownership over water sources and infrastructure, which is crucial for long-term sustainability.
- *Traditional Knowledge Integration*: Document and integrate traditional knowledge and practices related to water conservation and source protection.

3. Integrated Water Resource Management (IWRM) Approach:

- *Watershed-Level Planning:* Shift from isolated project-based interventions to holistic, watershed-level planning that considers all water users and land uses within a catchment.
- *Upstream-Downstream Linkages:* Promote cooperation between upstream and downstream communities, recognizing their interdependence for water resources.
- *Multi-Sectoral Coordination:* Foster coordination among different government departments (water, agriculture, forestry, health) and other stakeholders to ensure integrated planning and implementation.
- *Data Collection and Monitoring:* Establish robust systems for collecting hydrological data (rainfall, discharge, groundwater levels) and water quality data to inform decision-making.

4. Policy and Regulatory Framework:

- Strengthen Legal Frameworks: Develop and enforce clear policies and regulations for water source protection, land use planning in critical recharge zones, and pollution control.

- Incentives for Protection: Explore mechanisms like payment for ecosystem services (PES) where downstream users or beneficiaries compensate upstream communities for their efforts in source protection.
- Mainstream GEDSI: Ensure that all water resource management policies, plans, and projects explicitly integrate Gender Equality, Disability, and Social Inclusion (GEDSI) principles. This means:
    - Equitable Access: Designing infrastructure that is accessible to all, including people with disabilities.
    - Inclusive Decision-Making: Ensuring representation of diverse groups in WUCs and other decision-making bodies.
    - Benefit Sharing: Ensuring that benefits from water projects are equitably distributed among all community members.
    - Addressing Differentiated Impacts: Recognizing how climate change impacts on water affect different groups uniquely and designing adaptation measures accordingly.

5. Climate Change Adaptation Measures:

- *Rainwater Harvesting:* Promote rainwater harvesting at household and community levels to supplement water supply, especially during dry periods.
- *Water-Efficient Practices:* Encourage water-saving technologies and practices in agriculture (e.g., drip irrigation, mulching) and domestic use.
- *Diversification of Water Sources*: Explore alternative water sources where feasible, such as deep boreholes (with careful management to avoid over-extraction) or fog harvesting in appropriate areas.
- *Early Warning Systems*: Develop and implement early warning systems for droughts and floods to enable communities to prepare and respond effectively.

6. Public Awareness and Education:

- *Community Sensitization*: Conduct awareness campaigns to educate communities on the importance of water source protection, hygiene practices, and climate change impacts.
- *School Programs*: Integrate water conservation and environmental education into school curricula.

Module 5: Nature-Based Solutions for Water Resource Management

Nature-Based Solutions (NbS) for water resource management are gaining increasing recognition, especially in vulnerable regions like Chure Hills of Nepal. These solutions involve working *with* nature, rather than against it, to address water-related challenges like water scarcity, floods, landslides, and pollution, while simultaneously providing other environmental, social, and economic benefits. The essence of NbS lies in protecting, sustainably managing, and restoring natural or modified ecosystems to address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

Key Nature-Based Solutions for Water Resource Management

Given the hilly and fragile terrain, reliance on springs, and vulnerability to climate change, the following NbS are particularly relevant for the MaWRin project area:

1. Springshed Management and Revival

This involves delineating the recharge area of a spring and implementing various measures within that area to enhance groundwater infiltration and increase spring discharge. Major benefits of springshed management and revival are the increased spring yield, improved water quality, reduced soil erosion, enhanced biodiversity, and improved microclimates. The key techniques for springshed management and revival include:

- Reforestation and Afforestation: Planting native, water-friendly tree species in the springshed increases soil organic matter, improves soil structure, and reduces surface runoff, allowing more water to percolate into the ground.
- Contour Trenches and Pits: Digging small trenches or pits along contours on slopes helps to intercept surface runoff, slow down water flow, and facilitate water infiltration into the soil.
- Brushwood Dams/Check Dams: Constructing small, permeable structures using local materials (e.g., brushwood, stones) in gullies and small streams to reduce erosion, retain soil moisture, and promote groundwater recharge.
- Agroforestry: Integrating trees and shrubs into agricultural land to improve soil health, reduce erosion, and enhance water infiltration.

