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CLIMATE-SMART AGRICULTURE INVESTMENT PLAN

NEPAL

A study implemented in collaboration with Government of Nepal, Food and Agriculture Organization and World Bank

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NDC Support Facility

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Foreword

Nepal seeks to pursue a green, resilient, inclusive, and resilient development (GRID) path over the next decade to better address climate change and build back better from the COVID-19 crisis. Nepal is one of the most vulnerable countries to climate change and has already experienced changes in temperature and precipitation. These changes are important for agricultural growth and productivity for millions of people through impacts on water availability, soil, and livestock health. Climate projections suggest a continued increase in mean annual temperature and increased likelihood of heavy precipitation events. Millions of Nepalese face significant climate risks and are already experiencing reductions in agricultural productivity, food and water security, forest products, and agro-biodiversity. Their livelihoods are increasingly at risk.

Nepal aims to address this climate threat, adapting to the new conditions and contributing to reduced greenhouse gas emissions. To do so, it needs to trace a path forward for the agriculture sector that can better deliver agricultural productivity, economic growth and climate resilience and reduced greenhouse gas emissions. Evidence-based decision making is an important step in this process.
The Nepal Climate-Smart Agriculture Investment Plan (CSAIP) builds on solid analyses and elaborates a series of public and private sector interventions that contribute to a productive, resilient, and low carbon agriculture sector. In recognition of Nepal's federal system of government, the CSAIP focuses on the local investment needs of four Provinces (1, 2 Gandaki, and Karnali) and actions for a better enabling environment at the national level.

The Nepal CSAIP is the outcome of a partnership between the Government of Nepal, led by the Ministry of Agriculture and Livestock Development (MoALD), the World Bank, and the Food and Agriculture Organization of the United Nations (FAO). The CSAIP builds on key strategies of Nepal, including Nepal's Agriculture Development Strategy, Nepal's Second Nationally Determined Contributions (NDC) to the Paris Agreement, and the upcoming Nepal GRID Strategic Action Plan.

While the CSAIP is based on quantitative and qualitative methods, the wide consultations with civil society, private sector, farmer groups, federal and provincial government agencies shaped the conclusions and recommendations. The CSAIP identifies climate-smart agriculture practices for crop, horticulture, livestock, aquaculture, and agroforestry systems that will strengthen the resilience of the agricultural sector to climate change while improving livelihoods of farm families. The CSAIP identifies feasible, practical, and profitable investment to lift the sector to levels of higher growth, lower vulnerability, and greater sustainability and efficiency. There are recommendations for strengthening the enabling environment, including federal support for coordination, planning, and research as well for guiding the provincial governments on where to focus their resources and how to strengthen their capacity.

The next challenge is to take the report forward and bring it to implementation. This will require sustained collaboration horizontally and vertically across government agencies, knowledge providers such as academia and think tanks, civil society organizations, private sector firms and associations, and development partners such as FAO and the World Bank who can convene global knowledge, institutions, and financing. Such implementation will need to start while the COVID-19 pandemic is still ongoing and financing decisions are being made for the recovery from COVID in line with the

GRID approach. Climate change does not wait, however, and the success of the agriculture sector depends on prioritizing climate-smart investments, for a better future of Nepal's agriculture and its many farmers.

We look forward to continuing our close collaboration and supporting a strong, inclusive investment and policy dialogue around the priorities in the CSAIP and move quickly to finance and implement key actions for a climate-smart agricultural sector. This ambition is a critical element of Nepal's GRID and recovery plans as well as its international climate change commitments.

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Abbreviations

ADB	Asian Development Bank
ADS	Agriculture Development Strategy
AFOLU	Agriculture, Forestry and Other Land Use
AFSP	Agriculture and Food Security Project
AKC	Agriculture knowledge centre
ANSAB	Asia Network for Sustainable Agriculture and Bioresources
ARD	Agricultural Research and Development
AWD	alternate wetting and drying
B2B	business-to-business
BAU	Business as usual
BCR	benefit-cost ratio
CAESCs	Community Agriculture Extension Service Centres
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CCRC	Community Climate Resource Centres
CIAT	International Center for Tropical Agriculture
CIP	climate investment plans
CSA	climate-smart agriculture
CSAIP	climate-smart agriculture investment plan
CSV	Climate-Smart Villages
DAD	Directorate of Agriculture Development
DHM	Department of Hydrology and Meteorology
DII	development impact index
DWRI	Department of Water Resources and Irrigation
EIRR	economic internal rate of return
ENPV	economic net present value
ERR	economic rate of return
EU	European Union
EX-ACT	Ex-Ante Carbon Balance Tool
FANSEP	Food and Nutrition Security Enhancement Project
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmer Field School
FIRR	financial internal rate of return
FNPV	financial net present value
GACP	good agriculture and collection practices
GAEZ	Global Agroecological Zones
GAFSP	Global Agriculture and Food Security Programme
GCF	Green Climate Fund
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GIS	geographic information system
GLOFs	glacial lake outburst floods
GoN	Government of Nepal
HIMALI	High Mountain Agribusiness and Livelihood Improvement
ICIMOD	International Centre for Integrated Mountain Development
ICT	Information and Communication Technology
IFA	ICT for Agri
IMP	Irrigation Master Plan
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
IWRMP	Irrigation and Water Resources Management Project
LAPA	Local Adaptation Plans for Action
LDCF	Least Developed Countries Fund
LI-BIRD	Local Initiatives for Biodiversity, Research and Development
M&E	monitoring and evaluation
MALU	Municipal Agriculture and Livestock Units
MAPs	medicinal and aromatic plants
MFD	maximizing finance for development
MoAD	Ministry of Agricultural Development
MoALD	Ministry of Agriculture and Livestock Development

(continued)

MoF	Ministry of Finance
MoFAGA	Ministry of Federal Affairs and General Administration
MoFE	Ministry of Forestry and Environment
MoITFE	Ministry of Industry, Tourism, Forest and Environment
MoLMAC	Ministry of Land Management, Agriculture and Cooperatives
MOM	management, operation, and maintenance
MRPP	Mega Rice Production Program
MWRI	Ministry of Water Resources and Irrigation
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NARC	National Agriculture Research Center
NCCP	National Climate Change Policy
NCCSP	Nepal Climate Change Support Programme
NDCs	nationally determined contributions
NPC	National Planning Commission
NTFPs	non-timber forest products
PMAMP	Prime Minister Agricultural Modernization Project
PPP	public private partnership
PyAEZ	agro-ecological zoning approach using Python coding
R&D	research and development
RCMs	regional climate models
SALT	sloping agriculture land technology
SDGs	Sustainable Development Goals
SRI	System of Rice Intensification
UDB	Uganda Development Bank
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
VRA	Vulnerability and Risk Assessment
WB	World Bank
WFP	World Food Programme
WII	weather index insurance
WP	Working Paper
WUA	Water Users Association

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Executive Summary

Background and policy context

The purpose of the report is to provide the Government of Nepal (GoN) with analysis and guidance on priorities for investing in climate-smart agriculture (CSA) in the context of federalism. The report thus sets out guidance relevant to both the national and provincial-level investment planning. The agriculture sector is a mainstay of Nepal's economy, but the sector faces challenges, including climate change and impacts of other shocks. The GoN recognizes these challenges and the importance of developing a CSA sector. The core elements of CSA—increasing productivity and incomes, adapting and building resilience, and contributing to reduction of greenhouse gas (GHG) emissions, in an inclusive and sustainable manner—are reflected in Nepal's core national policies, including the Nationally Determined Contributions (NDCs), and Agriculture Development Strategy (ADS). However, results from various studies and projects assessing, piloting, and supporting climate-change efforts show that programs for the development of the agricultural sector, which focus on agricultural production, commercialization, and management of natural resources, need to further integrate CSA strategically and comprehensively. There is a need for concerted scaling up with justified priorities for larger investments. Further, systems for planning and implementation of CSA need to be localized to address context-specific priorities in line with service delivery under federalism. For this, strengthened capacities at the provincial and local levels are needed.

Objective and Overview of the Climate-Smart Agriculture Investment Plan and its Development Process

The objective of the climate-smart agriculture investment plan (CSAIP) is to identify interventions and policies to support the development of a resilient, productive, and low-carbon agriculture sector in four representative provinces of Nepal that address key climate challenges and identify how these can be implemented in the context of federalism.

Core approaches of the study were to use agreed CSA criteria for identifying, developing, and prioritizing interventions, aligned policy goals, and targets; draw on existing knowledge and experience and consult widely and validate analysis, priorities, and suggestions in a participatory manner with key

stakeholders; and develop options that can be invested in and applied in a flexible manner. The report also builds on other planning documents produced by the GoN, such as the NDCs and ADS.

The study process followed four phases, during which analysis and recommendations were refined iteratively:

1. Together with an overall review of existing information and experiences, climate impacts, including extreme events on key agriculture systems through modeling and the impacts of COVID-19 on agriculture in the study areas, were assessed.
2. Possible CSA options were identified, reviewed, and prioritized, such as CSA practices and technologies for crop, livestock, and aquaculture systems suitable for different agroecological zones, using core criteria for analysis aligned with the national policies relevant to CSA; the economic viability of adopting CSA practices was assessed.
3. Packages for investments at the federal and provincial levels were developed, identifying costs and major benefits and how these would be implemented and financed.
4. Findings were reviewed, refined, and validated with stakeholders for priority investments at the provincial and national levels to understand the implications for capacity building.

While the scope of the report is broad in relation to the agricultural sector, the options for addressing climate-smart value chains and impacts on trade could not be looked at in depth. These topics would form a key part of follow-up analysis and discussion, together with further localization that was not possible due to COVID-19, and other subsector-specific themes.

Agriculture Sector and Study Areas

Nepal is considerably dependent on agriculture, in a very diverse and changing setting. The country is strongly characterized by varied agroecological zones ranging from high mountains in the north to hills and the lowland Terai in the south and some climatic differences from east to west. The study looked at four key areas within three river basins, covering four provinces and all agroecological zones. The study areas were agreed on with the Ministry of Agriculture and Livestock Development (MoALD). Study area characteristics, including important value chains identified, and econometric analysis using district data showed that the study areas selected provide good overall representation of the country.

Rajendra Maya / WB

Climate Change and Other Shocks and Their Effects on Agriculture in Nepal

Nepal is a country facing various climatic risks and extreme events; climate change will add further pressures in a complex manner due to Nepal's varied geography. Basic trends indicate **increasing temperatures** in all areas but especially in high mountains. **Precipitation** will increase gradually, especially in the east and in central areas, with potential increases in downstream flows in the shorter term. However, modeling of extreme events indicates that rainfall will happen in more intense periods, especially in the wetter season, with high runoff from steep slopes, and increase the likelihood of flooding and landslides. Increased rainfall will not compensate for increased and extreme high temperatures and variability, which will likely contribute to increasing water scarcity and drought risks, especially in rainfed and lowland areas, in the west and mountains, and in dry and winter seasons.

For agriculture, this means increased stresses from high temperatures and dry periods for rainfed crops, especially in the Terai and hill areas, **in addition to direct damages and losses to production.** Additional effects such as diseases and pests of crops and livestock will increase, as well as stresses arising due to multiple extreme events. These stresses have potential to affect both food security, overall production and nutrition requirements at the household level.

Opportunities exist for increased productivity due to increased runoff and warmer temperatures in higher altitudes, but with limitations. More detailed modeling of water and production inputs in relation to both irrigated and rainfed areas for key cereal crops, indicate the potential boost from increased temperatures and carbon dioxide (CO_2), which, together with more river water, may provide opportunities for increased productivity under irrigated conditions. Tapping the potential requires a complementary increase in fertilizer. On the other hand, for rainfed crops, especially in hill areas, there are likely productivity declines without additional harnessing of water resources and managing soil systems. Warmer temperatures in higher altitudes provide opportunity for production expansion, but soil and water may be limited, and appropriate varieties are required.

Nepal's contribution to global GHG emissions is very low both on absolute and relative terms. At present, agriculture contributes about a third of country emissions, mainly from livestock, paddy rice, and land-use change. Soil carbon and tree biomass play an important role in the carbon balance, and thus it is imperative to protect and increase them.

The needs of various vulnerable groups of people in Nepal must be considered. It is also important to note that the vulnerability of these groups varies considerably, with those in remote rural areas and more marginal agroecological systems more susceptible to a range of climate change impacts on their food security and diet requirements. Because of out-migration of men, women have been carrying an increased burden of agriculture without the necessary resources and services adapted to their needs. The COVID-19 pandemic may have changed this pattern now that migrants have returned home and are looking for new employment.

Adaptive capacity of support systems is required to address local needs. Variability and complexity of climate impacts manifest themselves at larger and local scales. Thus, adaptive capacity at various levels is needed from the federal, provincial, and local governments and from other stakeholders, all playing key roles. In the context of federalism, capacities of provincial and local governments need to be considered. Farmer organizations and the private sector need to be further tapped to enable farmers to adopt CSA. Extension systems need to be strengthened and coordination with research and development (R&D) must be improved, for example on making accessible stress-tolerant seeds and breeds. Information and advisory and support services, including agromet services, need to be strengthened, especially to allow enhanced adaptation to climatic events in the short and medium term.

The shock of COVID-19 on production systems, including food security, nutrition, employment, and trade, has been considerable, highlighting the importance of building resilience across the agriculture system to deal with a range of shocks.

Prioritizing CSA options

CSA options span a range of practices suitable to different crop, agroforestry, livestock, and aquaculture systems in different agroecological zones. Based on literature review, project experiences, and expert input, a range of CSA options was reviewed and long listed. The long list was screened and prioritized based on a detailed list of criteria; then it was refined based on stakeholder views and local suitability and in line with key national policy aims. Examination of the options through the policy lenses of (1) improving production and productivity, (2) resilience, (3) inclusion, (4) environment benefits, and (5) mitigation of GHG emissions indicates those that have potential for large-scale benefits. Options to improve the enabling environment were generally considered for federal intervention, and investment options were considered for specific systems for provincial interventions. Some of the options also provide benefits across policy priorities. Priority CSA options include the following:

- Strengthening crop and land-management practices for soil structure and stability, particularly on-farm soil and water conservation, which also contributes to better soil carbon content
- Improving access to reliable water on-farm and climate-smart irrigation schemes
- Livestock resilience through better feed access (pastures, fodder development, and so on); helping feed conversion, reducing GHG emissions, and increasing herd-level productivity (thus reducing GHG emissions per unit livestock products); improving animal health services and good animal husbandry are key complements to this
- On-farm integrated livestock, crop, and agroforestry systems, along with integrated water resources and watershed management, are key for more stable land, steadier water flows, and increase in soil and biomass carbon
- Quality and variety of seeds and breeds will be important under a changing climate but also for improved productivity.

- Interventions for hills and mountains systems are particularly relevant for marginal smallholders and for most vulnerable groups. For improving livelihoods and resilience, off-farm activities such as targeted livelihoods interventions, off-farm employment opportunities and income diversification, mechanization, and social protection policies should be considered. This may be particularly important for women farmers in hills.
- Climate-smart value chain activities are important to all systems, and throughout the value chain there is a need to provide more timely and suitable inputs and to ensure farmers benefits from value addition and markets. The private sector plays a key role in all the steps of the value chains for enhancing CSA along the value chain.
- A focus on updated extension, information, early warning, and market information systems; access to inputs, storage, and logistics; and employment opportunities all play important roles for resilience to other shocks such as the recent COVID-19 disruptions.

Based on preliminary economic farm-level analysis, returns on applying different CSA options indicate considerable benefits from adoption compared to continuing with existing practices under climate change, over the long term. Also, most options indicated reduction in GHG emissions compared to business as usual.

To implement CSA options through scaled-up investments, some important enabling and cross support is required at the national level, while investment and service delivery capacity will have to be strengthened at the provincial level. At the national level, access to information and capacities and interlinkages among agencies need to be enhanced, overseen by the federal government. On a range of enabling factors such as fertilizer, finance, weather forecasts, and agricultural research, consistent policies need to be formulated and implemented. At the provincial level, the capacity to prepare and implement investments needs to be strengthened, and extension services need to be retrained and enhanced.

Investment Packages

The study was designed with a primary focus on provincial investment plans, reflecting both the specificity of agroecological differences and the imperative under federalism of decentralized service delivery. It focuses on four representative provinces, with potential scale-up to the remaining three provinces, and over longer time frames. These plans factor in the overall sectoral context, specific sectoral conditions and needs in target provinces, and potential for replication. They are prepared as possible investment packages by subsector and by geographic area and can with relative ease be further elaborated, especially by province.

The resulting priority interventions for climate-smart and resilient agricultural production systems in the targeted four provinces are packaged into six investment packages. Proposed interventions consider, among other things, (1) climate change implications for major crop value chains in target provinces (section 4), (2) corresponding priority CSA options identified to address key impacts (section 5), and (3) where possible, specific CSA practices suitable to specific provinces and agroecological zones. **Package A o**n the enabling environment would be **a federal responsibility; Packages B through F,** which will put in place improvements at the local level, **will be led by the provinces.**

- Package A—Creating an enabling environment for agricultural production systems to become more productive, competitive, climate responsive, and resilient, including to non-climate

shocks—to be implemented mainly at the national level
- Package B—Supporting productive and resilient crop production systems
- Package C—Supporting resilient commercial horticulture
- Package D—Supporting resilient and environmentally sustainable livestock production systems
- Package E—Supporting climate-responsive and resilient agroforestry
- Package F—Providing interventions for climate-responsive and resilient aquaculture
- Additional support packages for climate-smart irrigation, mainly supporting Packages B and C, are also developed.

While Packages B through F are presented by subsector, they are set up in that manner to provide a framework for investment options, or modules, that can be adapted further to province needs; tentative configuration by province is noted in the report.

CSA Under Federalism: Rolling Out and Localizing the CSA Investment Packages

The report presents a process for implementing the CSA investment packages and supporting the local governments to identify, implement, and plan their own investments based on more refined local analysis of changes, priorities, and needs, as well as best practices and experience already taking place. Such a process includes the following overlapping sequence of activities:

- As climate crosses political boundaries, there are clearly key roles and investments needed at the national level. Federal support will be needed for coordination and planning, resource allocation, and guidance for local governments. Furthermore, provincial investments need to take place within a reliable and predictable enabling environment for issues such as input supply, water management policies, training and education, and research and information systems.
- Most importantly, local adaptation plans need to be developed that identify, analyze, and select appropriate local options and assist farmers to identify and implement appropriate CSA options.
- Pluralistic agriculture extension systems need to be built that ensure the participation of the private sector and that facilitate linkages to finance and technical services. In the ongoing federalization process, these services are a key target to be strengthened.
- Monitoring and evaluation (M&E) systems need to be built, both nationally and locally and using participatory feedback mechanisms, to help track implementation and assess the effectiveness of CSA investments.
- Financing modalities that combine public and private resources need to be identified, and private finance needs to be encouraged, through removing policy and regulatory barriers and by reducing risks and high transaction costs.
- By harnessing these different elements in a coordinated fashion, the combined governments of Nepal will be able to pursue a demand-based CSA system that will enhance profitability while improving adaptation and reducing GHG emissions.

Section 1

Introduction, Background and Policy Context

Key messages

- The purpose of this report is to provide the GoN with guidance on priorities for investing in CSA in the context of federalism.
- The agriculture sector is the mainstay of Nepal's economy, but it is facing challenges from climate change and other shocks.
- The core elements of CSA, which focus on increasing productivity and income, adapting and building resilience, and contributing to reduction of GHG emissions, are reflected in core national policies such as the NDCs.
- Programs for development of the agricultural sector need to integrate CSA pillars strategically and comprehensively, scaling up experiences and new knowledge into investments.
- Systems for planning and implementation of CSA need to be localized to address context-specific priorities and have strengthened capacities to do so.

1.1 Introduction

This study is implemented in support of the GoN's efforts surrounding climate change in agriculture, addressing the country's main policy goals such as the ADS, the National Climate Change Policy (NCCP), the NDCs, and the National Adaptation Plan (NAP, in process). The study was conducted under the guidance of a Steering Committee led by the MoALD, funded by World Bank, and implemented with FAO technical support in conjunction with its Hand-in-Hand initiative. The report builds considerably on planning documents produced by the GoN (such as the ADS and the draft Irrigation Master Plan [IMP]).

The purpose of this report is to provide the GoN and its federal agencies, local governments, stakeholders, and partners with analysis and guidance on priorities for investing in CSA. . The report sets out guidance relevant to the national level and directly to the provinces for local-level investment planning. CSA boosts sustainable production and productivity, in an inclusive manner, while ensuring resilience to climate changes and shocks, contributing to mitigating GHG emissions where possible. The report reflects Nepal's current process of **federalism** and provides suggestions that represent the different provinces of Nepal and that can be customized to local conditions and priorities.

The objective of the study to support CSA investment and policy planning is to **provide non-prescriptive recommendations** and options for action to support the development of the CSA sector in four representative provinces of Nepal. These recommendations and options address key climate challenges for Nepal's agriculture sector with strategies that

- Address key policy actions and provide feasible and viable investment concepts and packages to support a CSA sector development; and
- Identify how these policies and investments can be implemented in the context of federalism and inform national policy commitments and territorial priorities.

The study was designed so that the process and the study areas selected would mean **the investment options identified would be scalable** and could eventually be also applied in other provinces of Nepal and elaborated for specific agroecological zones and river basins.

Recommendations for CSA investments and policy planning also support the **Green, Resilient, Inclusive Development, or GRID,** approach, to support Nepal to transition to longer-term resilience, inclusion, sustainability, and efficiency – to build back better after COVID-19 pandemic. The GRID approach recognizes that the challenges of poverty, inequality, COVID-19 and climate change are interrelated, and need to be addressed simultaneously. Given the urgency and magnitude of these crises, interventions and investments need to be accelerated and implemented at scale, supported by international cooperation. Thereby, recovery must consider vulnerable population groups, and create inclusive opportunities. This is critical as climate change and COVID-19 disproportionately impact the poor and vulnerable.

Rajendra Maya / WB

While the **scope of the report** is broad in relation to the agricultural sector, the options for addressing climate-smart value chains and impacts on trade could not be covered in depth. These topics would form a key part of follow-up analysis and discussion, along with other subsector-specific themes, together with further localization that was not possible due to COVID-19.

1.2 Agriculture-Sector Challenges and Need for CSA Investments

The agriculture sector is the mainstay of Nepal's economy, but the sector is facing a number of challenges, including climate change and impacts of other shocks such as the COVID-19 pandemic. The sector engages more than half of the labor force and produced 27 percent of the gross domestic product (GDP) in 2019 (Ministry of Finance [MoF] 2019). This sector has high potential to create employment, accelerate rural poverty reduction, and improve national food security and nutrition. The sector and its associated livelihoods are under a number of pressures and changes: small landholdings, out-migration and feminization of agriculture activities, environmental stresses, and, increasingly, effects of disrupted weather patterns, together with relatively low farm input levels (fertilizer, water), resulting in low productivity. Climate change affects most Nepali agricultural systems and livelihoods but in complex and different ways. While the direction of future trends is not clear, they have clear potential impacts on production, poverty, and food security, affecting some farm groups more than others. The challenges agriculture is facing are aggravated further by the severe adverse impacts of the COVID-19 pandemic on movement of labor and agricultural inputs and produce. In the context of federalism, Nepal's limited human, financial, and institutional capacities of the newly formed provincial and local-level governments, coupled with weak infrastructure, erratic input supply, and scanty farm advisory services, present challenges to the GoN for scaling up CSA practices.

A primary challenge is to identify the major needs, options, opportunities, and challenges for scaling up CSA so that it can support more resilient agriculture value chains and food systems in the face of climate change and multiple other future shocks and stresses, ranging from potential pandemics to earthquakes. These considerations need to be addressed while trying to reduce poverty, increase food security and nutrition, and support low-carbon economic growth (box 1). Then the key investments to support scaling up need to be identified.

Box 1. Climate-Smart Agriculture

- CSA has three main objectives:
  1. sustainably increase agricultural productivity and incomes
  2. adapt and build resilience to climate change

     Resilience is the capacity of social, economic, and environmental systems to cope with a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation (Intergovernmental Panel on Climate Change [IPCC] 2014).
  3. reduce or remove GHG emissions where possible.
- CSA does not imply that every practice applied in every location should deliver maximum positive results for each of these three objectives, as this may be difficult to achieve. Rather, the CSA approach seeks to reduce trade-offs and promote synergies by taking these objectives into consideration when stakeholders make decisions at all levels, from local to global.

Source: FAO 2017. CSA Sourcebook. Second Edition

The COVID-19-related disruptions created new challenges or exposed existing weaknesses in the agricultural sector that is already highly vulnerable due to its dependence on rainfall and its considerable exposure to natural disasters and climate-related events. The federal government had taken various response measures; however, the effectiveness of these measures was limited due to existing structural, functional, resource, and capacity deficiencies; weak coordination across and within agencies and government tiers; and dependence on imports of agricultural inputs. As a result, the combination of social distancing and travel restrictions, market closures, and lack of storage and market facilities have particularly affected perishables, resulting in significant losses (dairy, horticulture). Because the country depends on imports of fertilizers, disruptions to the consignment shipping process in the Indian ports delayed availability of fertilizer during the planting time for paddy, the main staple crop, in mid-2020. Its production was projected to decline considerably. Nevertheless, by the end of the year, the harvest was record high due to monsoons. However, MoALD recognized that it would have been even higher with adequate fertilizer supplies. Labor shortages and a lack of agricultural machinery also affected harvesting and processing of winter paddy, although this increased when return migrant laborers contributed to harvesting. Producers' access to input markets, finance, and extension services, which had been limited prior to the pandemic, was considerably affected. These constraints have resulted in a number of food security and household nutrition stresses, with increased food prices and negative coping.[1] Climate-smart investment options that can help build broader resilience to extreme events in the agricultural sector can therefore also play an important role in dealing with a range of economic and nonclimatic shocks.

1.3 Policies of the GoN in Support of CSA

Nepal clearly recognizes the need for increasing productivity, developing resilience, and contributing to reduction of GHG emissions, which is reflected in its core national policies. The

[1] "The Impact of Covid-19 on Households in Nepal: Third Round of mVAM Household Livelihoods, Food Security and Vulnerability Survey," March 26, 2021, Ministry of Agriculture and Livestock Development, Government of Nepal, and Evidence, Policy and Innovation Unit, WFP Nepal, https://reliefweb.int/report/nepal/impact-covid-19-households-nepal-third-round-mvam-household-livelihoods-food-security

recommendations of this report will address key policy actions and inform the development and process toward achieving Nepal's climate commitments for a number of key targets (see summary table 1 below; more details in Working Paper [WP] 1) as presented in its NDCs (2020). The identified CSA options and investment packages will support the resilience of farmers to climate change, help to reduce GHG emissions, and increase carbon pools. In addition, the recommendations aim to support the effective implementation of key government agriculture programs. This report thus builds on a number of key planning documents such as the ADS.

Within the NDCs, Nepal aims to achieve net-zero GHG emissions by 2050 while the country places climate change adaptation at the center of its development plans and policies. Nepal aims to strengthen implementation of environment-friendly local governance in development to complement climate change adaptation and promote renewable energy technologies, water conservation, green development, and CSA. The NAP with plan to be formulated by 2021,will incorporate adaptation and resilience milestones to be achieved in the short term (by 2025), medium term (by 2030), and long term (by 2050). It aims to reduce the country's vulnerability to climate change and to facilitate the integration of climate change adaptation in policies, programs, and activities across sectors and levels.

CSA is embedded in the ADS. The CSAIP will inform the implementation of the ADS and the recommendations of the recently approved GoN 2019 National Climate Change Policy 2076 (2019) (NCCP) at the local level, aiming to provide strategies to implement climate and agriculture-sector policy goals in a changing federalist structure. The ADS has four priority areas: (1) improved governance; (2) technology adoption, including CSA for resilience and productivity; (3) increased commercialization; and (4) competitiveness and private-sector development. The draft IMP provides important indicative directions for irrigation. The ADS aims to also contribute to the wider development targets for **poverty reduction** and **food security and nutrition** in the country under the country's Sustainable Development Goals (SDGs), supporting and reinforcing the generally positive trends in Nepal over the last decade.

Table 1. Key Policy Targets

This is not an exhaustive list of targets but gives examples that are most relevant for the CSAIP. Further details are provided in annex 1.

Nationally Determined Contributions (NDCs) 2020:

• Achieve net-zero GHG emissions by 2050. By 2030,
  • upgrade watershed health and vitality in at least 20 districts to a higher condition category
  • reach soil organic matter content of agriculture land to 3.95 percent
  • expand orchard areas to 6,000 hectares
  • establish 200 Climate-Smart Villages (CSV) and 500 climate-smart farms
• Promote intercropping, agroforestry, conservation tillage, and livestock and agricultural waste management
• Ensure increased access of CSA technologies to women, indigenous people, smallholder farmers, and marginalized groups.

National Adaptation Plan (NAP, in process information provided in latest NDCs 2020 document):
• By 2030, all 753 local governments will prepare and implement climate-resilient and gender-responsive adaptation plans • By 2025, a strategy and action plan on gender-responsive climate-smart technologies and practices will be prepared and implemented • Adaptation measures based on circular economy and sustainable resource use will be developed and implemented.

(continued)

Agriculture Development Strategy (ADS):

- Value of agricultural land productivity per hectare to reach US$2,302 in 5 years; US$2,938 in 10 years; and US$4,787 in 20 years. Baseline value in 2010 was US$1,804
- Share of farmers reached by agriculture programs to be 17 percent in 5 years; 25 percent in 10 years; and 50 percent in 20 years. Baseline value in 2010 was 12 percent
- Year-round irrigation targets are 30 percent in 5 years; 60 percent in 10 years; and 80 percent in 20 years. Baseline value in 2010 was 18 percent coverage
- Reduce trade deficit and achieve surplus in food grains in 10 years.

Sustainable Development Goals (SDGs) for Nepal

- Reduce poverty rates by at least 50 percent; proportion of population living below the national poverty line to be 4.9 percent by 2030 from 17 percent in 2019
- Reduce prevalence of moderate or severe food insecurity in the population; prevalence of stunting to be 15 percent by 2030 from 31 percent in 2019.

1.4 Promoting CSA in Programs on Agriculture

The federal government has put in place programs to strengthen the development of the agriculture sector, incorporating production improvements, commercialization, and management of agriculture-related resources. These programs include the following:

- **Prime Minister Agricultural Modernization Project** (PMAMP), launched by the MoALD in 2016. The PMAMP has an indicative NPR 130 billion budget (US$1.1 billion) and a ten-year timeframe to boost agricultural productivity through adoption of modern farm techniques and improvement of value chains through enhanced productivity and commercialization of major cereals, fisheries, fruits, and vegetables. PMAMP's main objective is to make the country self-reliant in food.
- **President's Chure-Tarai Madhesh Conservation and Management Master Plan,** established in 2014. The plan aims to provide strategic direction for conservation in the Churia (low hills), supporting integrated management of upstream and downstream land-use activities, poverty reduction, and mitigation of climate change-related impacts and damages. A number of projects address strengthening agriculture value chains, rehabilitation, and improved irrigated agriculture.

Specific climate change efforts in agriculture need scaling up. A number of development and science partners have been assessing, piloting, and supporting climate change efforts in Nepal for well over a decade. These efforts range from supporting national planning for the NDCs and national adaptation planning, studies on climate impacts and responses in specific areas, local planning for adaptation, and piloting resilience measures for different groups in the country, often within other agriculture projects. Nevertheless, studies have also noted that there are still knowledge gaps and insufficient scientific knowledge about climate change in agriculture, its effects on different systems and areas, and understanding appropriate local responses. While a number of smaller-focused projects are addressing adaptation in agriculture, and some larger projects are being started under the Green Climate Fund (GCF), major investments have not been made (see WP 1). Few larger programs integrate all CSA pillars strategically and comprehensively. Clear national and local investment priorities are required, linking to climate models with future scenarios and localized findings, which will bring together the efforts of national and local government programs, supported by multilateral and bilateral financing institutions, UN agencies, and private-sector efforts.

1.5 Need for CSA Investment Planning at the National and Local Levels

Mainstreaming CSA in agriculture investments. While a number of policies are emerging on climate change adaptation and mitigation in agriculture, and a considerable number of projects are implemented or planned, it is recognized that in agriculture there is a need for more comprehensive strategic, feasible, and viable investments to support adoption and scaling up of CSA. Projects and government programs have piloted, tested, and validated major CSA options in different areas of the country. Climate change policy and the NDCs proposed several important climate-smart options for agriculture. These need substantive investments to ensure their benefits are upscaled to a large number of farmers scattered in different agroecological regions of Nepal. Most of the project interventions have focused on specific crops, livestock, and fisheries and aquaculture with isolated efforts on specific farming systems. There are gaps in linking crops and irrigation priorities, upscaling support for integrated farming systems and ensuring related landscape and ecosystem management, and complementing with value chain service and their links to farmers while focusing on climate change adaptation and potential mitigation of GHG emissions. This also raises the need for cross-sectoral planning and collaboration between ministries and the need to consider agriculture within the watershed context.

Localizing CSA planning and implementation to address context-specific priorities. In addition to integrating climate change in agricultural policy and planning at the national level, it is important to understand the challenges and mechanisms in local implementation. Addressing climate change requires making systemic and local-level responses to climate impacts as a regular business of the agriculture sector through agricultural development programs. Separate ad hoc actions to address climate change do not bring lasting results. The development of the NAP follows a participatory process, which is an important mechanism for integrating climate change adaptation objectives in sector strategies (MOALD, 2019, with UNDP and FAO).The findings of the process show that localizing climate change scenarios and their implications for agriculture remains a daunting task in Nepal due to high microclimatic variation across short distances. With such complexity, the cost and benefits of investments in larger projects need to be assessed systematically.

Capacities at the provincial and local levels need to be strengthened to implement CSA. Due to limited resources, past projects attempted to address issues at the broader development zone level.[2] With emerging federalism, provincial-level issues have not been analyzed or addressed in an integrated manner. Consequently, investment proposals have often been based on project- or donor- specific priorities, with targeting of areas partly driven by ease for implementation and other criteria. More information and local priorities on the costs, multiple benefits, and trade-offs of CSA practices need to be generated along with challenges to adoption, but comprehensive information is necessary to develop related suitable policy and institutional support. Further, with the transition to federalism, the newly formed provincial and local governments' capacity is still growing and does not yet allow them to develop solid investment plans that address recent and pervasive problems in the agriculture sector. Staff in subnational governments need support to coordinate and track CSA implementation. There needs to be better understanding of the processes and capacities required at the subnational level to identify, plan, and implement investment plans to address emerging challenges effectively and strategically.

[2] Broad development regions spanning mountains, hills, and the Terai.

Section 2

Study Process and Methods

Key messages

- The study followed four phases in an iterative participatory process, building on existing knowledge:
  - Assess climate impacts, including extreme events on key agriculture systems through modeling, including assessing the impacts of the COVID-19 pandemic on agriculture in the study areas
  - Identify and prioritize possible options for CSA interventions using policy-aligned criteria
  - Develop packages for investments, identifying costs, implementation, and finance modality
  - Validate findings with stakeholders for priority investments.

The study approach was that the process and the investment options identified for the study areas can eventually be applied in other areas of Nepal, primarily other provinces, and adapted to different configurations of financing—by river basin, watersheds, or regions.

