COMPENDIUM OF CLIMATE-SMART AGRICULTURE TECHNOLOGIES AND PRACTICES

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CCAFS

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The Authors

FOREWORD

The agriculture sector is highly impacted by climate change induced issues and challenges. Nepal is one of the vulnerable countries to climate change due to its geographical diversity with micro-climates, weak topography and vulnerable agro-ecosystem. Hence, building resilience in the current agriculture production system for minimizing the effects of climate change is of the utmost importance and a challenge too.

Nepal has been actively implementing climate change management activities since 1994 when it became a member of the United Nations Framework Convention on Climate Change (UNFCCC). During this course, the Government of Nepal (GoN) developed the National Adaptation Programme of Action (NAPA) in 2010 and has implemented several climate change related programmes and projects as suggested by NAPA. Guided by NAPA, GoN also developed the National Framework on Local Adaptation Plans in 2011 with the aim of integrating climate change in the local development plans and has implemented various programmes through it. The GoN has also developed and endorsed the National Climate Change Policy 2011. Similarly, the National Agriculture Policy 2004, Agriculture Development Strategy, and 15th Five-year Plan have also tried to address climate change related issues.

Gandaki Province has huge potential for diverse agriculture and livestock commodities due to its geographical/ecological diversity ranging from the Terai to the mountainous regions, however it is equally vulnerable to climate change induced disasters. In order to reduce climate change impacts and increase agricultural production to ensure food security, the Ministry of Land Management, Agriculture and Co-operative (MoLMAC), Gandaki Province, has been implementing the Chief Minister Climate Friendly Model Agriculture Village Programme (CMCFMAVP) since 2018 in 87 villages of 85 municipalities. In these smart villages, several activities have been implemented to promote climate-smart agriculture (CSA) technologies and practices as adaptation measures to reduce the vulnerability of the farming communities and increase their resilience.

In this regard, MoLMAC and Local Initiatives for Biodiversity, Research and Development (LI-BIRD) have signed a Memorandum of Understanding (MoU) for collaboration in implementing climate-smart agriculture related programmes. Of the 87 model villages established by CMEFMAVP, LI-BIRD has directly supported in three model villages (Ramkot and Tallo Kudule villages of Phedhikhola Rural Municipality, Syangja; Hardiya and Baruwa villages of Madhyabindu Municipality, Nawalpur East, and Paudur village of Annapurna Rural Municipality, Kaski) by promoting various CSA technologies and practices, delivering capacity building training programmes, distributing gender friendly tools and disseminating various knowledge products.

In this context, MoLMAC, Gandaki Province and LI-BIRD have jointly documented a Climate-Smart Agriculture Compendium which I believe will be equally beneficial for agriculture practitioners, technicians, and stakeholders engaged in the agriculture sector. The Compendium has compiled nine different climate-smart agriculture technologies and practices that are relevant and useful for the current agricultural system. The technologies listed in the Compendium are expected to increase effectiveness of CMCFMAVP. I also hope that the content of the climate-smart agriculture practices included in the document will be implemented at farmers' level on the ground.

Your suggestions to further improve the publication in the future would be highly appreciated and welcomed.

Lastly, I would like thank the team of MoLMAC, Gandaki Province and LI-BIRD, and those who were directly or indirectly involved in producing the document.

Sabnam Shivakoti
Secretary
Ministry of Land Management, Agriculture and
Co-operative, Gandaki Province

FOREWORD

Globally there has been significant effort made by various organisations to promote Climate-Smart Agriculture (CSA) technologies and practices for building resilience in the agriculture sector and to achieve sustainable food production systems under a changing climate. However, satisfactory progress is yet to be realised, therefore, more work and investment in CSA research and development is urgently warranted.

This 'CSA Compendium' is an attempt to contribute towards strengthening the CSA knowledge repository and its application by potential users, both within Nepal and beyond. The compendium documents and presents a set of nine field tested CSA technologies and practices with potential application in different Agroecological regions of Nepal. The compendium is prepared by Local Initiatives for Biodiversity, Research and Development (LI-BIRD), in partnership with the Ministry of Land Management, Agriculture and Co-operative (MoLMAC), Gandaki Province under the project 'Supporting Gandaki Provincial Government through Climate Compatible Agriculture Development'. The project is implemented by LI-BIRD in Kaski, Syangja and Nawalpur districts, with financial and technical assistance support from the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS), and South Asia, and Climate and Development Knowledge Network (CDKN) through Local Governments for Sustainability, South Asia (ICLEI SA). I hope potential users, especially the agriculture development practitioners, extension workers, academia and researchers, will find this compendium a useful guide and reference source to their further work.

On behalf of LI-BIRD, let me take this opportunity to extend my sincere gratitude to the Ministry of Land Management, Agriculture and Co-operative (MoLMAC), Gandaki Province for their excellent cooperation and collaboration in the implementation of the project as well as throughout the preparation of this compendium. I would also like to thank the reviewers, and most importantly the authors of this compendium, who worked hard to produce this CSA compendium as a useful guide/reference source.

I hope this compendium will be brought to its full use by a variety of users, and we encourage interested individuals and organisations to further enrich this CSA knowledge repository by exchanging their own knowledge/experience with us.

Balaram Thapa, PhD
Executive Director
LI-BIRD

LIST OF ABBREVIATIONS

ABPSTC	Agribusiness Promotion Support and Training Center
CBM	Community-based Biodiversity Management
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agriculture Research
CSA	Climate-Smart Agriculture
CSB	Community Seed Bank
DAP	Di-ammonium Phosphate
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Green House Gas
HYV	High Yielding Varieties
ICT	Information and Communication Technology
IFOAM	International Federation of Organic Agriculture Movements
IFS	Integrated Farming System
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IRD	Informal Research and Development
LARP	Local Agriculture Resource Person
MAP	Medicinal and Aromatic Plants
MFS	Modern Farming System
MoLMAC	Ministry of Land Management, Agriculture and Co-operative
MOP	Muriate of Potash
MUS	Multiple Use System
NARC	Nepal Agricultural Research Council
NASA	National Aeronautics and Space Administration
NTFP	Non-Timber Forest Product
OMS	Outcome Monitoring Survey
SHF	Smallholder Farmers

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EXECUTIVE SUMMARY

Nepal is a vulnerable country to the impacts of climate change. The adverse effects of climate change have decreased agricultural production and productivity. Agriculture is the mainstay of the nation's economy, the largest employer of the population, and the primary source of livelihoods. Therefore, technologies and strategies to develop resilience agriculture and increased agriculture productivity are urgently needed to create climate-smart technologies and help the existing technologies to adapt to climate change.

This compendium presents climate-smart agriculture (CSA) technologies and interventions for enhancing food security with adaptation and mitigation as co-benefits.

To generate tangible benefits from CSA, especially for women farmers of varied ethnic origins striving with various risks and scarcity, CSA involves smart farming practices and strategies that help develop resilience agriculture, increase crop and livestock productivity, reduce greenhouse gas emissions, and enhance food security goals.

This compendium has been developed for extension workers to support up-scaling climate-smart technologies and build climate resilience villages that enhance food, nutrition, and income, mainly for marginal communities striving in marginal areas. Integration of high-value crops with improved husbandry practices into a solar-based irrigation system that irrigates over 170 hectares of croplands of around 700 households demonstrates resilience agriculture. This compendium also highlights the ecological and economic benefits associated with the interventions.

Community seed banks (CSB) have been another successful intervention that improve farmers' access to seeds of crop varieties adaptable to low inputs and marginal environments with minimal risks of crop failures even under climatic stress. CSB, with over 20 years of evolutionary history, now has a wide range of formal and informal institutions that have been promoting CSB regardless of ecological zones and production potential ecosystems in Nepal. CSB has been a great institution that provides essential services to the most vulnerable and marginal communities living in marginal areas barred from mainstream services. CSB has been integrated into different levels of government and civic society organisations.

Integrated Home Garden: an intervention designed and developed through repeated testing and piloting over decades across LI-BIRD's working areas, proven to enhance food and nutrition security, especially in smallholder farming households. Recognised intervention are climate resilience and the best means of maintaining crop diversity at the farm level.

The slow growth of agro-based enterprise in Nepal is associated with limited and uncertain public services, impacts of rapidly changing climate, poorly supported roads and market infrastructure, poor access to finance, and more importantly, the low risk-bearing capacity of prospective entrepreneurs. Such situations apply mainly to marginal communities. However, the introduction of insurance schemes has motivated farmers of marginal communities to engage in enterprise development. In this compendium, we present the process and steps to implement insurance schemes with success stories and the conditions under which small farmers could benefit through the procedure.

1. INTRODUCTION

In this compendium, a total of nine technologies and practices are documented. They have been developed either through participatory research with farmers and stakeholders, or through multiple sources and the evaluation of indigenous technologies and practices with specific and/or broad adaptation to climate and environment conditions.

We expect that the climate-smart practices presented in this volume will benefit extension workers, researchers, academicians, and policymakers working in climate change in general and climate-smart agriculture in particular with mitigation co-benefits. Research continues to develop technologies resilience to climate change impacts. In this volume, we present a total of nine CSA technologies and practices; Volume II will cover additional new technologies and strategies developed from on-going research within the country and abroad.

1.1. Agriculture production system in Nepal

Agriculture is the economic backbone of Nepal. According to the International Labor Organization, agriculture provides livelihoods for about 68 percent of Nepal's population, accounting for 34 percent of the GDP. Nevertheless, Nepal struggles to produce an adequate supply of food for its citizens (https://www.usaid.gov/nepal/agriculture-and-food-security). The agricultural sector contributes 28 percent to the national Gross Domestic Product (NRB, 2018). The Nepalese agricultural production system is multi-dimensional, which interacts in a complicated way for influencing the sustainability of the farming system. Sustaining the agriculture productivity chain is affected by different factors, including the cost of production, demand and supply of goods and services, food safety, and food and nutrition security and their impacts on the environment. Sustainable agriculture may mean different things for different people. Still, the most commonly used definition is 'producing good food and fiber, uses on-farm resources efficiently to minimize the adverse effect on the environment and people, preserves the natural productivity and quality of the land, water and sustains vibrant communities' (Sassenrath *et al*., 2009). Thus, sustainable agriculture production systems address the issues of supplying human needs with a minimal negative impact on the environment. It emphasises the optimal utilisation of the available resources while minimizing the production costs and thereby ensures the consumers' and producers' quality of life.

Like elsewhere, the agriculture production systems in Nepal are comprised of various farming systems. Some of the forms and practices in agriculture production systems are not limited to the traditional farming system, modern farming system, permaculture, integrated pest management, and integrated farming systems. In sum, the drivers of agriculture production systems include resource endowment, market, and production environments. Table 1 describes the key drivers of the agriculture production system.

The figure 1 characterises a typical Nepali farming system for improved food security, also ensuring the judicious use of natural resources for sustainable production. The integrated farming system adopted in fragmented, undulated, and resource-poor areas found in Nepal's hills and mountains serves the smallholder farm families. The modern farming practices are widespread in resource-rich regions; access to infrastructure, services, and markets of Nepal's Terai region contributes to national food security. As the above figure illustrates, different environment-friendly practices promote human and soil health. These practices are adopted in various production factors, including soil, water, livestock, crop, and labour, by farm families. The various farming system adopted in Nepal are described below.