2. Rainwater Harvesting

Rainwater harvesting means collecting and storing rainwater from rooftops, land surfaces, or natural catchments for later use. Rain water harvesting supplements water supply during dry seasons, reduces reliance on vulnerable spring sources, lowers water bills, and decreases storm runoff. The major techniques of rainwater harvesting include:

- Rooftop Rainwater Harvesting: Collecting water from house roofs and storing it in tanks or directly channeling it to recharge groundwater (e.g., through recharge pits or wells).
- Ponds/Recharge Ponds: Constructing or rehabilitating small ponds to collect surface runoff, which can then infiltrate and recharge local aquifers. For example, Dhulikhel Municipality in Nepal has successfully implemented this.
- Sub-surface Dams/Seepage Harvesting: In areas with seasonal rivers or significant sub-surface flow, constructing structures below ground to trap and store water for irrigation or other uses.

3. Wetland Restoration and Construction

Wetland restoration means protecting, restoring, or creating natural or artificial wetlands. Wetlands act as natural sponges, filtering water, recharging groundwater, and regulating water flow. The major benefits of wetland restoration and construction interventions are improved water quality, flood regulation, groundwater recharge, enhanced biodiversity (habitat for various species), and potential for livelihood diversification (e.g., fish farming). The following key techniques can be adopted for wetland restoration:

- Natural Wetland Restoration: Rehabilitating degraded natural wetlands by removing pollutants, controlling invasive species, and re-establishing native vegetation.
- Constructed Wetlands: Designing and building artificial wetlands for wastewater treatment (e.g., greywater from households) or to manage stormwater runoff. These use plants to naturally filter pollutants.

4. Riverbank Bioengineering and Riparian Zone Management

Water resource can also be protected and or managed by using vegetation and natural materials to stabilize riverbanks, prevent erosion, and maintain healthy riparian ecosystems. The major benefits of this intervention are the reduced flood risk, prevention of landslides and soil erosion, improved water quality, enhanced aquatic habitats, and increased biodiversity. The key techniques for riverbank bioengineering and riparian zone management include:

- Vegetative Cover: This involves planting grasses, shrubs, and trees along riverbanks to bind soil, reduce erosion, and filter pollutants from agricultural runoff.
- Live Fascines and Brush Layers: It uses bundles of live plant cuttings to create structures that stabilize slopes and promote vegetation growth.
- Gabion Structures with Vegetation: This technology combines rock-filled wire cages with live plants to provide strong, yet permeable, bank stabilization.
- Bio-dykes: In this technique, embankments are built along the river banks primarily from natural materials and reinforced with strategically planted local trees and other plants to prevent river overflow and erosion.

5. Sustainable Agricultural Practices

Sustainable and efficient water use practices are absolutely critical for climate change adaptation, especially in water-stressed. As climate change brings more erratic rainfall, longer droughts, and altered snowmelt patterns, communities must make every drop count. Agriculture is often the largest water consumer, and hence optimizing water use in agriculture through sustainable agricultural practice is one of the key measures for water management. This involves implementing farming methods that conserve soil moisture, reduce water use, and minimize agricultural runoff. The major advantage of this method is that it helps to reduce water demand for agriculture, improved soil health, less water pollution, and enhanced farm resilience to climate change. Some of the key techniques for sustainable agriculture practices are:

- Terracing and contour farming: It is the method of cultivating land along contours to reduce runoff and soil erosion.
- Mulching: Mulching is the technique to cover soil with organic material to reduce evaporation, conserve moisture, and suppress weeds.
- Drip irrigation and efficient irrigation: Efficient irrigation uses water-efficient irrigation methods to deliver water directly to plant roots, minimizing waste.

- Organic farming: Organic farming reduces reliance on chemical fertilizers and pesticides, which can contaminate water sources. This it indirectly helps to protect and manage water sources.
- Crop diversification and climate-resilient crops: Cultivating crops that are less water-intensive or more resilient to changing weather patterns can significantly contribute to reduce water scarcity and water use efficiency.
- Water-smart land preparation: Terracing, contour ploughing, and minimum tillage to enhance soil water retention and reduce runoff can reduce the water consumption in agriculture.