2.1 Process of the Study—Developing Recommendations for CSA Investment Options

The core approaches of the study were to

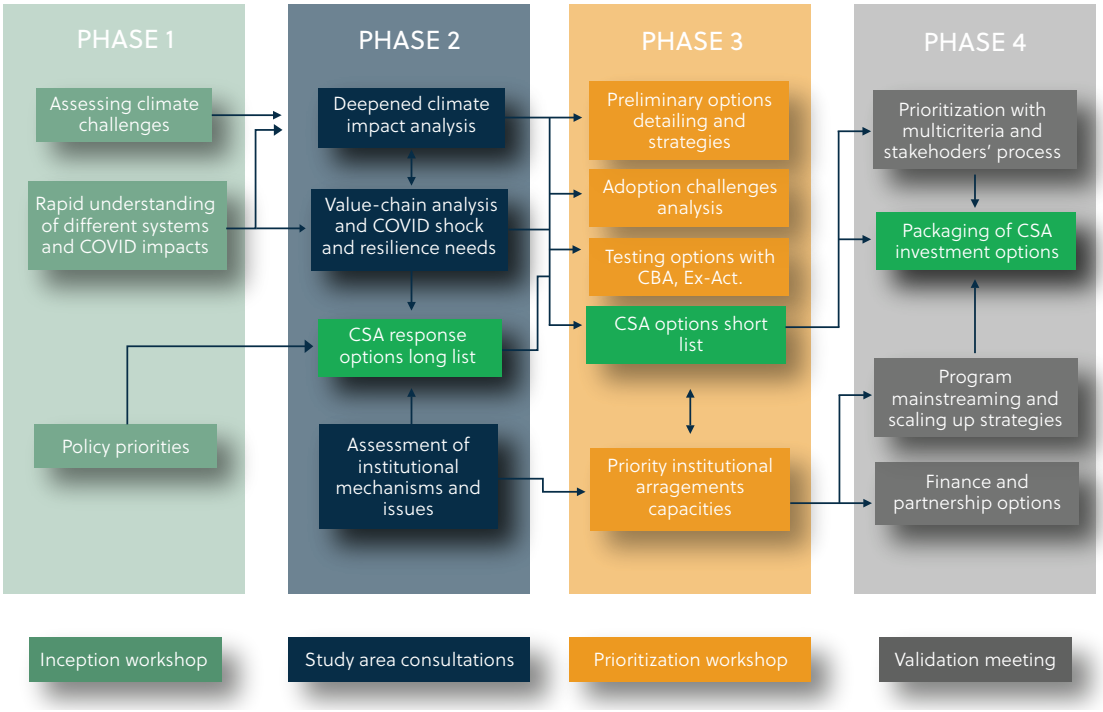
- Address existing policy goals and targets and incorporate these in the core criteria for identifying, developing, and prioritizing interventions;
- Draw on existing knowledge, expertise, and experience and refine analysis and detailed

recommendations iteratively, based on four key representative areas in the country;

- Develop flexible options and cost approaches that can be applied to localize investments to various contexts in the country, even non-study areas;
- Consult widely and foster dialogue on local priorities and validate analysis and recommendations with key stakeholders within the political and COVID-19-related constraints during the study period; and
- Identify key areas of institutional mechanisms and capacity required to operationalize the relevant country climate commitments and implementation of agriculture development strategies within the new federalist structure.

The study comprised four phases, during which a range of qualitative and quantitative approaches were used. Figure 1 presents the flow of activities for phasing of study. More details on all aspects of the study process and methods are in annex 1.

Figure 1. Flow of Activities for Phasing of Study



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Phase 1. Identification of challenges and opportunities. Based on literature review, stakeholder consultations, and expert interviews, the following steps took place: (1) identify and review basic challenges and opportunities for scaling up CSA; (2) review of relevant sector priorities and existing data and studies; and (3) analysis of agroclimatic conditions and constraints.

Phase 2. Strengthen the evidence base on climate impacts and options for CSA. The following assessments were conducted: (1) assessment of COVID-19 impacts and other key relevant shocks; (2) review of relevant value chains in Nepal; (3) assessment of institutional mechanisms and issues at the national and provincial levels; (4) detailed climate modeling and analysis of climate impacts on farming systems; and (5) identification and detailed documentation of existing and potential climate-smart practices and technologies to address the main expected climate change and development of a long list of CSA options. Activities 1, 2, 3, and 5 were based on stakeholder consultations, expert

interviews, and literature review.

To analyze climate impacts on the agriculture sector in four representative provinces, the following methods were used:

- An extensive literature review on climate change in the country took place, augmented by information from stakeholder consultations.
- Climate change modeling. As data from earlier modeling methods on climate trends are continuously being refined, an updated, fine-grained analysis of climate change mainly in the period 2000–50 using combined models was conducted, using CORDEX[3] (see WP 3). The analysis of projected climatic events was conducted using the Representative Concentration Pathway of 8.5, which has the highest radiative forcing values (that is, the one with highest CO_2 concentration).[4]
- Climate change impacts on the agriculture sector. The expected production changes on key crops by study province and agroecological zones were assessed using the Global Agroecological Zones (GAEZ[5] and PyAEZ, see WP 3) tools. The GAEZ and PyAEZ are based on internationally recognized standard climate change models and use readily accessible global, and where possible, national data on agriculture, soils, and crops sourced from FAO and national statistics to provide a more comprehensive national picture. The results build on earlier findings on climate trends, for example from the Climate-Smart Agriculture in Nepal Country Profile (CIAT et al 2017). The AquaCrop[6] model was used for a more detailed analysis of climate change impacts on key crops under different scenarios and refined water and atmospheric parameters under rainfed and irrigated systems and fertilizer constraints (WP 3).
- Extreme events. The GAEZ and AquaCrop modeling used standard IPCC indices and added an analysis for extreme events, primarily heavy rainfall, but also temperature extremes, which have cascading effects on availability of water, landslides, and flooding, and a number of factors causing stress on crops and livestock (see annex 1 for details).

Phase 3. Provide recommendations for action to support a CSA sector, with options for investments and enabling policy. During this phase, the following activities took place: (1) develop a short list of CSA options by reviewing and prioritizing options for crop, livestock, and aquaculture systems in targeted agroecological zones using a range of criteria (see below); (2) conduct cost-benefit analysis of selected CSA options and assess their potential for climate mitigation using the Ex-Ante Carbon Balance Tool (EX-ACT) and literature review; (3) identify interventions required to promote the adoption of CSA practices and their costs; (4) identify implementation arrangements, main agriculture support services, and capacities and roles of local stakeholders to implement interventions; and (5) prioritize CSA options, relevant interventions, and possible implementation arrangements and support services that were bundled into **CSA investment packages.** In addition, costs were identified and a detailed assessment of benefits and how these should be implemented and financed took place.

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[3] CORDEX is a climate initiative from the World Climate Research Programme that support coordination within the scientific community to generate, in a systematic and standardized way, regional climate models (RCMs)— that is, climate models that are downscaled at a finer spatial resolution (between 50 and 25 km2) than General Circulation Models. Three different RCMs were used: HadGEM2-ES, MPI-M-MPI-ESM-LR, and NorESM1-M. Multiple RCMs multi-model ensemble mean is a common practice on climatic analysis to even out trends and have more reliable results. See annex 1 for details.

[4] This scenario belongs to the Assessment Report 5 (AR5) for the IPCC (https://www.ipcc.ch/assessment-report/ar5/) .

[5] The GAEZ is a complex model for land evaluation that involves matching crop-specific parameters to climate, soil, and terrain conditions to assess potential productivity and suitability. PyAEZ is built on the same logic, but some evaluations are not implemented yet in this current version (for example, adjustment of perennial crops to Harvest Index and Leaf Area Index, crop-specific thermal screening).

[6] AquaCrop is a crop water productivity model developed by FAO to improve water productivity in rainfed and irrigated fields. It simulates yield response to water of herbaceous crops and is particularly suited to address conditions where water is a key limiting factor in crop production. It draws daily station data and includes trends on extreme water, temperature, and atmospheric parameters.

CSA aligned criteria for shortlisting options. Phase 3 relied strongly on stakeholder consultation and expert review and interviews to prioritize CSA options from an initial long list (Phase 2) to a short list, using some core criteria for analysis. These criteria were aligned with the aims of CSA and national policy priorities and were validated and refined through local stakeholder consultations (see section 5) and included the following:

- Production and productivity improvements for economic, food security, and positive environment benefits
- Climate resilience to longer-term climate changes and extreme events and increasing resilience to other non-climate shocks
- Contribution to climate mitigation by reducing absolute emissions, or at least reduction per unit production, where relevant
- Ensuring that benefits are inclusive for the poor, women, youth, and indigenous groups and vulnerable and marginalized people
- Economic benefits—examine CSA options with economic tools such as cost-benefit analysis.

Cost-benefit analysis of the CSA options and investment packages was done to assess their financial and economic viability (further details on methods provided in annex 1, with results in WP 10). This entails (1) a cost-benefit analysis of key investments on a range of CSA options for crop and livestock systems; the analysis looked at the main benefits and costs of each activity to derive the Return on Investment of each option, comparing "with" and "without" project scenarios. Data from a farmer survey was used (that is, based on the ongoing CRA GCF project preparation survey in Koshi River Basin), spanning a sample of 800 representative households from mountains, hills, and the Terai in the Koshi River Basin indicating the degree of existing and potential adoption of various CSA relevant practices; (2) for selected CSA options and overall investment packages, a discount cash flow

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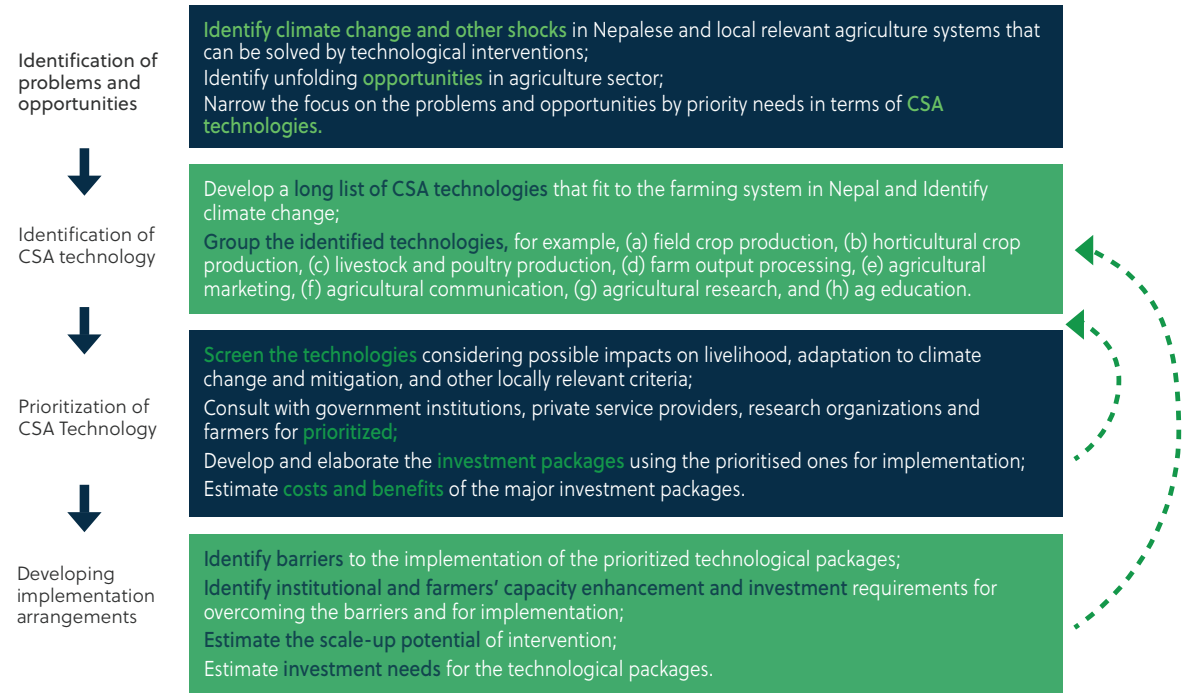
analysis was conducted to derive profitability indicators—Net Present Values and Internal Rates of the Returns; and (3) further, sensitivity analysis on the models' was conducted and GHG emissions assessment of different CSA practices was conducted using the EX-ACT, and net carbon balance was included in the economic analysis at a shadow price of carbon (World Bank 2017).

Figure 2. Iterative process of refining priority options (Phase 3) and investment packages (Phase 4)



Source: Original material

Phase 4. Review, consult, and validate with stakeholders at key various steps in the process, at the national level with ministries and scientific and partner financing agencies, and at the local level with devolved institutions responsible for implementing programs, as well as representatives of farmers, the private sector, and civil society.

Iterative process of identifying and prioritizing CSA options and investment packages. The implementation of Phase 1 through Phase 4 was an iterative process of identifying climate issues and their impacts, followed by identification and prioritization of potential options. Identifying suitable implementable packages of investments and the finance and institutional arrangements required around options was initiated fairly early in the process. Not all was done in a strictly linear manner, especially due to challenges imposed by the COVID-19 pandemic (for example, travel restrictions and the need to reach all relevant stakeholders through virtual meetings and consultations), and as investment packages were developed and refined, further revisiting of more specific options, issues, and priorities was required. Figure 2 shows the iterative process of refining CSA investment packages

2.2 Scope of Data Collection

The study was implemented with limited opportunities for information gathering in the field and face-to-face interactions with stakeholders due to COVID-19. With the outbreak of the pandemic, there were limited opportunities for fieldwork, especially within farming communities, delays in survey results, particularly for economic analysis, and considerable constraints in relation to national and local stakeholder consultation. Nevertheless, a considerable amount of information gathering and exchange could be done virtually, with the excellent support of the various ministry technical units, World Bank and FAO country officers, experts, and other local administration officers.

Developing databases for characterizing study areas for investment potential. A basic data-gathering approach broke down each province into agroecological zones to provide an important recognizable unit of analysis for a range of aspects under the study (more detail is provided in section 3). Further, because district-level data was widely available and with historical data in national agricultural and socioeconomic information statistics, analysis on climate change and representative impacts was done on different key crops and farming systems in the different agricultural zones within provinces. Some of the climate analysis (see section 4) also used finer-grained geographic information system (GIS) mapping but still summarized according to major zones in each province (and future GIS analysis can refine local analysis). District data also provide future options to do analysis on a basin basis and in other configurations, as well as possibilities to scale up the findings to other non-study provinces.

While the scope of the report was broad in relation to the agricultural sector, it could not cover in detail specific topics, which can be important for follow-up. For example, the issues and options for addressing climate-smart value chains, food and nutrition security and specific food systems, and climate impacts on trade could not be covered in depth. These topics would form a key part of follow-up studies and discussion, together with other subsector-specific themes, to examine in detail irrigation options, agroforestry or livestock, or policy or institutional capacity-building support. The study resulted in a number of working papers with more detailed analysis to further build on, including background and analysis of activities for interventions and investment options for the different subsectors.

Section 3

Agriculture Sector Situation and Study Areas

Key messages:

- Nepal is characterized by varied agroecological zones ranging from high mountains to hills and the lowland Terai.
- The CSAIP focuses on four areas within three river basins, covering four provinces and all agroecological zones, providing a good representation of the country setting and socioeconomic conditions.

To be able to define strategic options on investments, the study took the approach of analyzing the agriculture context in areas of the country that reflect diversity and important elements of the agriculture sector and farming systems.

3.1 Agriculture Sector Situation and Agroecological Systems

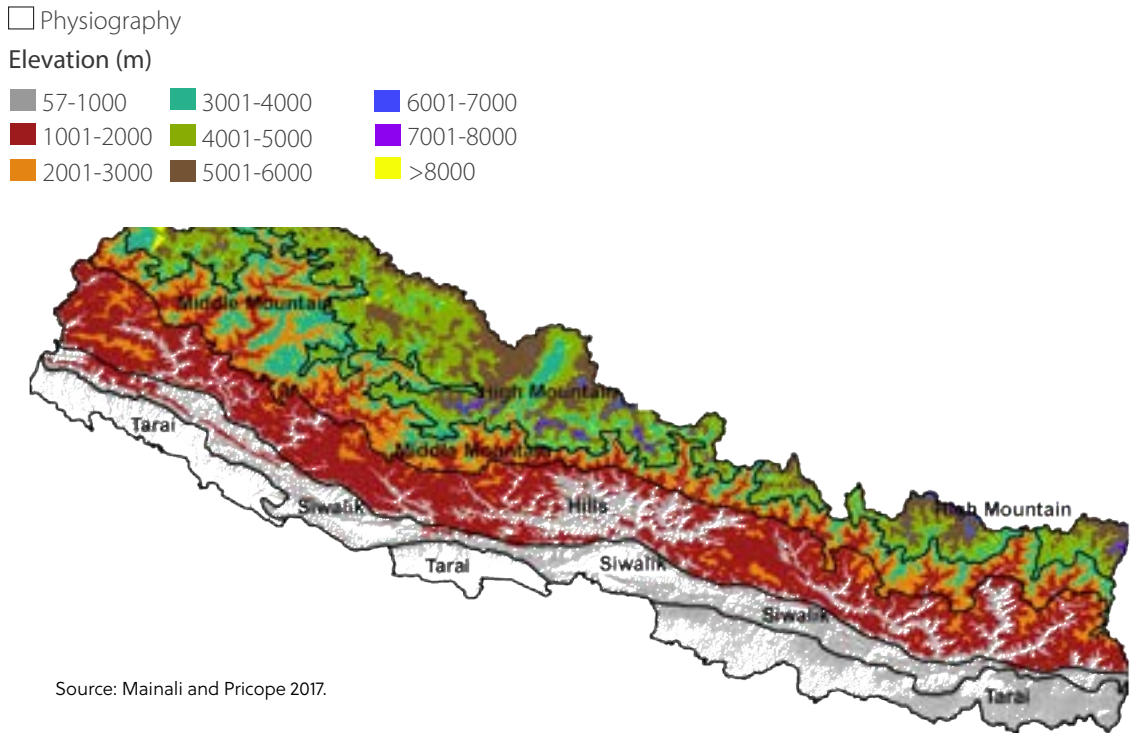
Nepal is dependent on agriculture in a very diverse and changing setting. Agriculture is the main sector of the Nepalese economy, contributing 27 percent of the GDP, and growing slowly prior to COVID-19. While there is a shift in economic structure from agriculture to services and industry, a large part of Nepal's rural population (approximately 65 percent) remains either directly engaged in or dependent on agriculture for sustenance. Further country agriculture profiling is provided in WP 2. With a range of farm systems from the lowland Terai to the hills and mountains, Nepal can produce a considerable range of commodities, and demands for livestock and high value crop products are growing due to several factors, including urbanization (CIAT et al. 2017).

Poverty, food security, and nutrition are closely linked with agriculture and rural conditions. Despite being largely an agrarian country, Nepal is increasingly dependent on imports of agricultural commodities due to low productivity and the inability of the sector to respond to changing consumer demands for higher value and nutritious food including vegetables, fruits, and livestock products. Despite significant development and income improvements in recent years facilitated by significant remittances, Nepal remains one of the poorest and most food-insecure countries in Asia, with many Nepalese suffering climate shocks and poor access to services, especially groups in remoter areas but also subgroups in populated plains. There has also been a significant feminization of agriculture due to out-migration of male farmers with potential empowerment of women in households but also additional burdens. While this has been undergoing some reversal due to COVID-19 with return of migrants, feminization and aging of agricultural workers is still the highest in the region. Any CSA investment needs to consider and balance a diversity of challenges and needs in a complex and dynamic setting.

Nepal is characterized by varied agroecological zones ranging from high mountains to hills and the lowland Terai. Analysis of the different agroecological zones in Nepal and their related farming systems is important for identifying suitable investments for different areas, whether provinces, basins, or other regional settings. While zones can be characterized by the topography of the high mountains, steep hills, valleys, and plains, there are huge variations and subtleties that define agriculture systems (Figure 3 and Table 2). They can be summarized as follows:

- **Mountains—**consisting of high mountains with agropastoral systems, mid-mountains with steep slopes, swidden agriculture, horticulture, and limited cereal growing
- **Hills—**consisting of steep hills and valleys, with considerable agriculture ranging from agroforestry to terraced slopes with cereal crops and horticulture, fertile valley floors, and more forested fragile lower hills of the Churia (also called Siwalik)
- **Terai lowland plains—**with flood plains, main cereal crop areas, and major irrigated areas.

Figure 3. Map of Major Agroecological Zones of Nepal and Elevation



Source: Mainali and Pricope 2017.

3.2 Focus Areas

The study looked at four key study areas within three river basins, covering four provinces and all agroecological zones, confirmed by the Steering Committee and an initial MoALD-led national workshop. The study encompassed major agriculture value chains, providing a good representation from across the country in relation to climate-vulnerable areas and systems. The focus areas covered the range of agroecological zones in the country and the climatic differences between east and west. This provided an opportunity to explore some variation between local institutional settings and approaches. A number of the watersheds in the focus areas, such as in the midwestern hills, have also been shown to be climate-vulnerable in other studies (for example, International Water Management Institute [IWMI] 2012). The following focus areas indicate features for selection (see figure 4):

Province 1—Koshi River basin, covering mountains to lowlands (east)

- This area represents a major part of the upper Koshi River Basin, the most eastern provinces, which has more favorable precipitation conditions but is also climate-vulnerable.
- upstream and downstream watershed connectivity

Province 2—Lowland productive areas, with small watersheds feeding the Koshi River basin (southeast)

- While part of the wider Koshi River basin, the watersheds originate in the low Churia foothills, some of which are included in the provinces.
- While also very productive, with considerable irrigated areas, some areas have relatively high poverty and food insecurity rates (lowest human development index in the country).

Province 4—Varied productive Gandaki/Nalayani basin, from mountains and hills to the Terai (central/west)

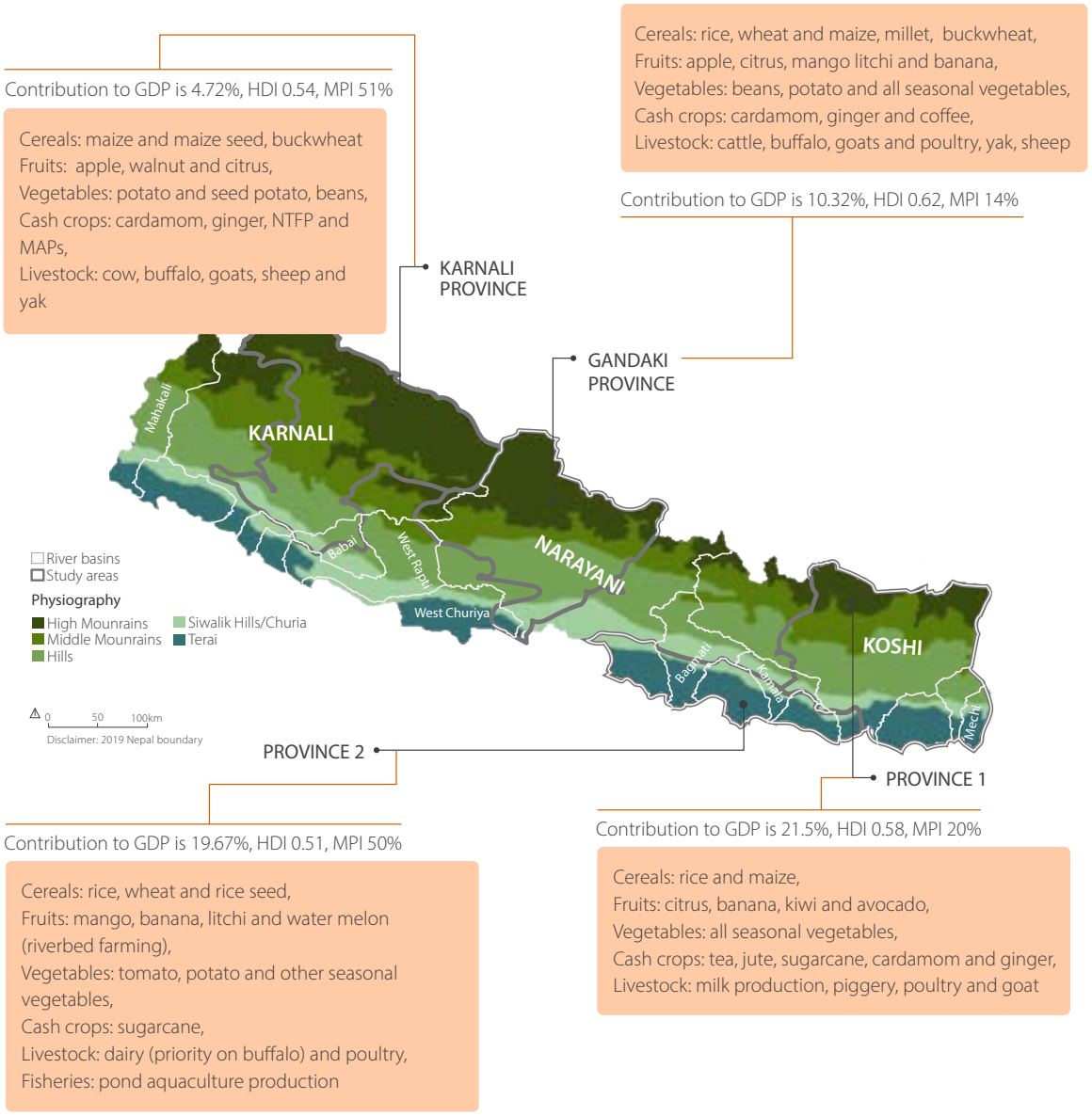
- Considerable agroecological diversity from arid mountain desert, in rain-shadow areas, to high rainfall hill areas and the Terai.

Province 6—Hills to high mountains of the Karnali basin (midwest)

- This province and basin consist of major mountain areas that are prone to droughts and have considerably high rates of poverty, food insecurity, and watershed vulnerability.

Data analysis and mapping and econometric analysis confirmed the initial choice of study areas and their diverse but representative features. Together with identification of crops and livestock value chains that were considered important based on literature review, and by national and local stakeholders (see section 3.3), the provinces and key zones were further characterized and provided basis for data analysis and mapping. The representativeness of the study areas was confirmed first through visual presentation and mapping of basic data that was closely complemented by stakeholder consultation feedback. Second, statistical and econometric analyses were done, which compared districts' data covering agriculture, socioeconomic, and other key geographical features to identify districts with similar features. These showed, for example, the distinctiveness of the high Himalayas in the midwestern part of the country but also the more productive nature of the hills in the central and eastern areas of the country. This confirmed the selected range of provinces and areas in relation to coverage and the representativeness of the key geographies in the country.

Figure 4. Map of Study Areas Showing Key Topographic Characteristics and Suitable Commodities



(HDI: Human Development Index 2019, MPI: Multidimensional Poverty Index Headcount %, 2014)

Source: CSAIP Provincial Consultation Data Collection; Human Development report 2020.

Note: HDI is Human Development Index 2019; MPI is Multidimensional Poverty Index Headcount %, 2014.

3.3 Important Agriculture Commodity-Based Value Chains in Focus Areas

Important value chains anchored on core commodities were identified for the study to provide a practical focus and to retain wider recognizable relevance for the agriculture sector. The initial criteria for identifying such chains were proposed and supported in stakeholder discussions. These criteria were around income, food security, economic importance, likely impacts from climate change, and contributions to GHG emissions—criteria also important in assessing and prioritizing CSA options later in the study. Based on initial document review, local consultations, and stakeholder workshop feedback, these major value chains were long listed. Those identified as important across all provinces and particularly important for specific zones systems were given emphasis in study analyses. Some

were further emphasized in specific provinces and agroecological zones:

Cereals:

- Rice (Terai/hills), both irrigated and rainfed; maize (hills/mountain); wheat (mountain), in all relevant province areas
- Barley, possibly millet and other grains to be considered in relation to importance for drought-vulnerable mountain areas

Fruits:

- Citrus (hills), mango (Terai), banana
- Apple, plum (mountains)

Spices and high value crops:

- Ginger (not in Province 2), potato (all areas), coffee, turmeric (hills in west), cardamom (in east), tea (in Province 1), onion (Province 2)
- Medicinal and aromatic plants (MAPs) in specific provinces, beans, and oilseed (in Province 6 Karnali)

Vegetables:

- Cole crops, tomato

Livestock:

- Goat/sheep, poultry (low areas), cattle, buffalo (in Province 2 Terai), possibly pigs (in Province 1)

Fisheries:

- mainly pond in the Terai, but also in hills (cold-water aquaculture)

Table 2. Agroecological Zones and Farming Systems of Nepal

Agroeco-zones	Landscapes	Dominant Farming systems	Value Chain	Forest cover (2015)	Grass-land cover	Cropland	Population (2011)	Ethnic Group
High Mountains (1,800–8,800 m)	Steep /flat highland	Agropastoral: Sheep and yak, potato/ buckwheat-barley systems	Yak, seed potato	1,919,120 ha (32,2%)	1,082,232 ha (63,6%)	225,400 ha (7%)	2,247,200 (8%)	Sherpas, Dolpo People, Larke and Siar People, Manang Bas, Lo Pas of Mustang, Olangchung People,
Middle Mountains (700–4,100 m)	Steep highland/ hill Slope forests	Swidden agriculture: pastures Upland cereal crops: Maize, millet, potato, wheat, mustard with cattle; buffalo and goats	Tea, cardamom, sericulture, apiculture dairy, meat					
	Gentle slopes and mountain valleys	Horticultural-led farming systems: Citrus, apple, tea, cardamom, ginger, seed potato vegetable seeds, and vegetable	Apple, seed potato, tea, cardamom, and vegetable seeds					

(continued)

Hills (20–3,500 m)	Upland terraced and gentle slopes, with some limited flat valley bottoms	Upland crops-dominated mixed farming systems: Maize, millet, wheat in terraces and potato in gentle slopes with buffalo, cattle, and goats Agroforestry	Off-season vegetables, vegetable seeds, citrus, ginger, meat, dairy, apiculture, sericulture	2,252,880 ha (37,8%)	545,335 ha (32%)	1,223,000 ha (27%)	12,078,000 (43%)	Brahman and Chhetris, Kirati, Newars, Tamangs, Magars, Gurungs, Thakalis
Churia / Siwalik (100–2,000 m)	Steep fragile low hills, and some fertile terraced river valleys and flat plains	Agricultural rainfed production, primarily low-yield fallow agriculture, and agroforestry, with different crops including upland rice, maize, vegetables and mustard, forage, and fodder	Tropical fruits and vegetables, export-quality rice, sugarcane	1,376,760 ha (23,1%)				
Terai southern flat plains (below 600 m)	Fertile terraced river valleys and flat plains, river flood plains	Paddy-dominated systems: Rice-wheat, Rice-mustard/lentil Rice-vegetables with cattle, buffalo, and goats	Tropical fruits and vegetables, export-quality rice, sugarcane, meat, dairy	411,240 ha (6,9 %)	74,101 ha (4,4%)	1,771,000 ha (55%)	14,045,000 (50%)	Tharus, Rajbansis, Satars
TOTAL				5,960,000 ha	1,701,668 ha	3,220,000 ha	28,090,000	

Source: DFRS (2015); NFGRC (undated); MoALD (2019) and NSA (2011).

Section

4

Climate Change in Agriculture in Nepal

Key messages:

- Nepal is facing various climatic risks and extreme events and climate change will add further pressures in a complex manner in varied geography.
- Basic trends indicate increasing temperatures in all areas, especially in the high mountains.
- Precipitation will increase gradually, especially in the east and in central areas, with potential increases in downstream flows. Modeling of extreme events indicates that rainfall will happen in more intense periods, especially in the wetter summer monsoon season, increasing the likelihood of flooding and landslides, and will slightly decrease in the winter dry season.
- For agriculture, this means further damage and losses to production, increased stresses from high temperatures and dry periods for rainfed crops, and effects such as diseases and pests.
- Increased temperatures and CO2 in higher altitudes, together with more river water, provide opportunities for production expansion, but soil and water constraints may arise.
- Nepal's contribution to GHG emissions is very low both in absolute and relative terms, with agriculture contributing about a third of the country's emissions, mainly from livestock, rice, and land use.
- The vulnerability of different groups of people in Nepal also varies, with groups in remote rural areas and more marginal agroecological systems more susceptible to a range of shocks. Women farmers, who have less ownership of productive assets but increasing responsibility for agricultural activities and thus multiple work burdens, require priority attention for support.
- The variability and complexity of climate impacts manifests at larger but also local scales. Thus, adaptive capacity at various levels is needed from the federal and local governments and other stakeholders, including CSA-responsive extension, research, information systems, and value chains.

Nepal is high on the list of countries facing a number of climatic risks and other extreme events, as well as economic and other natural shocks. The country also offers a highly varied and challenging geography to map out and model climate change effects with its complex agricultural systems.

Varied agroclimatic conditions in the country. Nepal's climate is influenced by its varied topography with high elevation Himalayan mountains in the north, low-lying Gangetic plains in the south, and the progression of the summer monsoon, reaching first the eastern parts of the country and then moving west. The climate ranges from subtropical in the south to permafrost in the high mountains in the north. Annual precipitation varies around 1,500 millimeters, with maximum precipitation occurring at 2,000 meters elevation and dry conditions in the rain shadows north of the Himalayan peaks. Precipitation varies strongly across the geography. The western part of Nepal receives low annual rainfall compared to the eastern part, although there are some high-precipitation pockets toward the central-western parts of the country, with over 3,000 millimeters. The summer monsoon progresses from east to west whereas there is scanty rain moving from west to east in the winter. The highest annual rainfall occurs in the middle part of the country, with large intra- and interannual variation, especially of the monsoon rains.

4.1 Climate Change Trends and Expected Effects

Climate change is happening and impacting agriculture. The maximum temperature in Nepal increased approximately at a rate of 0.05°C per year since the 1970s. Precipitation data from Nepal for the last three decades of the twentieth century show large interannual and decadal variability throughout the country, albeit with less distinct long-term trends. Nevertheless, 80 stations throughout Nepal indicate that annual precipitation over the country is slightly decreasing, more so in the Terai and the west, with only a few areas of some increase, and increase in extreme precipitation events over last several decades (Selvaraju, 2014). Figure 5 summarizes some of the key predicted changes, further covered in the overview below.

Trends in damages from climate disasters. Analysis of past trends in climate impacts on agriculture is difficult as data is not necessarily comparable due to the combined effects of socioeconomic changes (such as increased population and exposure and man-made pressures on watersheds) and decadal climate cycles. Since the late 1990s, the country has seen some of the most significant flooding disasters (for

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example, the Terai in 1998, 2008, and 2017), droughts combined with forest fires (2008 and 2009), and an increasing number of glacial lake outburst floods (GLOFs), with major impacts on agriculture and rural communities. Damages and losses due to floods, landslides, and fires nearly doubled from the period 1991–2000 to 2000–10 (Nepal Disaster Reports); in 2010 the cost was around US$85 million in agriculture (half of all damages).

Local observations on ongoing climate trends and impacts in agriculture point to a number of common but also some more locally specific effects, which are combined with other socioeconomic changes (table 5), indicating the considerable urgency with which climate change is perceived and the complexity and theory ability in the situations that have to be addressed in Nepal.

Expected Climate Change Trends in Temperature and Precipitation

Future projections have a large degree of uncertainty, but patterns are emerging. Uncertainty in the projection of future climate trends is due to factors that include the scientific understanding of complex atmospheric processes in the Himalayan region, the relatively short period of data collection (about 30–40 years), and the future developmental pathways. This uncertainty is magnified when it comes to understanding climate change effects and extreme events and their effects on the hydrological cycle. Such uncertainty itself, combined with increased variability, is something agriculture-sector planning needs to consider. While there is considerable literature on climate change assessments and vulnerability in Nepal (for example, the comprehensive review past and future changes, in FAO, 2014), these are rarely combined with specific analysis to match with broader strategic investment options in agriculture. Nevertheless, despite uncertainties in modeling and variability, some common trends and patterns emerge confirming earlier studies (see also Ministry of Forestry and Environment [MoFE], CSA profile, CGIAR Research Program on Climate Change, Agriculture and Food Security [CCAFS]).