Table 1: Drivers of Agriculture Production System

SN	Drivers	Description
1	Social drivers	Life style (farming as a way of life)
		Community support through the production system
		Conservation of the environment with minimum impact
		Use of advisory services in farming for decision making
		Awareness and concerns in government policy
2	Economic drivers	Risk management through crop and livestock diversification
		Support from government policies
		Marketing channels and market price of commodity
		Production strategies as per the farm size
3	Environment quality drivers	Types of the soil available e.g. erodibility, nutrient availability etc.
		Conservation practices (minimum tillage, cover crops, legumes integration)
		Effective crop pest and disease management strategies
4	Education	Capacity building of farmers, extension services
		Implementation of new mechanised techniques in the farm

Source: Modified from the table given by Walter et al., 2016

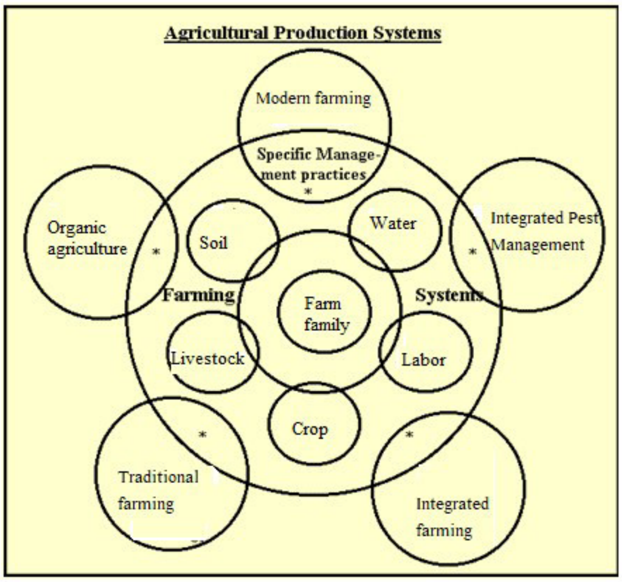

Figure 1: Agriculture Production system practiced in Nepal (Modified from Healthyag.com, 2001).

1.1.1 Traditional farming system

The majority of farmers, especially across poor resource areas such as the hills and mountains, practice traditional farming methods – using livestock for land preparation, using locally prepared manure, using local seeds, and using human labour for post-harvest operation. Thus, the productivity of the systems depends upon the fertility status of the soil, weather patterns, and production potential of crop varieties, disease and pest situation, and the intensity of water and crop management practices. The level of crop management determines the level of production. In other words, the system defines a low risk because it is already less productive, yet the products are healthier. The subsistence agriculture production system across the rain-fed areas where there is limited access to marginal farmers' resources and services with limited options is found to be more risky in terms of climatic hazards. A mixed and relay cropping such as maize/millet, rice/lentil, maize/soybean, and maize/potatoes are locally employed strategies to minimise the risks of crop failure and efficiently utilise the limited resources. These traditional farming methods not only efficiently utilise scarce resources (e.g. water, nutrients) and/or abundantly available resources (e.g. solar radiation) but are also considered low carbon emission technology.

1.1.2 Modern farming system

The modern farming system (MFS) is becoming more attractive for resource rich farmers of the resource affluent areas, especially with the development of high yielding varieties (HYV) and improved crop husbandry practices including post-harvest. Like elsewhere, modern agriculture performs best and is worth promoting to high production potential areas with improved access to roads and markets, public services, and farms suitable for using farm machinery such as in the lowland Terai region. The strategy of the MFS is aimed at maximising returns through the application of high levels of inputs including the use of farm equipment, inorganic fertilizers, and HYV under mono-crop system. The rationale behind MFS has been that only high input agriculture produces enough food to meet the food demand for an ever-growing population. However, sustaining agriculture productivity, producing healthy food, and keeping human and soil health and protecting the environment remain a challenging issue of our time.

1.1.3 Integrated farming system

The Integrated farming system (IFS) is an interrelated, inter-dependent, interlocking approach to agricultural research and development that views the whole farm as a system and focuses on the inter-dependencies between the major farm components (crop, soil, water, livestock, poultry, fishery, homestead, biomass etc.) under the control of smallholder farmers (SHF) households. These farm components interact with each other (connections) in respect of physical, biological and socio-economic factors which are not under the control of SHF households. The integrated farming system is a biologically integrated system that incorporates various agricultural components for the maximum replacement of off-farm inputs and sustainable farm income. This system helps farmers to diversify their cropping system, increasing the choices to generate benefits for the producers. IFS is very much adaptable to resource poor areas and marginal communities. This is because individual farmers produce a variety of crops including fruits, vegetables, milk, and fish in an integrated manner from where their daily needs of food, nutrition and incomes are secured. The IFS approach offers multiple benefits in terms of securing food and nutrition, reducing risks of crop failures and cost of production, and with minimal damage to the environment. The system contributes to reduce carbon emissions by reducing the application of inorganic fertilizers. IFS components are chosen based on the adaptation of food crops over ecological regions. The table 2 below presents and example of IFS by land use systems and components.

Table 2: Cropping patterns in different land use system in Nepal

SN	Eco-region	Land use	Cropping patterns
1	Terai	Irrigated lowland	Paddy-wheat/potato/legumes/oilseeds-maize/vegetables/paddy
		Rain fed lowland	Paddy-wheat/mustard/legumes-fallow
		Upland	Maize-mustard
2	Hills	Irrigated lowland	Paddy-wheat/potato/legumes-maize/vegetables/paddy
		Upland	Maize+millet paddy/legumes-black gram/vegetables/legumes/potato-fallow
3	Mountains	Irrigated lowland	Paddy-barley/beans-fallow
		Upland rain fed	Maize-vegetable/wheat/potato-fallow

Source: MOAC (2011) agricultural atlas

1.1.4 Organic agriculture

Organic farming: agricultural system that uses ecologically based pest controls and biological fertilizers derived largely from animal and plant wastes and nitrogen-fixing cover crops. Modern organic farming was developed as a response to the environmental harm caused by the use of chemical pesticides and synthetic fertilizers in conventional agriculture that yields enormous ecological benefits (Adamchak, 2008). The forms of benefits that an organic farming approach generates includes, but is not limited to, sustains the health of soils, and is beneficial to insects and soils organisms, ecosystems, and people. Organic agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved (IFOAM, 2008). In simple terms, organic agriculture is a way of eating and living a healthy life in an ideal environment. Along with the development of policy guidelines both government and non-government, individual farms and the private sector are increasingly attracted to organic farming including agriculture and forestry. The Provincial Ministry of Land Management, Agriculture and Co-operatives (MoLMAC), for example, has recently declared the entire Karnali Province as an organic province. FAO Nepal is also supporting GON's efforts of promoting organic agriculture in the country. Organic agriculture actually is driven by 4 R principles (reduce, recycle, reuse and rot). Application of organic manures in place of inorganic fertilizers and recycling of degradable and agricultural wastes for compost enhances soil microbial activities, produces healthy food crops at lower costs, reduces carbon emission, and contributes to maintain a healthy environment. If effectively implemented an organic farming approach leads towards developing a resilient and sustainable farming system.

1.1.5 Integrated pest management

Despite the basic concept being very similar, different agencies and scholars define Integrated Pest Management (IPM) differently. IPM deals with the environment, the pest species' population dynamics, utilises all suitable techniques and methods and maintains pest population levels below those causing economic loss (FAO, 1967). Other scholars' view is that IPM should not be treated as a technology, rather taken as a strategic approach to developing technologies (Kiss and Meerman, 1991). It is a combination of experience and intelligence which emphasises on growing healthy crops with less disturbance to the environment and encourages the natural pest control system. As a sub-system of crop development and managing cropping systems sustainably, there are certain practical useful tips to keep in mind while employing an IPM approaches on pest management. Approaches and components that IPM practitioner farmers require to understand are, but are not limited, to include:

Table 3: Various IPM approaches and points to be concider by IPM practtioners and farmers

IPM approaches	Important to IPM practitioners and farmers
Pre-requisite, precautionary measures	Preventive measure to avert risks of crop failure.
Early warning information	Preparedness to reduce possible damage.
Development of monitoring guidelines	Identify key factors for monitoring including weather, pests dynamics, crop husbandry, soil fertility.
Identify and multiply pests to control pest population through bio-control measures	Introduce and promote bio-control organisms for pest management.
Develop technology brief knowledge products that potentially manage post population	Promotion of cultural, mechanical, biological and physical method for managing pests.
Prepare pesticides as a last resort if all other measures are found ineffective	Application of pesticides which cause minimal damage to the environment, human health and beneficial insects.
Monitoring, evaluation and learning	Tracking the effectiveness of each practices employed stepwise and derive learning for future action.

Successful implementation of an IPM approach not only minimises health hazards, but also minimises the killing of beneficial insects, and the cost of production. This approach also contributes to produce healthy crops and maintain a good environment.

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2. CLIMATE CHANGE

The Intergovernmental Panel on Climate Change (IPCC) defines climate both in terms of a narrow and wide sense. The climate is usually defined as an average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a significant period, a minimum of 30 years. A change in climate state is identified by a mean value that persists for an extended period, typically decades or longer. Climate change (CC) may be due to natural internal processes or external forcing, or persistent anthropogenic changes in the composition of the atmosphere or land use (IPCC, 2020).

NASA defines climate change as *"a broad range of global phenomena created predominantly by burning fossil fuels, which add heat-trapping gases to Earth's atmosphere. Increased temperature trends are described by global warming but also encompass changes such as sea-level rise, ice mass loss in Greenland, Antarctica, the Arctic, and mountain glaciers worldwide; shifts in flower/plant blooming, and extreme weather events."*

Fossil fuels are the main drivers for green-house gases (GHGs) emissions resulting in global warming. Global warming is a facet of climate change that refers to the long-term rise in the earth's temperature caused by an increase in the concentrations of GHGs in the atmosphere, mainly due to the burning of fossil fuels, deforestation, farming, etc. Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), and fluorinated gases are the primary greenhouse gases. The effect of GHG depends on concentration, duration, and their impact on increasing earth's atmosphere. Understanding climate and climate dynamics is key to the selection of crop species and natural resources based enterprise. The following paragraph presents the climate of Nepal and evidence showing the impacts of CC on agriculture.

2.1 Climate of Nepal

The altitudinal regimes very much define Nepal's climate. In a simple term, Nepal's climate is described as temperate, warm temperate, sub-tropical and tropical. Different scholars have described the climate using other models. As presented below, estimated area by climatic regimes are described in eight categories.

The area coverage of different climate types in Nepal based on modified Koppen Geiger Climatic classification.

Scientific evidence suggests that warming was higher for maximum temperatures (~0.04^{0}C/year) than for minimum temperatures (~0.02^{0}C/year). It was more evident in the mountainous region than for valleys and lowland areas when calculated for the pre-monsoon dry season. Attribution comes from less cloud cover and snowfall, especially over-served in recent decades. A higher increasing trend for warm days (13 days/decade) than for warm nights (4 days/decade) with the same rates of decrease for both cold days and cold nights (6 days/decade) (Karki, *et al.,* 2018).