6. Sustainable Forest Management and Afforestation

Forests play a crucial role in the hydrological cycle, influencing both water quantity and quality, and therefore, sustainable forest management and afforestation is one of effective nature-based solutions for water source protection and management. It helps to regulate stream flows, reduces flood peaks, increases dry season base flows, prevents soil erosion and landslides, and improves overall watershed health. The major practices of sustainable forest management and afforestation as a NbS measure to manage water resource include:

- Community forestry: Community forestry empowers local communities to manage forest resources sustainably, ensuring regeneration and preventing deforestation.
- Strategic plantation: Planting trees on degraded lands and along slopes contributes to increase water infiltration, reduce surface runoff, and improve soil moisture retention.
- Forest fire prevention: Forest fire is one of the major reasons of forest degradation and deforestation. Therefore, implementing measures to prevent and control forest fires can increase water yield by stopping degradation of watershed health and watershed resources.

Benefits of NbS in Water Management in MaWRiN Project Area

Adoption of nature based solutions in the MaWRiN project area will have the following benefits:

- Increased water availability: It directly increases water availability through recharge and harvesting, and indirectly by improving water retention in the landscape.
- Enhanced water quality: nature based solution to water management provides natural filtration processes that reduce pollutants, improving the potability of water.
- Reduced disaster risk: NbS increases water availability by mitigating floods and landslides, which are common in hilly regions and exacerbated by climate change.
- Biodiversity Conservation: NbS helps to conserve biodiversity by creating and restoring habitats, increasing supply of water for wildlife and plants, supporting local ecosystems including aquatic ecosystems.
- Cost-effectiveness: NbS are often more affordable to implement and maintain than "grey infrastructure" (concrete dams, pipes) in the long run, especially considering co-benefits. Such practices also help to increase the life time of the grey infrastructures.
- Community empowerment and livelihoods: Many NbS are well-suited for community-led implementation, fostering local ownership and providing opportunities for skill development and income generation (e.g., through nurseries, eco-tourism).

- Climate change adaptation and mitigation: NbS contributes to building resilience to extreme weather events and contributing to carbon sequestration through afforestation. Hence NbS contributes to climate change adaptation and mitigation.
- Social and cultural value: Nature based practices adds to the social and cultural values by integrating traditional knowledge and practices, respecting local heritage. It contributes to improve the local indigenous knowledge and protects cultural heritages.

Challenges and Considerations for NbS Implementation

Although there are several benefits of adopting nature based solutions for water resource protection and management, its implementation has several challenges. The key challenges include:

- Land ownership and tenure issues: Implementing large-scale NbS like springshed management requires cooperation across multiple landholdings. Land ownership and tenure issues are the major issues in the project area, as many households in project are do not have land ownership.
- Technical knowledge gaps: While conceptually simple, effective design and implementation of NbS require specific technical knowledge (e.g., hydrogeology for springsheds, ecological engineering for bioengineering), which is generally lacking among the district line agencies, local governments and at the community level.
- Funding and investment: Despite their cost-effectiveness, initial funding for NbS can be a barrier, and private sector investment may be hesitant without clear benefits.
- Maintenance and long-term sustainability: Ensuring ongoing maintenance and community commitment is crucial for the long-term success of NbS.
- Policy mainstreaming: Fragmented governance and a historical preference and political priority for "hard engineering" solutions can hinder the widespread adoption and integration of NbS into national and local policies.
- Monitoring and evaluation: Robust monitoring systems are needed to track the effectiveness of NbS and provide evidence for their benefits.
- GEDSI integration: GEDSI integration isrucial for success, as NbS often rely on community participation. Ensuring women, people with disabilities and marginalized groups are actively involved in planning, implementation, and benefit sharing is paramount for the success of NbS in water resource management.

Overarching Principles for Implementing NbS

The following overarching principles are important for implementing NbS for water management:

- Integrated Watershed Approach: No single NbS works in isolation. All interventions should be part of a larger, integrated plan for the entire watershed, recognizing the interconnectedness of land, water, and ecosystems.
- Community participation and ownership: NbS are most effective when local communities are actively involved in their design, implementation, and maintenance. Their traditional knowledge is invaluable.
- Gender equality, disability, and social inclusion (GEDSI): It is important to ensure that the benefits and responsibilities of NbS are equitably distributed. Women often play primary roles in water management and have unique insights. People with disabilities

and other marginalized groups must have accessible solutions and a voice in decision-making in water management.