Temperature changes show a consistently warming climate in all areas, especially high mountains. Projections indicate that the annual temperature in Nepal is expected to increase by an average of 1.7°C by 2050, with the greatest increases in Province 4 and Province 6 and during the winter season. As a result, agroecological zones may shift upward altitudinally. Temperature increases in winter may lead to less snowfall, increasing glacier melt, and general reduction of soil moisture, impacting winter crops.

Precipitation might increase slightly but mainly in already wetter parts of the country and wetter seasons. Various studies, including in-depth climate modeling presented in this report (see WP 3), indicate annual precipitation might slightly increase overall in the medium term and long term, but with seasonal variations. The monsoon, postmonsoon, and winter seasons may receive higher precipitation, while premonsoon precipitation might decline. Any precipitation increases are likely to be greater in the central hills and eastern mountains and to some degree the Terai of the east and central areas—those areas with already higher rainfall than the rest of the country. There will be much less, even decreasing, precipitation in the mountains of the west. Together with consistently increased temperatures, the overall effect will be of reduced water availability, especially impacting rainfed agriculture.

Table 5. Major Current Climate and Related Challenges Affecting Agriculture Sectors Identified by Stakeholders in Four Provincial Study Consultations

Common challenges across all provinces
• Changes in rainfall pattern and erratic rainfall, particularly in summer, causing drought, flood, and landslide
• Increase in consecutive dry days and decrease in average precipitation in winter season, causing less water availability to crop growth
• Increasing water scarcity in hilly slopes and river basins due to reduction or drying of natural water resources and increased water conflict for irrigation and drinking water
• Less number of crop varieties to adapt in the observed environmental changes brought by a changing climate scenario
• Increasing cost of irrigation infrastructure (new construction and maintenance)
• Upward shift of production domain to higher altitude, particularly for fruit crops
• Increasing insect pests and diseases and severity of their crop damage
• Decrease in crop yield and increased vulnerability of household food security
• Increasing frequency of hot waves during summer and cold waves during winter, particularly in the Terai region
• Crop yield reduction due to delayed planting and increased postharvest loss
• Land abandonment and youth out-migration
• Investment priorities by public and private sectors outside agriculture.
Challenges identified only as important to specific provinces
• Precipitation largely dependent on variable western air and residual monsoon (Karnali basin)
• Rapid snow melt resulting in drying of natural water resources (Province 6)
• Decreased livestock population in high mountains (Province 6)
• Need for integrated system with traditional varieties and neglected underutilized crops
• Accelerated erosion of the Churia region and sedimentation with loss of agricultural land (Province 2)
• Reduced water recharge due to ecosystem degradation and habitat loss (Province 2)
• Reduction in yield of non-timber forest products (NTFPs) and MAPs and gradual loss of their diversity (Province 1 and Province 6)
• Loss of richness of highland grazing lands (Province 4 and Province 6)
• Delay in breeding and hatchery operations in fishery due to slow rise of water temperature (Province 1 and Province 2)
• More and extreme precipitation increasing the chances of amplification in frequency and severity of floods, which poses challenges to farmers, leading to crop damage, fishponds overflow, pasture inundation, and uneasy conditions for livestock dwelling (Province 2)
• Technologies are traditional or not used; problem of cost, access, availability (Province 6)
• Lack of critical investment at the household level and public level (Province 6)
• Governance problems in enterprise ecosystem with unfair prices (Province 6)
• Poor capacity of the government to invest in high-cost irrigation infrastructure (Province 6)
• Need to capture value chain opportunities for better local livelihoods (Province 1)
• Need to decrease production cost and become more competitive (Province 1)
• Need to improve technology support systems and market management systems (Province 1).

Climate Change and Possible Extreme Events

Climate change also brings changes in extreme events, although these are to be modeled in the future. Extreme events and year-to-year variability are of great significance to farmers, often more so than gradual long-term changes**.**

Expected trends, extreme events, and their possible effects relevant to agriculture. Trends show increased numbers of warm and hot days and increased minimum temperatures, especially in the mountains. Some of this may bring positive changes in relation to expanding agriculture possibilities. However, high temperatures in the mountains will increase ice melt, snow cover, and avalanches, and extreme heat, such as the increased number of days above 45 degrees, especially in the hills and the Terai, will increase stress on all animals, crops. and human systems.

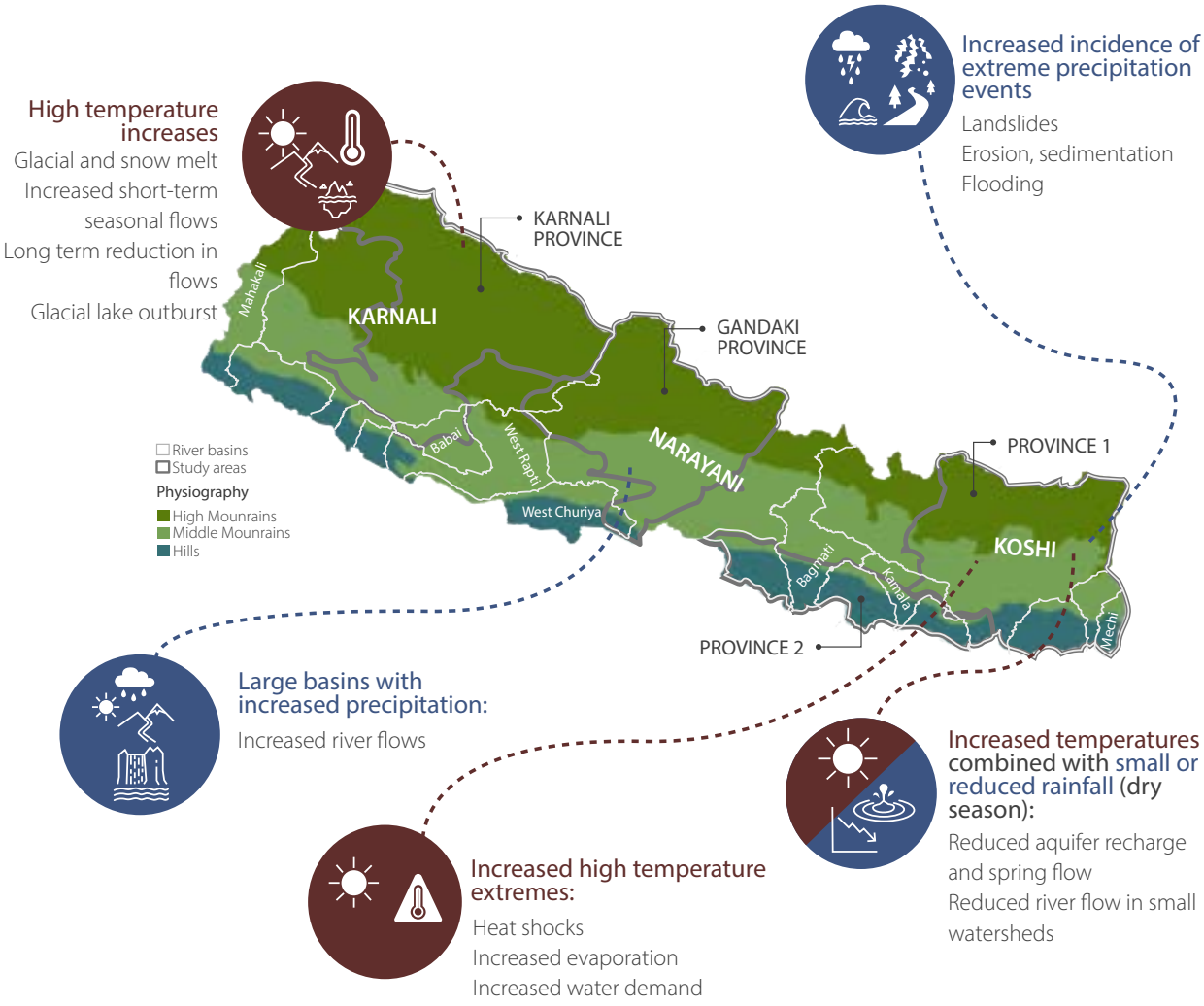
Trends in precipitation-related extreme events. Based on various indices there is a general pattern of expected increase in intensity of precipitation events, especially in the monsoon season and in the mountains and hills. The consequences will be increased landslides in the hills and mountains and flooding in the Terai. With precipitation concentrated in the wet seasons and overall increased temperatures, droughts in the non-monsoon periods are likely to increase.

Climate Change and Possible Effects on Water Availability and Hydrology

Possible hydrological changes as a consequence of climate change are complex and difficult to model. Drawing on various studies and the draft IMP, some key effects are expected:

- Increased glacial melt runoff is expected in the shorter term but will result in overall decreases in the longer term, with implications for the supply of water to irrigation systems. The draft IMP also noted that while some river flows may increase, others may decrease, and that climate models on hydrology should be considered with care.
- Snow-fed rivers may be shifting to earlier seasonal flows, and non-snow-fed rivers have a delayed onset and peak flows.
- As with ongoing trends, with even warmer temperatures GLOFs are likely to increase.
- Increased extreme precipitation events have multiple hazard effects—floods, landslides, and increased erosion—also impacting irrigation systems.
- There is a likelihood of increased water scarcity; levels have been found to be increasing over the last few decades, a trend that will likely continue, especially in the eastern Terai, for agriculture and water for irrigation (FAO ongoing Water Scarcity study, personal communication).

Figure 5 Summary of Key Expected Future Climate Trends and Extreme Events



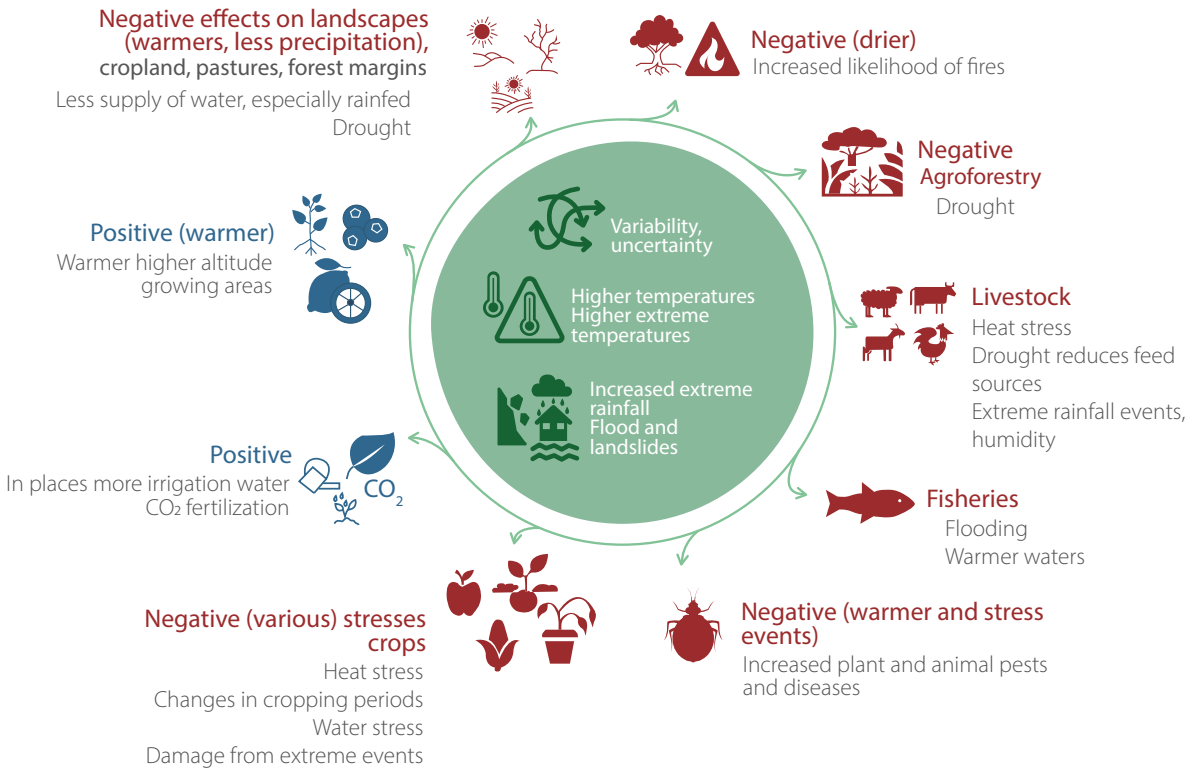
4.2 Impacts of Climate Change on Agriculture Systems and Agroecological Zones

Climate impacts on agriculture systems will bring a range of impacts, mostly negative, although with some positive aspects. Nepalese farming systems and crop production are predominantly rainfed (MOE 2010). Drawing on the MoFE and NAP-Agriculture process (FAO and UNDP supported) and other literature (see also FAO 2014), a range of impacts have been repeatedly noted, and some likely future scenarios are emerging. These also largely reflect ongoing observed trends (see table 5 above). Most of these scenarios have negative impacts, although some positive effects could emerge. The range of impacts likely to affect agriculture in Nepal is discussed below and summarized in figure 6.

Increasing temperatures change cropping patterns, including increased rate of crop growth with yield opportunities, but also increased stresses:

- Changes in the timing of sprouting, flowering, and fruiting of crop species and phenological disorder in animals are affecting crops and livestock productivity.
- Temperature warming leads to early blossom of fruit trees and higher levels of pest attacks.
- Extreme temperatures, including high night minimum temperatures, may cause limits to growth and key growth stages and reduce crop growing periods. Some species, such as fruits, may require cold periods.
- The CO_2 fertilization effect (particularly in C3 plants such as wheat, millets, oats, rice, maize, cotton, and sunflower), when combined with good availability of water, such as well managed irrigation, and fertilizer inputs, can lead to increased productivity. This is explored further through modeling, discussed below in section 4.3.
- Rising temperatures may also increase the altitudes at which vegetables and a few other crops can be grown, with possible new opportunities for farmers. However, the soil and slope conditions available may not be the same as in lower altitudes, and water availability must also match the growing opportunities. The types of crops and varieties must be adapted for new altitudinal and soil typologies and available to farmers to use.

Figure 6 Summary of Likely Effects of Climate Change Expected on Agriculture Systems in Nepal



Source: Original material

Reduced availability of water, heavy precipitation events, and risk of droughts:

- The combined effect of a slight increase in precipitation and the benefits it may bring may be offset by the large increases in temperature with higher evaporation and water stress (see above on water and hydrology). The trends also indicate dry season reduction in precipitation, which may offset benefits in cropping in the wet season and monsoon. Declining availability of water for agricultural uses may come at critical cropping times, decreasing soil moisture, with prolonged droughts resulting in crop failures and productivity losses.

- Climate change-related drought is a key driver of household-level vulnerability in the hill agriculture. Climate change is intensifying existing problems such as excessive rain in some places and reduced rain in others, runoff and increased heat stress, recurrent drought and floods, heavy loss of lives, loss of rural livelihoods, and food insecurity (Ghimire, Shivakoti, and Parret 2010).
- Heavier precipitation is contributing to increased climate-induced disasters such as erosion, landslides, and floods, resulting in further agricultural land degradation and increasing losses of crops, livestock, and other physical assets.
- Increased variability in river runoff can reduce the effectiveness in the operation of conventional irrigation systems and decrease water-use efficiency.
- Greater unreliability of dry season flows poses a potentially serious threat to water supplies in the lean season.

Climate change brings with it increasing variability and uncertainty in future climatic patterns and the possibility of multiple extreme events:

- Existing evidence suggests that climate-related disasters such as floods, landslides, and droughts and their variability are increasing in recent years, and their impact on livelihoods and food security is significant (MOALD, 2019). For example, floods across the country in 2008 affected over six million people (30 percent of the population) and crop production the following winter declined by over 15 percent due to drought. .
- Rainfall uncertainty has reduced food production. For example, the untimely start of monsoonal rainfall resulted in a rain deficit in the eastern Terai lowlands in 2005/06, reducing crop production by 12.5 percent nationwide (Malla 2008). While 10 percent of agricultural land was left fallow due to rain deficit, the midwestern Terai faced heavy rain with floods reducing crop production by 30 percent (Regmi 2007).

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Climate change has to consider interactions and ongoing changes in ecosystems and the need for wider environmental management:

- Increasingly degraded agricultural land and increased depletion of land from agricultural uses make it more vulnerable to extreme precipitation events.
- Changes in climate can lead to agrobiodiversity loss. Some indigenous crop varieties such as aromatic rice, wheat, maize, and other crops are disappearing (Paudel 2012).
- Agroecological changes, forest fires, and emerging alien and invasive species may result from weather changes and from changing ecological zones.
- There is a wide range of interactions regarding utilization of water that compound climate change stresses, including needs for extraction for urban and industrial uses, and resulting effects on the quality of water due to pollution.

Secondary stresses arising from climate changes and extreme events may increase:

- Disease and pest infestation in crops result from increased temperatures, adverse weather patterns and climate changes, droughts, and heavy precipitation. Higher precipitation and temperatures cause higher relative humidity, which contributes to the increase in pests and diseases. Crops are infected by diseases and pests such as club root in crucifiers, blight of solanaceous, rust of wheat, blast of rice and leaf spot of maize, red ants (Ghimire, Shivakoti, and Parret 2010), recent locust swarms in 2020, and the spread of fall armyworm since 2019.
- Major impacts on animal husbandry include pastoral degradation and decreasing forage productivity; increasing transboundary animal diseases, parasites, and vector-borne diseases; heat stress; and changes in reproductive behavior.

Expected important effects from climate change will vary considerably by major agroecological systems. Table 6 below summarizes the impacts from climate change and their major effects on agricultural systems in different zones. This is not an exhaustive picture, as these effects are distributed unevenly within zones depending on specific river and watershed alignments and slopes. There will also be some east-to-west differences, such as greater impacts from droughts in the mountains of the west and in the Terai of central areas with smaller watersheds that do not benefit from high mountain streams, as well as high risk of landslides in the central and eastern hills with their high levels of precipitation.

Diversity of impacts in complex systems, such as those related to agroforestry: Climate change impacts on agroforestry and the production of NTFPs and MAPs grown in integrated and forest related systems is expected to be negative. Heat, droughts, retreat of glaciers, flash floods, and soil erosion are projected to reduce the regeneration and growth of NTFPs and MAPs; increase the invasion of alien plants and pests and diseases; affect the quality of products; and increase postharvest losses. At the same time, production systems will be highly sensitive to changes in the forest, pasture, and wider watershed systems to which they belong.

Table 6 Summary of Key Climate Change Impacts and Their Effects on Agriculture, by Agroecological Zones

Temperature	Precipitation	Combined and Other Effects
Terai		
Climate changes • increase in temperatures in winter, higher in summer, more very hot temperatures	• modest increased overall precipitation • intensity of precipitation (based on two indices) likely to increase, mixed effects in monsoon period for single day events • some increase in runoff of usable water, however slightly less from smaller Churia (lower hills) watersheds basins • increased likelihood of flooding events	• increased variability and multiple stresses, increased humidity • winter fog may increase cold days
Effects on agriculture • heat stress to crops, livestock • heat stress farmers and labour	• productivity of wheat in rainfed areas will decrease • productivity of rice, maize, and wheat in rainfed areas will increase (see below analysis) • irrigated crops may get increased water, mainly in wet seasons, and increased variability • lowland and flood plain agriculture damages from floods	• uncertain cropping cycles • increased livestock diseases and crop pests and diseases
Hills		
Climate changes • increase in temperatures in winter, higher temperatures in summer • increase in extreme warm days	• gradual increase in average precipitation, especially east and central hills • intensity of precipitation likely to increase, especially in hills of Province 1 and Province 6 • increased runoff of usable water, particularly from large basin watersheds, east and central areas	• increased variability and multiple stresses, increased humidity

Effects on agriculture • with high increases in temperature, evapotranspiration will be higher, thus increasing risk of drought, especially in the west with less rain increase • summer season heat stress will increase for crops and livestock	• productivity of maize and wheat, especially rainfed, will decrease, but some irrigated crops may also benefit • productivity of rice, especially rainfed, will increase • increased likelihood of landslide events, mainly affecting hill agriculture, but also transport of products • increased likelihood of flooding events causing damage and loss in agriculture	• increased crop pests and diseases, livestock diseases
Mountains		
Climate changes • very high relative increase in temperatures in winter, higher in summer • fewer frost days • more ice melt	• almost none, or slight changes in overall precipitation • high temperatures leading to high risk of increased drought events • less snow cover and less ice buildup • intensity of precipitation (based on single day maximum and two indices) likely to increase, especially in mountains of Province 1 and Province 6 • increased rate of water runoff • increased likelihood of landslide events and floods • increased sedimentation, erosion affecting rainfed cropland pastures and rural infrastructure	• increased variability in extreme climate impacts, multiple stresses and rapid changes • complex effects on water cycle, such as more avalanches and GLOFS
Effects on agriculture • with increased temperatures, productivity of rice, maize, and wheat, both irrigated and rainfed, will increase from present low levels (areas available may be limited) • other crops can shift to higher altitudes • some fruit crops may lose required cold events	• with high increases in temperature (but almost no increase in precipitation), evapotranspiration will be higher, thus increasing the risk of crops and livestock pastures being affected by drought • landslides damaging limited lowland cropping areas and livestock pastures and infrastructure, especially transport to remote areas	• while higher altitudes may become more suitable for crops and trees, areas available for expansion are limited • increased fragility of soils and watersheds, reducing productivity • unpredictable disasters

Sources: Anecdotal and extrapolated effects. Original material and expert assessment.

4.3 Impacts of Climate Change on Key Crops

Refining assessment of climate change impacts on crops using PyAEZ and AquaCrop. To further understand future climate impacts on different key crops under different conditions, (although necessarily with somewhat simplified assumptions), PyAEZ and AquaCrop model analyses were used (WP 3). The PyAEZ could provide some downscaled information generalizable for study provinces and agroecological zones. Future yields of key crops in key cropping seasons, under more differentiated conditions of water availability—such as from irrigation—and fertilizer inputs were simulated and calibrated with the AquaCrop modeling tool, using data for a small selection of key cereal crops and major horticulture crops with good data availability (rice, wheat, maize, potato, and tomato), from three weather stations (the Terai, hills, and mountains) and for both current and anticipated future conditions under different irrigated and rainfed scenarios. The tool uses more detailed daily data with several water-related climate parameters and thus incorporates some extreme events such dry

[8] CIAT; World Bank; CCAFS and LI-BIRD 2017. Climate-Smart Agriculture in Nepal. CSA Country Profiles. https://cgspace.cgiar.org/handle/10568/83339

spells and heat stress; it also benefits from CO_2 increases that benefit some plants. For more specific future guidance, such modeling can be applied to a further range of crops and stations when more standardized localized data sets and parameters are available. The results help to indicate contrasting realities to farmers across various agroecological zones and in relation to access to irrigation water and possible changes in rainfall patterns.

These findings broadly reinforce the results for key crops such as rice and maize from earlier modeling (CIAT et al 2017). In addition, a number of trends were examined for the study regions and agroecological zones, under rainfed and irrigated systems.

- Climatic suitability and, consequently, potential productivity for irrigated rice will decrease slightly, even more so for rainfed rice crops. However, this does not consider the effect of future rainfall increase and CO_2 fertilization, which can have a positive effect on yield of up to 50–70 percent. The positive CO_2 effect is strong under irrigated conditions (contributing about 15–25 percent positive effect) and for other crops.
- Using PyAEZ, potential productivity and projected suitability for maize has a similar pattern to rice, with mixed slight decreases and increases, with slight increases especially in higher altitudes. However, more detailed modeling using AquaCrop with more extreme event parameters showed maize yields have some of the greatest decreases of over 10 percent by 2030, especially for rainfed hills.
- Generally, some improvements in rice and lesser mixed effects on maize yields could be expected in mountain areas from increased temperature opportunities; however, these are also the areas with already low yields and overall production levels. With further water constraints in mountains, together with extremes such as drought, the productivity is likely to suffer.
- Wheat scenarios are the worst affected with reduced suitability and, with detailed AquaCrop modeling, increases can only be expected with effective irrigation.
- Most irrigated crops and rainfed wet season rice yields, when modeled with good water availability and including effective fertilizer levels, have positive yield benefits, even with climate change. Water is not a key productivity constraint, at least for wet seasons, with increases in daily potential evapotranspiration offset by reductions in crop-cycle durations.
- There will be a reduction in suitable areas for rainfed production of millet, potato, and chickpea, but further in-depth analysis on highly productive areas (such as the Terai) is required. AquaCrop modeling with ideal irrigation conditions indicates yields of crops such as potato and tomato can also increase over 5 percent in the hill and Terai areas.

In both cases, the analysis highlights the importance of providing integrated irrigation and agricultural support services, as the current productivity levels are well below their potential; changes in agronomic practices require better irrigation management, both at the system and on-farm level, to overcome negative effects and to realize the potential benefits of climate change effects. This will have to include, but not be limited to, improving the flexibility of irrigation systems and their reliability of supplies, including during the critical stages of crop growth most impacted as a result of shifts in water availability.

In addition, as projections of water availability remain relatively uncertain, they will require further localization and hydrological assessments. While climate change models generally indicate some potential increases in flow rates, trend analysis suggests a more diverse situation. Furthermore, this uncertainty is coupled with anticipated increases in water scarcity, particularly in the Terai, and during critical parts of the year for crops. This highlights the need to look at climate-smart investments through a water lens and strengthen water-sector management in line with the future needs of the

agricultural sector, especially in areas experiencing water competition and scarcity, while ensuring that farmers in irrigated agriculture are able to have higher returns per unit of water consumed. This will require a fairly local-level analysis, complemented by more refined basin and watershed analyses, to better understand the potential dynamics and associated costs and benefits.

4.4 Impacts of Climate Change on Livestock and Aquaculture

Livestock accounts for 27 percent of Nepal's agricultural GDP, but productivity is low. Of the population engaged in agriculture, 70 percent keeps livestock, and a large proportion of the labor is provided by women. The ADS underpins the role of livestock for sustained agricultural and economic growth, poverty reduction, and improving food and nutrition security. It indicates that present productivity levels are low, and demand for livestock and livestock products, particularly milk and meat, has outstripped supply in Nepal, causing increasing reliance on imports, mainly from India.

Increased rainfall variability, increased winter drought, and an increased number of dry spells and days of heat stress are likely to negatively affect livestock productivity and production; this will lead to large annual variations in crop and pasture production, with an important impact on feed availability, compounding existing stresses on pastures from overgrazing. In addition, animal health is likely to be affected by climate change in four ways:

- Heat-related diseases and stress
- Extreme weather events
- Poor adaptation of animal production systems to new environments
- Emergence or reemergence of infectious diseases, especially vector-borne diseases that are critically dependent on environmental and climatic conditions.

Other climate tolls on livestock production are likely to include direct losses in floods, damage to shelters, and cuts in input supplies and access to markets.

Fisheries and aquaculture will also be impacted, largely by water-related effects. While less important on a large scale for the Nepalese economy and livelihoods, the sector does offer growth opportunities such as warm-water aquaculture (and even cold-water hill and mountain culture, but this is a relatively small subsector). This sector is likely to face climate impacts such as washing out or overheating of ponds in extreme events, flood and landslide events on lakes, and stress on existing species and breeds with changing temperatures and changing water bodies.

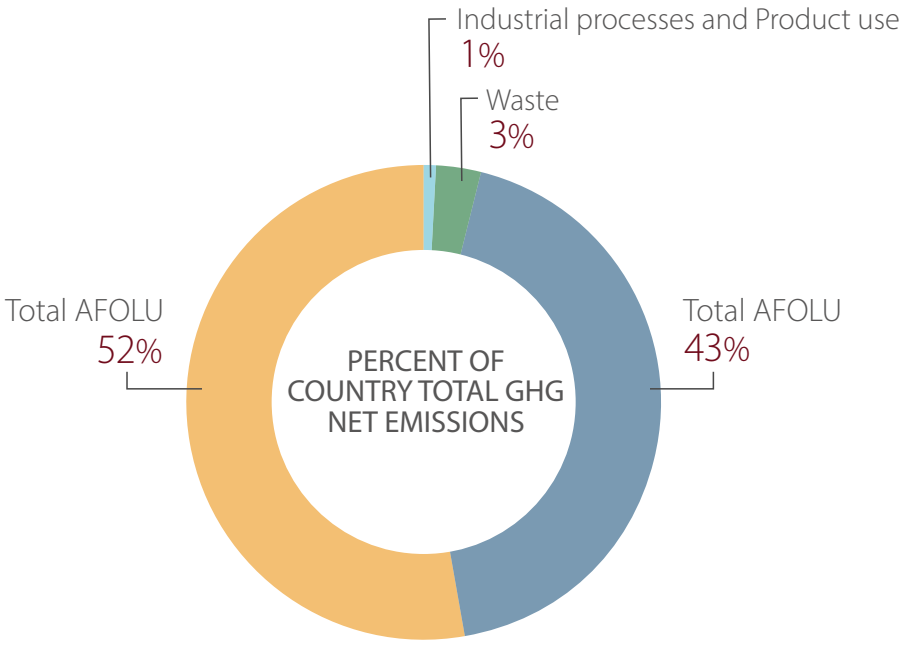
4.5 GHG Emissions in the Agriculture Sector

Nepal's contribution to overall global GHG emissions is relatively small both in absolute and relative terms, though agriculture plays an important contributing role. Nepal's Third National Communication to the UNFCCC (MOFE 2021) reports the overall country emissions of greenhouse gases (GHG) from 2011 of 28.17 Mega tonnes Carbon dioxide equivalent emissions ($MtCO_2eq$, see table 7. Note 1Mt is equivalent to 1 million metric tonnes). The agriculture, forestry and land use (AFOLU) sector contributes net emissions 12.12 $MtCO_2eq$, or 43 percent of this (figure 7a). A downward trend in net emissions was noted between 2001 and 2011, mainly due to increased afforestation contributing to increasing carbon stocks, and acting as important GHG sink. Emission data is also available from other sources, for example the Climate Watch platform (Climate Watch, 2020) which shows slightly higher emissions estimates of about 24 $MtCO_2eq$ for AFOLU for 2011. However, overall, it shows similar past trends, and steadily increasing emissions, with more recent values of about 26 $MtCO_2eq$ for 2018.

The Third National Communication (MOFE 2021) projects increasing net AFOLU emissions by 2030 and 2050, with stabilizing land use, but steadily increasing livestock and other agriculture production, contributing around doubling of emissions in the sector by 2050, under current practices.

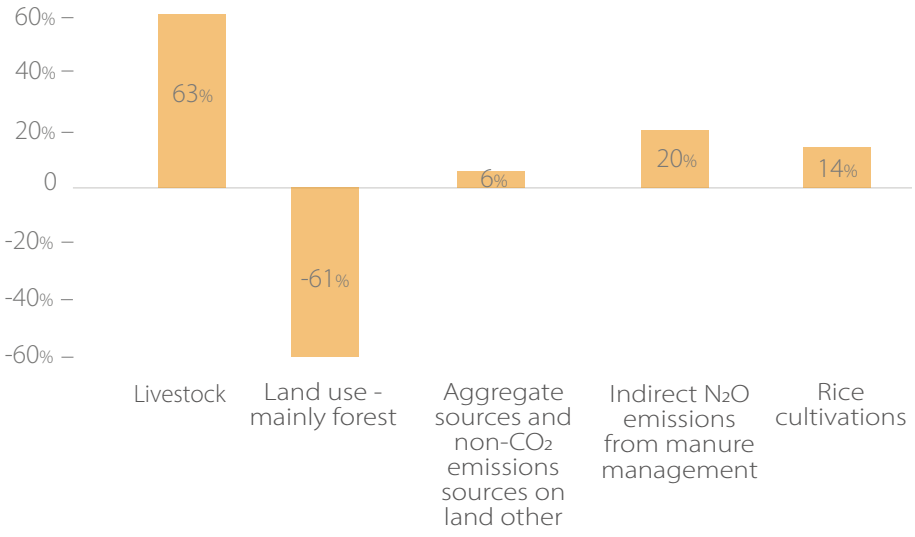
Figures 7b and 7c show the share of AFOLU activities in total GHG emissions and as share in total agricultural emissions, respectively.
Note: $MtCO_2eq$ = million metric tonnes CO_2 equivalent; CO_2 carbon dioxide; CH_4 methane; N_2O nitrous oxide

Figure 7a. Nepal's total GHG emissions, in percent by 2011



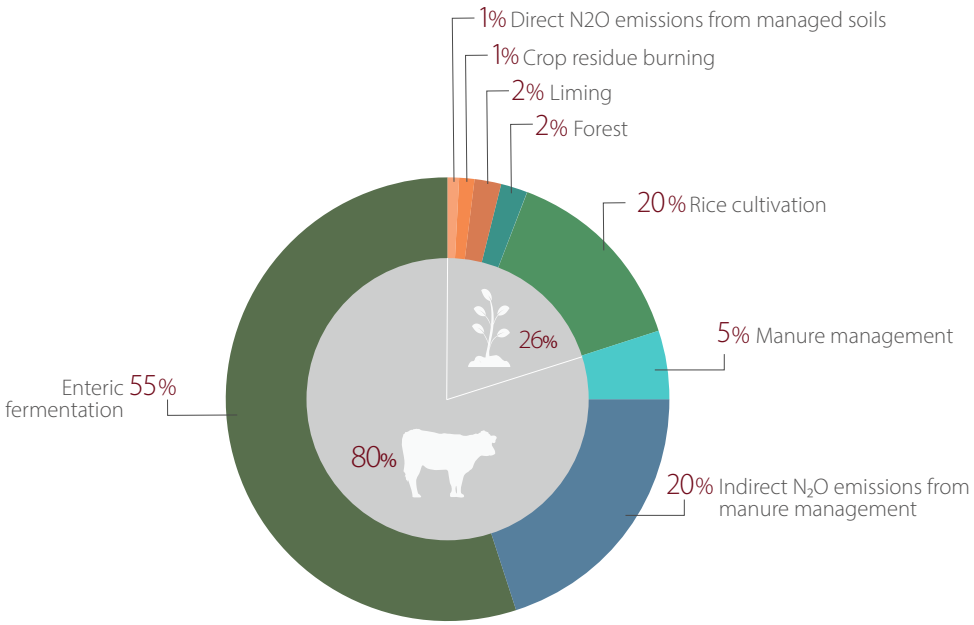
Source: Nepal's Third National Communication to the UNFCCC (MOFE 2021)

Figure 7a. Share of AFOLU in Nepal's total GHG emissions (positive) and sinks (negative), in percent



Source: Nepal's Third National Communication to the UNFCCC (MOFE 2021)

Figure 7c. Share of AFOLU activities agricultural GHG emissions, in percent



Source: Nepal's Third National Communication to the UNFCCC (MOFE 2021)

A major part of high agriculture GHG emissions is from methane arising from enteric fermentation by cattle and buffalo. The emissions are mainly from livestock enteric fermentation releasing methane (CH4) (see table 7), with smaller emissions from manure management. Livestock is estimated to contribute 76 percent of global GHG emissions from agriculture, or over half of total anthropogenic GHG emissions in Nepal. Unproductive animals, high mortality rates, and poor feeding and manure management practices translate into relatively high levels of GHG emissions per unit of product, as well as other environmental impacts such as inefficient use of water and nutrient loading. Paddy also contributes to positive net emissions, through anaerobic decomposition of organic materials in flooded fields leading to methane emissions. The net emissions from forests were negative and demonstrated to be a carbon sink. The data do not reflect emissions from the entire agriculture value chains. Value chains, with processing, packaging, and transportation, are sources of GHG emissions, as are irrigation systems if they are not energy efficient or based on renewable energy, however these are likely to be relatively small compared to the overall emissions and sinks.