Table 4: Estimated area by climate regines

S.N.	Climate	Area (km.sq)	% area
1	Tropical savannah	31,078	21.1
2	Arid steppe cold climate	864	0.6
3	Temperate climate dry winter and hot summer	46,011	31.3
4	Temperate climate dry winter and warm summer	33,133	23.5
5	Cold climate with dry winter and warm summer	6,232	4.2
6	Cold climate with dry winter and warm cold	669	0.5
7	Polar tundra climate	26,797	18.2
8	Polar frost climate	2,399	1.6

Source R. Karki et al., 2018

2.2 Climate change impact on water cycle

Any degree of change in climatic patterns impacts the hydrologic cycle. Atmospheric water vapor increased with increasing temperature resulting in variability and uncertainty of precipitation, and weather patterns became more unpredictable. Even if we receive the total amount of rainfall as in the base year, the nature and behaviour of precipitation change. As a result, the earth experiences heavier rain, storms, and extended dry spells period.

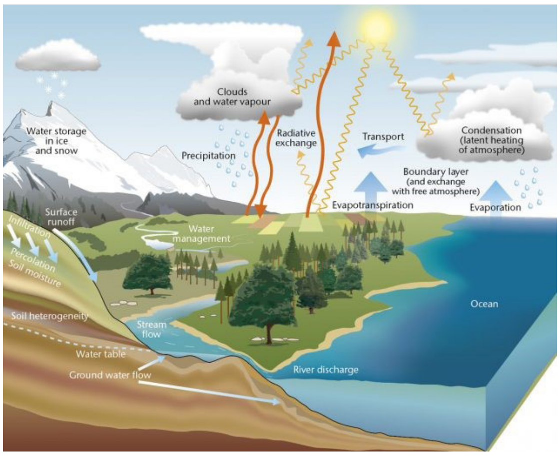

Figure 2: Water cycle

In situ assessment of 4,222 spring sources across five watersheds of Mahakali, Karnali, and Rapti River Basins revealed that water discharge for 70 percent of sources is decreasing. Nearly two percent of the spring sources were reported drying out. The analysis depicted that change inflow associated with rainfall combined with a change in land use land cover has decreased discharge flow (Adhikari et al., 2020).

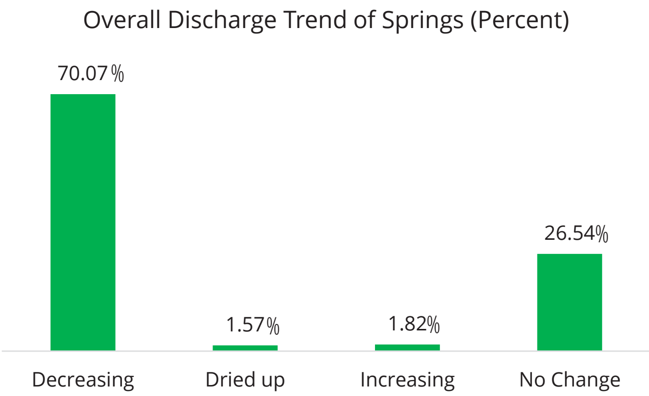

Figure 3: Overall discharge trend of springs (percent)

Source: Adhikari et al., 2020

2.3 Shifting of crop suitability area

Due to the effect of climate change, the temperature of the earth is rising. An average rise in temperature of 0.06% has been recorded in Nepal. Cropping areas of some crops are shifting upwards from the hills to the mountains, and some are reported extinct due to climatic risks. Crops such as rice, maize, and wheat, cultivated below 1,100, 1,350 and 1,700 meter above sea level (masl) respectively suffer from stress due to high temperatures during crop growth. The crop yields to a unit rise of temperature in the growing season vary from −6 to +16%, −4 to +11%, and −12 to +3% for rice, maize, and wheat, respectively, depending upon elevation. However, the increase in temperature has positively impacted some high elevation areas for rice and maize (Bocchiola, 2017). Improved apple sizes have been reported in the Manang and Mustang districts of Nepal in recent years. Farmers can grow vegetables like cabbage, cauliflower, chili, cucumber, and tomato that used to require a greenhouse previously (Regmi *et al.*, 2009).

2.4 Depletion in agriculture bio-diversity

Nepal is rich in agrobiodiversity. The ecosystem provides food, nutrition, fiber, fuel, and services to uplift the farming communities' livelihoods. However, climate change has degraded the quality of agrobiodiversity. The farming organisations from Bardiya and Kanchanpur districts reported short duration improved varieties replacing the local landraces. The local landraces required a more extended rainy season, and rainfall duration has decreased drastically in the past 15 years. Climate change has impacted beekeeping with a change in timing of flowering and reduced size of some fodder trees (Regmi et al., 2009). Local crop varieties like aromatic rice (Basmati, Kalanamak, Jhinuwa, Kanak Jira, Chananchura, Tuned Masino, Anadi both red and white); local rice varieties like Ghaiya, Marshi; maize varieties like Sathiya, Murali, Dhinde, Sete, Pahele; finger millet varieties like Okhale, Dale, Paundure, Jhapre, Mutthe, Samdhi; buckwheat varieties like Chuchhe, Bharule, Bhate, and few grain legumes and vegetables are on the verge of extinction (Paudel, 2016).

2.5 Incidence of pests and pathogens

Due to the lack of measuring tools, establishing a relationship between disease and weather change remains challenging. Climate change may favor or inhibit the pathogen incidences or even have no impact. It depends upon climate, host plant distribution and resistance, presence of vector, and virulence of the pathogen. Climate change modifies the host physiology, resistance and alters the stages and rates of development of pathogens i.e., increases over-summering and over-wintering of pathogens and transmission and dispersal of pathogens. The pathogens with short life cycles, high reproduction rates, and effective dispersion mechanisms respond quickly to climate change in susceptible hosts' presence, resulting in faster adaptation to climatic conditions. In case of vector transmitted diseases, climate can substantially influence the development and distribution of vectors increasing disease incidence and severity such as in chilli crop. The incidence of diseases namely bacterial wilt (*Ralstonia solanacearum*), bacterial spot (*Xanthomonas campestris* pv. vesicatoria) and Phytophthora blight (*Phytophthora capsici*) increases under elevated temperature and carbon dioxide whereas, the incidence of anthracnose disease (*Colletotrichum acutatum*) decreased at elevated temperature (Shin and Yun, 2010). Climate change influences the latent period of leaf rust (*Puccina recondita f. sp. tritici*) on triticale, showing a faster disease development threat.

2.6 Climate change and agriculture

Since agriculture sector accounts for about 96 percent of the total water use and 60 percent of the rainfed areas, it suffers the most with a change in weather patterns resulting in heat stress, longer dry seasons, and uncertain rainfall (CBS, 2006). Due to unfavorable weather and climate, the declining yield will lead to vulnerability in food insecurity, hunger, and shorter life expectancies (Thakur and Karki, 2018). It is the rural low cultivating marginal and rainfed areas that will be hardest hit. As presented in the tables 5 below, floods carrying rocks, sediments, and debris increase the intensity of landslides and erosion; deteriorate soil and water quality; wash away houses and properties; cause human injuries and deaths, and destroy infrastructures such as schools, roads, and markets (Chaudhary and Aryal, 2009).

Table 5: Loss of agriculture land as a result of climate induced hazards in Nepal (1971-2007)

Climate induced hazards	Loss (ha)	% of total loss
Drought	329,332	38.85
Flood	196,977	23.25
Hailstorm	117,518	13.86
Rain	54,895	6.47
Strong wind	23,239	2.74
Cold waves	21,794	2.57
Others (forest epidemic, snow storm, fire, storm)	83,336	9.83
Total	**847,648**	**100**

Source: (IFAD, 2013)

Table 6: Affected crop area from climate related extreme events in Nepal (ha)

Crops	Year							
	2002	2003	2004	2005	2006	2007	2008	2009
Paddy	115,000	6,967	116,506	3,585	120,000	888,000	30,873	92,000
Maize	4,435	954	1,293	20	47	4,271	549	1,700
Millet	-	-	500	419	-	1,451	3	-
Others	2,067	611	-	-	-	-	324	-
Total	**121,502**	**8,532**	**118,299**	**4,024**	**120,047**	**94,522**	**31,749**	**93,700**

Source: (IFAD, 2013)

Due to dry spell persisting for a more extended period, the crops are deprived of irrigation during their developmental stages causing moisture-stress-leading desertification. Massive and intense rain causes flooding, which damages the crops. Similarly, various problems are associated with agriculture, like the extinction of local crop varieties, the emergence of crop-specific pest-diseases, low production, etc. In the winter drought of fiscal year 2008/09, some districts received less than average rainfall, and the crop yield was reduced by more than half. The production of wheat and barley reduced by 14 and 17 percent, respectively. The impacts of climate change are observed in rain-fed agriculture. The crop loss analysis revealed that over 90 percent of the total crop loss happens due to climate-induced hazards, including drought and floods (Adhikari, 2018).

In sum, climate change impacts agriculture negatively if the impacts persist on the availability of usable water, solar radiation, and soil nutrients. Unless CC impacts are minimal on these resources, increased atmospheric CO_2 and Methane reduces agriculture production. To minimise the risks of hazards, scientists have been developing technologies and strategies for smarting agriculture, presented in the following chapter.

Further reading

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3. CLIMATE-SMART AGRICULTURE

Climate change causes a direct impact on food production by changing the Agroecological conditions and indirectly by affecting the growth and distribution of incomes, increasing the demand for agricultural produce (Schmidhuber and Tubiello, 2007). The negative impacts of climate change cause different risks in agriculture, reducing agricultural production and productivity. The climatic hazards such as floods, landslides, and incidences of insect-pests are more prevalent in Nepal. Therefore, it is essential to tackle and reduce the possible climatic risk in the farming system. Smarting agriculture practice is an option to minimise the impacts.

Climate-Smart Agriculture (CSA) is a strategic approach that aims to sustainably improve agricultural productivity and enhance food security, increase community resilience and adaptation to climate change, and reduce and remove GHG emission where possible (FAO, 2013). CSA serves as an alternative to increasing production, thereby reducing the loss. CSA is an approach to transform and re-orient agricultural systems under the new verity of climate change (Lipper et al., 2014). CSA's approach embraces smart technologies and techniques that promote sustainable agriculture and create a resilience production system. CSA also prioritises actions to transform the agricultural plan for securing food and a healthy environment. CSA comprises selective smart technologies and practices that minimise the negative impact of climate change in agriculture. This strategy helps diversify the products in the farming system, which helps to build resilience. It also contributes to prioritising the CSA technologies and practices and creates an enabling environment for policy coherence to mitigate climatic risks.

3.1 Evolution of CSA in Nepal

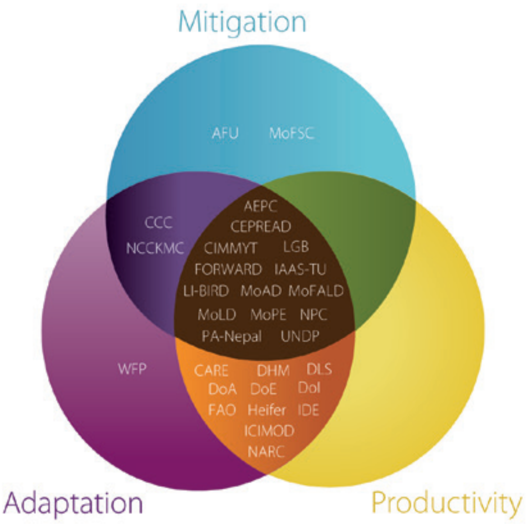
Nepal ranks as the fourth most climate-vulnerable country globally and is highly exposed to a range of water-related hazards such as floods, droughts, and landslides. Current projections predict increased climate variability and increased frequency, and higher intensity of extreme events. These hazards pose enormous costs to Nepal's economy. An estimated one percent of the country's Gross Domestic Product (GDP) is lost due to natural disasters consisting of frequent floods and landslides. Poor and rural populations, including women, tend to be the most vulnerable to such risks. In the climate-sensitive agricultural sector, farmers need timely weather and climate variability to adjust their farming practices and minimise adverse impacts on rural livelihoods, agricultural productivity, and food security (WB, 2013).