- Capacity building: Provide technical training and awareness programs for local government officials, community leaders, and water users on NbS techniques, monitoring, and maintenance.
- Policy and financial support: Local government policies should support and incentivize NbS. Exploring innovative financing mechanisms (e.g., payments for ecosystem services) can help sustain these initiatives.
- Monitoring and adaptive management: Regularly monitor the effectiveness of implemented NbS (e.g., spring discharge, water quality, vegetation growth) and adapt strategies based on results and changing conditions.

Module 6: Mainstreaming Gender Equality, Disability, Social Inclusion in Climate Change Adaptation for Water Management

Mainstreaming Gender Equality, Disability, and Social Inclusion (GEDSI) in climate change adaptation for water resource management is crucial for ensuring equitable, effective, and sustainable outcomes. Climate change disproportionately impacts vulnerable groups, and a GEDSI-blind approach can exacerbate existing inequalities.

What is GEDSI in Climate Change Adaptation for Water Resource Management?

GEDSI is an approach that recognizes that certain groups – such as women, people with disabilities, Indigenous Peoples, cultural minorities, the elderly, sexual and gender minorities, and the extremely impoverished – face various barriers and forms of discrimination that hinder their full inclusion and participation in society, particularly in the context of climate change impacts on water resources.

- *Gender equality*: Focuses on fairness and equal rights for all genders, recognizing that traditional gender roles often result in unequal opportunities and outcomes in water access, control, and decision-making. Women, for instance, often bear the primary responsibility for household water management but have limited say in larger water governance.
- *Disability inclusion*: Ensures that people with disabilities have equal access to water resources, services, and decision-making processes, considering their specific needs and challenges, which can be heightened during climate-related water crises.
- *Social inclusion*: Addresses the marginalization of various social groups, ensuring their meaningful participation and benefit from water resource management initiatives, especially those related to climate adaptation. This includes considering factors like ethnicity, caste, age, economic status, and migrant status.

Why is Mainstreaming GEDSI Important?

- *Equity and human rights*: Access to water is a fundamental human right. Mainstreaming GEDSI ensures that climate adaptation efforts in water management uphold these rights for all, leaving no one behind.
- *Effectiveness and sustainability*: Inclusive approaches lead to more robust and sustainable solutions. When diverse perspectives, knowledge, and needs are considered, water management strategies are better tailored to local realities and more resilient to climate impacts. Marginalized groups often possess valuable traditional ecological knowledge and coping strategies.
- *Reduced vulnerability*: Climate change impacts (e.g., droughts, floods, water scarcity) disproportionately affect vulnerable communities. GEDSI helps identify and address these differentiated impacts, building resilience where it's most needed.
- *Enhanced decision-making*: Incorporating diverse voices in planning and decision-making processes leads to more informed and equitable outcomes.
- *Donor requirements*: Many international donors and climate funds (e.g., Green Climate Fund) mandate the integration of GEDSI considerations in funded projects.

Mainstreaming GEDSI in Climate Change Adaptation for Water Resource Management

Mainstreaming GEDSI requires a systematic approach across all stages of policy, planning, and implementation. The following activities need to be considered for mainstreaming GEDSI in CCA for water resource management:

1. Conduct Comprehensive GEDSI Analysis

- *Contextual understanding*: Understand the specific social, cultural, economic, and power dynamics in the target area.
- *Data collection and disaggregation*: Collect and analyze sex, age, and disability-disaggregated data (SADDD) and other intersectional data. This helps reveal who bears the biggest burden or receives the most benefit from water infrastructure and policies. This is often a significant challenge due to data gaps.
- *Vulnerability assessment*: Identify how different groups are uniquely vulnerable to climate change impacts on water resources. For example, women and girls may face increased time burdens for water collection, while people with disabilities may struggle with evacuation during floods.
- *Capacity and knowledge assessment*: Identify the roles, knowledge, and capacities of diverse groups in water management and climate adaptation. Recognize women and marginalized groups not just as vulnerable but as agents of change with valuable insights.