Table 7. Nepal GHG Emissions and Removal in 2011

Sector and Subsector	Net GHG emission/ sink - $MtCO_2eq$	Main emission /sink gas (AFOLU only)	Percent of country total
AFOLU:			
Livestock	17.66	Mainly CH4	63%
Land - mainly forest	-17.04	CO2	-61%
Aggregate sources and non-CO_2 emissions sources on land - other	1.76		6%
Indirect N_2O emissions from manure management	5.76	N2O	20%
Rice cultivation	3.97	CH4	14%
Total AFOLU	**12.12**		**43%**

(continued)

Other sectors:			
Energy	14.75		52%
Industrial processes and Product use	0.36		1%
Waste	0.92		3%
Total Country net emissions	**28.17**		**100%**

Source: Summarised from MOFE 2021

The trends point toward the importance major mitigation options for the AFOLU Sector (MOFE 2021). This would be from maintaining and increasing the reduction of emissions per unit production for livestock, and greater efficiency in production and value chains, and carbon capture from good forest and good land management, which are also adaptation and resilience-building practices:

- **Livestock—**maintaining current emissions as far as possible and reducing emissions per unit production for livestock, including through dietary changes in livestock
- **Paddy Rice—**new practices with less flooding periods, and more efficient rice production systems
- **Biomass—**good forest management, including integrated agroforestry, reduction of deforestation from agricultural land expansion, and, where possible, increasing tree and forest cover. Also with urban forestry
- **Soil carbon—**strengthening integrated land-management and improved crop-management practices (for example, conservation agriculture, no tillage, intercropping or successional planting systems), strengthening grazing land management, that stabilize soil and increase soil carbon
- **Value chains—**increase efficiency of transport and storage to reduce waste and losses and thus productivity per unit GHG emissions.

4.6 Impacts of Climate Change on Value Chains

Climate change will affect products and their use along the value chains but also have direct effects on value chains that will affect producers. While there is not an extensive literature on the impact of climate change on agricultural value chains (some reviewed in WP 4), the impacts can be seen from three perspectives:

- The effects on products that go into the value chain, such as the supply of sufficient quantities of crops and livestock products that are traded, as well as damage to harvested crops affecting the quality of the produce
- Direct effects on the value chain, such as landslides and flooding that impact the supply of inputs, processing, or storing, and the transport of products
- Losses during storage and transportation due to extreme weather conditions, accelerating senescence and increasing fungal and insect infestations. Climate change will also increase storage costs and processing requirements along the value chain.

4.7 Vulnerability of Livelihoods Groups, Food Security, and Nutrition

The vulnerability of different groups of people in Nepal varies considerably. Typically, groups living in remote rural areas and more marginal agroecological systems, with fewer resources and opportunities for diversification, will be more susceptible to a range of climate change impacts. Such groups include smallholder farmers in most parts of the country, especially high mountain pastoral

groups in the west and women farmers in the hills, where male household members have migrated to the Terai, urban areas, or foreign countries for employment. An important and often food-insecure group is the laborers in the Terai, who are dependent on seasonal agricultural wage labor that may be impacted due to droughts or floods affecting harvest and planting requirements and are under increased heat stress from agriculture work conditions. Smallholder farmers with poor quality land without irrigation facility are particularly vulnerable, as they will be faced with increased variability of harvests and few opportunities for diversification.

For the vulnerability of producers, climate change is unlikely to be gender neutral. Existing evidence (for example, Jost et al. 2015) suggests that climate change is likely to increase time burdens and decrease asset ownership for women. In Nepal, women already own a limited amount of relevant assets, with only 20 percent of land and other property owned by women (FAO 2019). Lack of agriculture experience by women is a key element in lower adoption of CSA practices. Another potential effect of climate change is an increase of male migration, leaving women as main actors in the agrifood value chain (although COVID-19 has produced some temporary reversals of this). Where caste, ethnicity, and poverty further intersect, the challenges for groups also increase.

Food security and nutrition. As noted above, a number of different trends may be expected around climate impact on agriculture, which would contribute to a range of food security and nutrition implications. These will vary considerably according to the nature and location of different vulnerable groups (also further analyzed under the World Food Programme (WFP) and CCAFS, n.d.). However, food security and nutrition are not only about effects on farms; there is a dynamic that relates to imports and trade between regions and also from other countries, and the accessibility of products to different food-insecure groups, including requirements in growing urban areas. Clearly climate change will impact the amount of production and especially affect areas that are already vulnerable to highly variable yields. There is also the potential for some level of import substitution; for example, rice production yields can be increased through better irrigation and fertilizer use, and value chains can be improved to ensure flows of produce. However, this would need a more detailed food systems analysis. COVID-19 has shown how sensitive food systems are to a range of interacting shocks, even as governments prioritize them as core functions.

4.8 Institutional Needs for Addressing Climate Change and Other Shocks

Address variability and complexity of climate impacts also at local scales. With its highly complex geography, assessing potential climate impacts in Nepal and developing eventual responses is challenging. In this regard Nepal has benefited from efforts at more local and theme-specific assessments, with a range of localized data and approaches. Participatory Local Adaptation Plans for Action (LAPA) and agriculture Vulnerability and Risk Assessments (VRAs) were prepared for eight municipalities by the Global Environment Facility and Least Developed Countries Fund (GEF/LDCF) and in a number of localities under the National Adaptation Planning for agriculture (NAP-Agriculture, see more below under section 5 –with synthesis of process in MOALD 2019a). These, together with other experiences, have showed the need to

- Consider climatic variability even on local scales and variability that is likely to intensify together with considerable future uncertainties. There is a need to build and strengthen the adaptive capacity of government, farmers, communities, and other stakeholders;
- Deal with small-scale geographic variability in ongoing and potential impacts. There is a need for more integrated and localized processes of assessing impact trends and locally suitable responses;

- Recognize that vulnerabilities are also dependent on socioeconomic factors, both at the local scale and between regions and agriculture areas in the country;
- Integrate approaches combining livestock and other different cropping and land-use systems and to support greater diversity and agroecological resilience;
- Consider wider hydrological and watershed dynamics so that wider ecosystems can contribute to resilience; and
- Build the resilience of value chains to a range of shocks, which helps to buffer the effects of extreme events both on producers who depend on inputs and on stable markets and also for greater stability in the flow of food to consumers.

Build the adaptive response capacity that is critical to implement CSA at scale and in varied contexts, in the context of ongoing federalism and devolution. In moving forward on CSA, it is essential to recognize the changed and evolving institutional setting for agriculture in Nepal—a process that is still very much in change and review across the country at the time of report preparation. Nepal adopted a new constitution in 2015 that transformed its unitary structure into a federal one with three-tier governance: a federal government, seven provincial governments, and 753 local (municipal) government units, including 460 rural ones. While this system is not strictly hierarchical, ambiguity remains in the exact division of responsibilities for agriculture. This offers opportunities on the one hand for local governance in adapting programs to local challenges and addressing climate change. On the other hand, there have only been a few years for the different levels to establish capacities and build coordination mechanisms across governance levels and different local agencies. For example, extension services are defined as being the sole responsibility of local governments, while the federal and provincial governments retain authority over Agricultural Research and Development (ARD) and issues in land use. The actual capacity at municipal level for supporting agriculture is very limited, however, due to inadequate human resource capacity in relation to manpower, knowledge, and skills.

However, there is a strong political will in the provincial and local governments to adapt to specific challenges at the local level. Experience with COVID-19 showed that provinces were allocated inputs and support for farmers,

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albeit to varying degrees—building policy planning capability for analysis, formulation, and implementation thus remains a fundamental priority. CSA would automatically benefit from an enhanced overall capacity, but it also requires specific capacities and skills. Overall budgetary and investment resources at the national and local levels should be planned and designed to match needs. Policies, resources, and support mechanisms need to be targeted and complementary between public and private sectors on key inputs, services, and capital investments such as seeds, fertilizers, machinery and labor, finance, extensions, pest and disease control, quality control, and postharvest and market infrastructure.

The role of farmer organizations and the private sector on the extension and provision of appropriate services responsive to climate is limited. The private sector, such as input traders for seedlings, seeds, feeds, veterinary supplies, kids, piglets, chicks, and fingerlings plays an important role in providing advice to farmers on improved and suitable technologies and inputs. However, the private traders also need to access information on local priorities for CSA and farmers' needs in the context of climate changes and how best to complement public services.

To support decision-making for the above, greater climate understanding and awareness is needed on trends and impacts on a larger scale and regarding local changes, including appreciation of local knowledge and perceptions, and coping strategies around climate and agriculture. For this, agromet and early warning systems, analytical tools, and mechanisms to develop appropriate advisories need to be in place, taking advantage of new mechanisms of information delivery that are being offered by digital technologies and services.

Agriculture research capability has become more fragmented, which is challenging for implementing CSA. Additionally, agriculture research has to address issues stemming from years of uneven focus on agroecological zones, which led to low availability of technologies suitable for hills and mountains. Capacity strengthening is required to address climate change challenges in the sector and to close the gap in technology development for all zones, information, research, and more rapid climate change responsive links to extension.

Section

5

Responding to Climate Change in Agriculture; Related Challenges

Key messages:

- Prioritized CSA options span a range of practices suitable for different crops, livestock, and aquaculture systems in different agroecological zones. The study examined the options through the policy lenses of (1) improving production and productivity, (2) resilience, (3) inclusion, (4) environment benefits, and (5) mitigation of GHG emissions and identified a number of options that have potential for large-scale benefits. A number of the options provide benefits across policy priorities. They include the following:
    - Strengthening crop and land management practices, particularly on-farm soil and water conservation, for structure and stability and also contributing to better soil carbon content
    - Improving access to reliable water on farm and climate-smart irrigation schemes
    - Improving access to feed (pastures, fodder development) and helping feed conversion to increase livestock resilience, reduce GHG emissions, and increase herd-level productivity (thus reducing GHG emissions per unit livestock products). Improving animal health services, housing, and good animal husbandry are key complements to this
    - On-farm integrated livestock, crop, and agroforestry systems, integrated water resources, and watershed management are key for more stable land and steadier water flows, as well as building soil and biomass carbon
    - Quality and variety of seeds and breeds will be important for adapting to changing climate but also for improved productivity.

- Agroforestry interventions focusing on integrated systems and livestock for hills and mountains systems are particularly important for livelihood improvements of marginal smallholders and for the most vulnerable groups, including women hill farmers, with diversification, mechanization, social protection, and employment opportunities. For women and more marginal groups, benefits

need to be both short- and long-term, and specific mechanisms are needed for them to access services such as extension, information, and finance.
- Strengthening value chains (access to markets, opportunities for storage and processing for value addition) are important to all systems to provide timely and climate-smart inputs so that farmers can benefit from value addition and markets, with the private sector playing a key role.
- To implement the above CSA practices and options, access to information is critical. This includes weather forecasts, capacity building and capacitated extension services, and interlinkages among agencies to deliver support, as well as enabling factors such as access to farm inputs and finance.

5.1 Prioritization of Suitable CSA Technologies and Practices

CSA options were identified, reviewed, and long listed based on their importance for different agriculture systems and zones. Nepal has benefited from a considerable number of initiatives, studies, and projects to identify adaptation and resilience responses to climate change in the agriculture sector. CSA options, which include mainly on-farm and some value chain technologies and practices, were long listed based on learning from past projects for crops, livestock, and aquaculture for mountain, hills, and the Terai regions (see WP 4 for analysis and WP 5 for long lists of options and examples).

To identify and prioritize relevant CSA options, criteria covering the core dimensions of CSA were applied. These qualitative and quantitative criteria address the core principles of CSA, are aligned with policies (see section 1), and were refined during the study with stakeholders. They encompass the priorities for farmers who have adopted CSA to address society, national policies, and global issues (box 2, and detailed in WP 5). For example, farm production, income generation, livelihood, adaptation, and resilience are important for the adopters of CSA technology. For society, gender and social inclusion and environmental effects are included. Import substitution of agricultural products is taken for the national interest, whereas emission reductions are considered for the global interest. The alignment and synergies of options in contributing to the span of national policies and local needs and priorities is examined further in section 5.2.

CSA options span a range of practices suitable to different crops and livestock systems in different agroecological zones. The identified CSA options are summarized in table 9 (drawing from more detailed lists examined in WP 5). These were also confirmed through common priorities identified in the four provincial study consultations, summarized in table 8. In their simplified form, these indicate their importance for alternative provinces and agricultural zones. These options reflect the importance of addressing key expected climate change impacts on different systems, as discussed in the previous section. Using a simple semiquantitative summing of importance across various policy criteria, the highlighted technologies and practices in table 9 demonstrate the priorities that involve strengthening land use and land cover improvement, especially with tree-based systems, use of on-farm systems for soil fertility, and integration between on-farm systems and using green and efficient technologies. Some key observations on these options are as follows:

- **Strengthening crop, land, and water management practices.** All major agricultural systems include elements of strengthening on-farm **soil and water management** practices. For livestock this includes pasture management. For **cereal and vegetable crops** there are a number of practices indicated that disturb the soil less and add structure and stability, which

also contributes **to better soil carbon** content, including **intercropping and managing sloping land,** supporting **ecosystems resilience.**

- **Improving access to reliable water on-farm and irrigation schemes.** For crops and horticulture, water plays a central role both in better use on farm and in accessing additional resources through reliable supply from climate-resilient off-farm irrigation systems. This is important for boosting production but also for evening out increased variability and possible declines in water due to climate change and it reduces damage from shocks, especially drought. Water supply to irrigation depends on water flows and watershed conditions and on acceleration of glacial melt.
- **Enhancing livestock resilience and mitigation.** In addition to pasture management for more reliable feeds, drought-resistant and -tolerant fodder help to improve feed conversion, reduce GHG emissions, and increase herd-level productivity. Improving animal health services and good animal husbandry practices and breed development not only increase productivity but also enhance resistance to tropical disease and increase feed conversion and heat tolerance, also important for resilience and reducing emissions.
- **Strengthening on-farm integrated livestock, crop, and agroforestry systems.** These help to preserve and maximize the benefits of on-farm soil, water, and nutrient resources for productivity and to reduce stress, but they also provide a range of sources of food and income to farm households.
- **Climate-resilient seeds and breeds.** All systems also indicate the need to ensure good quality inputs, particularly in the form of seeds or breeds, to ensure good production but also provide varieties and stress-tolerant types that are suitable to changed climatic conditions.

Clearly CSA priority practices are options that can contribute to more than one aim, such as integrated farming supporting production, resilience, and inclusion and GHG emission mitigation aspects. These synergies are explored further in section 5.2 under Contribution to Different Policy Aims (and see figure 8 below). Nevertheless, balancing different goals should be considered, such as increasing production and value chain activities with practices and technologies to increase efficiency and reduce emissions. For smallholders, reducing GHG emissions will be a low priority without appropriate incentives. This highlights the importance of coordinated analysis of local needs, prioritizing, and planning.

Box 2. **Criteria to Identify, Screen, and Prioritize CSA Options**

Note: * indicates that quantitative estimates have been examined.

- Production and productivity may include various combinations of the following:
  - o increased yields*
  - o increased overall production*
  - o national food security
  - o nutrition and local food security
- Commercialisation and competitiveness - economic benefits from agriculture:
  - o Greater efficiencies result in greater farm profits*, with profitability and incomes
  - o More value addition, diversification, and employment

- o Import substitution
- o Contribution to agriculture GDP

- Resilience and adaptation:
  - o Addresses long-term climate change trends, new climatic conditions (alternate crops, varieties, breeds, and practices)
  - o Help to address shocks and extreme events and uncertainty associated with climate change but also with ongoing climate risks
  - o Resilience to respond to multiple shocks, including non-climate related
- Inclusion and reduce inequality:
  - o Livelihood stability and opportunities
  - o Small-scale farmers' income benefits
  - o Benefits for women, marginalized, and poorer groups*, youth, and the most vulnerable
- Environment:
  - o Sustainability and reduced environmental impact
  - o More efficient and less wasteful use of inputs
  - o Increased (agro)biodiversity
- Mitigation (if any)
  - o Direct reduction in GHG emissions
  - o Increased efficiency in resources and inputs, reducing emissions per unit production*.

Value chain support for CSA. Table 9 (g) indicates the importance of value chain activities for all systems and throughout the value chain—from inputs of right types of quality seeds and breeds, to mechanization, better collection, and processing that, together with marketing, add value for farmers and for the private sector. There is a need to examine more in detail the type of linkages and relationships that will be important for strengthening key value chains in the context of climate change. Analytical work by FAO focuses on dairy value chains in mountains, ginger in the hills, and mango in the Terai in the Koshi River Basin. A number of important, specific value chain-related interventions with a particular private-sector role were identified through value chain stakeholder consultations, including the following:

- Agromet (digital) services tailored to crop or commodity (climate-risk management along the value chain)
- Planting material and seed commercialization (for resilience)
- Machines and equipment supply for production and postharvest management
- Stud breeding program (for resilience)
- Commercial livestock feed sector development (to address seasonal variability in supply and improve efficiency in resource use leading to overall resilience)
- Packhouses (managing weather and variability, postharvest storage)
- Market access to small-scale water management infrastructure (on-farm management of temperature extremes), such as solar pumps and micro-irrigation.

In the section on investment packages (section 6), further examples are provided of potential private sector- and value chain-opportunities for supporting CSA.

Table 8. **Prioritized Systems for Applying CSA Options by Province and Agroecological Zone**

Ranking through provincial consultations. Color code:

- cereals
- horticulture
- livestock and aquaculture
- integrated systems (cereal – livestock – horticulture/agroforestry combinations)

	Province 1	Province 2	Province 4 Gandaki	Province 6 - Karnali
Terai region	1. Cereal systems (rice, wheat) 2. Integrated Terai farming system 3. Dairy animals 4. Fisheries and aquaculture 5. Horticulture systems (litchi, banana, vegetables)	1. Cereal systems (rice, wheat) 2. Fisheries and aquaculture 3. Sugarcane 4. Integrated Terai farming system 5. Cattle/ buffalo	1. Cattle/buffalo 2. Cereals (rice, wheat) 3. Horticulture (banana, mango, vegetables) 4. Integrated Terai farming system 5. Aquaculture	Not applicable
Hill region	1. Integrated hill farming system 2. Horticulture systems (citrus, pear, peach, plum, avocado, Japanese persimmon, vegetables) 3. Fisheries and aquaculture 4. Cereal systems (rice, maize, millet, wheat) 5. Dairy animals	Not applicable	1. Integrated hill farming system 2. Horticulture (citrus, pear, peach, plum, avocado, Japanese persimmon, vegetables) 3. Small ruminants 4. Cereals (rice, maize, millets) 5. Cattle/buffalo	1. Integrated hill/ mountain farming 2. Horticulture (apple, walnut, pecan nut, olive, citrus, vegetables and vegetable seeds) 3. Dairy animals 4. Meat animals 5. Cereals (barley, wheat, buckwheat) 6. Agroforestry/NTFP/ MAPs
Mountain region	1. Cold-water aquaculture systems 2. Integrated, agroforestry, NTFPs/ MAPs systems 3. Horticulture systems (walnut, vegetable seeds) 4. Integrated mountain farming systems 5. Dairy animals	Not applicable	1. Horticulture (apple, walnut, vegetable seeds) 2. Small ruminants 3. Integrated mountain farming system 4. Cattle 5. Cereals (Barley, buckwheat)	

Table 9. Identified CSA options with relative importance.

Note: In tables 9a to 9g, green dots indicate a rating based on a mixed qualitative and semi-quantitative extent of benefits, drawing on expert inputs (blank = not significant, ● = low, ● ● ● = higher importance). Options in bold have the overall highest number of priority scores. It should be noted this is a semi-quantitative approach and local priorities will be context specific.

Colour coding of options is as follows:

Mainly water management/ irrigation related options, together with related crop management practice
Main focus on crop, land and soil management practice
Mainly varietal and breed improvements

a) Terai crop production system options	Province	6	4	2	1
Terai cereal systems with rice, wheat, pulses, winter maize, (with alternate cropping such as oilseeds) **Major climate impacts:** drought, flash flood and siltation of farmlands, cold waves in winter, hot waves in summer, and increased infestations of weeds, insects and diseases	Mountains	n.a.	n.a.	n.a.	n.a.
	Hills	n.a.	n.a.	n.a.	n.a.
	Terai	n.a.	● ●	● ● ●	● ●
Key climate-smart criteria	**Production**	**Resil-ience**	**Inclusion**	**Envi-ronment**	**Mitigation**
System of Rice Intensification (SRI) with alternative wet and dry irrigation system	●	●		●	● ●
Good irrigation practices for gravitational and pressurized irrigation (flow rates, schedule, evapotranspiration measurement, water balance assessment, and so on)	●	●		● ●	
Adaptation and strengthening of existing irrigation systems to new cropping methods and diversification; climate proofing	●	● ●			●
New irrigation systems (surface and groundwater) for expanding agriculture areas with reliable water sources	● ●	● ● ●	●	●	
Soil and irrigation management and flood prevention, combined with optimized fertilizer application	●	● ●	●	● ●	● ●
Laser land-leveling to increase water-use efficiency and reduce weed infestations	●	●		● ●	
Relay cropping of pulses and oilseeds in rice fields for catching residual moisture	●	● ●		●	
Zero tillage of wheat and direct sowing of rice to reduce fuel consumption and costs of production; System of Wheat Intensification (SWI)	●	● ●		●	●
Land pooling and terrace improvement for efficient mechanization	●	●	● ●		●
Precision use of chemical fertilizers and management of farmyard manure, green manures, and crop residues for mulching	●	●	●	● ●	● ●
Promotion of boro (winter) rice and winter maize	●	●			
Drought and flood tolerant varieties of crops to increase resilience		● ●	●		
Varietal improvement of niche products such as linseed, mustard, soybean, and aromatic rice	●	●			

b) Hill and mountain crop production system options	Province	6	4	2	1
Hill crop systems comprise maize, rice, wheat, millet, pulses, and oilseeds **Mountain cropping system** include maize/ potato-barley and buckwheat **Major climate impacts:** drought, flash flood, soil erosion and landslides, hailstones, wind, and increased incidence of diseases and pests	Mountains	●●●	●	n.a	●
	Hills	●●●	●●●	●	●●●
	Terai	n.a			

Key climate-smart criteria	Production	Resil-ience	Inclusion	Envi-ronment	Mitigation
SRI in river basin lowlands	●	●		●	●●
Good irrigation practices for gravitational and pressurized irrigation (flow rates, schedule, ET measurement, water balancing, and so on)	●	●		●●	
Strengthened and new irrigation facilities through rainwater and snow harvesting, drip irrigation, and solar-based lift irrigation	●	●●	●	●	●
Soil and irrigation management through increased soil organic matters	●	●	●	●●	
Laser land-leveling in terraced areas to reduce soil erosion	●	●	●	●●	●
Sloping agriculture land technology (SALT) with integrating cereal crops	●	●●	●	●	●●
Cover crop plantation, legume integration in maize crop, strip crop plantation using shade-loving plants such as ginger and turmeric in maize field	●	●	●	●	●
Mulching to reduce evapotranspiration and weed infestations	●	●		●●	●
Protection from flash floods and soil erosion through bioengineering and transplantation of tree saplings and forage plants, and protecting stream banks through gabion wire, check dam, plantation	●	●●●		●●	●
Drought-tolerant varieties of crops and deep-rooted crop species to increase resilience	●	●●	●		

c) Commercial horticulture system options (all zones)	Province	6	4	2	1
The **horticulture systems** include fruits based on climatic conditions; vegetables are based on market access. **Terai:** mango, banana, litchi, papaya, pineapple, potato, watermelon, and vegetables **Hills:** citrus fruits (sweet orange, mandarin orange, lime), plum, peach, pears, persimmon, avocado, butter tree, potato and vegetables (cole crops and various) **Mountains:** apple, walnut, apricot and potato, and seed potato. **Major climate impacts:** shifting production zones, irregular rainfall/snowfall, prolonged drought, wind, and heavy downpours and hailstorms; flowering and fruiting seasons are changed in many fruits	Mountains	●●	●	n.a	●
	Hills	●●●	●●●	●	●●●
	Terai	n.a	●●	●●●	●●●

Key climate-smart criteria	Production	Resil-ience	Inclusion	Envi-ronment	Mitigation
Establishment and maintenance of energy-smart and water-efficient irrigation systems such as solar lift irrigation, zero energy Barsha pump, electric pump, or gravity flow	●●	●●	●	●	●
Rainwater and snow harvesting/conservation ponds, wastewater collection, eyebrow pit, climate-smart irrigation canals, multiple water-use system, and furrow- and drip- irrigated beds	●●	●●	●●	●	
Precision and protected horticulture (green house /poly tunnel)	●●	●			
Nurseries for production of quality (disease free, high vigor, high yielding, climate tolerant) grafted fruit saplings (use of quality rootstock) and tissue culture labs	●	●			●
Suitable seeds and inputs for vegetable varieties to changing climate and soil conditions, with high quality and market demand	●●	●●	●●		
Postharvest and value chain options will be important; see also table 9(g) below	●●	●●	●	●	●

d) Agroforestry, NTFPs and MAPs system options (all zones)	Province	6	4	2	1
The integrated systems include multipurpose agroforestry trees, NTFPs, and MAPs. The multipurpose trees include fodder and fruit trees, trees useful for spices, and vegetables (such as moringa). Other plants include medicinal plants, aromatic plants, vegetable oils and butter plants, natural fibers, spices, and bamboo. **Major climate impacts:** water shortage to regenerate and grow, replacement by invasive alien plants, increased insect pests and diseases and increased soil erosion reducing habitats. Also postharvest losses due to shocks.	Mountains	●	●	n.a.	●
	Hills	●●●	●●●	●●	●●●
	Terai	n.a.	●	●●	●●

Key climate-smart criteria	Production	Resil-ience	Inclusion	Envi-ronment	Mitigation
Development of package of production/ agronomic techniques for supporting uptake of integrated agroforestry practices and enhancing NTFPs sources	●●	●●	●●	●●	●●●
Seed production and nursery raising	●●	●	●	●	
Establishment of high-tech nurseries with irrigation facility, snow/rainwater harvesting, conservation/recharge ponds, drip/sprinkler irrigation, and solar-based water uplifting	●●	●●			●

e) Livestock production system options (all zones)	Province	6	4	2	1
The livestock systems include the following: Terai: cattle, buffalo, chicken, and duck Hill: cattle, buffalo, goat, and chicken as backyard poultry; pig is important in hills of Province 1 Mountains: cattle, yak, chauri, chyangra goat, and sheep **Major climate impacts:** heat stress, cold stress, drying of water ponds and water sources and degradation of pasturelands; shortage of fodder and increased diseases and parasites	Mountains	●●	●	n.a	●●
	Hills	●●●	●●●	●	●●●
	Terai	n.a	●●	●●●	●●●

Key climate-smart criteria	Production	Resil-ience	Inclusion	Envi-ronment	Mitigation
Improving feed management# via increased production, conservation, and storage of fodder crops (for example, through drought-tolerant fodder cultivation and agroforestry) and dietary technologies for reducing enteric fermentation	●●	●●	●	●●●	●
Improving pasturelands through seeding, improved varieties, water management, and rotational grazing	●	●●	●●	●●	●●
Shifting to total or partial stall feeding# through fodder, hay, and silage production to improve manure and soil-nutrient management and biogas production	●●	●	●	●●	●●
Improving animal housing to protect them from hot and cold waves and heat from direct sunlight	●	●●			
Increasing herd-level productivity# through herd health management while reducing number of animals, and reducing risks of diseases and mortality and increasing resilience	●●	●●●	●●		●●
Breeding to increase productivity while retaining climate-resilient traits such as resistance to disease and tolerance to heat	●	●●	●		

Increased production may mean increased number of animals, but better productivity and efficiency, also in value chain, would mean reduced emissions per unit animal production.

f) Aquaculture production system options	Province	6	4	2	1
Fisheries and Aquaculture Systems consist of Terai river and lake capture fisheries and pond aquaculture Hill river and lake capture fisheries Hill cold-water rainbow trout culture **Major climate impacts:** drying of water bodies, rising water temperature, and increased fish diseases; risk of flooding and siltation	Mountains		●		●
	Hills	●	●		●
	Terai		●	●●●	●●

Key climate-smart criteria	Production	Resil-ience	Inclusion	Envi-ronment	Mitigation
Fish breeding and supply of fish fry and fingerlings (carp, pangas, tilapia, rainbow trout) by high-tech hatchery and improvement of fish feed production technologies	●●	●			
Improvement of ponds and lakes, water supply, water quality enhancement through pond/lake cleaning and their aeration	●●	●	●	●	●
Development of climate-resilient fish ponds and protection of ponds and lakes from flood and siltation	●	●●	●	●	
Development of fish production package for indigenous fish breeds such as Himalayan trout	●	●		●	

g) Value chain inputs and postharvest processing and marketing. ✓ marks activities with significant additional private-sector potential involvement. Practically all activities already have some private-sector involvement.	**Terai cereal crops**	**Hill cereal crops**	**Horti-culture (fruit and veg)**	**NTFP & MAPs**	**Live-stock**	**Aqua-culture**
Inputs: seeds, fertilizers, feed, saplings, livestock breeds, fingerlings	●●✓	●●✓	●●✓	●●✓	●●✓	●●✓
Mechanization on farm (planting, harvesting) and land management, equipment for irrigation and livestock production	●●✓	●●✓	●✓	●✓	●✓	
Postharvest processing (cleaning, drying, milling, grading, essential oil extraction, chilling, freezing)	●●✓	●●✓	●●●✓	●●✓	●✓	●✓
Storage, collection centers, and logistics (such as energy-efficient cooling facilities and logistics)	●	●●	●●✓	●●✓	●●	●●✓
Marketing and information	●	●	●●✓	●●✓	●✓	●✓
Transportation	●✓	●●✓	●●✓	●	●✓	●●✓

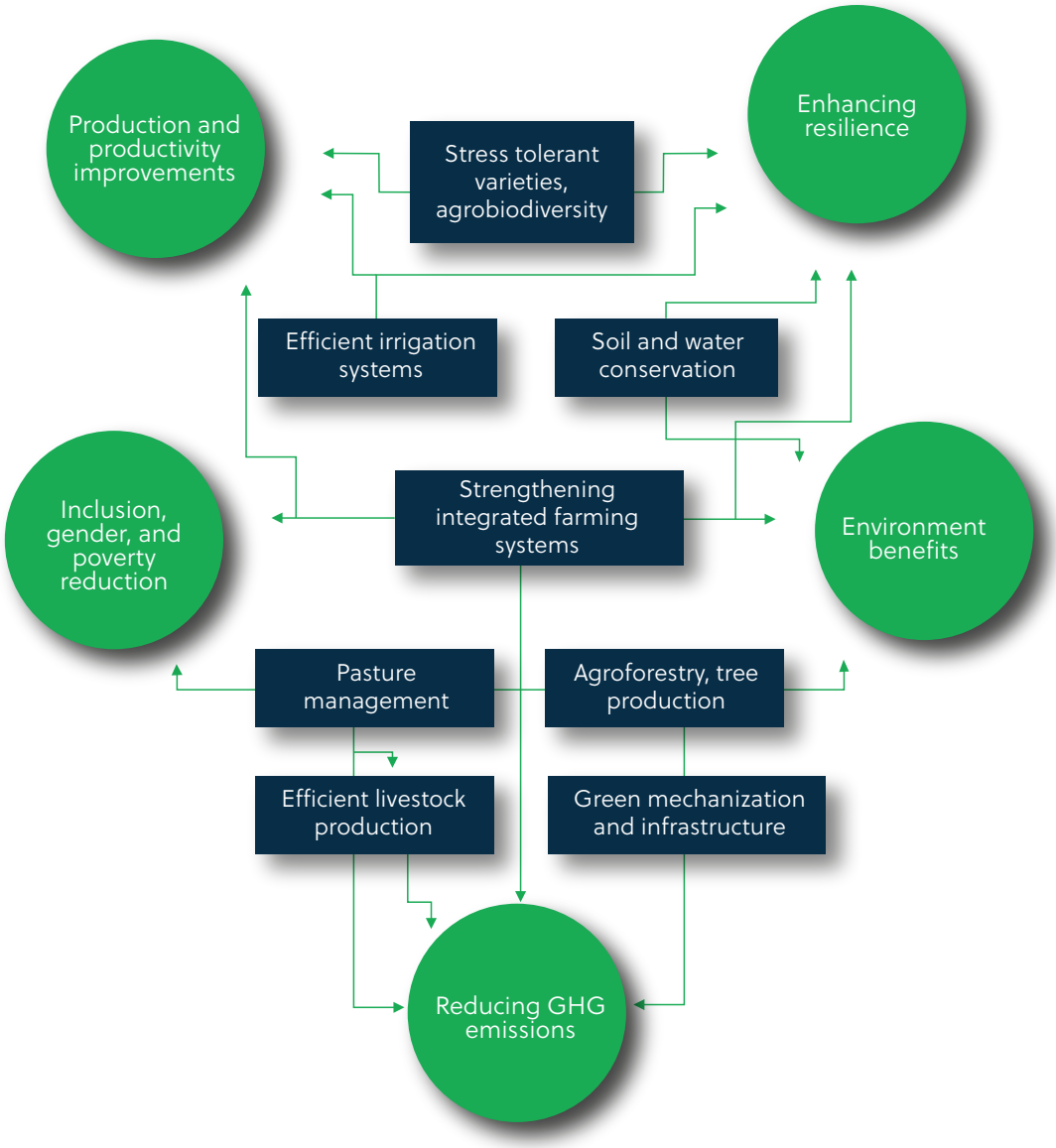
5.2 Contribution of CSA Options to Policy Goals

Two important elements are required to implement CSA options at scale and in relation to local priorities: aligning with relevant policy and local priorities and ensuring that the necessary enabling environment and capacities are in place to support the adoption of prioritized options.

Combinations of options for addressing multiple policy aims. This section examines the contribution of different technical and practical options identified from experience and pilots (see table 9a–9g above) toward addressing key policy and local priorities in relation to CSA (production, resilience, mitigation) and related development aims (inclusion and environment) that the federal and subnational governments and other stakeholders may want addressed (see section 1.3). The analysis of the options below indicates that they comprehensively address policy priorities, which can have major agriculture and rural benefits for Nepal. Production increases also address the multiple aims of fostering direct economic benefits, commercialization, value chain development, and overall agricultural growth and food security (see figure 8). Strengthening integrated farming systems has multiple benefits, especially for more vulnerable farmers and households, contributing to diversified diets and incomes and increasing resilience and sustainability on livelihoods and ecosystem levels. The cumulative benefits will depend ultimately on the choices made in relation to selection of investments that incorporate these options, as they are planned and implemented at a more local level.

Crosscutting support mechanisms are required for enabling investments in CSA. While the summary tables above focus on technologies and practices directly affecting production, long-listed practices and options in the literature and from stakeholder consultations also recognized that a wider range of support is required, often cutting across different subsectors. This includes access to information on practices, capacities, and interlinkages among agencies to deliver support and system requirements such as irrigation and a range of critical production and value chain inputs, especially fertilizer, finance, weather forecasts, extension services, and agricultural research. Other services that also may play an important role, not confined to the agriculture sector alone, are access roads for remote areas, flood and landslide control, water supply, improved communications services, early warning systems, and the wider private-sector environment.

Figure 8. Key Synergies Between CSA Options in Addressing Policy Priorities .