In response to growing risks of climate-induced hazards, CSA, like elsewhere, has been evolving in Nepal. A few credible institutions have been engaged to design, test, and scale-up various aspects of CSA in a package of practices. Government agencies are primarily promoting technologies and techniques for enhanced agriculture production and productivity for food and nutrition security. However, non-government institutions dedicated to R&D have been packaging key elements and pillars of CSA to enhance the community and agriculture system's resilience through policy advocacy.

Table 7: The following few credible institutions have been contributing to develop and promote CSA in Nepal:

S.N.	Name of institution	Specific area	Refer web-site where their detailed results, recommendations are available
1	ICIMOD	ICT based agro-advisory	https://servir.icimod.org/news/the-power-of-data-for-nepals-farmers
2	IDE Nepal	Drip irrigation, MUS technology	https://www.idenepal.org/mit.html https://www.idenepal.org/Mus.html
3	CEAPRED	ICT based agro-advisory	https://www.ceapred.org.np/content/agri-information-to-farmers-through-sms
4	NARC	Zero tillage, system of rice intensification, use of drought-tolerant varieties, and water-logging resistant varieties	https://narc.gov.np/wp-content/uploads/2020/11/278th-Yr-6-No-33_AAB_2077-08-12_National.docx.pdf
5	Helvetas	Farmyard manure, riverbed vegetables	https://www.helvetas.org/en/nepal/what-we-do/how-we-work/our-projects/Asia/Nepal/nepal-riverbed-farming
6	LI-BIRD	Solar-based irrigation system, ICT for agro-advisory, system of rice intensification, cattle shed and farmyard manure, zero tillage wheat cultivation, plastic pond, plastic house, drip irrigation, climate-resilient crop varieties, Use of leaf colour chart, rice cum duck farming, bio-pesticides, Jivamrit and Bijamrit, soil-cement tank construction	http://libird.org/app/publication/view.aspx?record_id=415 http://libird.org/app/publication/view.aspx?record_id=386 http://libird.org/app/publication/view.aspx?record_id=416 http://libird.org/app/news/view.aspx?record_id=72 http://libird.org/app/publication/view.aspx?record_id=400
7	CIMMYT	Zero-tillage wheat cultivation, direct seeded rice cultivation	https://www.cimmyt.org/news/nitrogen-in-agriculture/

3.2 Institutions and organisations working in CSA in Nepal



AEPC Alternative Energy Promotion Center **AFU** Agriculture and Forest University **CCC** Climate Change Council **CEPREAD** Centre for Environmental and Agricultural Policy Research, Extension and Development **CIMMYT** International Maize and Wheat Improvement Centre **DHM** Department of Hydrology and Meterology **DoA** Department of Agriculture **DoE** Department of Environment **DoI** Department of Irrigation **DLS** Department of Livestock Sevices **FAO** Food and Agriculture Organization **FORWARD** Forum for Rural Welfare and Agricultural Reform for Development **IAAS-TU** Tribhuwan University - Institute of Agriculture and Animal Sciences **ICIMOD** International Centre for Integrated Mountain Development **IDE** International Development Enterprises **LGB** Local Government Bodies (DDC & VDCs) **LI-BIRD** Local Initiatives for Biodiversity, Research and Development **MoAD** Ministry of Agricultural Development **MoFALD** Ministry of Federal Affairs and Local Development **MoFSC** Ministry of Forests and Soil Conservation **MoLD** Ministry of Livestock Development **MoPE** Ministry of Population and Environment **NARC** Nepal Agriculture Research Council **NCCKMC** Nepal Climate Change Knowledge Management Centre **NPC** National Planning Commission **PA-Nepal** Practical Action Nepal **UNDP** United Nations Development Program **WFP** World Food Programme

Source: CIAT, World Bank, CCAFS and LI-BIRD, 2017

3.3 Challenges and gaps of CSA

Despite potential positive contributions to enhancing community and agriculture system resilience through low carbon emission, CSA is passing through various challenges to demonstrate the extent and ways communities' realise benefits. As a result of limited research, huge knowledge gaps related to CSA technologies and practices are widely realised. In order to develop packages of CSA technologies, the practices developed through conventional research, and objectives are enveloped without interpretations of how they become climate-smart. For example, zero tillage, inter-cropping, and mulching.

Because of the lack of a clear understanding of the CSA framework, most efforts have been to increase productivity and often overlooked carbon emission factors. The implementation of CSA technologies are used for short term economic benefits leaving the long term adaptation benefits behind. Due to the lack of adaptive and integrated research CSA database is very sparse and incomplete. The agricultural extension among various stakeholders is limited, and priority is elsewhere. There is a restricted forum through which climate-related information is shared and reached out to beneficiaries. It is of utmost importance to design, pilot, and implement the climate-smart agriculture concept to develop climate-resilient farming communities. The farming communities are very poor in climate change adaptation and mitigation measures; nevertheless, their concern is only agricultural production. There's a considerable gap between stakeholders and farming communities on climate science-related activities where climate-smart agriculture technologies and practices are slow. Private sector engagement in climate-smart technologies is shallow. Without the attention of private sectors scaling-up CSA, technologies such as drip irrigation, plastic house, gender-friendly tools (zero tillage machine, jab planter, corn seller, farm rake, etc.) cannot be promoted.

3.4 CSA generates opportunities

Climate-smart agriculture technologies and practices have considerable potential for contributing to food security, also embracing adaptation and mitigation benefits. This promotion of the CSA package helps achieve multiple goals, including employment for the farming community. Although CSA technologies adopt a part or partial basis, assuming the CSA can ensure adaptation and mitigation benefits. Similarly, it can create a strong bond among multiple institutions and organisations working in climate-smart agriculture for a triple win.

3.5 Prioritisation of CSA technologies

CSA technologies and practices promoted to increase agricultural productivity and reduce the impacts of climate change-induced risks and greenhouse gas emissions. The choice of CSA technologies and methods vary depending on the crops, agro-ecology, landscape and the intensity of climate-induced hazards observed in the areas. The CGIAR programme on Climate Change, Agriculture and Food Security (CCAFS) describes CSA technologies and practices as five categories using smartness criteria: weather/knowledge-smart, water-smart, carbon/nutrient-smart, seed/breed-smart, and institutional/market-smart. Furthermore, technologies and practices are considered climate-smart when they contribute to three pillars of climate-smart agriculture: adaptation, mitigation, food security, or productivity.

Considering these smart criteria, adaptation and mitigation co-benefits, the nine priority technologies, practices, and approaches developed by LI-BIRD are described in this compendium. The selected CSA technologies are widely adopted reducing the impacts of climate change by communities as highlighted in this compendium (Table 8).

Table 8: Champion climate-smart technologies, practices and approaches based on smartness criteria

S.N.	Champion CSA technologies, practices and approaches	Smartness
1	Integrated home garden	Weather/knowledge-smart enhancing nutrient security
2	Solar-based irrigation system	Water/energy-smart with adaptation and mitigation co-benefits
3	Agro-advisory information system	Weather/knowledge-smart, reducing risks, protection of livelihood assets, and crop failure
4	MUS technology (rain water harvesting, gray water pond, plastic pond, soil cement tank)	Water-smart, adaptation, nutrition and income objectives
5	Plastic house and drip Irrigation	Weather/water-smart, adaptation and food security benefits
6	Community seed bank	Seed/breed and knowledge-smart, local adaptation benefits, reduce risks of crop failure
7	Climate resilient crop varieties (rice, wheat, maize etc.)	Seed/breed and weather-smart, reducing risks of crop failure, securing optimum yield
8	Organic and Agroecological farming	Weather-smart, carbon/nutrient-smart
9	Crops and livestock insurance	Weather-smart, safety net

The technologies and practices are proved smart through testing in different Agroecological regions of Nepal. The use of these technologies has demonstrated increased farm production. Integrated home garden, community seed banks, and climate-resilient varieties, and the plastic house with drip irrigation are recommended for small scale farming and resource-poor areas such as hilly areas, including Nepal's foothills. Similarly, the Terai regions have adopted solar-based irrigation systems, agro-advisory systems, crops, and animal insurance. These technologies and practices are proven adaptable to the smallholders but replicable to medium scale farming. The insurance scheme had been introduced to protect livestock raised by the poor and smallholder farmers.

4. CSA Technologies and Practices in Nepal

Technology I

INTEGRATED HOME GARDEN

Women farmer working in home garden.

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Integrated Home Garden refers to growing fruits, vegetables, species, mushrooms, plant species of religious, recreational, medicinal, ornamental importance, and small livestock and fish species to meet the family's nutrition and income needs. Home gardens have three dimensions: i) sustainably increasing small scale agricultural production and revenues, ii) adapting and building resilience to climate-induced stresses, and iii) reducing greenhouse gases emission.

Integrated Home Gardens follow sustainable farming principles that also enhance community capacity to deal with climate change stress factors. Innovative technologies, yet those practiced for generations of farmers such as drip irrigation, soil and nutrient management, intercropping, conservation farming, crop rotation, mulching, and integrated crop-pest management are integrated into home garden with adaptation and mitigation as co-benefits.

Weather-Smart: Diversifying livelihood options can be smart strategies for reducing risks associated with climate and non-climate factors. Raising crop and livestock species enhances both production and productivity with minimal chances of climate induced impacts. Integrated Home Gardens are thus considered weather smart, which enhance resilience of the system and community together.

Water-Smart: Water-smart options are employed to enhance the productivity of the home garden. The technological options include i) water harvesting pond for storing wastewater, runoff water, and even water from other sources such as taps or wells for later use, ii) straw or plastic mulch to retain soil moisture and suppress weed growth, iii) MUS technologies such as drip and sprinkler irrigation for efficient use of water, rainwater harvesting by constructing bunds, iv) terraces, pits, trenches, furrows with vegetables planted in or around these structures – all are different forms of an Integrated home garden.

Nutrient/Carbon-Smart: The practice of i) agroforestry system, ii) conservation tillage, ii) organic manures (farmyard manure, compost, green manure, vermin-compost, poultry manure, jibaamrit, bijaamrit, bokashimal, Jholmal), iii) crop rotation, iv) mixed, relay and intercropping, are part of the Integrated Home Garden. All these practices are meant to reduce the use of inorganic fertilizers, pesticides, and GHGs emissions. The application of improved manures and bio-fertilizers contributes to retaining soil moisture and nutrients and carbon retention.

Market/Institutional-Smart: Home garden products are for household consumption yet sold in the local market if there is surplus production. Because of the small scale, farmers must collect their surplus products to make the volume that would be economical for sending to the market. The Integrated Home Garden links farmers to the consumers, developing strong institutions. Until recently, there wer only very few, yet broken, market networks, for HG products in Nepal.