2. Ensure Meaningful Participation and Representation

The meaningful participation and representation of GEDSI can be achieved through:

- *Building capacity*: Empower local actors, including women and marginalized groups, with the knowledge and skills to actively participate in decision-making processes related to water resources and climate adaptation.
- *Inclusive consultations*: Design and implement participatory processes that actively engage diverse stakeholders, including women, people with disabilities, Indigenous groups, and other marginalized communities, at all stages (planning, design, implementation, monitoring, and evaluation).
- *Addressing barriers*: Identify and address social, cultural, and economic barriers that limit the participation of certain groups. This might include providing childcare, transportation, or holding meetings at convenient times and accessible locations.
- *Accessible communication*: Provide information in accessible formats and languages to ensure everyone can participate.
- *Supporting leadership development*: Promote the equal representation of women and marginalized groups in leadership and decision-making roles within water governance structures.

3. Integrate GEDSI into Policy and Planning Frameworks

The following aspects need to be considered to integrate GEDSI into policy and planning frameworks:

- *Legal and policy frameworks*: Develop and strengthen legal and policy frameworks that explicitly mandate GEDSI integration in water resource management and climate adaptation plans.

- *Strategic action plans*: Develop concrete GEDSI strategies and action plans with time-bound frameworks and dedicated budgets.
- *Sectoral integration*: Ensure GEDSI is integrated as a cross-cutting theme in all relevant sectoral strategies (e.g., water, agriculture, disaster risk reduction).
- *Budgeting*: Implement gender-responsive budgeting to ensure adequate financial resources are allocated for GEDSI-focused activities within water programs.

4. Design and Implement GEDSI-Responsive Interventions

- Context-specific solutions: Design solutions that are tailored to the specific needs and vulnerabilities of different groups. For example, ensuring accessible water infrastructure or providing water-saving technologies that reduce women's workload.
- Nature-based Solutions (NbS): Incorporate GEDSI principles into the design and implementation of NbS for climate resilience in water management, ensuring benefits are shared equitably.
- Technology and innovation: Leverage digital tools and other innovations to support inclusive climate action and enhance women's leadership in decision-making.
- Capacity building: Provide training for water resource professionals on integrating GEDSI into their practices, including water modeling, data analysis, and project design.

5. Monitoring, Evaluation, and Learning

- Development of GEDSI-disaggregated indicators: Develop and use GEDSI-disaggregated indicators to track and assess progress on equity and inclusion outcomes.
- Regular review and feedback: Establish robust monitoring and evaluation mechanisms that allow for regular review of GEDSI integration and provide feedback loops for adaptive management.
- Documentation and sharing of lessons learned: Document and disseminate best practices and lessons learned on successful GEDSI integration to promote wider adoption.

6. Foster Partnerships and Collaboration

- Multi-stakeholder approach: Strengthen partnerships among government agencies, civil society organizations, academic institutions, local communities, and development partners to promote cross-sectoral learning and coordinated action on GEDSI in water and climate sectors.
- Institutional capacity building: Building the institutional capacity of organizations to effectively integrate GEDSI into their operations, including through training and technical support.

Module 7: Challenges of Mainstreaming Climate Change Options in Water Sector

Mainstreaming Climate Change Adaptation (CCA) options into the water sector in the project area faces a complex array of challenges, stemming from institutional, policy, technical, financial, and socio-cultural factors. Despite growing awareness of climate change impacts, translating this understanding into effective, integrated, and widespread adaptation action remains difficult. The key challenges include:

1. Policy and Legal Gaps

- *Fragmented policy landscape:* While Nepal has climate change policies (e.g., National Climate Change Policy 2019) and a National Adaptation Plan (NAP) in development, the water sector policies themselves are often not fully integrated with climate change considerations. There's a need to explicitly embed CCA into water resource management strategies, acts, and regulations.
- *Implementation gaps:* Even when policies exist, their effective implementation at the local level is often hindered. This is due to a lack of clear operational guidelines, insufficient understanding of policy implications, and a disconnection between national directives and local realities.
- *Outdated legal frameworks:* The Water Resources Act 1992 and Rules 1993, while foundational, may not adequately address emerging issues like climate change, inter-sectoral water allocation in a changing climate, or the complexities of managing transboundary water resources under climate stress.
- *Lack of specific legal documents:* There is currently no single legal document in Nepal that exclusively addresses climate change issues, which can lead to ambiguity and challenges in enforcement across sectors.