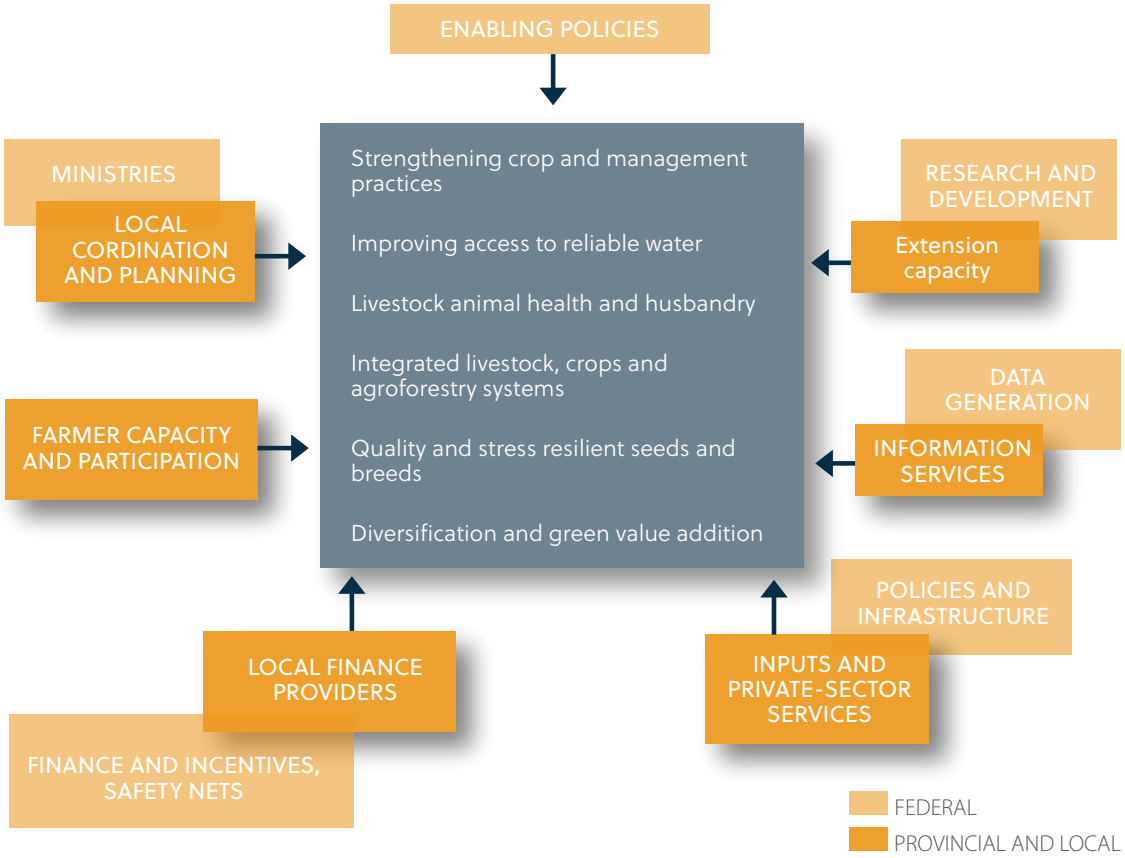


Source: Original material

The review below of how CSA options contribute to policy and local CSA and development goals highlighted how these crosscutting support mechanisms require a wider enabling environment, from federal to local levels, to ensure that investments can be appropriately scaled with services and resources. Key enabling mechanisms include coordinated planning, capacity building, supportive policies, and financing mechanisms (see figure 9). This combination of enabling mechanisms, at both the national and provincial levels, form an integral part of investment packages that support the implementation of CSA technologies and other activities (see section 6).

Quantifying benefits in relation to number of farmers is at present based on estimates of rural households from national data and investment scoping in section 6, including consideration of broad degrees of adoption of practices.

Figure 9. Overview of Crosscutting Support and Enabling Environments Required for Ensuring Successful Implementation of CSA Options at the National and Local Levels



Source: Original material

Production

Policy context: Because the majority of Nepal's population still depends to a large degree on agriculture for their food security, livelihoods, and economies of their communities, a fundamental element for their resilience and adaptation to climate change is their ability to grow and maintain strong and sustainable agriculture production. Increasing agriculture, livestock, and fisheries production is a major development aim in Nepal, touching on a number of key policy priorities (see section 1.3, table 1), especially in the ADS (such as **increasing productivity** by 50 percent and **surplus food grain production** over 10 years, with **potential for import substitution),** but also for SDG 2 targets on **malnutrition and poverty reduction.** Increasing productivity helps to boost **farmers' incomes,** generate more **economic activity,** create **opportunities for a value addition,** and enhanced **employment** prospects in rural areas. Sustainable and carefully considered approaches to increasing productivity with greater efficiency and less waste means that scarce resources can be used more effectively, also reducing environmental pressures (see section below on Environmental Considerations). Some of the priority options that particularly boost production and productivity are expected to be in the following subsectors:

Staples. Increasing yields, especially from cereals such as rice and maize, in the Terai and in the hills, requires a range of better land-management practices, especially strengthening irrigation systems and timely and judicious use of fertilizer. The cereal staples play a key role in national food security; boosting their production and stable supplies would also help address import substitution.

Information in the form of weather and farm advisory will be key, both for improving production practices and being more responsive to climatic events and changes. Some promising systems are shown in box 3.

Horticulture and agroforestry. Increasing horticultural production, both vegetables and fruits and agroforestry, helps to increase household dietary diversity but is also critical in providing opportunities for diversification of agriculture livelihood activities, especially where there are profit advantages, such as in the hills for off-season products. Again, CSA interventions with smarter irrigation systems, using more integrated systems to maximize farm and other local resources, and opportunities for farmers to readily access inputs are important complements (such as high-quality seeds and appropriate varieties, seedlings and trees from nurseries, small-scale machinery, and access to markets). Demand-oriented extension covering value chain aspects and private-sector support and linkages, together with appropriate finance, are especially important here.

Benefits from CSA options uptake. Financial returns resulting from increased production and productivity arising from adoption of various CSA practices are described below in section 5.3, and aggregate economic benefits are described under respective investment packages in section 6. With 20–50 percent increases in yield using the selected CSA options on various key crops supported under the investment packages, around 5–10 percent increases in overall production could be foreseen per year in the study provinces (depending on the rates of adoption).

Box 3. **Direct-Seeded Rice and SRI in Nepal, Supporting Production and Resilience**

Direct seeded rice

Delay in rainfall is affecting rice seedling raising, which affects timely rice transplantation. The delayed rainfall causes farmers to transplant 30–35 days or even older rice seedlings, which reduces productivity. Moreover, transplanting rice manually is a drudgery for women. Direct-seeded rice sown either in dry soils (dry-DSR) or pregerminated seeds sown in puddled and leveled soil (wet-DSR) help to solve these problems. The average yield of Sukha Dhan-3 rice in Siraha district was recorded to be 4.86 tons/ha under wet-DSR technology and 4.25 tons/ha under dry-DSR technology, which is higher than the rice yield under conventional planting in the area.

Source: GEF/LDCF Project, Nepal 2015–19.

SRI and experience in Nepal

The SRI is a set of management practices whose principles today have spread to more than 50 countries of Asia, Africa, and Latin America. The principles of SRI promise climate co-benefits and increased production with reduced input and water use, leading to higher farm incomes. SRI presents a shift in focusing on agronomy practices and less on input focus. SRI is based on the principle of developing healthy, large and deep root systems that can better resist drought, waterlogging, and wind damage. SRI plants develop stronger stalks and more tillers, with higher yields and even better flavor qualities, and it enhances tolerance to abiotic (drought, heat waves, cold snaps, winds) and biotic (pest and diseases) stresses, with reduced methane emissions.

The emphasis on agronomic practices is also its key challenge because agronomic changes are much more location specific and much more knowledge and management intensive, making them more difficult to prescribe. SRI needs to be linked with strengthening of advisory services and with farmer training programs, supporting farmers' own innovation in adapting and adopting SRI, often on part of their land, as has been shown in Nepal (Uprety 2016). Nevertheless, large 50-percent yield benefits

have been noted, and its adoption has spread rapidly among smallholder farmers, for example in India, who can use family labor and especially where there are strong FFS systems and networks that facilitate peer-to-peer learning between farmers.

The first SRI trials in Nepal were undertaken in 1998. An assessment of a 15-village program in 2005, where over 100 farmers participated in SRI FFSs, showed 40–50 percent yield increases, 75 percent reduction in seed requirements, and 50–75 percent reduction in water use, as well as reduced labor for transplanting and irrigation. However, the cost of weeding was 50–60 percent more. Trials were also successful in higher altitudes. A similar SWI, an adaptation of SRI principles to wheat, has shown average grain yield increased by 91 to 100 percent compared with traditional practice. Experiences in the Kailali district of far western Nepal pointed to successful adaptation and adoption of SRI with support of mechanized SRI (which also facilitates weeding) and had positive impacts in Sunsari and Morang districts. By the end of 2016, SRI had been promoted in 35 districts through Nepal's Mega Rice Production Program (MRPP). The MRPP emphasizes wider spacing of plants, line transplanting, and mechanical weed management, integrating SRI principles into the conventional rice production system. SRI has also been recommended for use in new Terai irrigation project areas.

Summary information on Nepal: Nepal Profile, SRI International Network and Resources Center, Cornell University, http://sri.ciifad.cornell.edu/countries/nepal/index.html.

Source: Rajendra Uprety, 2016, "Agricultural Intensification in Nepal, with Particular Reference to Systems of Rice Intensification," PhD thesis, Wageningen University, Netherlands.

Livestock. As most agriculture households incorporate livestock (mainly cattle, buffalo, goats, and backyard poultry), these form a central element of household assets, both as sources of animal proteins and in generating smallholder income from sales of meat and surplus milk in the dairy chain. Key climate-smart livestock interventions to support productivity are in strengthening sources of feed, appropriate breeds (balanced with the need for more stress-tolerant breeds for resilience), and animal health services, supported by appropriate animal husbandry and veterinary services. Animal shelters are of importance for a number of reasons (box 4).

Box 4. Animal sheds

Shelter plays a major role to protect animals from adverse climatic conditions. Animal shed establishment should consider appropriate location, proper space and ventilation, face a suitable direction according to the agroecological zone, use suitable construction materials, and be at a proper distance from the dwelling house. Such sheds protect livestock from climate risks, enhance production and productivity, and reduce drudgeries in handling feed and collecting animal dung, reducing methane emissions, and opening possibilities of biogas production. Sheds are also a key part of reducing free grazing and increasing agroforestry-based fodder production, which have high environmental and GHG emissions mitigation impacts.

Source: GEF/LDCF Project, Nepal 2015–19, and original material.

Other critical support required to facilitate the above production and productivity improvements are linkages to timely quality inputs, well-designed and -managed irrigation schemes, and private-sector postharvest collection and processing to add value and generate further market demand. Given the increasing land fragmentation, it is also important that farming communities can maximize the use of available land.

Resilience

Policy context. The need for resilience and adaptation is widely recognized in policy, by the National Planning Commission (NPC), in the NAP process, and in the ADS, in relation to resilient practices and local adaptation planning processes. The need for resilient livelihoods and agricultural systems has gained in importance in policy debate in light of the COVID-19 pandemic and recovery efforts. Considering climate change projections, all crops, livestock, agroforestry, and fisheries systems, in almost all parts of the country, need to have strengthened resilience and adaptation. A number of these practices and interventions are particularly important to **implement in an integrated manner,** at the farm and landscape level, as they helped build overall **ecosystem resilience,** where the soil, water, crop, and agroforestry systems complement each other to **enhance and preserve essential resources,** and so **buffer against shocks and changes.** Some resilience measures are important for addressing a wider range of non-climatic shocks.

Farm-level resilience. Key elements to build resilience to climate change are better water capture and storage, as well as judicious and efficient use of water to maximize available resources in the face of likely future reductions, and the use of cover crops and integrated crop and agroforestry practices. Expected concurrent heavier precipitation events will require improved retaining and restoring soil properties through soil cover and integrated systems to help protect from local erosion, especially on sloping farmlands. These interventions also maximize soil water storage and contribute to the buildup of aquifers in the face of increased periods of water scarcity.

Measuring resilience is not a straightforward concept. A key feature of a resilient system is adaptive capacity, including the knowledge, capacity, and access to resources to adopt CSA and resilience-building practices that reduce risks and actual effects from climate shocks and trends.

Benefits on number of smallholder households taking up CSA: On a very broad level, there are about two million smallholder farmer households in the study areas, of whom a large proportion will be exposed to a range of increased climate risks. With a 10–50 percent adoption rate of practices, 700,000 to one million farmer households could be expected to have some form of CSA practices in place on their farms.

Watershed and landscape resilience. The above farm-level measures will be cumulatively important for protecting watersheds to stabilize hydrological flows, develop more predictable water supplies, and protect against damage from increasing landslides and floods. Good pasture management for livestock is also important. Forests play a central role for resilient watersheds and landscapes, and CSA might help reduce deforestation by making agroforestry and tree-based horticulture more attractive and reducing pressures of forest margins.[7]

For irrigation and water systems, particular measures for resilience are climate-proofing infrastructure, which could feature a superstructure or an elevated platform to withstand the impact of high wind,

[7] See, for example, the new initiative on addressing forests in Nepal, "Nepal and World Bank Sign Innovative Financing Agreement on Forests and Climate Change for Building Back Greener," February 26, 2021, https://www.worldbank.org/en/news/press-release/2021/02/26/nepal-and-world-bank-sign-innovative-financing-agreement-on-forests-and-climate-change-for-building-back-greener.

heavy precipitation, floods, increased sedimentation, landslides, and headwater storage systems, and including drains for increased surface runoff from extreme precipitation and flooding. This should be complemented by supporting farmers with a range of community and on-farm water harvesting and microirrigation systems. Consequently, farmers have access to water throughout the cropping cycle and for a range of other purposes. The climate-resilient irrigation schemes should be energy efficient, thus contributing to climate mitigation.

For resilience of livestock, improving shelters, good general animal husbandry practices, and better feeds will lead to healthier stock, which is critical for their capacity to deal with stressors such as increased heat, cold, humidity, or other unpredictable severe climate events and variability.

Number of livestock keepers benefiting from CSA: Over half a million livestock farm keepers, who are mainly women, could be expected to adopt some climate-smart livestock practice.

More stress-tolerant crop varieties and livestock breeds accessible to farmers will be critical measures to increase resilience, especially to deal with heat stress, reduced water availability, or submergence from flooding.

Supporting on-farm diversity and flexibility and safety nets. It is important that the local agriculture system provides enough diversity, stability, and income for members of the household to deal with a range of shocks and have enough buffer to deal with production losses from time to time. Integrated systems have long been part of traditional farming systems, although pressures of migration have reduced their effectiveness, and the opportunities of these systems to diversify incomes is only beginning. This requires that irrigation systems can be well-controlled and are flexible to various crop options; it also requires that farmers have access to advice on various systems and support for

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productive diversification, linkages to markets, inputs, and finance, and ability to make such choices. Also necessary are accessibility to financial systems to be able to address shocks and build resilience and recovery through improved disaster insurance and social protection. Building employable skills at the household level also helps to diversify sources of income. These are especially important to the vulnerable poor (discussed under inclusion below) to address a range of stresses and shocks. Supports such as social protection and employment have been shown during the COVID-19 pandemic to be of critical importance.

Systemic and value chain resilience. A number of options are identified above under section 5.1 for supporting resilience in value chains, including robust storage systems, climate-proofed infrastructure, and the ability to process vulnerable products more quickly. In addition, developing real-time information on and flexibility in logistics and transport systems helps to get products to the market in times of crisis. Inadequate storage information and logistics were also shown to be critical bottlenecks during the COVID-19 crisis. Proposed interventions to strengthen the sector's resilience from the non-climate shocks such as the COVID-19 pandemic will also have to focus on institutional and technical capacity weaknesses (coordination, preparedness, access to data, operational capacity).

Coordinated planning and implementation and emergency response mechanisms. It is crucial that local level-resilience and adaptation support is planned to align with farmers' and community needs. Here there is an opportunity to learn and build on CSV and scale up local adaptation planning experiences (see section 7). As is also the case for environment aims outlined below, this support will need to incorporate coordinated land and watershed planning and management and stronger links between agencies for effective implementation. The need is clear, from the Nepalese experience of numerous climate shocks, COVID-19, and other non-climatic events and their responses, to put in

place effective multipurpose early warning systems, mechanisms for planning emergency responses by local governments, information systems for input and markets under crisis situations, and support for access to different types of federal support.

Inclusion

Policy context. Local and national stakeholder consultation indicated **that inclusion of smallholder farmers, women, and youth in CSA and of vulnerable groups in climate change prone areas** is a high priority. Nepal has a high percentage of smallholder farmers in all areas of the country, with 2.7 million smallholder farms making up 70 percent of the food produced. Only about one-fifth of those farms use improved seed varieties. Other factors include a major **feminization of agriculture** in Nepal, especially in the hills, in **vulnerable groups in the mountain**s, and among a significant group of **agricultural laborers** and migrants in the Terai. Their priorities and needs are clearly reflected in the country's SDGs, the ADS, and the emphasis on gender equality and social inclusion in the NDCs and NAP process.

Agriculture production and livelihoods of smallholders. There was an emphasis on production and productivity improvements of key crops and livestock in the CSAIP stakeholder consultations because they are highly important to smallholder and poorer farmers, including women farmers. Boosting diverse production systems helps to generate income, diversify livelihood opportunities, and improve food security and dietary nutrition at the household level. Building up livelihood opportunities and assets is also fundamental to building household resilience. As prioritized a number of times in provincial consultations, support to the integrated farming systems typical of Nepal is especially important for resilience and production. In the study areas, 20–25 percent are poor, mainly rural farming households with higher rates of 30–40 percent in the mountains.

Women farmers are taking on most agriculture activities, especially when male household members are working elsewhere. The lack of services or resources to do so effectively is a major burden to them and a hindrance to the development of the agricultural sector. Suitable extension needs to be provided and adjusted to the needs of women farmers. Female farmer champions should be identified and

Box 5. Yak Cheese Value Chain

Low milk-producing yak is crossbred with hill cattle to produce chauri. The small-sized alpine dweller chauri is a high milk-producing animal; the milk is traditionally processed into fermented milk and then churned to produce yak butter and buttermilk. The buttermilk is further processed into a cottage cheese-type product that, after prepressing and drying, becomes Chhurpi, a hard cheese that is nonperishable and can be transported to cities for human consumption and export to Western countries as dog food. Reduction of the transhumance system of herding is decreasing yak populations, leading to fear of loss of a hardy, cold-resistant genetic resource highly needed for CSA in high mountain areas.

Source: T. B. Thapa, (n.d.), "Diversification in Processing and Marketing of Yak Milk-Based Products," DSP/National Dairy Development Board, Kathmandu, Nepal

http://agtr.ilri.cgiar.org/sites/all/files/library/docs/yakpro/SessionG2.htm.

Box 6. Linking Social Protection and Resilience Against Shocks

Social protection enables individuals and households to make investments necessary to enhance their productivity and develop an income strategy that will increase their adaptive capacity to covariate shocks, such as adverse climate events, and build their capabilities. As has been done in India with the national rural employment scheme, synergies could be made with existing social protection programs such as the Prime Minister's Employment Program that was initiated in 2019 to create job opportunities for Nepali youth and reduce their dependence on jobs abroad.

Social protection schemes can be linked to early warning systems to provide temporary employment and income support to disaster-affected households, while creating community assets. Studies have shown that investment in early warning and adaptive safety net programs can form an integral component of climate-risk management strategies and has led to resource savings in the medium to long term and secured resilient livelihoods.

empowered so they can lead and influence other farmers to adopt new approaches, techniques, and varieties. This support needs to be matched with consideration to their lack of land ownership and decision-making and their access to appropriate finance. An especially important area to reduce the burden of farming for women is appropriate mechanization to help them better manage their farms for increased productivity and resilient agricultural practices. Women also play a major role in animal husbandry, thus inputs, extension, and veterinary services need to be tailored and accessible to their needs.

Benefit on number of vulnerable households taking up CSA: Approximately 0.5 million farm households, who are especially poor and vulnerable—close to three million people—would be the priority targets groups for investments. With the high percentage of **women farmers,** establishment of improved extension and other services mechanisms under investments in support of CSA, would specifically consider how to scale up to better support over 0.5 million women farmers in the study areas.

The most vulnerable food-insecure farmers and communities to be affected by climate change are in often remote, marginal agricultural areas. These groups depend on their local agriculture and natural resources to a very large extent also for nutrition, but similarly they are highly exposed to climate shocks, either cut off in remote valleys by landslides, by floods in shifting floodplain areas, or by droughts. This means that they can be severely affected by **stunting or wasting** under these frequent intense shocks or prolonged events with chronic food insecurity. At the same time, such communities are often also guardians of important watersheds, using and managing forest margin resources and pastures, and are stewards of important agrobiodiversity and located close to significant natural protected areas. Social protection may play an important role for the poorest in protecting against a range of shocks (see below and box 5).

Employment and youth. While migration and remittances have provided major opportunities for and contributions to poverty reduction in the country, for the poorest and for landless laborers in areas such as the Terai, most opportunities are low-wage work. These rural wage laborers have been some of the hardest hit by COVID-19 in relation to increased food prices. The pressure of returning migrants

has also further added to the critical necessity of employment generation. In agriculture and rural areas employment must come largely from expanding production but also through value addition and related agribusiness development. As in many South Asian countries, more commercialized and skilled agriculture activities, focusing on the green economy, mechanization, and more innovative technologies may also help attract youth. This can also create opportunities for boosting local rural economies.

Livelihoods strengthening access to services and markets. Complementing production, diversification unemployment, agriculture households livelihoods' stability to shocks and potential for growth depends on poorer farm households' access to employment (see above) and value chain opportunities. This also requires increased development and support to smallholder and women farmers' organizations and special efforts to facilitate links with private-sector organizations, especially for horticulture, livestock, and agroforestry, where there is interest in and opportunity for developing local processing, generating jobs, and building skills. Special efforts should be made to develop increased recognition of products from marginal areas and communities where there may otherwise be few diversification opportunities.

Finance—payment for environmental services. Community environmental support activities, such as watershed management and forest rehabilitation, need to be recognized as major contributions to carbon capture. Protecting natural areas could also bring resources to communities and households as incentives for further sustained management. Outside agriculture, this is piloted under REDD+ (Reducing Emissions from Deforestation and Forest Degradation) forestry activities and payment to communities for watershed environmental services to protect dams from sedimentation.

For CSA-related processes to ensure inclusion, the identified key groups need to be participating, together with local agencies, in the analysis of needs, decision-making, and planning for local CSA activities. Further, for implementation, there must be special efforts to ensure access to extension for these groups. The types of CSA advisories and information and the best access modality must be adapted to the needs and languages of rural poor farmers in Nepal. Digital services can play a role in reaching out to dispersed farmers; these services do not need to be sophisticated but should help farmers link to each other and identify and exchange important information such as on good practices, inputs, and markets.

Environmental Considerations

Policy context. The NDC, ADS, and NAP lay out important aims and targets for sustainability and environmental health relevant to the agricultural sector. This includes improving **watershed health and vitality and is also** related to **reducing land degradation and land restoration.** The Forestry Sector Strategy (2016–25) vision is for the **sustainable management of forest ecosystems, biodiversity,** and watersheds, fully optimized for national prosperity. Complementing this, the National Agroforestry Policy 2019 is to increase the production of agricultural, livestock, and forest products by **increasing productivity though multipurpose land use and conserving environmental and biological diversity** by reducing pressure on forests, while developing climate-resilient ecosystems and creating opportunities for livelihoods. The NAP also identifies adaptation measures based on a **circular economy, and sustainable resource use** will be developed and implemented. The plan also aims to protect, promote, and support **climate-resilient indigenous seeds and crop varieties** through community seed banks and national gene banks.

Synergy between resilience and natural resources management benefits. The identified farm-level CSA technologies and practices build on the synergy between resilience and benefits from

environmental practices. For example, the on-farm soil and water management technologies, through stabilizing terracing, using intercropping and mulching, multilayered integrated farming systems linking crop, horticulture, and agroforestry residues for livestock feed, and using livestock manure for fertilizing crops.

Watershed and landscape management for soil and water conservation. At watershed protection level, overall land and tree cover are important for reducing erosion and soil loss. This is linked to the overall pattern of farming practices and systems noted in the previous paragraph, especially in the hills and mountainous areas and along streams and rivers, generally encouraging productive trees and agroforestry on forest margins and sustainable use of NTFPs. Similarly, it will be important to restore degraded lands by shifting free-range livestock to stall feeding to reduce overgrazing in degraded forest margins, as it was done under the leasehold forestry system with very poor farmers, which led to increased agroforestry and fodder development and strengthened pasture management.

Quantifying environmental benefits of CSA options application: Environmental benefits from soil and water conservation and landscape management options are estimated at over US$1,000 per hectare over 20 years in relation to reduced erosion and water source rehabilitation, often greater than the original production investments (Bockel and Grewer 2014).

Watershed management is fundamental to contribute to more stable water supplies in rivers, irrigation systems, and aquifers and to reduce sedimentation. This, together with creating more efficient water and irrigation systems that allow for more cropping per unit of water delivered to irrigation systems, will create more efficient use of water resources overall and possibilities for multiple uses and for more equitable allocation.

However, such watershed water management requires more **integrated landscape and Integrated Water Resource Management (IWRM) and basin-based planning approaches**; it also requires related local-level regulation that requires close coordination between various ministries and local agencies (agriculture, land, water, forestry, and environment). For farmers and communities, however, it also requires the right incentives and capacities for them to adopt, invest, protect, and undertake natural resource management activities (see above, especially for poorer farmers and communities).

More sustainable use of resources and less waste. While only a portion of fertilizer supply and use needs to be addressed to increase production, the trade-off is that it is also important to ensure efficient use of inputs to reduce excess runoff and pollution in waterways and, where possible, to use locally sourced natural fertilizers and to enhance soil properties as noted above.

Biodiversity. Supporting more traditional stress-tolerant varieties and animal breeds is also important for resilience, to help strengthen local and national agrobiodiversity. Efforts to conserve native plant genetic resources through community seed banks are critical. At the farm and watershed levels, building up vegetative and forest tree cover and complementing forest conservation also supports opportunities for wider biodiversity.

Mitigation of emissions

Policy context. The NDCs aim for overall **net-zero emissions by 2050, and by 2030 they target improving selected watersheds and increasing orchards and soil organic matters** (see table 1). While agriculture does not have specific emission reduction targets allocated, it is important in relation to farm-level land use and practices, **change in land-use** patterns at the landscape level, and how these can affect soil and **biomass carbon stock.** Agriculture related emissions will thus be affected by

the types of technologies used and practices, including for livestock, as well as the overall patterns of increased, or reduced, adoption of the practices and related use of inputs.

Synergy between resilience, environment, and mitigation approaches. There is a close relationship between CSA practices that are environmentally friendly and build resilience (a number of them discussed above), which include more integrated farming systems, increased tree and vegetative cover, and less disturbance of soils—leading to greater soil and above-ground biomass and therefore carbon at the farm level. Together with fruit and agroforestry practices and conscious management of watersheds and pastures, these add up to greater carbon capture at the landscape level.

Finding synergies and co-benefits between increased production and mitigation of emissions. With greater opportunities for expanding production of crops and horticulture through better irrigation and other inputs and resulting returns, there is a possibility that fallow land may be brought back into productive crop use, reducing the standing biomass. Therefore, it will be particularly important to promote and incentivize practices that disturb soils less, are integrated and multilayered, and enhance as far as possible groundcover and soil structure, including with the use of local biofertilizers.

Technologies for reducing methane emissions. There are specific technologies and practices that are important for reducing GHG emissions, in particular methane, such as the method of alternate wetting and drying (AWD) for paddy rice and capturing methane from livestock manure through the use of biogas units (the latter form part of the NDC targets; see section 6 "Livestock"). It should be noted that AWD needs well managed and well-equipped irrigation systems to be able to provide careful control of water to make the system effective.

Increasing efficiency to reduce GHG emissions per unit of production. Considering that rice and livestock are so central to the agriculture economy and livelihoods of rural Nepal, there may be an overall increase of production under a local CSA strategy. Therefore, the above technologies may only partially compensate for an increase in GHG emissions. It will be particularly important to increase crops and livestock as efficiently as possible, in relation to inputs and reducing waste, to reduce emissions per unit of production.

Benefits of CSA options on reducing emissions: The financial analysis of CSA options (see 5.3) indicated that practically all shortlisted CSA options analysed using EX-Act would result in reduction of GHG emissions compared to business as usual, ranging from annual net reduction in emissions to 0.02 $MtCO_2eq$ per head of cattle and goat, to over 5.5 $MtCO_2eq$ per reduction for crops. At an aggregate level, economic analysis of investment packages (section 6), with conservative assumptions on CSA adoption in 0.5 million hectares of crops, and for 0.5 million head of livestock, this is close to 3 $MtCO_2eq$ per year in study areas alone.

Similarly, if value chain activities are successful, they may also increase the overall level of related activities such as processing and transport, which could lead to increased use of fossil fuels and thus GHG emissions. Therefore, as for environmental considerations, it is important to **promote and introduce the use of green technologies,** such as non-fossil energy, from hydropower (including micro-hydropower units) and solar power for irrigation and postharvest handling such as solar drying. It will be essential to incorporate general improvements in production efficiency in processing, and reduction in waste, so that the footprint of unit agriculture produce is decreased. Greater efficiency will also have financial benefits as incentives. More localization of value addition can reduce emissions from transport, increase territorial circular economies with use of by-products (such as processing waste used for fertilizer), and create local economic and employment benefits for rural areas.

5.3 Economic Analysis of Benefits of Applying CSA Options; GHG Emission Changes

Potential benefits to adoption of CSA options will vary depending on types and mix of technologies adopted, climate implication on production systems and agricultural commodities, among other factors. Table 10 provide a summary analysis. For cereals, adoption of minimum tillage practice is projected to generate incremental net returns of US$19 per hectare of maize (manual), while its adoption in wheat would generate higher returns at US$324 (mechanized) due to relatively low impact of climate change on the latter. In horticulture, improved access to irrigation, adoption of improved and CSA technologies and practices, and reduced losses to weather events, pests, and storages would generate incremental net margins in the range of US$400 for cauliflower, US$653 for potato, and US$1,680 for tomato. Combination of improved access to forage and fodder crops, adoption of improved animal health, and improved breeding practices in livestock production systems is expected to generate net returns per average herd from US$326 for poultry to US$1,441 for goats. In aquaculture, adoption of CSA technologies and practices at production and postproduction levels and improved water- and land-management practices, is expected to generate an incremental return of US$1,680 per average sized pond.

Table 10. Incremental Net Returns to CSA Options by Production Systems

Crop and technology (BAU: business as usual)	Net margin ($/ha)			Assumptions on climate change impact, and response effects
	Without	With	Incremental	
Cereals, pulses and legumes				
Maize: from conventional (BAU) to minimum tillage, manual	37	56	19	Minimum tillage and substituting conventional ploughing, coupled with enhanced manure use increases soil carbon and fertility, reduces soil loss and erosion (on steep slopes), increases labour productivity, overall resilience, and reduce GHG emissions
Maize: from conventional (BAU) to minimum tillage, mechanized	123	241	118	
Wheat: from conventional (BAU) to minimum tillage, mechanized	769	1,093	324	
Paddy: irrigated, from broadcasting (BAU) to SRI	52	131	79	
Millet: from conventional manual (BAU) to minimum tillage, mechanized	76	170	95	Improving profitability through productivity increases for lentil, mustard, and pulses enhances farmers' resilience; enhanced access to water increase crops' productivity and reduces risk of failure and GHG emissions
Pulses: from conventional (BAU) to improved	214	318	104	
Mustard: irrigated, from low input/ output (BAU) to improved	293	359	67	
Lentil: irrigated, from low input/output (BAU) to improved	108	186	78	
Horticulture				
Tomato: irrigated, from open field (BAU) to production inside tunnels	618	2,300	1,682	Production inside tunnels is more resilient (reduced climatic risk) and makes better use of soil and water resources, enhances soil and labor productivity, and reduces GHG emissions
Cauliflower: irrigated, from low input/ output (BAU) to improved	1,153	1,244	91	
Potato: irrigated, from low input/ output (BAU) to improved	891	1,544	653	
Livestock - per average herd				
Cattle: from low input/output management (BAU) to improved	308	1,517	1,209	Intensification of livestock production based on improved feeding and breeding management practices; improvements in the fertility rates and reduction in the mortality rates, increases in the herd size for all animals, and farm resilience (enhanced farm income); increased GHG emissions efficiency
Goat: from low input/output management (BAU) to improved	2,942	4,382	1,441	
Pig: from low input/output management (BAU) to improved	2,018	6,247	4,229	
Poultry: from low input/output management (BAU) to improved	630	956	326	

Agroforestry				
Mixed agroforestry model: banana, cardamom, tomato-fodder and buffalo, chilli-fodder and ginger	1,697	1,765	68	Adoption of CSA technologies and practices and improved access to inputs, irrigation, and markets will result in higher productivity, value addition and resilience, and reduced GHG emissions
Aquaculture				
Fish farming, common carp production	1,269	2, 286	1,010	Income improvements through farm resilience, improved land use, productivity increases, value addition, and reduced GHG emissions

Net GHG emissions. Adoption of proposed interventions is estimated to reduce GHG emissions for all production systems compared to a business as usual (BAU, without project) scenario. Crop-wise, adoption of CSA technologies is projected to mitigate annual tCO2eq emissions by 0.02 tons per head of cattle and goat, 5.49 tons per hectare of vegetables, and 5.59 tons per hectare of millet (table 11).

Table 11. Annual net GHG emissions by CSA options and production systems.

	Annual net emissions (metric tCO_2eq/ha or head)
Cereals—crops and technology	
Maize: from conventional (BAU) to minimum tillage, manual	-2.68
Maize: from conventional (BAU) to minimum tillage, mechanized	-2.77
Wheat: from conventional (BAU) to minimum tillage, mechanized	-3.01
Paddy: irrigated, from broadcasting (BAU) to SRI	-0.72
Millet: from conventional manual (BAU) to minimum tillage, mechanized	-5.59
Pulses: from conventional (BAU) to improved	-1.96
Horticulture—crops and technology	
Tomato: irrigated from open field (BAU) to production inside tunnels	-5.10
Cauliflower: irrigated, from low input/output (BAU) to improved	-5.49
Potato: irrigated, from low input/output (BAU) to improved	-5.49
Mustard: irrigated, from low input/output (BAU) to improved	-5.49
Lentil: irrigated, from low input/output (BAU) to improved	-5.49
Livestock and technology, per average herd	
Cattle*: from low input/output management (BAU) to improved	-0.02
Goat*: from low input/output management (BAU) to improved	-0.02
Poultry*: from low input/output management (BAU) to improved	0.001
Aquaculture	
Fish farming, common carp production	-5.67

Notes: Annual net GHG emissions from livestock (cattle/goat) are based on Nepal Livetsock Sector Innovations Project projections.