Seed and Sapling-Smart: Farmers themselves primarily maintain the seeds and saplings of the crops grown in a home garden. The seeds and saplings grown in home gardens are disseminated and exchanged through the farmer-to-farmer system. The crops include vegetables, fruit, fodder, medicinal plants, and ornamental plants. In recent years farmers have started growing improved crop varieties and planting materials obtained through formal seed systems. Furthermore, community-based seed production and its distribution are maintained. These crops include locally adopted crops like pea, cowpea, yam, sweet potato, etc. All these crops are drought and/or frost tolerant and even resistant to insects, pests, and diseases.

The Integrated Home Garden approach is different from the existing practices in applying chemicals and follows the principles of a local resource-based low agriculture input such as local seeds, sustainable soil and water management traditions, and integrated farming. It works as an approach and in practice. The components in the Integrated Home Garden include all the techniques developed and implemented individually. However, individual practice does not produce better results. In this context, implementation of Integrated Home Garden comprising all the components is utmost for creating a synergetic effect that increases agricultural production, making the entire system climate-resilient.

Contribution to CSA pillars

Pillars	Description
Adaptation	Maximum use of local crops and livestock species that can survive in harsh climatic condition, with low risk of failure.
Mitigation	• Increases carbon sequestration. • Reduces emission of greenhouse gases along with the decreased use of inorganic fertilizers.
Food security	• Increase production and yield through efficient use of water, soil, nutrient, seed, and labour. • Improves family nutrition by diversifying products. • Growing diversified crops and livestock contributes to food security and income.
GESI	Reduces workload of women as they can easily collect fodder, water and manure from nearby areas and used them effectively. The gender friendly tools also save the time required for agricultural operations and increases income.

Advantages

Ecological Advantages	Economic Advantages
• Increases the population of both pollinators and the predators of natural enemies. • Conserves plant genetic resources on-farm. • Intercropping decreases pest and diseases incidence. • Ensures to sustain the ecosystem functions and services, although on a small scale. • Reduces the application of potentially harmful chemical pesticides. • Reduces the risk of water contamination by chemical pesticides. • Improves soil health. • Enhances conducive homestead environment. • Ensures nutrient recycling and regulation of local hydrological processes.	• Provides year round diversified dietary sources and micro-nutrients in daily diet. • Saves cost of purchasing agrochemicals – e.g. pesticides, herbicides, insecticides. • Improves crop health due to application of additional fertilizer from farmyard manure and urine. • Allows organic production of crops. • Can be practiced with traditional knowledge and low cost technologies. • Increases food security, nutrition and cash income year round. • Can be easily maintained and managed by women hence women-friendly.

Implementation steps/methods

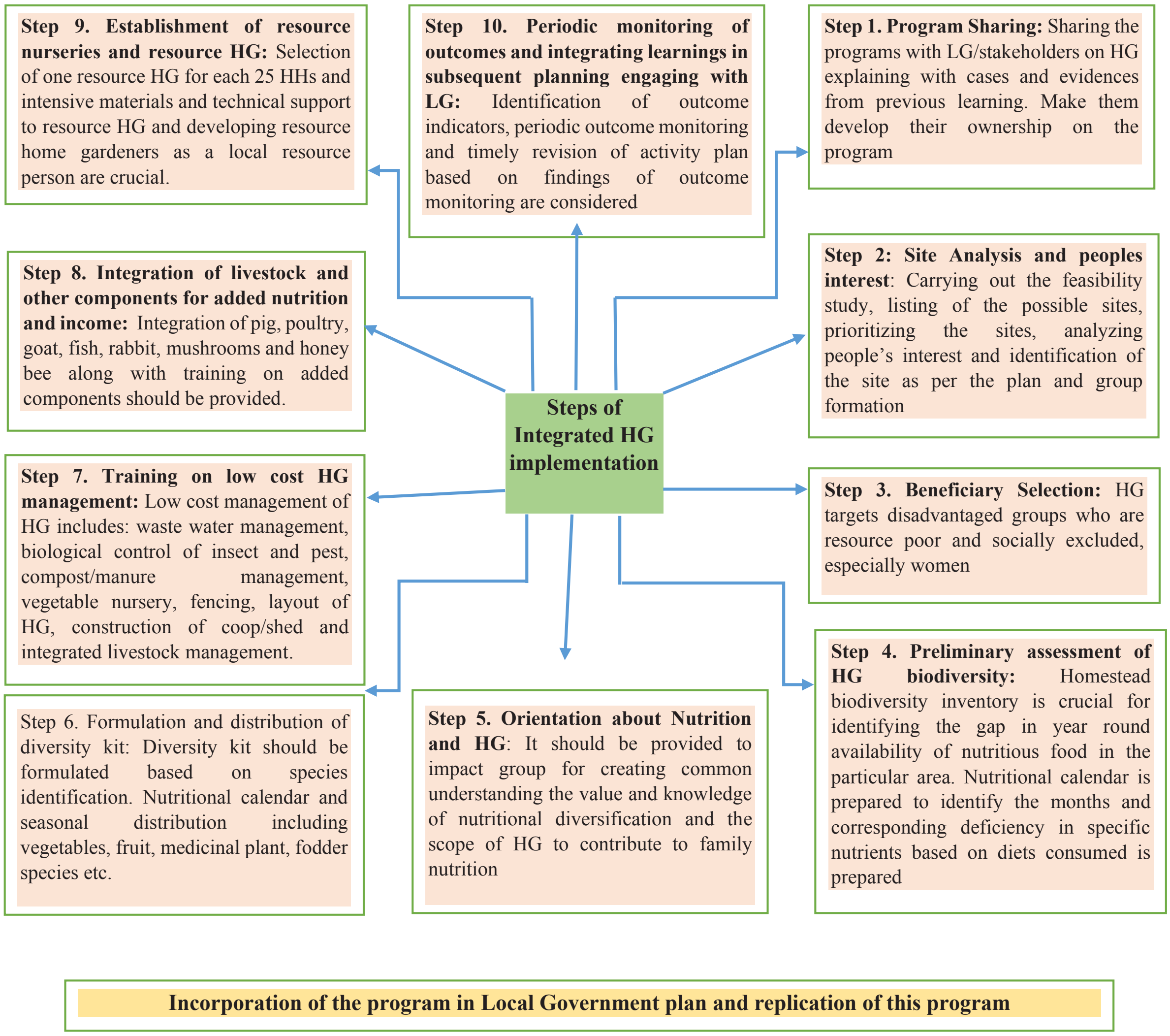

Figure 4: Steps of Integrated Home Garden Implementation. Source: MSFP, Mainstreaming Home Gardening Guideline (LI-BIRD, 2014)

Agroecological suitability

Integrated Home Garden is a highly adaptable strategy for different agro-ecosystems practiced across the mountains, hills, and Terai areas. However, the practices and technologies for Integrated Home Gardens differ for different temperature regimes. Most of these technologies and techniques are suited primarily in small scale farming. Table 9 presents the climate-smart technologies and methods incorporated into the Integrated Home Garden by individual ecological regions:

Table 9: Technologies and practices incorporated in Integrated Home Garden and their relevancy to Agroecological zones

SN	Technology/Practices	Mountains	Hills	Terai
1	Climate resilient crop varieties (local and improved, legumes)	√	√	√
2	Soil solarization	√	√	√
3	Nursery bed (tunnel type in winter season, raised in rainy season)	√	√	√
4	Mulching (plastic and straw)	√	√	√
5	Preparation of organic pesticides and manure (Jholmal, Beejamrut, Jeevamrut, Bokashimal, compost)	√	√	√
6	Use of IPM tools (lures, traps etc)	√	√	√
7	Multiple water use technologies (plastic pond, soil cement tank, grey water collection pond, rain water harvesting etc)	√	√	√
8	Livestock management (goat, poultry, pig, rabbit)	√	√	√
9	Other elements of HG (fish, mushroom, bee keeping, seed production and storage)	√	√	√
10	Knowledge smart: package training on home garden	√	√	√

Implementation cost

Apart from the initial steps of programme sharing with stakeholders, beneficiary selection, baseline data collection, and feasibility study costs, the anticipated cost for the development of a single home garden project given below:

Table 10: Anticipated cost for the development of a home garden (500 sqm).

SN	Activities	Anticipated cost (NPR)	Remarks
1	Fencing with locally available materials	3,000	
2	Land preparation manually or with small farm equipment	2,000	
3	Layout and design for allocation of plots for different interventions	500	
4	Climate resilient crop varieties (vegetable composite kit, fodder and fruit saplings, MAPs and NTFPs distribution)	5,000	Composite kit of vegetable seeds (average 10 types) distributed two times (winter and summer), at least five types of fruit, five types of fodder and five types of MAPs/NTFPs
5	Mulching (straw or forest litters)	500	Should be 2,000
6	Nursery materials	500	Not enough
7	Preparation of organic pesticides and manure (Jholmal, Beejamrut, Jeevamrut, Bokashimal, compost)	3,000	Not enough
8	Purchase of IPM tools (lures, traps etc)	1,000	
9	Multiple water use technologies (plastic pond, soil cement tank, grey water collection pond, rain water harvesting etc)	5,000	Home gardener can implement various technologies depending upon their area
10	Livestock management (goat, poultry, pig, rabbit)	20,000	At least two goats, two pigs, 10 chicks and two rabbits per HHs distributed
11	Other elements of HG (fish, mushroom, bee keeping, seed production and storage)	20,000	
12	Knowledge smart; Package training on home garden	2,500	Training cost of each person
	Total	63,000	

Note: The cost may differ from quality of the inputs and place. Some of the home gardeners may have materials for the fence preparation themselves and farmers/householders can build it themselves, reducing costs.

Case Story

Mrs. Lila Giri, a permanent resident of Bihibare 14, Dhangadhimai Municipality, Siraha, is a proactive female farmer of Hariyali Mahila Krishak Samuha from the Samarthya Project. She is a member of a women's farmers' group and she also looks after all the household work at home. As she lives in a joint family with 21 members, it was always difficult for her to manage vegetables for the family. Some days they only had rice and pulses to eat. On other days she purchased vegetables from the market. She always had to ask for money from her husband for small household matters such as vegetables. After the formation of farmers' group Hariyali Mahila Krishak Samuha in 2019 under the Samarthya Project, she became a member of that group and started a climate resilient home garden. Now she is growing seasonal vegetables and fruit trees like papaya and mango in her home garden. She has grown diverse vegetables which provides her an opportunity to cook different varieties of fresh vegetables. She now can cook at least one type of vegetable in each meal. Since she no longer has to purchase vegetables, and even has some surplus to sell, with a smile, Mrs Giri says that from her home garden she made a saving of NPR 30,000 to NPR 35,000 during 2019. The vegetables she grows are sufficient for her family and she doesn't have to purchase any from outside.

Also, she now knows the negative impacts of chemical fertilizers and pesticides on human health and doesn't use them. Instead she uses organic manure and

Ms Lila Giri working in her home garden.
Photo: Indra Bahadur Magar, LI-BIRD

pesticides like jholmal and compost prepared in the pit at one end of the home garden. For irrigation she has a grey water collection pond in which waste water from different household purposes is collected. The support she received from the organisation for seeds, plastic drums for preparation of organic manure, and pesticides, as well as various trainings related to crops and their management has been very helpful to her. "I feel proud that I am able to support my family from my own earnings which has changed my social status. I am now providing suggestions to other members from our group on different techniques of growing vegetables and transferring my experience on successful management of a home garden," Mrs Giri states. She also explains that she is very thankful to the organisation and her family for support in this process.