2. Institutional and Governance Challenges

- *Fragmented institutional arrangements:* Water governance in Nepal is characterized by multiple, fragmented, and often top-down institutional arrangements. This leads to poor coordination, overlapping mandates, and a "siloed" approach among different ministries, departments, and agencies involved in water resource management (e.g., Water and Energy Commission Secretariat, Department of Hydrology and Meteorology, Ministry of Water Supply, Ministry of Agriculture, etc.).
- *Limited institutional capacity:* Government institutions at all levels (federal, provincial, and local) often lack the technical, human, and financial capacity to effectively assess climate risks, design climate-resilient water projects, and implement adaptation measures. This includes a shortage of trained personnel in climate science, hydrology, and adaptation planning.
- *Weak coordination mechanisms:* Despite the need for integrated water resource management (IWRM) in the face of climate change, effective coordination platforms among stakeholders (government, civil society, private sector, communities) are often weak or non-existent.
- *Political will and prioritization:* A weak government and a lack of sustained political will can lead to insufficient allocation of resources and slow progress in mainstreaming CCA. Climate change issues may not always receive the high priority needed in development planning.

3. Technical and Data Challenges

- *Data scarcity and unreliability:* There is a significant lack of reliable, long-term hydro-meteorological data in Nepal, especially at disaggregated levels. This makes it difficult to accurately project future climate impacts on water resources, conduct robust vulnerability assessments, and design evidence-based adaptation interventions.
- *Uncertainty in climate projections:* Projections of future climate change in Nepal show high uncertainty, with large differences across scenarios and between climate models. This "deep uncertainty" makes adaptation planning challenging, as it's hard to decide on specific measures when future conditions are so variable.
- *Limited research and knowledge generation:* While some research exists, there's a need for more localized, context-specific research on climate change impacts on Nepal's diverse water resources (glaciers, snowmelt, rivers, springs, groundwater) and the effectiveness of various adaptation options.
- *Technology transfer and adoption:* Access to and adoption of climate-smart technologies for water management (e.g., efficient irrigation systems, remote sensing for water monitoring, advanced water treatment) remains limited, particularly in remote and rural areas.

4. Financial Constraints

- *Inadequate funding:* Implementing climate-resilient water infrastructure and adaptation measures requires substantial financial investment. Nepal, being a developing country, faces significant budget constraints.
- *Accessing climate finance:* While international climate finance is available, accessing and effectively utilizing these funds can be challenging due to complex application procedures, limited technical capacity to prepare bankable projects, and issues related to absorptive capacity.
- *Lack of private sector involvement:* The private sector's involvement in financing and implementing CCA options in the water sector is still nascent. Incentives and policy frameworks to encourage private investment are often lacking.
- *High investment cost of water technology options:* Even for efficient water management technological options that offer immediate benefits (e.g., rainwater harvesting, improved irrigation), the initial upfront investment can be a barrier for vulnerable communities.

5. Socio-Cultural and Community-Level Challenges

- *Limited awareness and understanding:* While some communities are aware of changing weather patterns, a deeper understanding of climate change impacts and the long-term benefits of adaptation options may be lacking among local populations, decision-makers, and even some technical staff.
- *Top-down approaches:* Despite policies promoting community-based adaptation (e.g., LAPA), implementation can still be top-down, limiting true community ownership and participation in designing and managing adaptation solutions for their water sources.
- *Traditional practices vs. new challenges:* While traditional water management practices are valuable, they may not be sufficient to cope with the unprecedented scale and intensity of climate change impacts. Integrating traditional knowledge with modern adaptive techniques is a challenge.

- *Equity and inclusion:* The impacts of climate change on water disproportionately affect vulnerable groups (women, Dalits, indigenous communities, the poor). Ensuring that adaptation options are inclusive and address the specific needs and vulnerabilities of these groups is a continuous challenge.
- *Lack of public participation:* Insufficient consultation with communities and local governments, and unclear roles for community groups, can hinder effective adaptation planning and implementation.

Mainstreaming CCA in the MaWRiN project area's water sector requires a concerted effort to address these challenges through integrated planning, enhanced institutional capacity, robust data systems, increased financial investment, and meaningful community engagement.