Section

6

Prioritized Investment Packages

Key messages:

- **The study focuses on provincial investment plans** for four representative provinces, with potential scale up to the remaining three provinces and considering a 10-year timeframe.
- **The priority interventions for climate-responsive and resilient agricultural production systems in the targeted four provinces are packaged into the following six investment packages**
  - Package A: Creating an enabling environment for mainstreaming CSA and resilience in agriculture, to be implemented mainly on the national level
  - Package B: Climate-responsive and resilient crop production system
  - Package C: Climate-responsive and resilient commercial horticulture
  - Climate-Smart Irrigation Subpackages (supporting Package B and Package C)
  - Package D: Resilient and sustainable livestock production system
  - Package E: Climate-responsive and resilient agroforestry
  - Package F: Climate-responsive and resilient aquaculture
- **Proposed interventions are prepared based on priority value chains in target provinces.**
- **Configuration of investment packages considered specificity and needs of production systems as well as complementarity and linkages between various interventions.**

6.1 Overview of Packages

The study was designed with a primary focus on developing investment packages that can be incorporated into provincial investment plans. The CSAIP preparation was initiated under the

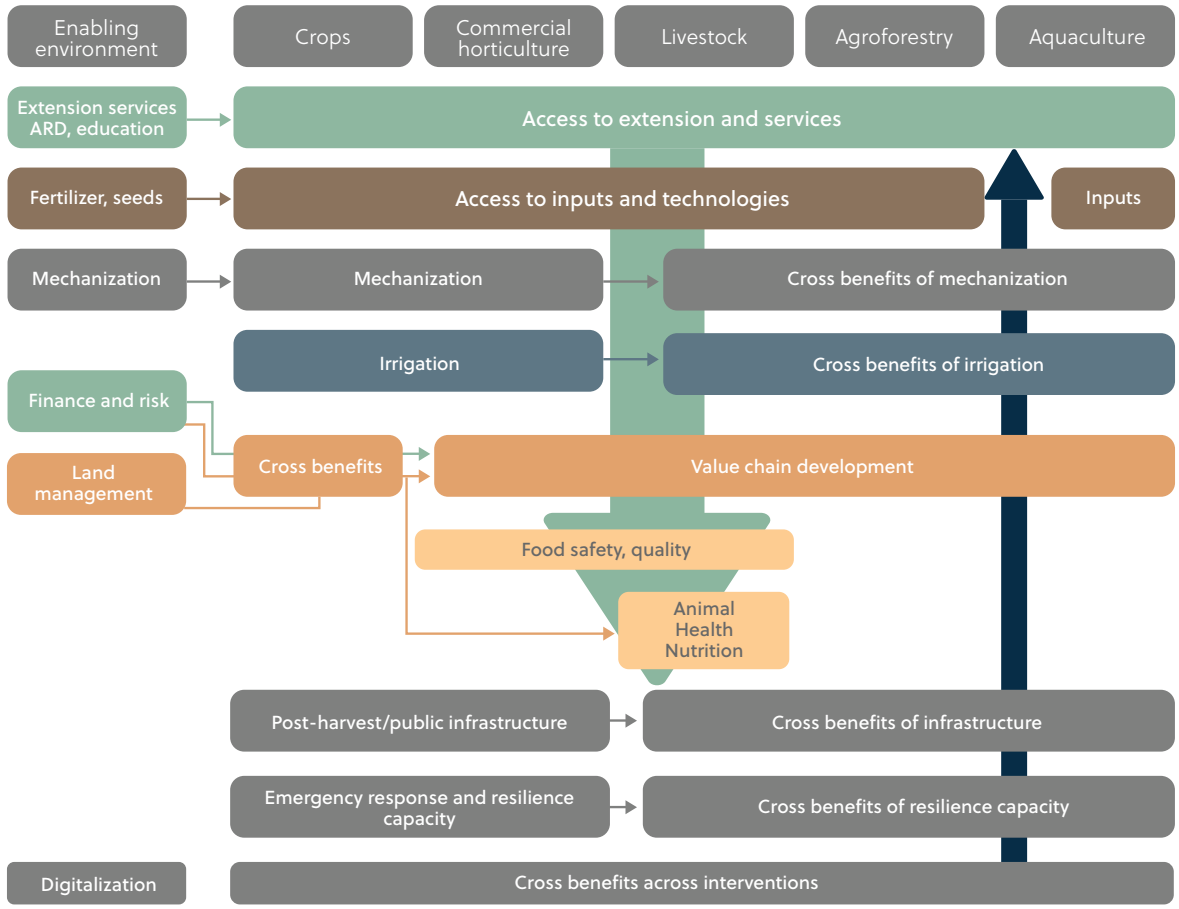
ongoing transition to a federalist system of governance under which provinces would drive their own development agenda. Therefore, the study was designed with a primary focus on provincial investment plans for an initial four representative provinces with highest exposure to climate-change events and their potential scaling up to the remaining three provinces. As such, CSA interventions factored in the overall sectoral context, specific sectoral conditions and needs in the initial set of provinces, priorities and mandates of provincial governments (which are primarily limited to the production level), and potential replication of interventions to remaining provinces. While organization of investment packages around provinces seems logical, potential replication of proposed interventions to the remaining three provinces also had to be factored in. Configuration of investment packages considers these factors and presents the packages by focus intervention areas and by provinces, reflecting specific needs and scopes of each province and allowing easy customization. This approach will also allow scaling up of provincial interventions based on intervention unit costs. Additionally, it is worth noting that at the time of drafting the report, the country has faced political changes that may affect the ongoing transition to federalism and transfer the developmental agenda back to the federal government. If such a chain of events takes place, the current configuration of investment packages will be still relevant as these can easily be adjusted to other configurations of geographical development zones.

Configuration of packages considered specificity and needs of production systems as well as complementarity and linkages between various interventions. Combining crops and horticulture, livestock, and agroforestry and aquaculture, for instance, would not be possible due to specificity of needs and to differences in their relevance across provinces and agroecological zones. Similarly, while crop and horticulture systems are very close, commercial horticulture, especially export-oriented horticulture, requires different interventions than overall crop production systems that combine subsistence and commercial production. However, interventions such as improving access to extension, services (pest and disease control, mechanization), inputs (fertilizer, seeds) and infrastructure (storage, processing, packaging) are similar to what was covered under the investment package on crops and not duplicated under the investment package for commercial horticulture.

Priority interventions for climate-responsive and resilient agricultural production systems in four target provinces are divided into six investment packages. A rough approximation of the relationships is shown in figure 10 below. Proposed interventions are prepared based on the analyses of climate change implications on major crop value chains in the target provinces and on corresponding priority CSA options identified to address key impacts (section 5). More specific technical practices under each package would be implemented based on suitability to specific provinces and agroecological zones. The study on the impact of the COVID-19-related disruptions on agriculture and food systems in the target provinces supported preparation of interventions for strengthening emergency response and resilience capacity from non-climate shocks (WP 6). The latter focused on the priority value chains selected through stakeholder consultations for the target provinces. Detailed technical analyses on focus production systems are presented in WP 7 and WP 8.

Current configuration provides flexibility for prioritizing investments in each province, considering multiple factors that include (1) relevance of production systems to the province and across agroecological zones within each province; (2) suitability of CSA options across agroecological zones and the importance of the role each production system plays within the provincial agricultural economy; (3) financial capacity within the proposed 10-year timeframe; and (4) capacity to implement within the 10-year period. The prioritization process at the provincial level will be discussed under chapter 7.

Figure 10. Configuration of Investment Packages



Source: Original material

Proposed investment packages and costs are summarized in table 12, followed by descriptions in subsequent sections. **Package A** focuses on creating an enabling environment at the national level for agricultural production systems to become more productive, competitive, climate responsive, and resilient both from climate and non-climate shocks. As the package focuses on the national-level interventions, its cost is expected to be covered primarily by the federal budget with limited to no external financing. **Package B** focuses on making crop production systems across all agroecological zones in the four target provinces more productive and resilient. **Package C** focuses on commercial horticulture and proposes interventions and investments for scaling up and strengthening the system's resilience from climate and other shocks. Climate-smart **irrigation interventions**, which are to support both Package B and Package C are summarized in table 12. **Package D** consists of interventions to strengthen resilience and environmental sustainability of livestock production systems. **Package E** focuses on making the agroforestry production system climate responsive and resilient. **Package F** consists of interventions for strengthening climate responsiveness and resilience of aquaculture system in Province 1 and Province 2.

Cost assessment: Costs of investment packages and main interventions were estimated based on recent market prices for relevant studies, capacity support, and investments in the country and regions. Distribution of costs across provinces considered scopes of production systems and interventions as well as differences in unit costs for major interventions such as modernization of irrigation schemes. Potential financing options, from public, private, and other sources, are discussed under section 7.

Table 12. Prioritized Investment Packages by Key Characteristics and Indicative Costs

Package	Relevance				Estimated cost, US$, millions
	Sectoral	Beneficiaries[8]	AEZ	Provinces	
A. Enabling environment for mainstreaming climate agenda and resilience	Crop, horticulture, livestock, aquaculture, agroforestry	All	Terai, hills, mountains	All	25.0
B. Climate-responsive and resilient crop production system	Crops—all **Target** area: 481,000 ha of rainfed and 300,000 ha of irrigated croplands, of which around 115,000 ha through physical irrigation investment	Smallholders and other value chain actors Approximately 1.1 million farmers	Terai, hills, mountains	1, 2, 4, 6	420.0
C. Climate-responsive and resilient commercial horticulture	Floriculture, coffee, tea, spices, vegetables, fruits, and medicinal plants **Target** area: around 50,000 ha, of which 10,000 ha is through physical irrigation investments	Smallholders and other value chain actors Approximately 120,000 horticulture farmers	Terai, hills, mountains	ibid	180.0
D. Resilient and sustainable livestock production system	Dairy, goat, poultry **Target** numbers: 3M cattle, 3M goats, 10M poultry	Smallholders and other value chain actors Approximately 600,000 livestock	hills, mountains	ibid	40.0
E. Climate-responsive and resilient agroforestry	NTFPs, MAPs **Target** area: around 350,000 ha	Smallholders and other value chain actors Approximately 70,000 farmers	hills, mountains	1, 4, 6	20.0
F. Climate-responsive and resilient aquaculture	Capture/culture fisheries **Target** area: 8,200 ha	Smallholders and other value chain actors Approximately 205,000 pond operators	Terai, hills	1, 2	15.0
				Total	700.0

Notes: Priority strategic focuses were the basis for prioritization of climate-smart options discussed in section 5.

6.2 Climate-Responsive Enabling Environment in Agriculture at the National Level

Package A. Enabling Environment for Mainstreaming Climate Agenda and Resilience

Proposed investment Package A focuses on creating and strengthening the enabling environment at the national level, through federal government agencies. The main objective of the package is creating an enabling environment for productive and commercial agriculture that is climate responsive and resilient. Key interventions cover all agricultural production systems (crops, horticulture, livestock, agroforestry, and aquaculture) and across all agroecological zones and provinces in the country. Main interventions with estimated costs are summarized in table 13, while details are discussed in subsequent paragraphs.

[8] There will be overlap between some of the farm groups below, and they cannot be added together because many households also implement crop and livestock practices at the same time.

Key features include the following:

- Strengthening policies and regulations across sectors for mainstreaming a CSA agenda, agricultural extension, and ARD
- Consolidating and sharing data and information relevant to CSA, including on good practices, and on inclusive participatory processes
- Facilitating regulations and support for fertilizer and seed sectors, agricultural finance and risk management, and agricultural land regulations and markets; strengthening agricultural educational institutions
- Financing of the package is expected primarily from the federal budget, with potential limited investments from donors in technical assistance, especially in areas of ARD and digitalization of public services
- Adaptation and implementation of enabling environment changes will be captured under subsequent investment Packages B–F that focus on provincial-level investments.

Table 13. Summary Breakdown of Investment Package A

Main focus areas	Estimated Costs, US$, millions
A1. Policies and regulatory environment for CSA	5.0
A2. Agricultural extension and services, research and educational institutions	5.0
A3. Seed and fertilizer systems	4.0
A4. Agricultural finance and risk management	3.0
A5. Digitalization of services	3.0
A6. Agricultural land administration and management	5.0
Total	**25.0**

Source: Original material

A1. Strengthening policies and regulatory environment for mainstreaming a climate-smart and resilient agriculture agenda. Main interventions include (1) building capacity for integration and harmonization of the CSA in policies, plans, strategies, and programs and setting up a functional cross-sectoral Dynamic Information Framework to couple the various models, AEZ data layers, and CSA interventions for supporting decision-making (building on MoALD (2019b) Roadmap for Adaptation Planning in Nepal's Agriculture Sectors; (2) enhancing public-private partnerships to leverage resources, expertise, and capacities for mainstreaming CSA; and (3) developing coordination mechanisms, supporting the above interventions (1) and (2), including implementation of the ADS and integrated watershed management approaches (see section 7).

A2. Building stronger and climate-responsive agricultural extension and services, ARD, and educational institutions. The main interventions for extension and services include (1) building capacity at the national level to mainstream CSA in agricultural policy on extension and services (building on guidance by MOALD (2019a), for integrating climate change adaptation in agriculture); (2) enhancing knowledge and skills of extension workers on CSA advisory services; (3) promoting a pluralistic and participatory extension system involving the public and private sectors; (4) digitalization of extension and services for increased outreach and for improved emergency response capacity; and (5) strengthening extension and ARD linkages. Making agricultural research climate responsive will require strengthening the institutional and technical capacity of ARD for the CSA agenda; strategic planning and implementation of CSA research across all agroecological zones; and fostering knowledge and skills across agricultural research, academic institutions, and extension services. Enabling agricultural education systems (vocational schools and universities)

to respond more effectively to needs and challenges in agriculture and labor markets will require strengthening functional collaboration among agricultural education, extension and ARD; updating the curricula to incorporate emerging innovations and best practices in agriculture, including around CSA, digitalization, and innovations in agricultural value chains; and improving the information infrastructure.

A3. Building climate-responsive and resilient fertilizer and seed sectors. Key interventions for the fertilizer sector include improving the fertilizer subsidy policy to reduce fiscal pressure and the environmental footprint and facilitate equitable and efficient distribution; and strengthening resilience from shocks (climate, natural disasters, and COVID-19) through improving existing supply mechanisms and stocking capacity (WP 7). Main interventions for the seed sector include (1) enabling a formal and market-driven seed system; (2) strengthening local seed production and distribution capacity, especially for climate-responsive and high-yielding varieties suitable to all agroecological zones; (3) inclusion, production, and dissemination of climate-responsive indigenous genetic materials for multiplication; and (4) strengthening the resilience of seed producers from pandemic-like shocks through building digital connectivity and increasing stocking capacity.

A4. Making agricultural finance and risk management more inclusive, climate responsive, and conducive for increased private-sector financing. Key interventions include (1) improving regulatory and policy barriers and risks to the private sector's access to finance (that is, restrictive collateral requirements); (2) promoting incentives to financial and insurance institutions for increased lending to agricultural value chains and adoption of innovative products that facilitate climate-responsive, responsible, and sustainable investments, in alignment with Building Back Better and Greener principles; (3) promotion of lending mechanisms such as warehouse receipt, leasing, value chain finance and capital and equity finance; (4) promotion of innovative risk-management products such as Weather Index Based Insurance or Forecast Based Financing (see box 7); (5) digitalization of services; and (6) removing respective policy and regulatory barriers for maximizing finance for development through foreign direct investments.

A5. Digitalization of public services and information dissemination that include agricultural extension (box 8), mechanization, agricultural market information, infrastructure, weather forecast, logistics and registration services, and farmer knowledge-sharing and partnership networks (water users associations, WUAs, FFSs, productive alliances).

A6. Strengthening agricultural land administration and management through (1) strengthening technical and institutional capacities of respective agencies for planning, implementation, and monitoring of the Land Use Act 2019 and Land Act 2020; (2) development and promotion of business

Box 7. Piloting Weather Index Insurance

Realizing the increased vulnerability of smallholder farmers to weather-related risks, Sakchyam, a UKAID project—with the support and guidance from the Insurance Board of the Nepal and in collaboration with Shikhar Insurance—introduced a weather index insurance (WII) to apple farmers from Jumla in 2016. After conducting a feasibility study and analyzing 30 years of historical weather data from a weather station based in Chandannath–Jumla, Sakchyam's WII product was developed to cover insurance from drought. Hailstorm was added as an additional rider. Unlike other insurance products, the WII helps farmers to avoid hassles with settling insurance claims and the payment is automatically made once the predefined event takes place. Shikhar Insurance has now expanded the product to Kalikot, Mugu, and Dolpa districts.

Source: https://sakchyam.com.np/financial-inclusion/shikhar-insurance/.

Box 8. Toward Digital Agriculture for Outreach

With major investments made in the recent past in expanding information and communication technology, Nepal possesses significant potential for applying e-extension tools and methods. Given its difficult terrains, such tools are critical to support the GoN to reach its target extension outreach. Efforts have been made by both public research agencies and private sector players in the development and provision of mobile application services. Digital application of GeoKrishi, which provides an intelligent digital agriculture platform to solve challenges faced by commercial and smallholder farmers, is one example.

GeoKrishi applies a data-driven system approach to translate knowledge into actionable, timely, and context-specific advisories, covering all stages of the crop value chain. It simplifies and amplifies farmer and intermediator efforts by adopting scientific methodology to provide location-specific timely actionable information to increase farm productivity and maximize profitability. The approach is to focus on service delivery mechanisms by empowering local networks of representatives. The application empowers local representatives by building their capacity with Geo-ICT agronomic tools so that they can better advise farmers. The network members will use the knowledge to support farmers and other stakeholders with location-specific, contextualized, appropriate, and data-driven information in local languages. The application is currently piloted in 12 municipalities.

Source: http://www.db2map.com/Default.aspx

Box 9. Community Block Farming in Malawi

Phata Sugarcane Outgrowers Cooperative is a smallholder farmer-owned organization in Malawi formed in 2011. It was established in partnership with Agricane, a professional farm management company. The cooperative started with 380 smallholder farm household members and has grown to 1,100 members. Before joining the cooperative, farmers were engaged in rainfed cotton and sorghum cultivation. Their farmlands were converted into sugarcane production. Shareholding is determined by the share of members' landholdings in the area allocated for development. The cooperative secured two EU grants at €4.5 million to develop 600 hectares of sugarcane. Its contribution to the grant was financed through the capital loan of €980,000 from Agdevco. The development grant was used for the development of irrigation infrastructure and establishing sugarcane fields. It also developed additional lands for irrigated food crop production to provide food security for the members.

After two production seasons, Phata achieved positive cashflow and paid US$6.5 million of dividends to member farmers over the last six years. Its impact on the local community has been significant, providing employment, income, food, and access to credit. Key to the success of the business model was a sound fiscal discipline and governance and a secure long-term off-take agreement which provides a guaranteed market.

Source: https://www.agdevco.com/our-investments/by-investment/PHATA-SUGAR-COOPERATIVE.

models for consolidated farming operations (contract farming, commercial community block farming approach, box 9); and (3) promoting successful models for consolidated service provision to smallholders (mechanization and pest and disease control).

A7. Promoting agricultural mechanization through (1) developing policies and programs to facilitate rapid mechanization of farming operations and private-sector participation in financing by promoting mechanisms such as custom hiring, leasing, and cooperative and group ownership mechanisms; and (2) removing trade regulations and policy distortions for imports of machinery, tools, and spare parts.

6.3 Climate-Responsive Crops, Horticulture, Livestock, Agroforestry, and Aquaculture

Package B. Climate-Responsive, Resilient, and Better-Performing Crop Production Systems

Investment Package B will support interventions for productive and resilient crop production systems across agroecological zones in the target provinces. It will aim at increasing crop productivity, diversification toward resilient, nutritious, cash crops, bringing abandoned croplands back in production, and strengthening resilience of farmers from adverse climatic and non-climate shocks.

Key features include the following:

- The package will support crop farming communities—subsistence and commercial—operating 481,000 hectares of rainfed and 300,000 hectares of irrigated land (of which around 115,000 hectares through physical irrigation investments and remaining existing irrigated areas of 185,00 hectares largely through institutional and farm-level irrigation technology promotion interventions) and other crop value chain actors.
- Proposed interventions were analyzed based on priority crop value chains including paddy, maize, and other cereals. However, these interventions are strongly relevant to all crop categories.
- Ensuring that implementation of CSA technologies and practices are locally prioritized, based on selection drawn from options, such as one in chapter 5, especially soil and water management practices and stress-tolerant varieties and, in the hills, sloping land technology.
- Modernizing irrigation systems and services to support farmer-driven and climate-responsive production, at both the farm and scheme levels, to ensure optimal

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water supply for production and in times of water stress.

- Increased production of staple crops is central to improving the country's food security situation of both subsistence producers and consumers, and with production surplus improving incomes of smallholder farmer households and thus contributing to local economic development, poverty reduction, and household resilience.
- Increased production of staples contributes to import substitution and better terms of trade.
- Supporting mechanization to facilitate production, especially reducing women's drudgery.
- Scaling up extension outreach and implementing CSA with adoption of pluralistic and participatory local extension and research systems, and accessible digital information services.

Table 14 presents key interventions and estimated investment costs by province, while their descriptions are provided in subsequent paragraphs. It should be noted that the total irrigation investment envelope is divided between the investment Package B on crop production and investment Package C on commercial horticulture production.

B1. Stronger and climate-responsive agricultural extension and services at the provincial level. Key interventions include (1) building policy and operational capacity of provinces for mainstreaming climate change and resilience considerations in agricultural policy and practices; (2) developing human resource capacity for scaling up extension outreach and implementing CSA; (3) adoption of pluralistic and participatory extension system involving public- and private-sector extension services (box 10); (4) strengthening pest and disease warning and treatment services; and (5) digitalization of agricultural extension and services.

B2. Improving access to productivity-enabling and climate-responsive technologies and services through (1) facilitating seed producers' access to knowledge on climate-resilient technologies and practices for seed reproduction and dissemination; and (2) strengthening resilience, production, and distribution capacity of nurseries, seed producers, and entrepreneurs.

B3. Modernizing irrigation systems and services to support farmer-driven and climate-responsive production. Proposed irrigation interventions are prepared for crop production systems, which then were divided into the current investment Package B on crop system and Package C on commercial

horticulture (see box 15). Main interventions specific to current investment Package B include (1) adoption of climate-responsive infrastructure and technologies such as water harvesting and micro-irrigation (see box 11) and piped canals to protect from landslides and flooding; (2) development of new irrigation, where feasible; and (3) strengthening institutional capacities of water managing bodies for improved agricultural water management, irrigation service delivery, asset management, and climate-responsive water management.

Table 14. Breakdown of Investment Package B

Focus areas	Estimated Investment Cost, US$, millions				
	Province 1	Province 2	Province 4	Province 6	Total
B1. Agricultural extension and services	2.0	5.5	2.0	0.5	10.0
B2. Access to technologies and services	2.0	5.5	2.0	0.5	10.0
B3. Modernizing irrigation systems and services	60.0	165.0	60.0	15.0	300.0
B4. Agricultural mechanization	4.0	11.0	4.0	1.0	20.0
B5. Agricultural finance and risk management	1.0	2.8	1.0	0.3	5.0
B6. Agricultural and basic public infrastructure	14.0	38.5	14.0	3.5	70.0
B7. Emergency response and resilience capacity	1.0	2.8	1.0	0.3	5.0
TOTAL	**84.0**	**231.0**	**84.0**	**21.0**	**420.0**

Source: Original material

B4. Promoting agricultural mechanization to facilitate a CSA agenda and in response to feminization and aging of agriculture labor through (1) establishing public-sector financed mechanization services for critical and emergency support; (2) facilitation of private-sector financing and operation of mechanization services through various financing and co-financing mechanisms (public private partnerships (PPP), leasing); and (3) promoting adoption of mechanized climate-responsive practices (conservation agriculture, zero tillage).

B5. Facilitating access to agricultural finance and risk-management products through (1) promotion of financing and co-financing mechanisms such as matching grants, guarantee fund, warehouse receipt, value chain financing, and group borrowing; (2) facilitation of private-sector financing of agricultural mechanization, storages, value addition and market infrastructure, and logistics, including through PPP; and (3) support for development and promotion of a diverse choice of financial and insurance products suitable for all actors of value chains and also for adoption of CSA (box 12).

B6. Improving access to agricultural and basic public infrastructures through (1) investments in basic public infrastructure (farm roads, electrification) with climate and disaster resilience features and energy-saving technologies and in alignment with Building Back Better and Greener principles; (2) developing storage infrastructure with climate- and disaster-resilient features for critical emergency support (solar power-operated); (3) promoting private-sector financing in storage, market, and processing infrastructure and logistics, including through PPP (that is, warehouse receipt and equity financing); and (4) support for strengthening logistic services.

B7. Strengthening emergency response capacity of agricultural agencies to non-climate shocks through improving coordination, M&E capacity, and the development of digital database and information transmission systems. Establishing public infrastructure (storages, processing units, agricultural machinery stock) for critical emergency support is covered under the intervention area B6.

Potential benefits: The proposed interventions are estimated to generate net margins per hectare at various levels depending on types of CSA options and farm practices adopted, irrigated conditions, and degree of climate impacts on crop categories, among other factors. For example, in cereals, adoption of minimum tillage practice is projected to generate incremental net returns of US$19 per hectare of maize, while its adoption in wheat would generate higher returns at US$324 per hectare due to insignificant adverse impact of climate change on the latter. On average, incremental net margins per hectare will vary from US$100 for rainfed pulses, to US$135 for irrigated cereals, and to US$800 for irrigated vegetables. At the package level, the interventions are projected to generate financial returns at FIRR of 12 percent, FNPV of 230 million, **a**nd BCR of 1.6. Economic returns, exclusive

Box 10. **Digital Agriculture Advisory and Services by Private Sector**

Information and communication technologies (ICT) for Agri (IFA) is a youth-led social enterprise that supports farmers with digital advisory, weather forecasting, and farmgate price information. Its advisory services cover topics on farming, marketing, prices, water and soil management, postharvest management, fertilizers, and product quality and safety. The ICT supports farmers with customized three-day weather forecasting of superior accuracy for any location within Nepal, which facilitates better planning and management of farm operations. Through its farmgate price services, the company helps farmers to make better marketing decisions by providing them with local, regional, national, and international farmgate prices. IFA's extensive database is accessible to users at any time, including through SMS.

The IFA's digital product named ICT for Agriculture (IFA Krishi) has won multiple awards, including the Data Driven Farming Prize, ReConnect Challenge prize, agriculture category winner and grand winner of the Ncell's App Camp, and ICT For Mountain Development Award from ICIMOD. The enterprise works in several districts in Nepal, including through partnership with various NGOs and INGOs. Source: https://ict4agri.com/.

Box 11. **Smart Meters Integrated Solar Irrigation Pumps—Toward Data-Driven Agriculture Practice**

Gham Power Nepal Private Ltd is a renewable energy-focused social enterprise based in Kathmandu, Nepal. it partners with multinational agencies and local government entities to pioneer products that increase energy uptake among rural populations. One of them is the solar water pumps solution that provides a viable and reliable means of irrigation to farmers. The solar water pumps are integrated into the in-house smart meters that trace real-time data on water and power consumption. The company is developing additional parameters such as pH concentration and soil moisture to the smart meters. The latter features will inform farmers on enhanced cropping practices. This is the first mainstream use of a data-driven precision farming approach to be piloted in Nepal. In addition, the company operates an online platform—Offgrid Bazaar—that collects and uploads data and information related to farming. The platform advises farmers on optimal and cost-effective solar energy water pump designs based on farm sizes and water requirements. Additionally, it assists farmers with assessment of a bankability score—an alternative credit score. Such a personalized risk assessment tool supports investor's decision-making on potential investments. The company currently serves 20 districts in the Terai zone, which is the agricultural hub of the country.

Source: https://ghampower.com/.

Box 12. Greening the Uganda Development Bank's Agricultural Lending Portfolio

Uganda Development Bank (UDB) is keen to expand its agricultural lending portfolio. Through its leading, the Bank also aims to generate positive social, developmental, and environmental impacts. To achieve this, the UDB approved a green financing strategy. The strategy envisions the creation of a green finance fund to consolidate and enlarge UDB's investment portfolio of low-carbon risk investments by 2024. In partnership with the FAO, UDB strengthened its knowledge of agriculture's environmental impact and its capacity to assess the GHG emissions and carbon balance of loan applications. The partnership was implemented through the AgrInvest initiative in Uganda, a three-year initiative on promoting private investments in Uganda's agriculture and agribusiness sectors with an aim to contribute to achieving the SDGs.

Currently, the UDB's interest-rate calculation, which incorporates the SDGs, is based on prime lending (internal), farm profitability, risks, and the development impact index (DII). The DII in turn takes into consideration GHG emissions and environmental and safeguard impacts of the proposed business operation.

Source: http://www.fao.org/support-to-investment/news/detail/en/c/1298227/.

of value of GHG emissions, are estimated at EIRR of 12 percent, ENPV of US$524 million, and BCR of 2.3. The CSA interventions are projected to reduce GHG emissions considerably. As such, when the economic values of net GHG emissions at low shadow prices for carbon are accounted for, the ENPV increases to US$1,154 million, ERR to 17 percent, and BCR to 3.9. At the high carbon prices, the ENPV is US$1,780 million, ERR is 21 percent, and BCR is 5.5.

Package C. Support for Resilient and Competitive Commercial Horticulture

Package C will support a commercial horticulture system for increased farm incomes, improved nutrition, and improved trade balance. Horticulture provides considerable opportunities in relation to diversification, commercialization, and value addition, if it can adapt to climate risks. Challenges in the commercial horticulture system require interventions similar to those already proposed for crop production systems (Package B). However, the needs of commercial horticulture differ in areas of irrigation, value chain development, resilience from non-climate shocks, and trade facilitation. Therefore, only such additional interventions specific to commercial horticulture development are proposed. Proposed interventions and indicative costs by province are summarized in table 15 and details are discussed in subsequent paragraphs.

Key features include the following:

- Horticulture farming communities (existing and potential) operating around 50,000 hectares across all agroecological zones and other actors in respective value chains will be supported. Of the total area, around 10,000 hectares will be supported through a combination of physical and institutional investments, while the remaining 40,000 hectares will be supported through institutional and farm-level irrigation technology promotions.
- Target value chains will include vegetables, fruits, and, where identified locally, floriculture, coffee, tea, spices, and medicinal plants with import substitution and export potentials.
- Greater horticulture activities at the farm level contribute to both farm household-level dietary diversification, through increased consumption of fruit and vegetables, and to greater availability of these products in local and urban markets, contributing to food security and

reduced malnutrition.

- Increased incomes of smallholder farm households contribute to greater purchasing power for nutritious foods, especially where women benefit directly from such incomes.
- Key CSA options (section 5) include quality inputs, especially access to stress-tolerant and market-demand seeds and fruits, saplings, nursery development, and protected cropping (such as poly tunnels).
- Key irrigation and water harvesting support to provide targeted water supply, and on-farm increasing access to energy-smart systems (solar pumps, gravity systems)
- Building capacities for providing services on product quality, safety, and innovation; enhancing women's roles in entrepreneurial aspects of value chains
- Bringing digital information services to support farmers and private-sector actors to facilitate marketing and value addition; ensuring digital information is accessible to women and youth
- Promoting and facilitating access to renewable energy to support farmers and private-sector actors in processing and other agriculture economic activities
- Facilitate links to appropriate finance services and promoting innovation financial and risk products.

Table 15. Summary Breakdown of Investment Package C

Focus areas	Estimated Costs, US$, millions				
	Province 1	Province 2	Province 4	Province 6	Total
C1. Horticulture knowledge support and services	3.0	2.5	2.5	2.0	10.0
C2. Modernizing irrigation systems and services	39.0	32.5	32.5	26.0	130.0
C3. Horticulture value chain development	12.0	10.0	10.0	8.0	40.0
TOTAL	**54.0**	**45.0**	**45.0**	**36.0**	**180.0**

Source: Original material

C1. Horticulture knowledge support and services will focus on addressing the specific needs of commercial horticulture value chains through (1) strengthening extension capacity in areas of food safety and quality, market intelligence, market linkages (see box 14), innovations in value chain development and financing, and trade; (2) improving agricultural services specific to target commodities (pest and disease control, mechanization); (3) strengthening capacity for food safety and quality control and certification; and (4) in the context of higher vulnerability of horticulture produce from pandemic-like shocks, strengthening emergency support to horticulture value chains in accessing information and services on agricultural infrastructure (storage, processing), markets, and logistics services (WP 7).

C2. Modernizing irrigation systems and services to respond to the specific needs of the horticulture system through (1) enabling the irrigation systems and services to ensure higher water control and security and (2) support for adoption of micro-irrigation and water storage technologies (water storages, micro-irrigation suitable for hilly areas; see box 13), together with improved overall links to effective and efficient irrigation systems (box 15).

C3. Building resilient commercial horticulture value chains through a process of cluster-based stakeholder facilitation: (1) linking value chain actors' access to finance and risk-management products through innovative financing mechanisms (matching grants, guarantee funds, value chain financing); (2) promoting the export of niche products; (3) facilitation of private-sector participation in financing of agricultural infrastructure through warehouse receipts, leasing, equity financing, and PPP; (4) strengthening standardization and certification services and facilitation of adoption of quality and safety standards and quality tracking systems; and (5) strengthening logistics services. In the

context of higher vulnerability of horticulture produce from pandemic-like shocks with movement restrictions, additional interventions will include support for improved access to information and services on production, postproduction and market infrastructure, and markets.

Potential benefits. The proposed interventions are estimated to generate net margins per hectare at various levels depending on types of CSA options and farm practices adopted, horticulture commodities, degree of climate impacts on crop categories, and export orientation, among other factors. An average incremental net margin per hectare is therefore estimated at US$600 for all commodities. The financial results to the overall package are estimated at FNPV of US$129 million, FRR of 13 percent, and BCR of 1.6. The economic results, exclusive of GHG emission values, are estimated at ENPV of US$177 million, EIRR of 11 percent, and BCR of 1.3. When values of net GHG emissions at low-carbon prices are added, ENPV reaches US$318 million, EIRR 15 percent, and BCR 1.8. At the high shadow prices for carbon, ENPV is US$459 million, ERR is 17 percent, and BCR is 2.3. The sensitivity analysis shows that the investments are moderately sensitive to all sensitivity variables.

Box 13. Micro-irrigation solutions for smallholder farmers

Sital Thopa Sichai (STU) has been producing, assembling and marketing low-cost and simplified drip-irrigation technology adapted to the needs and resources of small farmers. The low-cost and simple drip irrigation system also known as a non-conventional micro irrigation technology was developed in Nepal by IDE Nepal (International) in 1994 with the financial support of SNV under drip irrigation action research grant. Depending on the end market, STU manufactures and assembles drip irrigation system with irrigation areas ranging from 80 m2 to 1,000 m2. Additionally, it produces micro-sprinkler systems, including rolling version which could be installed in previously rainfed lands in steep locations. The company supplies micro-irrigation technologies through government agencies, international and local NGOs and private sector dealers. It currently has a network of 35 dealers through which it sells irrigation technologies and products in different parts of the country.

Source: https://sitaldripnepal.com/

Box 14. Connecting Farmers and Consumers in Nepal

DV Excellus envisions to design, develop, and implement innovative solutions in the sector of food-and-agriculture technology. With offices in three market centers (Pokhara, Kathmandu, and Chitwan), the company connects and builds relationships between thousands of farmers and consumers, both digitally and physically. KHETI, an agrifood-tech digital platform, is a product of DV Excellus. It is an integrated web and mobile-based platform with three modules: **KHETI** Farm, Farm Management Tool, and KHETI Food. The platform integrates the entire food value chains delivering services primarily to two major actors— farmers and consumers—whereas other agri-ecosystem players such as cooperatives, development agencies, governments, and products and service providers can use the platform to interact and engage with farmers and consumers. **Farm Management Tool** assists and incentivizes farmers in reducing production costs and increasing productivity and profitability. Farmers get customized advisory services, including high quality inputs with doorstep delivery, soil testing, crop protection, sustainable farming practices, value addition, and market access. **KHETI Food** brings local produce from the farmers, market vendors, and food companies to consumers.