Further Reading

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Technology II

SOLAR-BASED IRRIGATION SYSTEM

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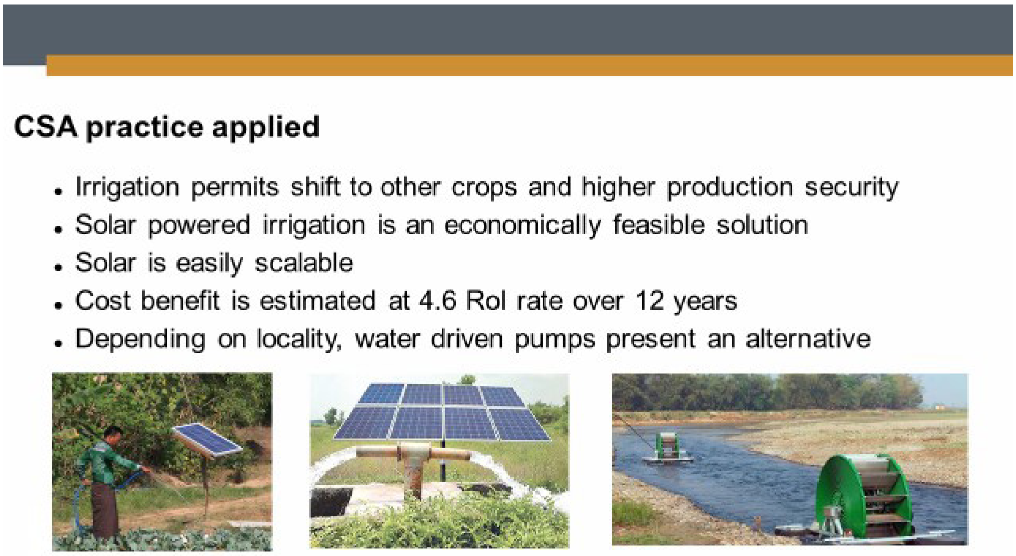
Solar-based irrigation system at Agyauli, Nawalpur
Photo: Aastha Bhusal, LI-BIRD

The solar-based irrigation system is an environment-friendly technology that utilises solar energy for pumping water against gravity for irrigation purposes. The solar energy automatically pumps underground water directly into the agriculture field, depending on the solar panel's capacity and the available solar radiation. A solar based irrigation system is one of the climate-smart and economical alternatives for pumping water from downstream rivers and underground. It is very suited for commercial agriculture like vegetable production, as well as for drinking water supplies.

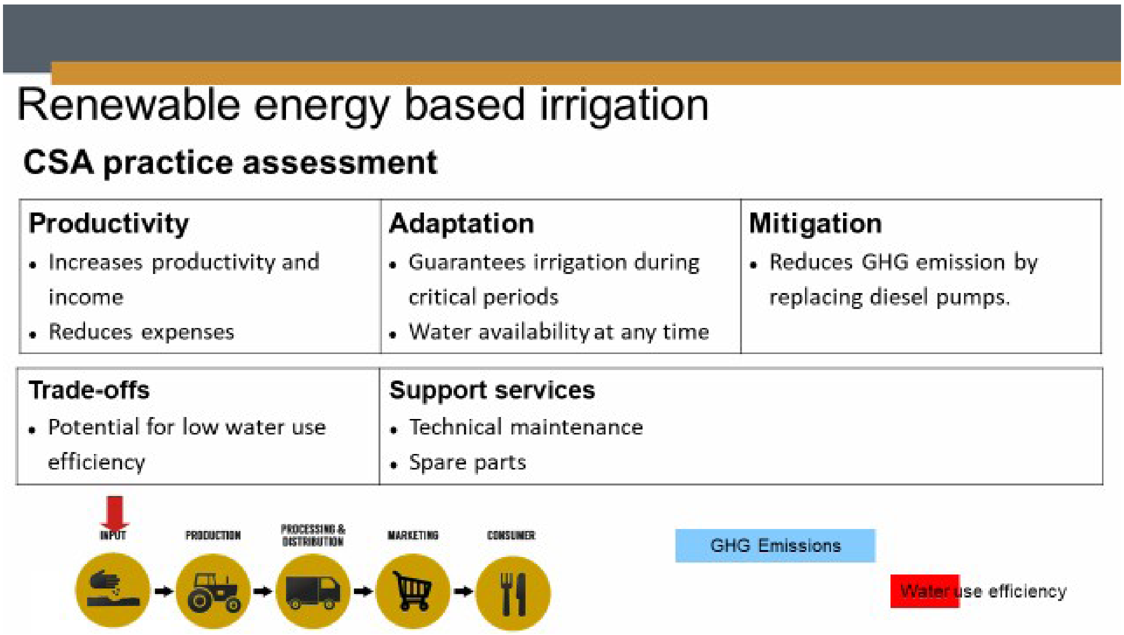


Description of the technology

Solar-based irrigation system contributes to all three pillars of climate-smart agriculture. It helps the farming communities irrigate their crop fields during the dry season and supports smallholder farmers switching from traditional rain-fed subsistence agriculture to high-value crops Co-operatives. Similarly, it helps to mitigate/reduce greenhouse gas emissions by replacing the diesel pumps used for irrigation. Additionally, the year-round availability of water enhances rice cultivation by enabling rice nursery and transplanting to take place on time. There is no GHG emission in this system, and it can significantly reduce the GHG emission caused by a diesel pump. Increases in crops and vegetable productivity due to assured irrigation facilities combined with high cropping intensity also increases by growing multiple crops in a year rather than keeping land fallow after the summer crop.

Water-Smart: The solar-based irrigation system is a water-smart technology as this system utilises water effectively and efficiently. The construction of a water-harvesting tank and connecting it with micro-irrigation such as drip irrigation and sprinkler irrigation can aid in the effective utilisation of water in the farming communities.

Carbon/Nutrient-Smart: The solar-based irrigation system is a carbon-smart technology as it utilises clean energy and reduces greenhouse gas emissions in the atmosphere. The massive use of diesel pumps is reduced, thus reducing emissions, hence it serves as clean technology.



Contribution to CSA pillars

Pillars	Description
Adaptation	Increases water availability during water scarcity
Mitigation	Reduces GHG emission by replacing the diesel pumps used for irrigation
Food security	• Increases crop yield year due to year round availability of water • Improves family nutrition by diversifying products. • Enhances crop diversification and increases income and thus contributes food security
GESI	When packaged with drip irrigation, it reduces the women drudgery since women don't need to travel long distance inorder to fetch water

Advantages

A solar-based irrigation system has massive positive effects in the farming communities. A few are described as below:

i) Increases overall production and productivity of crops and vegetables.
ii) It offers year round cultivation of crops, especially vegetables, and can increase income.
iii) It can replace the diesel pumps hence reduces GHG emissions and is environment friendly.
iv) It is more suitable for establishing nursery beds of paddy in rainfed conditions and increases production, hence reduces dependency on rain.
v) Reduces the requirement of labour for water delivery.
vi) When packaged with drip irrigation, it can reduce weed and pest infestations and increase the water-use efficiency.
vii) Saves electricity costs.
viii) Fast and easy installation.
ix) Is durable and requires minimal maintenance.

Implementation steps/methods (present in diagram with short explanation)

The solar-based irrigation system can be implemented on a smallholder farmer's field.

Process of solar-based irrigation system:

i) Site selection: The first steps regarding the implementation of a solar-based irrigation system is site selection. An appropriate site (such as having no blockage of sunlight) is required.
ii) Feasibility study of the site.
iii) Estimation of the specific type of the solar system with cost verification.
iv) Initiate the process of boring/ community pond.
v) Install the solar system component.
vi) Final outflow of water.
vii) Distribution of water through drip irrigation and sprinkler irrigation.

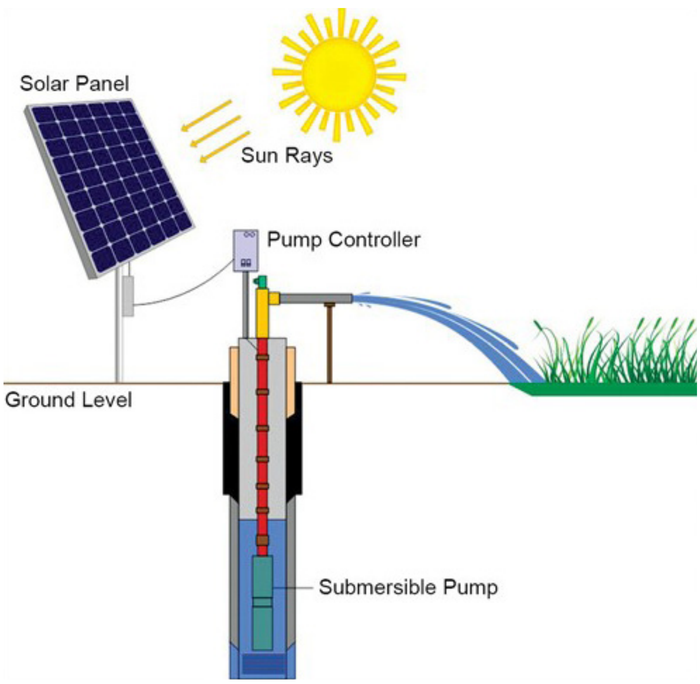


Figure 5: Solar-powered irrigation system (Courtesy: www.taiyosolar.in)

A solar-based irrigation system built on drip and sprinkler irrigation maximises the benefits. The drip irrigation technology drops the water exactly on crop roots and reduces excess overflow.

Agroecological suitability

Regardless of temperature regimes, a solar-based irrigation system works well across all ecological regions. However, solar-based irrigation systems are more economically profitable for the commercial and or semi-commercial scale farming. In the Terai region, a solar-based irrigation system works best, especially for underground water or surface water. Underground boring is found more in the Terai region; however, in maintaining water availability, the establishment of community ponds and water utilisation from such ponds to uplift water can be found more realistic and durable. Similarly, solar energy is used to lift water to a certain height in Nepal's mountain areas.

Investment cost

The solar-based irrigation system, once established, can be sustainable. There are various types of solar-based irrigation systems, from small to large systems. The cost for individual systems varies from NPR 60,000 to NPR 3,000,000 depending on the system chosen. Details of the cost of installation of the solar-based irrigation system in Hardiya village of Madhyabindu Municipality, Nawalpur, are briefly highlighted below:

Table 11: Detailed cost of installation of solar-based irrigation system

S.N.	Description	Total cost (NPR)
1	Solar PV Module 140 Wp/12V (24 panels)	285,600
2.	Solar DC pump (3.2 hp)	205,000
3.	Grounding system with one set of earthing electrode, one set of backfill chemical, lightening arrestor	73,450
4.	DC surge protector	24,860
5.	Aluminium MS Module Mounting Structure with PCC base foundation	135,600
6.	Submersible copper cable 2.5m^2 3 core	20,340
7.	Installation materials including PV module cable 2.5m^2 20 m, weather proof combiner junction box, required HDPE pipe and fitting, DC circuit breaker, steel rope, grundfos, termination kit and other required accessories	67,800
8.	Initial feasibility study	33,900
9.	4" boring 25 meter with required materials complete	101,700
10.	Installation accessories, transportation	67,800
	Total cost	**1,016,050**

Solar-based irrigation installation connected with a water harvesting tank for water collection improves water-use as water is efficiently utilised during morning and evening hours.