Source: https://dvexcellus.com/

Box 15. Climate-Smart Irrigation Subpackage

A well performing and climate-smart irrigation sector will become even more critical to mitigate projected climate risks and take advantage of opportunities that could arise. This requires comprehensive modernization of systems, adjusting existing practices to emerging shifts in supply and demand, establishing strategies to manage extreme weather events, and build the capacity of farmers and government staff. Climate-smart irrigation requires addressing performance improvements, improving the resilience of areas particularly vulnerable to the impacts of climate change and where possible reducing GHG emissions.

Irrigation investments are cross-cutting and integrated into CSAIP Package B and Package C, applied at different scales, and they are critical to foster a climate response, resilience, and better performing crop production system and resilient and commercially competitive horticulture value chain. Irrigation investments under the CSAIP would support an estimated 73,000 hectares across all agroecological zones and include the following:

1. **Modernization of existing irrigation schemes.** Climate-smart modernization of irrigation, which comprises simultaneous technical and managerial upgrades, will result in (1) improved irrigation service delivery (adequacy, reliability, flexibility, equity, and management, operation, and maintenance [MOM]); (2) increases in water use efficiency; (3) allowing farmers to adopt CSA practices, including crop diversification; and (4) increasing the profitability of farming while managing risks associated with the impacts of climate change (shifts in seasons, variability, crop suitability, and so on). This will require investments from the water source to the farm and require a shift toward a more holistic climate-smart modernization approach.
2. **Provide irrigation services to rainfed areas particularly vulnerable to the impacts of climate change.** Expanding irrigation services to rainfed cropping systems is critical to mitigate climate change impacts in vulnerable communities. In the hills and mountains, this will require investments in source protection, rainwater harvesting, and conventional irrigation systems, while an increasing focus in the Terai will come from investments in developing available groundwater resources, where feasible, and strengthening conjunctive use.
3. **Pilot innovative gravitational pressurized irrigation system.** The topography of Nepal provides opportunities to explore innovative approaches, including gravitational pressurized systems, in the hilly parts of the country, both to upgrade current conventional irrigation systems and as an option to expand irrigation into currently rainfed areas. Such pilots could be designed as small- to medium-scale on-demand pressurized irrigation schemes and serve drip and sprinkler irrigation to farmers, thereby ensuring high levels of efficiency, while reducing the energy consumption usually associated with pressurized systems.
4. **Strengthen MOM.** Current design standards and MOM practices need to be modified to consider the possible variations caused by climate change, to provide the irrigation services required to support CSA practices in the different agroecological zones, and to allow farmers to respond to new market opportunities. This should include introducing new systems such as aquaculture, hydroponics, and emerging climate-smart practices such as alternate wetting and drying methods for rice, which are expected to help reduce GHG emissions. In addition, alternative scheme management arrangements for agency management irrigation schemes should be explored, potentially including the use of management contracts for larger irrigation schemes in the Terai.
5. **Build climate-smart irrigation capacity.** A comprehensive capacity building and institutional strengthening program needs to be carried out so that the concerned stakeholders, including the government agencies across the three tiers (national, provincial, and local levels) and the farmers are fully aware, organized, and capable of implementation.

Benefits: While the impact and economic returns will vary between schemes, analytical work as part of the CSAIP preparation indicates significant benefits from the combined effects of irrigation investment and adaptation of climate-smart agronomic practices. AquaCrop modeling highlights the potential for increasing yields of major commodities (rice, +30 percent; wheat, +50 percent), while economic analysis suggests returns in the range of US$ 385 per hectare of irrigated crops on average per investment across all proposed irrigation investments. In addition, the use of low-carbon technologies, including the use of solar energy, will contribute to building a greener future; increasing water use efficiency could reduce power consumption and environmental degradation,

while irrigation investments could generate substantial economic multiplier effects and create much needed job opportunities in rural Nepal.

Costs. Cost assessment is based on unit cost of civil works recorded for ongoing and recently completed Irrigation and Water Resources Management Improvement and Modernization Project of the Rani, Jamara, and Kulariya Irrigation Project (Phase 1 and Phase 2). The total cost of the irrigation investment, which considers the implementability factor in the coming 10-year timeframe, is estimated to be US$430 million, inclusive of US$420 million (95 percent) for hard investments and US$10 million (5 percent) for soft investments. Of the total cost, around US$300 million will be under Package B on crop production system, which includes the total project cost of proposed institutional investments. The remaining US$130 million will be under Package C on commercial horticulture. Under Package B, the irrigation investments are estimated to improve irrigation water delivery for roughly 115,000 hectares of land through a combination of physical and institutional interventions, while existing irrigated lands at 185,000 hectares will be supported primarily through institutional support and promotion of farm-level irrigation technology. Similarly, the irrigation investments under Package C will support around 10,000 hectares with combined physical and institutional investments, whereas 40,000 hectares of existing irrigated lands will receive institutional and technology promotion support.

Table 16. Estimated cost of irrigation investments

Subpackages	AEZ	Total Costs (US$, millions)	Estimated areas (ha)	Distribution of costs (US$, millions)	
				Package B	Package C
Modernization major projects	Terai	172.20	57,400	117.60	54.60
Modernisation minor schemes	Terai	82.80	41,400	56.55	26.25
	Hills	41.51	11,861	28.35	13.16
	Mountains	30.21	5,035	20.63	9.58
New irrigation	Terai	9.72	972	6.64	3.08
	Hills	19.86	1,655	13.56	6.30
	Mountains	10.56	880	7.21	3.35
Pilot pressurised systems	Existing schemes	23.28	2,910	15.90	7.38
	New schemes	19.86	1,986	13.56	6.30
Sub-total for capital investments		410.00	124,099	280.00	130.00
Climate-smart MOM practices		10.00		10.00	
Comprehensive capacity building		10.00		10.00	
Sub-total for institutional investments		20.00		20.00	
Total		430.00	124,099	300.00	130.00

Package D. Support for a Sustainable and Resilient Livestock Production System

Package D will support building a sustainable, productive, and resilient livestock production system with reduced environmental footprint. Key interventions will aim at increasing livestock productivity, strengthening resilience of livestock value chain actors from climate and non-climate shocks, and sustainable use of natural land resources. Proposed interventions and indicative costs are summarized in table 17, while focus interventions are described in subsequent paragraphs.

Key features include the following:

- The package will support livestock farming communities and actors in dairy, goat, and poultry value chains across all agroecological zones of targeted provinces.
- Target livestock numbers will be approximately three million cattle (cow and buffalo), three million goats, and 10 million poultry.
- Key CSA options (section 5) implemented through this package are improving feed management, including from fodder and pasture management, with stall feeding and animal housing; health management to improve herd productivity and deal with stresses; and stress-tolerant breeds.
- Women are a major target group and they will be supported to better manage integrated farm and agroforestry systems, including livestock, for which they are usually the primary caretakers.
- Increased livestock production has been shown to directly benefit smallholder farmers' dietary diversity, especially through increased animal protein intake but also through improved incomes and thus purchasing power, especially where women are more in control of incomes.
- The package is expected to benefit indirectly from the Package B investments (crops) in increased production of fodder crops, storage infrastructure, and farm mechanization; and the Package E investments (agroforestry) should benefit from increased production of forage crops, fodder trees, and grasses.

Table 17. Summary Breakdown of Investment Package D

Focus areas	Estimated Costs, US$, millions				
	Province 1	Province 2	Province 4	Province 6	Total
D1. Animal nutrition	1.8	0.9	1.8	1.5	6.0
D2. Animal breeding services and breeds	2.1	1.1	2.1	1.8	7.0
D3. Improved animal health	1.8	0.9	1.8	1.5	6.0
D4. Food quality and safety	0.3	0.2	0.3	0.3	1.0
D5. Value chain development	6.0	3.0	6.0	5.0	20.0
TOTAL	**12.0**	**6.0**	**12.0**	**10.0**	**40.0**

Source: Original material

D1. Improving animal nutrition through increased production of and access to animal feed and fodder. Main interventions include (1) strengthening capacities for increased production, conservation, and storage of fodder crops (drought-tolerant fodder and agroforestry) by improving access for nurseries, private producers, and processors to planting materials, infrastructure, and knowledge; (2) adoption of stall-feeding practices to improve manure and soil-nutrient management; (3) strengthening farmers' knowledge and facilitation of adoption of improved animal nutrition practices; and (4) promotion of waste management and renewable energy technologies and practices which can be ideally combined with biogas digesters (see box 16.)

D2. Improving access to animal breeding services and breeds through (1) for cattle, strengthening resilience and efficiency of cattle-breeding services by investing in infrastructure, high-yielding genetics and breeding materials, knowledge, and skills; (2) for goats and sheep, development of breeding systems for climate-resilient indigenous breeds with higher resistance to disease and heat through community-based buck exchange, contract farming, and establishing private sector-run breeding services (see box 17); and (3) for poultry, support for restocking parent stock, which has diminished due to import disruptions during the COVID-19 pandemic, and strengthening border clearance, quarantine and disease prevention procedures, processes, and infrastructure.

D3. Improving animal health services through (1) strengthening disease surveillance, reporting, and coordination mechanisms; (2) building capacity for animal disease risk analysis, disease prevention, and emergency response; (3) strengthening capacity for animal diagnostics, treatment, and vaccination; and (4) facilitation of private-sector participation in animal health service provision.

D4. Strengthening livestock produce quality and safety through (1) strengthening food quality and safety control and compliance mechanisms; and (2) improving access to control and certification services.

D5. Development of resilient value chains through (1) improving access to finance and risk-management products by building linkages with financial institutions and various co-financing mechanisms (matching grant, guarantee funds, and value-chain financing), facilitating private-sector financing in postproduction infrastructure through value chain financing and productive producer alliances; and (3) strengthening knowledge and skills of all actors of the livestock value chain of emerging and innovative value-chain development approaches and mechanisms.

Potential benefits. The proposed interventions are estimated to generate net margins per hectare at various levels depending on types of CSA options and farm practices adopted, livestock category, and degree of climate impacts on animal categories, among other factors. Incremental net margins per average heads are therefore estimated at US$325 for poultry, US$1,200 for dairy, and US$1,400 for goat. At the package level, when a 60-percent adoption rate is applied, the proposed interventions are estimated to generate financial returns at FIRR of 11 percent, FNPV of US$26 million, and BCR of 1.8. Economic results, exclusive of GHG emission values, are estimated at ENPV of US$35 million, EIRR of 8 percent, and BCR of 1.7. Proposed investments are expected to reduce GHG emissions. As such, when values of net GHG emissions at low-carbon prices are added, ENPV reach US$160 million, EIRR 13 percent, and BCR 4.8. At the high carbon prices, ENPV is US$163 million, EIRR 13 percent, and BCR 4.9. The sensitivity analysis shows that the investments are moderately sensitive to all sensitivity variables.

Box 16. **Small-Scale Biogas Development in the Hills: experience under International Fund For Agriculture Development (IFAD) Adaptation for Smallholders in Hilly Areas (ASHA) Project**

In Nepal, more than 80 percent of rural communities rely on traditional fuels such as firewood and charcoal. Biogas represents a versatile source of renewable energy and a suitable technological solution for smallholder farmers in rural areas. Methane generated through anaerobic digesters from human, livestock, and agricultural waste (including garbage, sewage, garden, and kitchen waste) can be directly used as an energy source for cooking, lighting, and generating electricity. In addition, the biogas digester effluents ("slurry") can be used as crop fertilizer with long-term effects on soil fertility, replacing the reliance on expensive chemical fertilizers. Farmers should operate preferably zero-grazing systems (or at least keep the livestock stalled overnight) to provide about 20–30 kilograms of animal manure that can yield 700–800 liters of methane gas, which is enough for 2–3 hours of cooking fuel on a stove. Ideally, farms with 3–4 cows can fulfill daily cooking requirements. A portable, tubular biogas digester has been piloted that is more suitable in hilly areas given the high costs of installing more conventional underground dome biogas digesters. Source: IFAD ASHA project.

Source: IFAD ASHA project

Box 17. **Public-Private Partnerships in Commercial Goat Farming**

Jahada and Dhanpalthan are two rural municipalities that, as part of their recovery from the 2015 earthquake devastation, initiated a program to support private goat breeders with goat breeding and improved farm management development.

The municipalities have implemented the private-sector goat development program through Sahaj (Nepal Agriculture Market Development Project, executed by Swiss Contact). Sahaj has provided technical and financial support to four farms in Jahada and three in Dhanpalthan and the farms have developed themselves as the resource centers for improved goat breeds.

The private farms that were part of the initiative see it as an opportunity to make an investment in commercial goat production and value-chain development. It helps them to access technologies and knowledge on low-cost shed construction, improved breeding, and fodder and forage production. The municipality-driven private-sector goat development has been well accepted by the goat breeders and growers and can be scaled up. The municipality, however, should maintain the data recording system of the breed to maintain the quality of genetic stock and to minimize inbreeding risks.

Source: Interview by the CSAIP team.

Package E. Support for Sustainable and Resilient Agroforestry

The investment package will support building sustainable and resilient agroforestry-based livelihoods with an aim of increasing productivity and resilience of agroforestry value chains. Main interventions and indicative province-specific cost estimates are summarized in table 18, and descriptions are provided in subsequent paragraphs.

Key features include the following:

- The package will support value-chain actors in NTFPs and MAPs, households dependent on

agroforestry for livelihoods, community forest user groups, leasehold forest user groups, and farmer groups.

- Expansion of both private and public agroforestry lands of around 350,000 hectares will be promoted.
- Main agroforestry-based production models include a mix of NTFPs, MAPs, aromatic, essential, and vegetable oils, spices, fodder trees and crops, agricultural crops, grasses, herbs-based silvo-pasture system, livestock, and walnuts.
- Aside from smallholders using integrated farming systems with trees, this package has important target groups of hill and mountain vulnerable communities often living on forest margins. Women need to be a key part of targeted support, as in households they often collect NTFPs and MAPs and tend trees. NTFPs are also important sources of key nutritious food, especially under periods of stress and lack of access alternative food sources.
- Key farm activities are support for farmers in good production, harvesting, and postharvest processing. Investment Package B on crops in areas of improved availability of key inputs (seeds, fertilizer) and improved access to public and agricultural infrastructure will cross benefit this package.
- Due to its enhancement of tree cover and soil stability, the package will contribute to environment conservation, improved use of water resources, enhanced agroecosystems, and sustainable landscapes. Financing options will include making linkages with payment for environmental services and social protection mechanisms to help poorer farmers adopt practices and cover risks in extreme climate events.

Table 18. Summary breakdown of Package E

Focus areas	Estimated Costs, US$, millions				
	Province 1	Province 2	Province 4	Province 6	Total
E1. Access to technologies, inputs, and services	2.0	1.5	3.0	3.5	10.0
E2. Value chain development	2.0	1.5	3.0	3.5	10.0
TOTAL	**4.0**	**3.0**	**6.0**	**7.0**	**20.0**

Source: Original material

E1. Improving access to agroforestry technologies, inputs, and services through (1) strengthening production and distribution capacities of nurseries and private seed producers by increasing their access to climate-responsive, high-yielding, and disease-free planting materials, infrastructure, and knowledge; (2) promoting private-community—public partnership in financing research and infrastructure; (3) strengthening knowledge and skills on climate-responsive agroforestry and promoting adoption of CSA technologies (water harvesting, conservation/recharge ponds, micro-irrigation, solar-powered water lifting); (4) scaling up successful CSA agroforestry models; and (5) restoration of degraded agroforestry assets.

E2. Support for development of sustainable and resilient agroforestry enterprises and value chains through (1) scaling up agroforestry entrepreneurships that are based on quasi-public-private-community ownership and management; (2) facilitation of improved access to finance and risk-management products through PPP, matching grant, and value-chain financing models; (3) strengthening access to quality control and certification services; and (4) improving access to basic public infrastructure (farm roads, electrification) and postharvest agroforestry infrastructure.

Potential benefits. Climate change impact on agroforestry is expected to be negative. Therefore, returns to the package investments in addressing vulnerabilities to climate and other shocks, in

addition to poor productivity and weak value chains, will be considerable. Potential benefits are estimated based on a mixed agroforestry production model representing high priority products such as banana, cardamom, tomato-fodder and buffalo, chilli-fodder, and ginger. Proposed interventions are projected to increase net margins from US$1,690 to US$1,770 per hectare. The package as a whole would generate financial returns at FIRR of 24 percent, FNPV of US$22 million, and BCR of 2.4. Economic results, exclusive of values of net GHG emissions, are estimated at ENPV of US$32 million, EIRR 24 percent, and BCR of 2.3. Proposed interventions are projected to lead to significant reduction in GHG emissions. As such, when values of net GHG emissions at low-carbon prices are added, ENPV increases to US$123 million, EIRR to 53 percent, and BCR to 6.5. At the high shadow prices for carbon, ENPV reaches US$214 million, EIRR 73 percent, and BCR 10.8. The sensitivity analysis shows that the investments are moderately sensitive to all sensitivity variables.

Package F. Support for Sustainable and Resilient Fisheries and Aquaculture

This package aims at supporting aquaculture systems in Province 1 and Province 2 to become sustainable, resilient, and productive. It is expected to benefit all value chain actors in capture and culture fisheries in the Terai and the hills. Main interventions and indicative province-specific costs are summarized in table 19 and descriptions are provided in subsequent paragraphs.

Key features include the following:

- The package will support hatcheries and farmers operating around 25,000 ponds with a water surface area of 8,100 hectares.
- The package will get cross benefits from Package B investments (crops) in public and postharvest infrastructure, irrigation and flood control, farm mechanization, and increased resilience from nonclimate shocks.
- Improved monitoring of aquaculture farming and leasing regulations will contribute to improved use of water resources (excluding wetlands and small lakes from fisheries), improved wild fish resources and habitats, conservation of fish biodiversity, and overall benefits to the aquatic environment.
- Fisheries and aquaculture provide a key source of highly nutritious animal protein.
- Ensuring that implementation of CSA technologies and practices is locally prioritized, based on the selection drawn from options such as the ones in section 5.
- Scaling up extension outreach and implementing CSA with adoption of pluralistic and participatory local extension and research systems and accessible digital information services.
- Strengthened value-chain development will support, in addition to higher value addition, increased adoption of CSA options across the value chains and stronger linkages between various chains, contributing to higher resilience of fish farmers from shocks.

Table 19. Summary Breakdown of Investment Package F

Focus areas	Estimated Costs, US$, millions		
	Province 1	Province 2	Total
F1. Aquaculture extension and services	0.6	1.4	2.0
F2. Access to technologies, practices, and inputs	1.2	2.8	4.0
F3. Value-chain development	2.8	6.2	9.0
TOTAL	**4.6**	**10.4**	**15.0**

Source: Original material

F1. Strengthening aquaculture extension and services through (1) improving human resources and operational and knowledge capacities of fisheries extension and services, including on the CSA agenda; (2) improving the monitoring of aquaculture farming and leasing regulations for more regulated and environmentally responsible production practices (discourage leasing of wetlands and small lakes); and (3) facilitating the adoption of climate-responsive technologies and practices.

F2. Access to productivity-enabling and climate-responsive technologies, practices, and inputs through (1) strengthening production and distribution capacity of hatcheries by increasing their access to climate-responsive and quality production materials, infrastructure, and knowledge; (2) conservation, production, and dissemination of indigenous fish varieties; (3) enabling adoption of climate-responsive fish varieties and production technologies and practices (warm-water aquaculture and integrated rice-fish farming); (4) improving access to other inputs by improving linkages between respective value chain actors; and (5) restoration and conservation of Terai wetlands.

F3. Development of sustainable and resilient aquaculture value chains through (1) promotion of linkages and partnerships within and across value chains; (2) strengthening knowledge and skills of value-chain actors in areas of climate-responsive technologies and practices, management, and marketing; (3) improving their access to financial and risk-management products and services, including various co-financing practices; (4) improving access to quality and safety control and certification services; and (5) promoting private-sector financing in aquaculture infrastructure through PPP.

Potential benefits. Climate change events such as heat and increased frequency of flooding, droughts, avalanches, and landslides and associated changes in river water quality are projected to have adverse impacts on aquaculture value chains. The proposed interventions to address vulnerabilities to climate and other shocks, poor productivity, and weak value chains are expected to generate significant returns. Analysis of the carp production model, for instance, demonstrates considerable incremental net return of US$1,010 per hectare, suggesting currently unutilized productivity and income potential. At the package level, the proposed interventions are estimated to generate financial returns at FIRR of 13 percent, FNPV of US$10 million, and BCR of 1.7, when adoption of technologies and practices are assumed to be 60 percent. Economic returns, exclusive of value of GHG emissions, are estimated at ENPV of US$32 million, EIRR at 9 percent, and BCR at 1.1. Inclusion of values of net GHG emissions at low shadow prices of carbon increases ENPV to US$27 million, EIRR to 16 percent, and BCR to 2.0. At the high shadow prices for carbon, ENPV is US$36 million, EIRR 19 percent, and BCR 2.4. The sensitivity analysis shows that the investments are moderately sensitive to all sensitivity variables.

Section 7

Rolling out CSA Investment Recommendations in Coordination Between the Federal Government and Provincial Governments

Key messages:

- This chapter provides guidance on (1) how to prioritize investment recommendations identified in chapter 6; (2) how to localize the packages—that is, to customize them to the local institutional setting to facilitate adoption by provinces; and (3) how to finance the investment packages.

- The chapter presents a process for developing and implementing CSA investments and supporting the local government to identify, implement, and plan their own investments based on local analysis of priorities and needs and on best practices and experience already taking place. Such a process includes the following overlapping sequence of activities:

    - Putting in place key enabling federal support for coordination and planning, resource allocation, and guiding local governments, including with appropriate research and information systems
    - As investments are rolled out at the local level, further federal policy support is important for ensuring key inputs such as fertilizers, finance, and so on
    - Developing local adaptation plans with supporting frameworks for identifying, analyzing, and selecting appropriate local options and assisting farmers to identify appropriate CSA options and allocating resources to implement
    - Strengthening a pluralistic agriculture extension system, capacity and research links, farmer capacity, private-sector support for CSA with appropriate linkages to finance, and technical services
    - Harnessing the above to implement demand-based, integrated CSA options at the farm level.

- Strengthening M&E both nationally and locally, combined with participatory feedback mechanisms to help track implementation and assess the effectiveness of CSA investments.

- Financing requires (1) attracting more investment from the private sector by creating a conducive environment, reducing risks and transaction costs, and increasing access to financing; (2) increasing public investments, taking into consideration the investment needs projected by ADS, historical decline, and current public investments in agriculture; (3) improving efficiency of public investments, also through increased investments in agriculture-related infrastructure and by actively promoting PPP; and (4) maximizing financing by development partners, including the private-sector arms of international financing institutions.

The CSAIP provides recommendations for indicative investment packages to mainstream the CSA agenda and promote the adoption of CSA options and practices in four target provinces. The CSA options presented in section 5 consider (1) significant variations in agroecological zones and microclimates, especially in the hills, and suitability of CSA practices; (2) availability of road and other agricultural infrastructure and market opportunities and their effect on financial attractiveness of identified commodities; and (3) the need to apply the principle of federalism according to Nepal's new constitution. The investment recommendations to scale up the CSA options are indicative and need to be prioritized to address the most pressing needs of the province or watershed at the time, as well as adapted and localized to fit the local institutional conditions to facilitate their adoption by local authorities. The investment packages themselves incorporate key elements important for mainstreaming CSA in agricultural systems, including key enabling mechanisms for planning and coordination among stakeholders, and developing local capacities and ensuring stakeholder engagement, including farmers and other private-sector actors. This would also require the capacity for implementation and delivery of key supports such as extension, research information, and linkages between value-chain actors and the farmers they support. Another key consideration is the financial resources available for supporting implementation.

7.1 Setting Up a Process for Prioritizing and Supporting Investment Packages at the Local Level

Further mainstreaming analysis of priorities. In a similar vein to the development of the CSAIP, the prioritization process needs to be localized so that agencies at different levels can apply it in a coherent manner depending on local conditions. This means translating national policy targets to local conditions and ensuring that an appropriate process and analytical and planning tools are applied. This is also in line with MOALD (2018) guidance on localizing efforts towards the achieving SDGs, through integration of climate change in agricultural planning and budgeting at the national and sub-national levels. Prioritization of investment packages should entail the following steps:

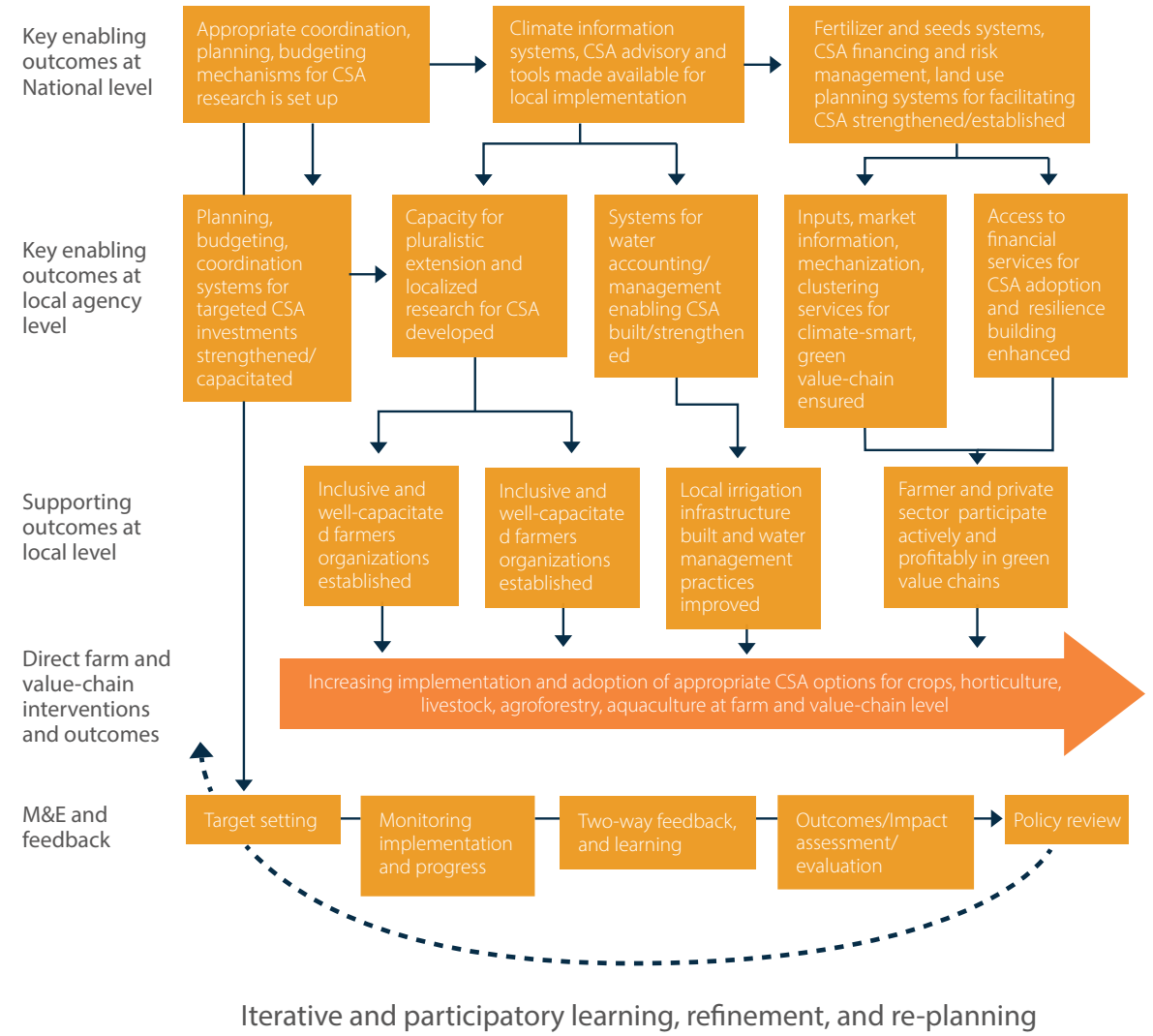
1. Reviewing roles and responsibilities of various stakeholders, at respective levels, who are key actors in implementing CSA investments. See table 20 for an overview of agencies.
2. Translating national policies to the local level using **the following key prioritization criteria:**
    - Alignment of investment packages with national policy priorities and strategies on green recovery, growth, jobs creation, policy goals, and important locally determined goals

- Stocktaking of ongoing activities in Nepal on which CSA investment packages can build
- Evaluating the investments for a set of economic, environmental, social, and climate benefits and the extent of inclusion and gender inclusivity, outreach, and scope. With further refinement, CSAIP criteria such as poverty indicators and female-headed households could be used for project locations (climate hotspots and vulnerable watersheds), target groups, and interventions (cost-benefit analysis). Agromet data, agroecological zoning, and collection of locally relevant scientific evidence and experiences are important to identify interventions

3. Localizing intervention priorities and relevance through participatory assessments, consultation, and planning
4. Identifying interventions in accordance with appropriate institutional capacity and needs, and identifying areas of capacity, coordination, and enabling support
5. Identifying appropriate sequencing of activities to ensure prerequisite interventions are in place and subsequent scaling up follows available resources and services established.

Localising investment recommendations to scale-up CSA. Essential to implementing prioritized investment packages are investment planning at the local level, building local capacity for implementation, and strengthening coordination across stakeholders. This process requires sequencing key activities, taking into consideration whether a national-level enabling environment is present, availability of financial resources, and existing capacity to implement within the respective timeframe. Some activities that are of larger scale and require complex preparation arrangements need proper planning. Other interventions require national support for building up local systems and developing direct support to farmers and other stakeholders. Figure 11 shows a schematic flow of how the outcomes from recommended climate-smart investment packages would be built up sequentially, ensuring the enabling system provides the key elements of successful on-farm uptake of appropriate CSA options.

Figure 11. Sequencing Activities and Outcomes to Roll Out, Mainstream, and Localize Investment Packages



Source: Original table for this publication.

Table 20. Matrix Summarizing Implementation Responsibilities

Investment packages	Key agencies responsible
Overall national agriculture planning and coordination	MoALD establishes a mechanism for coordination among three tiers of governmental structure dedicated to agriculture to avoid duplication of functions and align investments. Using ADS and other resources available under general agricultural development programs such as the Prime Minister's Agricultural Modernization Programme, with appropriate realignment of priorities, further capacity building of Community Agriculture Extension Service Centres (CAESCs) on CSA will be done. Also, agreeing on inter-ministerial coordination for agroforestry and NDC-related functions with MoFE on agricultural land use with the Ministry of Land and for irrigation with the Ministry of Water Resources and Irrigation (MWRI).
Provincial agriculture planning and coordination and research	Develop appropriate linkages with MoALD and the municipal agricultural and livestock units (MALU) of the local governments and assisting the latter with capacity-building support for planning and execution of CSA, including the piloting and scaling up of CAESCs.
Municipal agriculture implementation and extension	Focus mainly on helping to develop CAESCs with CSA-related planning, coordination, and execution capacity at ward level with MALUs. Identifying opportunities related to agriculture and resourcing their development, working closely with farmers and other private-sector actors.

Crop production systems and livestock development	MoALD for agricultural technologies; Department of Water Resources and Irrigation (DWRI) for creating irrigation infrastructure; National Agriculture Research Council (NARC) engaged in crop and livestock breeding programs for drought-resistant varieties and stress-tolerant animal breeds, as well as agro-advisory. Department of Hydrology and Meteorology (DHM) to provide weather forecasts and alerts. Provincial governments provide technologies, whereas municipalities provide extension services. Farmers' groups are to implement the technologies with support from the Federation of Cooperatives for appropriate policy guidance and capacity-building support to village-level cooperative societies.
Commercial horticulture-floriculture, tea, vegetables, fruits, spices	Agricultural technologies, creating irrigation infrastructure, and weather forecast services as above. NARC to implement vegetable and fruit breeding programs for drought-resistant varieties and also provide CSA agro-advisory for horticultural crops. Private companies multiply and market planting materials and seeds with support from relevant commodity groups promoted by the Agro Enterprise Center (AEC), the agricultural wing of the Federation of Nepalese Chambers of Commerce and industry (FNCCI).
Agroforestry and medicinal plants	MoFE to support agroforestry through supply of seeds and saplings. Private companies multiply and market such seeds. For province-level support, the Ministry of Land Management, Agriculture and Cooperatives (MoLMAC) and the Ministry of Industry, Tourism, Forest and Environment (MoITFE) implement the NTFP/MAP activities at the local level. Technical expert organizations such as the Asia Network for Sustainabile Agriculture and Bioresources (ANSAB) and International Centre for Integrated Mountain Development (ICIMOD) to deliver services for improving knowledge, skills, and technology. Various producer and farmer groups such as community forest/ leasehold groups, traders, and manufacturers engage in primary production, processing, and so on. Apex-level bodies of these organizations engage in policy advocacy.
Fisheries	MoALD collaborates with DWRI for multiple use of water bodies for fisheries. The Central Fisheries Promotion and Conservation Center, under the Department of Livestock Services, undertakes extension of aquaculture and natural water fisheries. The Fish Research Centre of NARC to implement research on fish. Private companies produce fish feed and fingerlings. Provincial governments provide technologies, whereas municipalities provide extension services. Farmer groups are to implement the technologies.
Water and irrigation at the national and local levels	MWRI through DWRI to create infrastructure and help build the capacity of WUAs and promote water-use efficiency; through DHM provide agrometeorological services tailored to assist farmers to make farming decisions, and through its climate change division, formulate strategies to cope with the adverse impacts of climate change on irrigation, and by extension to agriculture.

7.2 Strengthening the Policy and Regulatory Environment at the National Level for Supporting Dissemination and Adoption of CSA

Develop cross-sectoral and subsectoral planning and coordination and set up mechanisms for implementing CSA. This needs to be done horizontally among the agencies within each tier, as well as vertically among multiple tiers within specific agencies of the government and other stakeholders. This needs to be done in broader alignment with the GoN's Climate Change Financing Framework, a roadmap to systematically strengthen climate change mainstreaming into planning and budgeting.

To implement the CSA investment packages at the local level, a key interface is needed for building close coordination between agriculture departments, water resources and irrigation departments, and environment/forestry departments. This is especially important for supporting wider-area water basin and landscape planning through IWRM in order to optimize water flows and allocations in the context of future changes and needs (box 18). To effectively localize the investment recommendations to scale up CSA adoption, it is critical that the recommended investment packages address the challenges and goals laid out in policies and strategies of the federal and provincial governments, and that they are effectively communicated to municipal governments and other agencies—both public and private—involved in agricultural development. This will facilitate the planning and forecasting of financial resources from different sources and the integration into respective departmental budgets, from national to local levels.

Box 18. Strengthen the Implementation of IWRM Practices

IWRM is a key pillar of ongoing water-sector reforms in Nepal; an integral strategy to adapt to the impacts of climate change requires a shift from a sectoral focus to a more holistic management framework. Ongoing reform processes are expected to more formally embed IWRM practices, including through expected provisions for (1) a revised Water Resources Policy; and (2) an updated Water Resources Act. Advancing IWRM will also require substantial capacity building across the different layers of the federated system of governance and implementation through pilot initiatives that are problem-focused and target water management and climate impact hotspots, where agricultural use of water plays a critical role as a major abstractor. Two critical areas of concern are (1) watershed management, including the sustainable management of land and water resources and addressing existing and anticipated climate change-induced changes (including water availability and floods), affecting water flows and allocations for different uses; and (2) sustainable groundwater development and management, ensuring that the anticipated increases in groundwater use for irrigated agriculture are safeguarded against future overuse, competition, and quality degradation and to actively manage groundwater levels and secondary impacts of increased surface irrigation. Key activities would focus on hotspots, to be selected using multicriteria ranking.

Coherent and clear strategies and guidance on building back greener and better from events such as COVID-19 and other shocks, which emphasize the relevance of sustainable and inclusive interventions that support the scaling up of CSA. Such planning exercises will show that there is considerable overlap between strategies for building back better and CSA. CSA strategies help to build resilience of the vulnerable to future shocks, maximize economic opportunities to generate employment, make ecosystems resilient and reduce the environmental footprint, take advantage of new innovations and best use of scientific data and climate modeling, and provide risk assessments to help future planning.

Include recommendations in policy revision and build coordination to ensure financial allocations for selected CSA investment packages. The MoALD in general, and MoFE and MWRI in specific cases related to forestry, land use, and water resource management-related aspects, may incorporate the investment packages while revising the ADS and NDCs and roll out their implementation through programs such as Prime Minister Agriculture Modernization Project. This ensures that the MoF allocates funds to the MoALD, NARC, MoFE and the DWRI for implementing the national-level CSA investment packages, particularly for multiple use of water resources and large irrigation projects. In addition, coordinating the implementation of the investment packages in agriculture and M&E of implementation at subnational levels is critical to show results and justify the fund allocations made by the MoF.

Adequate financing of CSA ensures that the positive impacts are maximized. The impact of investment packages on the lives of farmers practicing CSA would also depend on how well the crosscutting systemic issues are addressed and financed, in addition to the autonomous adoption and farmers' own investments in CSA technologies. The challenges of channeling adequate funding to provincial governments to support implementation of CSA are related to the recent federalization of the country's administration. Agencies such as the NPC, Ministry of Federal Affairs and General

Administration (MoFAGA), and the MoF would be necessarily involved along with technical ministries such as MoALD, MoFE, Ministry of Land management, Cooperatives and Poverty, and the DHM in addressing such systemic issues. In addition, productive engagement with financial-sector institutions is required to make financing available to farmers. These include the Nepal Rashtra Bank, commercial banks, finance companies, non-bank financial institutions, cooperative societies, and insurance companies and their regulators. Furthermore, the two public agencies involved in fertilizer procurement and distribution would have to increase their investments in developing infrastructure, such as warehouses, and meet working capital needs once policy constraints on the fertilizer subsidy is addressed; the supply of fertilizer from formal sources need to be increased substantially. In addition, a host of private-sector agencies involved in inputs supply, processing, imports, and exports will have to infuse additional capital. See more on this below under Maximizing Financing for CSA.

Build capacity for localizing CSA in policies, plans, strategies, and programs related to agricultural, water resources development and agroforestry, and land-use management. This will also involve enhancing key federal and provincial officers' understanding and capacity to work across government tiers, link efforts of federal, provincial, and municipal governments, and work across sectors and subsectors. Typically, the MoFAGA guides provincial and local governments in the process of selecting and implementing priorities. This will necessarily include building devolved planning skills for analysis, prioritization, and cost-benefit analysis of CSA options; formulating implementation strategies and actually implementing them; and encouraging information sharing on programs and activities of CSA with development and research partners.

Development of information and advisory systems to support the local level. While the DHM provides indicative national- and provincial-level weather advisories, it is important to develop and provide more specific localized weather forecasts, alerts, and early warnings specific to different geographic locations in a format that farmers can use effectively in decision-making. NARC can use these to issue agro-advisory information and train provincial-level staff to develop agro-advisory services for targeted locations (see box 19 below). Digital advisory services with high resolution could also be developed by private-sector companies. This will also include **digitized services** with localized information to assist in further increasing outreach and improving the quality of advisory services, which will contain the latest technological options available for climate-smart and sustainable agricultural practices. Capacity building for women farmers and smallholders in less accessible areas to make the best use of digital tools also needs to be considered. Young farmers with interest in innovation can serve as a key bridge toward this in their communities. They could be provided with seed funding for developing and scaling up digital services in their communities.

Enabling support for private-sector activities for input provision would include a stocktake of the existing industry, analyzing the environmental, societal, and economic cost and benefits of the current fertilizer subsidy regime and its effectiveness in reducing poverty and food and nutrition insecurity. The analysis may provide guidance on possible reforms to address the challenges[9] and identify alternatives for public spending to support climate-smart agricultural sector growth, improve livelihoods, reduce poverty, and enhance food and nutrition security.

[9] Resulting recommendations may include the integration of mechanisms for equitable targeting to benefit small farmers and improve the efficiency of program spending; pairing the subsidy scheme with a soil-fertility management program to redress imbalanced use of fertilizer; improve application efficiency and farm profitability; and deliver subsidy through the private sector using an e-voucher system. World Bank 2016, Nepal, "Sources of Growth in Agriculture for Poverty Reduction and Shared Prosperity," Report No ACS18679; J. Kyle, D. Resnick, and D. Karkee, 2017, "Improving the Equity and Effectiveness of Nepal's Fertilizer Subsidy Program," International Food Policy Research Institute (IFPRI) Discussion Paper 01685.

Box 19. Agro-advisory services

Agro-advisory weekly bulletins were developed in the Nepali language on the basis of crop and livestock status reported from districts, problems faced by the target farmers, and weather outlooks issued by DHM. The bulletins were disseminated through mobile apps and shared with farmers in FFSs. Other modes of dissemination were short message services, emails, and locally printed copies. Leader farmers were trained to access and interpret the bulletins. The GEF/LDCF project developed and disseminated 55 weekly agro-advisory bulletins to its project areas in a one-year period. The agromet advisory services linked agriculture and weather information with farm-level decision-making to reduce loss from adverse weather conditions due to climatic variability and climate change.

Source: GEF/LDCF project Nepal 2015–19.

7.3 Stronger and Climate-Responsive Agricultural Extension and Support Services to Implement CSA Investments at the Local Level

Developing local adaptation plans. Implementation of irrigation projects and development of crop and livestock subsectors are provincial responsibilities under the new constitution. Local-level governments are responsible for the management, operation, and control of agriculture extension and for extending CSA technologies to farmers' fields, together with farmer organizations and private-sector actors where relevant. This ideally needs to take place under the wider framework of developing LAPA (see box 20).

Developing a framework for identifying, analyzing, and selecting appropriate local options and assisting farmers to identify appropriate CSA options. Once the provincial governments, with assistance from MoALD, develop the framework, local extension staff should work with farmers in using the CSA prioritization framework to identify the best CSA practices for their communities. They engage farmers in a participatory process for developing appropriate climate-smart plans for their districts, communities, and villages to lay out requirements and pathways to scale up CSA. These customized plans can build on examples from exemplary **CSV (Pudasiri et al 2019)** that have been piloted (see box 21) **and climate FFS**[10] and include recommendations for (1) appropriate CSA practices, (2) guidance on knowledge sharing and successfully implementing outreach activities, (3) encouraging peer-to-peer learning, and (4) ensuring collaboration between research, extension, and farmers to support localizing adaptive R&D. Such recommendations can be incorporated in provincial **climate investment plans**, a process also being piloted (box 21).

Strengthening pluralistic agriculture extension systems, capacity, and research links. In view of the devolution of agricultural extension services, it is critical that municipal governments understand the rationale of CSA and have the capacity to plan and implement CSA practices and coordinate with provincial and federal governments on CSA-related agricultural research. These will also involve developing human resource capacity to implement CSA and enhancing knowledge and skills of

[10] The NDCs 2020 under agriculture aim to establish 200 CSV and 500 climate-smart farms by 2030. Meeting these targets is conditional to the availability of international support.

Box 20. Local Adaptation Plans for Action (LAPA)

Aiming at supporting vulnerable people in adapting to the adverse effects of climate change, the GoN initiated climate adaptation planning and implementation with NAPA in 2010. The GoN has been preparing and implementing LAPA on a selective basis, using the National Framework on LAPA to operationalize NAPA, under which the role and leadership of local bodies is given high importance (piloted under the Nepal Climate Change Support Programme, UNDP 2020). These administrative units were considered best at capturing location and community-specific adaptation priorities and ensuring national-level support for local adaptation without fragmentation or large transaction costs. The intent was to enable a match between bottom-up and top-down adaptation planning and to design a mechanism that is bottom up, inclusive, flexible, and responsible. An enhanced LAPA Manual (2018) was developed after the governance restructuring to develop LAPA in municipalities and rural municipalities. The enhanced LAPA framework follows a sub-watershed assessment approach, application of GIS in the assessment, and a participatory scenario development approach. The CSAIP investment packages may constitute part of the enhanced LAPA in the agriculture sector.

LAPA Manual 2018: http://asha.gov.np/wp-content/uploads/2018/10/Enhanced-Local-Adaptation-Plan-for-Action-LAPA-Manual.pdf.

Box 21. Climate-Smart Villages and Climate Investment Plans

Provinces in Nepal started implementing Climate-Smart Villages (CSV) with the support of CCAFS South Asia Regional Program allocating NPR 368 million per year and aiming to cover 697,207 hectares of agricultural land and six million farmers in five years (CCAFS 2019). The project is implemented in Gandaki Province (Nawalparasi), Province 2 (Mahottari), and Lumbini Province (Bardiya) from 2017 to 2021. The project partners are the MoALD, Nepal Agricultural Research Council (NARC), Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Agriculture and Forestry University. The CSV covers priorities and policies for CSA, climate-smart technologies and practices, low emissions development, climate services and safety nets, gender and social inclusion, and scaling up of CSA. The villages for CSV implementation are selected based on vulnerability identified by LAPA. ICIMOD piloted the CSV approach in eight villages in Bagmati Province (Kavrepalanchok district) under its Himalayan Climate Change Adaptation Programme. The NDCs 2020 aim to establish 200 CSV by 2030. The CSAIP investment packages can be part of CSV, as this approach covers both agriculture and nonagricultural sectors in the selected villages.

In a pilot of scaling up the CSV approach, LI-BIRD is in the process of developing climate investment plans (CIP) in Gandaki Province. CIP have been designed as a decision-making tool for scientific planning and for increasing investment in adopting CSA technologies and practices.

grassroots-level extension workers and local resource persons, such as paravets, to assist farmers with CSA-related advisory services. Promoting a pluralistic and participatory extension system by involving public- and private-sector extension services and "communitizing" extension services as envisaged in the ADS is a way that CSA-related advisory capacity can be internalized in all CAESCs.
This will include strengthening and promoting agricultural research and extension linkages at various tiers of government and establishing three-way communications between research, extension, and farmers in a way that ensures research activities are of direct relevance to farmers. CSA-dedicated activities will be developed in R&D stations in each agroecological zone, with satellite stations under NARC. CSA needs to be mainstreamed in all the research stations for crops, livestock, poultry, fisheries, agroforestry, and pasture.

Implementing demand-based and integrated CSA options. This is where refined and localized versions of the identified options would be rolled out so that advisory services and inputs are actually delivered and implemented together with farmers for crops, livestock, agroforestry, and so on, so that they can adopt appropriate CSA practices (such as one described in section 5 and planned as above). This needs to be done in conjunction with cluster-based value-chain promotion and support, formal and informal communication media and training support, and matched with appropriate financing sources and other critical inputs and support mechanisms (as packaged together in investment, described in section 6, and as facilitated below).

Strengthening capacity of farmer organizations. Key to ensuring that farmers can play an increasing role in defining their own needs and solutions for CSA, demanding and accessing right services, and managing their local store resources, is strengthening local community-based institutions such as farmer organizations, water user associations, and cooperatives in the adoption and sustainability of CSA and irrigation investments.

Local agriculture budgets will have to form the core support for farmers to adopt CSA, together with her or his own resources and working with private-sector actors. This, in turn, would require (1) increased allocation for agriculture in the federal budget (see 7.5 below); (2) a more balanced allocation of resources with increased prioritization of agriculture at provincial and municipal governments; (3) reducing duplication among agricultural development programs of various tiers of government and aligning the expenditure pattern with programs of strategic importance;[11] and (4) improved capacity of the federal, provincial, and municipal governments to implement the budgets allocated effectively.[12]
In addition, systems that assist in assessing the outputs and outcomes generated by public resources invested in agriculture, and tracking the resources being allocated and spent for CSA-related activities, either stand-alone or part of larger agricultural development programs, need to be put in place in a way that helps maximize the return on investments made and uses such information to advocate for higher allocation of budgetary resources in the future. In general, resource allocation priority has to shift from increasing the production and productivity objective pursued so far to the development of an agriculture that is more sustainable and resilient to climatic and non-climatic shocks, including pandemics.

Value chains and private-sector support for CSA and mobilizing private resources. Support cluster-based planning for value chains aimed at achieving economies of scale for more cost-efficient

[11] In the MoLMAC, Province 2, there were 315 program headings listed and many were found to overlap and duplicate those of the Directorate of Agriculture Development (DAD), Agricultural Knowledge Centres.
[12] Despite relatively low allocation, spending in Province 2 was just 12.9 percent during nine months of the fiscal year 2018/19 and the capital expenditure was 4 percent in the first quarter of the same fiscal year; it was even lower for DAD.

delivery of inputs and advisory services and for produce marketing. This would involve actors from the private sector, farmer organizations, local planners, extension units, and local research agencies who would identify key actions for addressing the needs of CSA-related value chains such as inputs supply, agricultural infrastructure development and mechanization, farm production, processing, and marketing. This would also assess where private sector financing also would play a key role (see further in Section 7.6).

Strengthening the capacities of locally based financial institutions such as the self-help groups, savings and credit societies, and the branch networks of national and provincial financial institutions to offer agricultural finance services including agricultural risks management instruments, and developing financial products that are suitable for a wider range of climate-responsive production systems.

Strengthen technical and institutional capacities for implementing land-management practices for piloting and scaling up land banks, promoting land pooling, enabling contract farming, and mechanizing farms, mainly by developing custom hiring services and giving these leasers access to financial services to facilitate efficient use of lands. This is important due to the land fragmentation and weak tenure situation for many smallholder farmers (especially for women), which make more efficient farming systems difficult to implement.

7.4 M&E in Support of CSA Investments

An M&E system for assessing the performance of CSA needs to be updated and strengthened. With a greater emphasis on the multiple dimensions of CSA, but also under the current changes in government structures, which have somewhat weakened the reporting linkages between different levels, issues to be urgently address are as follows: (1) adding the sustainability dimension, in particular, climate smartness of agricultural practices on top of production and productivity focus of M&E systems practiced to date (see key indicators in Box 22 below); and (2) realigning reporting lines following the federalization of the administrative structure among various tiers and across agencies, thereby ensuring effective flow of information for planning and monitoring of agricultural development programs, including CSA. Attention should be paid to strengthening the M&E system, bringing in new innovative technologies that facilitate data capture, processing, and analysis—both nationally and locally—combined with participatory feedback mechanisms to help track implementation and assess the effectiveness of CSA investments. Corrective actions must be timely and must enhance the overall impact in the long run. The system improvements will draw on a common results framework and M&E system for CSA that may include the following:

- Policy and strategy framework indicators and investment targets, along with a methodology for assessing performance in relation to climate smartness. This would guide the relevant ministries and local governments and the NPC in monitoring the overall progress toward CSA in Nepal
- A national tracking system that monitors the progress made in developing capacity to plan, coordinate, and implement CSA practices and in setting up plans and budgets
- Investment package indicators, including further refinements and adaptations of targets, to be undertaken locally.

There are many useful tools available, including benchmarking, Remote Sensing, GIS and management information systems, geotagging, drones, that are especially useful for agriculture and land management and that can be adopted and adapted to help facilitate data gathering for

Box 22. Measuring the Success of CSA

In selecting potential indicators of success for adoption of CSA, it must be recognized that such indicators are very context and intervention specific (see table below for basic framework). The main intermediate outcome indicator is actual adoptions of CSA practices at the farm level. This can be monitored through digital-based mobile monitoring of focused program interventions and farm-level activities, supplemented by remote sensing of land-use changes, where these can be identified as having strong enough visible signal. Further outcomes in relation to production and productivity and their variability can be done through agriculture surveys but also require closely matched information on actual farm activity and climate data and on actual intervention support.

	Inclusive Sustainable Agriculture	Adaptation	Mitigation
OUTCOMES	• Adoption of sustainable agriculture practices (water saving, soil conservation, supporting biodiversity, reducing chemical inputs, etc.) • Increase production • Livelihood strategy changes	• Adoption of locally appropriate climate resilient practices (drought, flood tolerance practices and crop and livestock varieties) • Diversification of cropping • Uptake of climate insurance	• Reduced deforestation • Adoption of emission reducing livestock practices • Adoption of emission reducing rice practices (e.g. AWD)
IMPACTS	• Increased agriculture productivity • Reduced negative environmental impacts • Increased food security diets • Increased incomes and reduced poverty	• Reduced loss and damage to hh and agriculture sector • Farming and livelihoods strategies operating viably under new climate conditions	• Reduced GHG emissions • Increased carbon sequestration

Source: FAO 2021[21].

M&E. Development of local monitoring tools that ensures widespread application of participatory M&E, using techniques such as participatory rural appraisal and appreciative inquiry, also help to strengthen local feedback mechanisms and monitoring appropriateness of CSA. All these will require M&E systems to be significantly redesigned and staff retrained to effectively implement these systems.

7.5 Overall Financing Requirements for the CSAIP and Distribution

National- and provincial-level investment costs. Table 21 summarizes indicative national- and provincial-level investment costs. These costs only provide a rough sense of proportions, which could be refined by more detailed assessments of planning and feasibility, and a review of financing capacity. The cost of Package A in creating an enabling environment for mainstreaming CSA is projected to be

[21] FAO. 2021. Making climate-sensitive investments in agriculture – Approaches, tools and selected experiences. Rome. http://www.fao.org/documents/card/en/c/cb1067en

financed by the federal government. Provincial-level costs of other investment packages are indicative and reflect respective shares of provinces in each production system, cost differences in interventions across agroecological zones, and coverage of productions systems by recent and ongoing projects and programs. The most significant costs are associated with irrigation investment in Province 2 and mostly the Terai, where the bulk of irrigable cropland areas in need of improvement and development are located, showing higher investment envelopes overall, with the lowest in Karnali, which is mostly mountains and hills.

Current investment costs are base costs in 2021 prices. As such, total actual costs will be different depending on rates of inflation over the 10-year period (as well as phasing of implementation). Apart from this, adjustments to irrigation interventions by choice or need are another important factor in change to investment envelopes. For example, the current estimate for irrigation needs could slightly differ from actual needs, especially in relation to distribution of lands across agroecological zones with significantly different unit costs, thereby affecting the irrigation envelope. Similarly, some schemes that are currently considered operational could require repairs due to potential natural disaster events. Projected costs of new irrigation area development or water storages could also change if found to be technically unfeasible.

Financing. Proposed interventions and investments are built around requirements, needs, and implementation capacity to mainstream CSA options in agriculture in 10-year timeframe. At the national level, financing of proposed interventions will factor in availability of the government resources, the government priorities for development partner financing, and priorities and resources of development partners to finance proposed interventions. Therefore, identification of potential resources and financing gaps will be facilitated during dissemination, follow-up, and partnership dialogue activities.

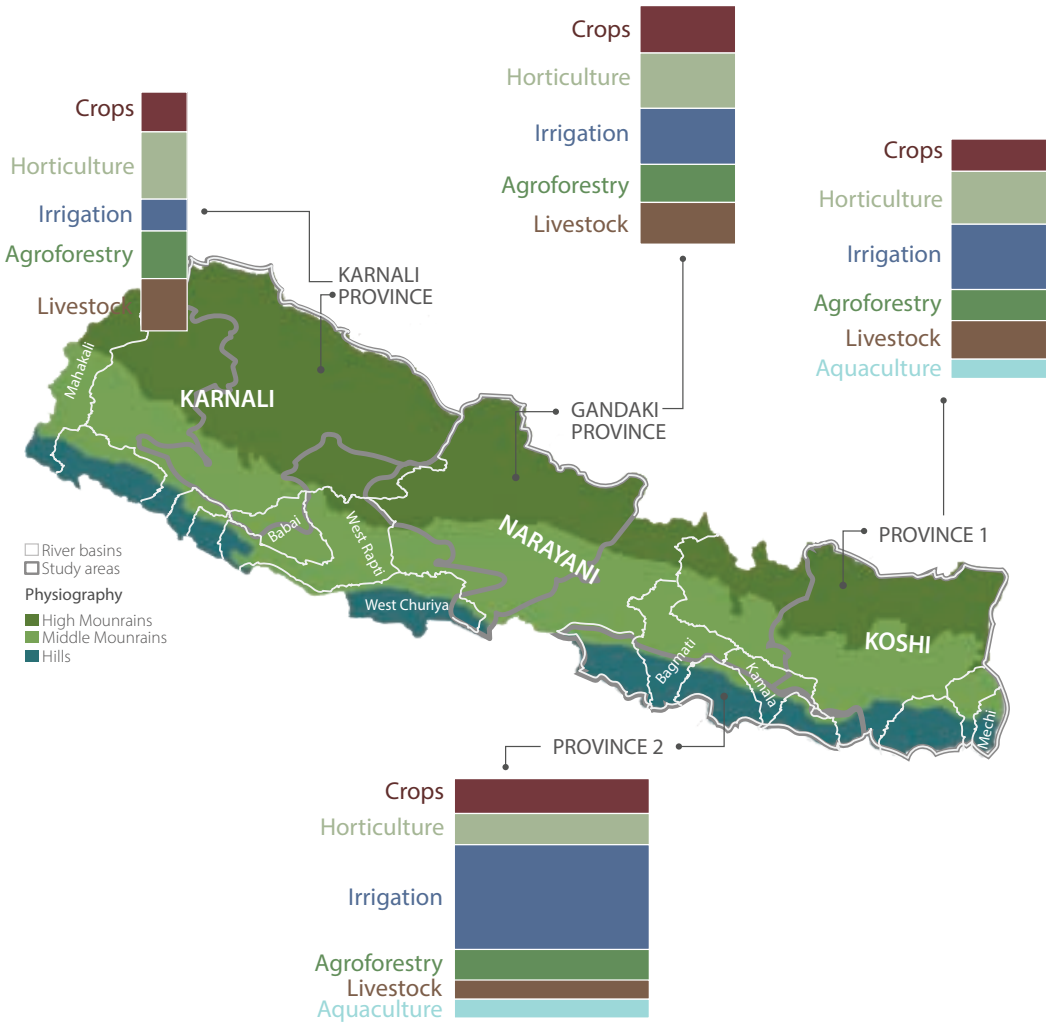
At the provincial level, the financial capacity of provinces, if a subnational lending approach is introduced, is not considered in this assessment. As per the current practices, the investments in farm-managed irrigation schemes involve cost recovery (contributions vary across agroecological zones), while some investments in agricultural infrastructure would be implemented through a matching grant scheme. Estimated costs of proposed interventions include some contributions from the private sector that cannot be accurately estimated at this stage.

Table 21. Indicative Distribution of Investment Costs by Provinces

Investment packages	Federal	Estimated cost, US$, millions				
		Province 1	Province 2	Province 4	Province 6	Total
A. Enabling environment for CSA	25	0.0	0.0	0.0	0.0	25.0
B. Climate-responsive crop production system	0	84.0	231.0	84.0	21.0	420.0
C. Commercial horticulture	0	54.0	45.0	45.0	36.0	180.0
D. Climate-responsive livestock production system	0	12.0	6.0	12.0	10.0	40.0
E. Climate-responsive and resilient agroforestry	0	4.0	3.0	6.0	7.0	20.0
F. Climate-responsive and resilient aquaculture	0	4.6	10.4	0.0	0.0	15.0
TOTAL	25.0	158.6	295.4	147.0	74.0	700.0
Shares (%)	4%	23%	42%	21%	11%	100%

Source: original material.

Figure 12. Showing Approximate Distribution of Investment Costs by Province (size of tables only indicative for illustration, based on table 21)



Source: original material.

7.6 Maximizing Finance for Development to Support CSA

Maximizing finance for development (MFD) requires crowding-in private resources to assist in achieving development goals, optimizing the use of scarce public resources, promoting good governance, and ensuring environmental and social sustainability (WB 2018). Proposed investment packages and interventions were designed taking into considerations these factors, which were determined through the decision tree approach and guided by World Bank's MFD for agricultural value chains (2018). The decision tree is presented in figure 13, and key considerations are discussed below.

Crowding-in private-sector financing, domestic and foreign. The private sector, farmers, and other value-chain actors are the largest investors in agriculture. However, the country has significant potential to mobilize further private-sector financing (domestic and foreign) for development. This requires multiple actions, which are considered under the proposed investment packages. First, there

is a need to create an enabling environment to increase private-sector activity in the sector, including through removing policy and regulatory barriers in the areas of agricultural land, finance, fertilizer, and seeds; and there is the need to engage private-sector participation in diagnostics of current policies and regulations and develop more private sector-oriented policies and regulations. These interventions are proposed under investment Package A. Second, there is a need to reduce risks and high transaction costs. This will require investments to improve access to extension and services, irrigation, information, risk and insurance products and services, and market and postharvest infrastructure. Together with risk management, and better access to the right insurance products and related services this will help to strengthen resilience from climate and non-climate shocks. Also required are incentives through improving access to finance, securing land titles, and forming partnerships in risk and cost sharing (for example, through PPP and matching grants); standardization and certification services and basic public infrastructure and logistics; and facilitation of private-sector engagement in productive and resilient agricultural value chains. Ensuring responsible investments in alignment with the principles of environmental and social sustainability and Building Back Better and Greener will be supported under each relevant investment package.

Optimizing use of public-sector resources. ADS (2015) estimates that meeting the annual agricultural targets requires US$500 million annually. The current agricultural spending is much below this target, leaving significant room for scaling up. This also calls for improving efficiency of existing public resources, especially in areas such as fertilizer, seeds, land management, and governance, which are the focus in investment Package A. Additionally, there is a need to increase investments in public infrastructure (roads, electricity) using existing resources and through improved coordination with respective sectors. A key consideration will be given to using public resources on PPP and other cost-sharing mechanisms to facilitate private-sector financing in agricultural infrastructure and logistics. The latter interventions are proposed under select provincial-level investment packages.

Maximizing development partner financing. Nepal needs development partner financing to achieve its development goals. It currently receives financial and technical assistance from major international and bilateral development partners to finance its development agenda. However, there is further potential to maximize financing from private-sector arms of international financial institutions such as the International Finance Corporation of the World Bank and the Private Sector Window of the Global Agriculture and Food Security Programme (GAFSP). This will, however, require creating an enabling environment for private-sector financing from international and multinational investors proposed under the interventions of Package A.

Figure 13. Decision Tree for Maximising Finance for Development: Mapping of public sector support to mobilise private sector financing

Source: Decision tree was adopted from World Bank (2018) and adjusted to the Nepal CSAIP

Section

8

Conclusions and Ways forward for Scaling up CSAIP in Nepal

CSA is an important contributor to Nepal's NDCs. Agriculture-sector development needs to adjust to the inevitable reality of climate change, risk, and occurrence of more intense and frequent extreme events. Resilience building to climate change shocks and other shocks such as COVID-19 through adoption of CSA practices is critical and cannot be postponed. While climate adaptation in the agriculture is critical for strengthening rural livelihoods, agriculture in Nepal is also a major contributor to GHG emissions. Improving agricultural performance head-on to strengthen climate adaptation, which is a priority for farmers, local stakeholders, and climate change mitigation, is an essential part of Nepal's NDC commitments. CSA will allow the country to reduce its GHG emissions levels, improve its resilience, and enhance its agricultural productivity and income levels. The abatement costs of several mitigation options is low because they will be combined with enhanced profitability and higher resilience.

The recommendations for investment that have been identified provide substantial opportunities for putting Nepal's agriculture on a sustainable pathway. The CSAIP has elaborated investment opportunities in cropping, horticulture, livestock, agroforestry, and aquaculture. It has also indicated the types of changes in the enabling environment that would facilitate such progress. CSA is fully compatible with the objectives of the ADS that guides Nepal's government; CSA, by nature, will be location specific and its adoption will require local ownership at the level of provinces and municipalities. Nepal's transition to CSA will also require commitment at the national level, especially to address the policy dimension and to create an enabling environment for CSA adoption and private-sector involvement.

CSA is within reach in Nepal but will require attention to several dimensions. It will often require a change in production systems and the adoption of new technologies, which underscores the need to strengthen research at the national level and extension systems at the provincial and municipal

levels. It will require policy changes in input markets to allow access to the best possible seeds and the optimal fertilization strategies. Infrastructure investments, especially for water and irrigation management, will enhance the resilience of the sector. Better-trained farmers will be better able to introduce and manage more sustainable production systems. CSA can become the overall focus for advancing the sector.

In recognition of the need for ownership at all levels of government, the report was prepared under the guidance of a Steering Committee and in partnership and consultation with provincial authorities, farmers, and other stakeholders. The participatory process will facilitate the next steps toward implementing and financing the CSA investment recommendations. In those next steps, the principles of consultation and evidence-based decision-making will need to be maintained in order to ensure maximum buy-in. Decisions will need to be made on government investment priorities and spending and on which investments can be left to the farm and the agribusiness community. In the end, the synergy between public and private partners will lead to the best and quickest way forward.

This report should be widely disseminated within Nepal at different levels. Federal and provincial governments may pursue the investment packages that have been outlined in the report, but they may also be inspired to adopt a CSA lens in their agricultural policy planning and decision-making and develop further options. Financiers, including The World Bank Group itself and other partners, may find in the report ways to support the country that are compatible with current principles for responsible investments. Entrepreneurs and farmers may identify opportunities for their own investments that will contribute to a healthy bottom line and a more sustainable sector.

The report provides due attention to federalization. In recognition of the ongoing federalization process, the first Steering Committee meeting concluded that it would be better to focus the analysis at subnational level and to develop investment packages at the level of provinces or watersheds. Therefore, the current report does not cover all of Nepal's territory. By repeating the analysis in other parts of the country, the coverage of the report may be scaled up. To facilitate this replication, the team in charge of this report has put special attention on the development of a methodology that can easily be repeated in other provinces, supported by nationwide data also gathered. When applying the methodology to other parts of the country, similar but not necessarily identical conclusions may be reached, but the results will be comparable with the rest of the country. If there is national or provincial interest in repeating such analysis, MoALD, FAO, and WB would be keen to explore options to take this forward. At the national level, however, the report has provided an outline of the most important dimensions in an enabling environment that will hold across the whole country and would not need to be repeated.

Further technical and financial support may be needed to implement the plan. Pursuing collaboration based on the CSAIP may be attractive to most of Nepal's mainstream development partners (WBG, ADB, IFAD, FDCO, United States Agency for International Development [USAID], SDC, and so on) because it would guarantee contributions to the country's welfare that are sustainable and globally responsible. At the same time, the federal government may pursue specific climate funds to support the implementation of the CSAIP, such as those funds available through the NDC process, the GCF, the Climate Action Fund, the GEF, or others. The CSAIP may also form an important contribution to more programmatic approaches at the national level to support funds such as the GCF to be as strategic as possible in their resource allocations in the country.

The Nepal CSAIP process provides many important lessons. Several lessons are similar to conclusions reached in CSAIP exercises in countries such as Bangladesh and Zimbabwe, such as the importance of participation and the balance between analytical depth and the accessibility of the findings. Doing this exercise, however, in a virtual world hit by COVID-19 provided several additional lessons: the pandemic has changed priorities over the last year; more importance is given to the need for clean and healthy production and marketing systems, which might reinforce the attention to the One Health perspective and to developing hygienic market places.

All consultations and analysis were undertaken virtually. While the amount of field verification has been limited, a lot of detailed assessment was possible with existing data which may have yielded more insights than might have been obtained by collecting new data. Virtual communications and meetings allowed the team in charge of the report to consult with many people, and possibly, to bring even more people into the decision-making process than would have been done otherwise. However, this was only because of the excellent team in Kathmandu who were able to undertake limited travel and could maintain their networks at the national and provincial levels.

New experiences provide new wisdom. This report was prepared in a way that no one would have imagined in 2019. The quality of analysis remains high, but nevertheless there is a chance that something important may have been overlooked. This could also have been the case with a report produced in the traditional way, but we might not have been so aware. Now, however, we hope that everyone is conscious that this CSAIP report should not be the final word on climate change in agriculture in Nepal. Let's take the report as the beginning of the journey, not the end.

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Relevant Programs and Projects

Climate Change:

- Reducing vulnerability and increasing adaptive capacity to respond the impacts of climate change and variability for sustainable livelihood in agriculture sector (FAO GEF LCDF)
- Nepal Climate Change Support Programme, UNDP
- Nepal National Adaptation Programme of Action (NAPA)
- Supporting developing countries to integrate the agricultural sectors into National Adaptation Plans: Nepal
- Mountain Ecosystem-based Adaptation in Nepal
- Global Ecosystems Based Adaptation in Mountains Programme
- Climate Change Impact and Adaptation in Nepal
- Adaptation for Smallholders in Hilly Areas Project, IFAD
- Forest and Water Management for Mitigating the Effect of Climate Change in the Middle Hills, Nepal, IRC
- Building a Resilient Churia Region in Nepal (BRCRN), FAO GCF.

Agriculture Value chains Key projects and programmes:

- The Prime Minister's Agriculture Modernization Project (PMAMP, https://pmamp.gov.np/)
- Project for Agriculture Commercialization and Trade (PACT, World Bank)
- Agriculture Sector Development Programme (ASDP) IFAD, building on HVAP
- Value Chain Development of Fruit and Vegetables in Nepal, UNDP
- High Mountain Agribusiness And Livelihood Improvement Project (HIMALI), ADB)...
- Nepal Livestock Sector Innovation Project World Bank
- Promotion of organic farming practices in Karnali region, FAO

Poverty reduction:

- Community Infrastructure and Livelihood Recovery Programme (CILRP), UNDP
- Cooperative Market Development Programme, UNDP
- Poverty Alleviation Fund Project, IFAD
- Poverty Alleviation Fund, World Bank
- European Aid for Nepal Poverty Eradication
- Nepal Western Uplands Poverty Alleviation Project, IFAD
- Accelerating progress toward the economic empowerment of rural women in Nepal: A joint pilot contributing to the implementation of the agricultural development strategy, (FAO - UN)

Food security:

- Technical Assistance to the Agriculture and Food Security Project (AFSP), (FAO UTF/NEP/073)
- Nepal Agriculture Food Security Project (Global Agriculture and Food Security Program, GAFSP)
- Nepal Agriculture and Food Security Project, World Bank
- Agriculture and Food Security, USAID
- Food and Nutrition Security Enhancement Project, World Bank (FANSEP, under Global Agriculture And Food Security Program)
- Enhancing livelihoods and food security from agroforestry and community forestry in Nepal, Worldagroforestry/ICRAF

List of annexes and working papers

The following documents can be found in an online folder in a link under the Nepal note for the FAO Hand in Hand initiative on the following webpage:

https://www.fao.org/hih-geospatial-platform/en/country-cases/index

Annex 1. The Process and Methods of the Study

- WP 1. Relevant Agriculture Policies, Programs and Projects
- WP 2. Profiling the Agriculture Sector and Systems
- WP 3. Climate Change Modelling
- WP 4. Climate Smart Agriculture Options
- WP 5. Prioritization of CSA Practices and Technologies
- WP 6. Impact of COVID-19 on Agriculture Sector and Food Systems
- WP 7. Compendium of Proposed Investment Packages
- WP 8. Compendium of Proposed Irrigation Interventions
- WP 9. Documentation of Stakeholder Consultations
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