Case Story

Mr and Mrs Bhattarai harvesting cowpea.
Photo Aastha Bhusal, LI-BIRD

Tara Prasad Bhattarai, the chairperson of Hardiya Saurya Urja Krishak Samuha, Hardiya village of Madhyabindu municipality lives with his wife and owns less than half a hectare of land. His main occupation is agriculture. He used to grow Maize followed by mustard in his field, i.e., two crops in a year. Since there was no source of irrigation, he used to depend upon rainfall for farming. If it rains, he was able to harvest few and utilize for home-consumption, else the harvest was negligible. However, after the installation of solar-based irrigation system, through Piloting and Scaling-Up Climate-Smart Villages in Nepal (CSV) project implemented by LI-BIRD with financial support from CCAFS, he was able to cultivate 8-12 crops within a year. The land which used to remain dry was now irrigated throughout the year. After availability of irrigation, he was able to cultivate different kinds of vegetables such as cucurbits, cole crops, chilies and pulses. He shares," the solar-based irrigation system has been a boon to the village. The condition after solar-based irrigation system installation has changed the scenario of the village." He further shared that we were confined with two crops before solar-based irrigation installation but now we are able to grow different crops and even sell the surplus after home consumption. We do not need to go to market to purchase vegetables. The land which used to remain dry are now covered with greenery all the round. He further added "The villagers contact me directly for purchasing the vegetables." Seeing the benefits, he has taken 3 kattha land under lease and started cultivating crops. He is happy after earning more than 30,000 rupees of additional income annually. He is motivated towards farming and expect to further double his earning. He has become a source of inspiration to the villagers. In addition, he has received trainings on biopesticide preparation and vegetable cultivation through the programme and targets for agricultural production with minimal use of pesticides and ultimately move towards organic in coming days.

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Technology III

AGRO-ADVISORY INFORMATION SYSTEM

Agro-advisory services information board.
Photo Kartiklal Chaudhary, LI-BIRD

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Agro-met advisory services focus on the livelihood enhancement of smallholder farmers through improved agriculture, market, weather information, and various communication processes. Agro-advisory information flows through e-media, including telephone, radio, television, mobile phones, and social networks. The information and communication technologies (ICT) based agro-advisory services, tools, and ownership of local government (LG) through various mechanisms (such as the implementation of Local Agriculture Resource Person LARP) could be a cost-effective idea for wider dissemination of agro-advisory services and information.

Description of technology/practice

Agro-advisory services are regarded as weather and knowledge-smart technology that provide advisory services related to agronomic practices, disease and pest management, livestock management, weather, and market information. Although the government has initiated various approaches to reach farmers with agro-advisory services, this has been unsuccessful due to inefficient and inadequate extension workers. Thus, the agro-advisory information system bridges this gap, develops the local governments' ownership, increases the agro-advisory services coverage, and creates a local agriculture resource person within a specific area. As the agro-advisory information system aims to enrich the various factors involved in the process and disseminate weather and related information, it is a knowledge-smart technology.

Contribution to CSA pillars

Pillars	Description
Adaptation	• Provides advice on climate resilient varieties to be used as per the climatic situation. • Helps farmers to adjust the sowing and harvesting time as per the weather forecasting.
Mitigation	• Reduces the haphazard due to decreased use of agro-chemicals and protects environment through effective use of the information. • Provides information on technologies and practices which reduces the emission of greenhouse gases.
Food security	• Farmers can use the best production practices and save their crops from weather calamities and can increase their production. • Helps to reduce the losses contributing to food security.
GESI	The dissemination of timely and exact forecasts helps women in agriculture operation especially during harvesting and shortens the time required to carry out the activities.

Smarting agro-advisory systems

In previous agro-advisory systems, many governmental and non-governmental organisations supplied information to farmers through SMS. The smallholder farmers could not benefit from the text message because of inadequate details in the message. Additionally, many of the target beneficiaries did not have mobile phones and even if they had they could not get messages on time because of poor network connections in many rural areas. Governance was an issue in the previous system. An improved SMS system has been devised such that it benefits smallholder farmers. LI-BIRD, with support from the Samarthya project, worked with local government and the issue of ownership and sustainability of the system was resolved when local government took management responsibility. The improved system provides facilities to have two-way communication and focuses on receiving feedback from the farmers for further improvement on the system.

Advantages

- With timely available agro-advisory information farmers can minimise climate induced risks and uncertainty and protect livelihood assets and reduce crop loss that are likely to affect farming operations from sowing/ transplanting, pest management, harvesting, and storage.
- Farmers receive information about fertilizer application procedures of chemical fertilizer and organic manure.
- If properly followed and they keep connecting with technicians, individuals farmers need not necessarily visit agriculture knowledge centres to take technical advice.
- The agro-advisory includes market information for agri-products, which helps farmers negotiate prices with middle men and get the right price for their products.
- Based on the information received from the farmers themselves can forecast potential climatic hazards such as floods and landslides, and prepare themselves to protect lives and livelihood assets.

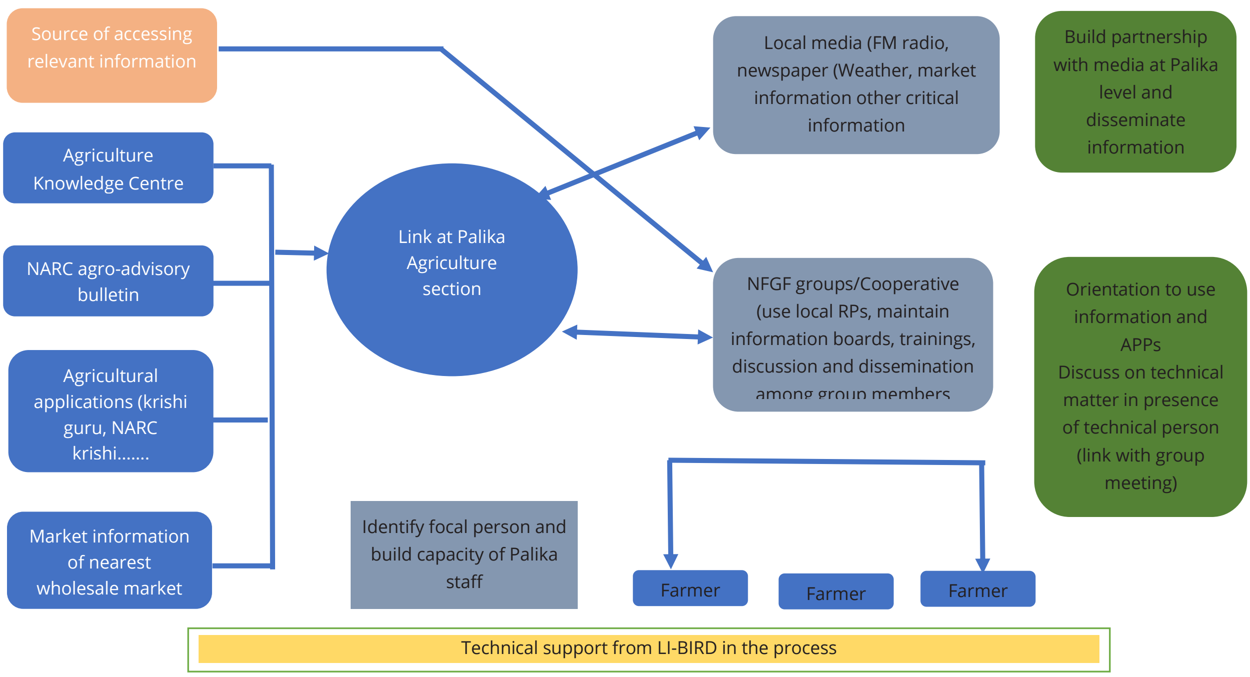

Figure 6: Implementation process of Agro-advisory Information system

Agroecological suitability

As the agro-advisory information system mostly works on extension i.e, dissemination of agriculture and weather forecasting related information, it is suitable to all the ecological region, namely high-hills, mid-hills, and Terai.

Investment cost

The anticipated implementation cost of the agro-advisory information system at Belaka Municipality with nine Wards is given below:

Table 12: Anticipated cost for the implementation of an agro-advisory information system.

SN	Particulars	Unit	Qty	Rate	Amount (NPR)
1	Stakeholder consultation meeting (to share information briefly about the system)	No.	2	5,000	10,000
2	Package training to identify Local Resource Person and LG staff on extracting agro-advisory information and production of package training	No.	1	30,000	30,000
3	Installation of agro-met advisory services notice board	No.	10	7,500	75,000
4	Dissemination of bulletin	Month	12	1,000	12,000
5	Coordination and local media cost for transmission of the information	Month	12	9,000	108,000
	Total				**235,000**

Note: The cost mentioned above may vary upon the situation and need of an organization.

Until recently, LI-BIRD has been disseminating agro-met information to the farmers through partner organisations, especially the National Farmer Group Federation (NFGF) and Local Agriculture Resource Person (LARP) assigned by the Palika. It is now being institutionalised by passing the guideline through the Palika executive for its sustainability and putting it in the local governments' plan for the coming years.

Mr Nandilal Chaudhary reading agro-met advisory information on a notice board. Photo: Kartiklal Chaudhary, LI-BIRD

Case story

Mr. Nandi Lal Chaudhary, a member of Madhyawarti Gharbagaincha Krishak Samuha and one of the beneficiaries from Belaka Municipality, Udayapur, expressed that he along with his neighbouring farmers have benefitted from the information obtained in the form of the bulletin that describes agricultural operations. “We used to cultivate potatos without knowing their names or knowing what diseases may damage our crops. However, now we farmers know about the varieties we grow and disease (Janakdev and Kufri Jyoti) and its control measures. I did not have knowledge about how pesticide controls late blight. But now, I am able to use the advisories and use the appropriate agro-chemicals to minimize crop loss from possible pests and diseases,” says Mr. Chaudhary.

Mr. Bishnu Dev Chaudhary, a farmer from Karhaiya Sabal Krishak Samuha Ward 2 of Belaka Municipality, used to traditionally cultivate chilli but could not harvest a good yield per the prescribed potential of the variety because of lack of knowledge about controlling leaf spot diseases. After listening to Saptakoshi FM 90 MHz, he has begun to apply practices that minimize crop damage. The practices include disposing of damaged leaves and spraying Dimethane M 45. In this way, the communication mechanism through FM radio has helped solve his farm's problems and get a better yield than previous years.

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Technology IV

MULTIPLE-USE WATER SYSTEM TECHNOLOGY

Multiple use water system technology.

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A multi-use water system (MUS) is a combined water facility useful for drinking water and irrigation for smallholder and marginal farmers in Nepal. In MUS, mostly water is collected by gravity from a highland source into a reservoir tank and shared through distribution pipes and other means. MUS technologies are popular among the smallholder landowners and marginal households in rural areas.

Description of technology

Most of the community from rural and peri-urban areas rely on agriculture as their primary occupation, and thus on water for their livelihood. Most of the community depends on a single system for their multiple purposes, which creates system efficiency, conflict between users, shortage of water, and failure of the system. (Shakya *et al.*, 2019). A simple solution for this could be the multiple uses of water systems. Multiple-use water system (MUS) is a poverty reduction focused participatory and integrated approach which addresses the diversified water need of community people (Mikhail and Yoder, 2008).

MUS is a water-smart technology. These MUS technologies such as rainwater harvesting, drip irrigation, sprinkler irrigation, water recharge ponds, and solar-based irrigation increase water availability through reuse, recycling, or reducing the available water and increasing crop production. MUS considers many technologies that are related to efficient water use. MUS is focused on smallholder farmers of rural areas. However, some of these technologies cover a larger number of families, too (IWMI, 2011). MUS can be applied to both subsistence and commercial farming. In Nepal, rural communities with limited agricultural land and most rural farmers practicing subsistence farming can benefit from MUS technologies and improve their livelihoods by increasing production and reducing the workload by saving time to fetch water.

Contribution to CSA pillars

Pillars	Description
Adaptation	• Increases water availability for crops during scarcity. • Increases water use efficiency by minimising water use per unit of production.
Mitigation	• Reduces energy required for irrigation. • Reduces GHGs emissions due to reduced fuel required for pumping and/or carrying water.
Food security	• Increases yield due to efficient and effective water management practices. • Increases income and household nutrition by enabling vegetable and crop production in extremely dry situations.
GESI	• Reduces the workload of women and time saving in fetching water of rural households

Source (World Bank, CCAFS and LI-BIRD, 2017)

Advantages

- MUS is a low-cost technology that addresses the diversified water needs of people. In a separate water system, people have to invest more and suffer an inadequate water supply because of improper handling of the system and using it for both purposes.
- Farmers can bring fallow land to cultivate high-value crops in their gardens, causing minimal impact on the environment.
- It is time and labour-saving. It also has significant importance for women and girls as they do not have to carry heavy loads while collecting water. They also can use the time saved on other productive activities like growing high-value crops, giving more time to their children, etc.
- The benefit-cost ratio is very high (11:1) in terms of investment return through agriculture-generated income, enhanced social and gender equity, and women empowerment (GC and Colavito, 2015).

MUS Implementation steps/methods

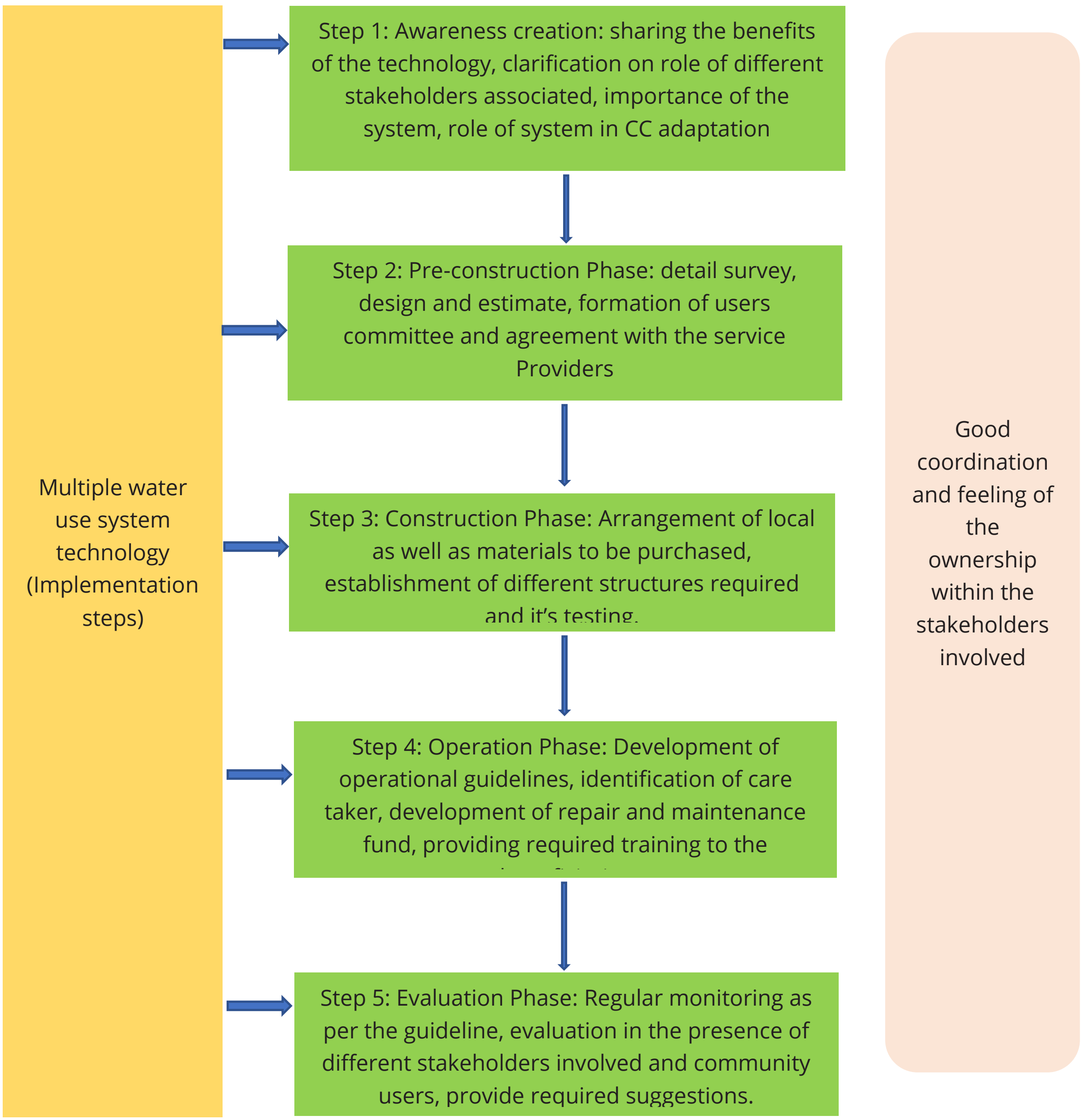

Figure 7: Implementation steps of MUS

Agroecological suitability

Most of the MUS technologies are relevant to all the Agroecological zones. However, some may fit only with specific environmental conditions. In Nepal's mid-hills and high-hills, the water source may be far from the community settlement. MUS technology plays a vital role in fulfilling water needs for different domestic and irrigation purposes. The multiple uses of water sources in the western, mid-western, and far western regions of Nepal and have been found beneficial in the mid-hills of the country (Shakya *et al.*, 2020). But there are some small technologies like grey water collection ponds, drip irrigation, rainwater harvesting, etc. that can be suitable for all ecological regions. The table 14 below indicates technologies and practices that work with Multiple Use Water System:

Table 13: List of the MUS technologies as per their relevancy to ecological zones

SN	Technology/practices	High-hills	Mid-hills	Terai
1	Plastic pond		√	
2	Water harvesting pond		√	
3	Multiple use and water source protection	√		√
4	Drip irrigation	√		√
5	Sprinkler	√		√
6	Solar based irrigation		√	
7	Water mills and irrigation	√		√
8	Rain water harvesting	√		√
9	Soil cement tank	√		√
10	Grey water collection pond	√		√

Source: Paudel et al., 2017

6.7 MUS implementation cost

The cost of the different MUS technology may vary as per the location. Anticipated costs of some of the technologies are as follows:

Table 14: Anticipated cost of various technologies that are used in MUS.

SN	Technology/practices	Anticipated cost (NPR)
1	Plastic pond (3 * 3 * 3.5) m^3 (purchase of Silpaulin plastic and labour cost for pit digging)	3,000
2	Drip irrigation set (100 ltr drum with 6 distribution lines of 12 m)	4,500
3	Sprinkler (plastic with rotating metal head)	450
4	Solar based irrigation (8 solar panels, 2 Hp motor, controller)	600,000
5	Water mills and irrigation	NA
6	Rain water harvesting (pipe and water collection 1,000 ltr plastic tank)	11,000
7	Soil cement pond (3 * 3 * 3.5) m^3 (includes labour cost, cement cost, sand and soil transportation cost)	7,000
8	Cemented pond (3 * 3 * 3.5) m3 (includes cement cost, sand, aggregate and stone cost and also labour cost)	22,000
9	Grey water collection pond (1 * 1 * 1) m^3 (includes plastic and pit digging cost)	500

Source: Personal communication with Kartik Lal Chaudhary

Case Story

Mr. Rajendra Prasad Acharya, a resident of Belaka Municipality, Tapeshwori Ward 2, is a dedicated farmer but often failed to have a good harvest because of the lack of irrigation. With support from the CARE funded and LI-BIRD implemented Samarthya project, Mr. Acharya prepared a plastic pond lined with silpaulin plastic and received a drop set for an irrigation tunnel. He began to collect waste water released from the household in the pond and put it in the drip set for filtering. Mr. Acharya shares that 100 litres of water used to be only enough to irrigate the tunnel for two days but the same amount is sufficient now for a week since he now uses drip irrigation technology. Thus the adoption of drip irrigation technology has helped many farmers to solve their water scarcity problem and is successfully producing above 200 kilograms of tomatoes for Mr. Acharya. Of the total produce, almost 100 kg was sold at the market and earned NPR 4,000 which was used to cover household expenses such as children's education and gifts for relatives and friends. Mr. Acharya tells us he is happy with the technology.

Farmer installing drip irrigatin system along with mulching in the field.
Photo: Sagar GC, LI-BIRD

Further reading

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Technology V

PLASTIC HOUSE WITH DRIP IRRIGATION SYSTEM

Agriculture technician from LI-BIRD observing the drip irrigation system in farmers field. Photo: Sagar GC, LI-BIRD

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Plastic houses are structures constructed to successfully cultivate vegetable all year round. This facilitates the protection of crops from extreme climatic conditions. These structures can be built with bamboo or iron and protect crops from excess sunlight, heavy precipitation and heat stress. The structure regulates a micro-climate trapping sunlight and soil, and speeds up the growth and development of the crops. This structure allows cultivation of fruits and vegetables all year round especially in the off-season when they fetch a premium price. The plastic house can be semi-circular or elongated or a compete covering. The temperature is maintained well inside the plastic house (above 10° C or below 30° C.) which favours the good growth and development of crops. (iDE Nepal and Rupantaran, 2019)

Description of the technology

Plastic house and drip irrigation are considered climate-smart technologies and their contribution to adaptation, mitigation and food security is well acknowledged. Growing vegetables, fruit or flowers in a plastic house with drip irrigation protects them from stress and makes water available to the crops by minimising the use of water per unit area. Through drip irrigation, the water enters directly to the roots of the plants. This ultimately increases water use efficiency and eventually increases crop production.

A plastic house is, per se, considered weather-smart because it regulate the micro-climate inside the house. This structure helps to cultivate diverse crops all year round and protects crops from climatic risks. Similarly, a drip irrigation system is one of the water-smart technologies which utilises water efficiently. It is a micro-irrigation technology which helps the required amount of water drop directly into the root zone of the plants reducing loss from evaporation. In addition, drip irrigation helps to maintain the optimum level of moisture in the soil around root zone and ensures sufficient amount of water to the plants. This protects the plants from water stress and increases production.

Contribution to CSA pillars

Pillars	Description
Adaptation	• Maintains crop production during water stress periods. • Farmers can cultivate high value crops. • Reduces damage to the crops from hailstones, to some extent. • Maintains temperatures required for the crop growth.
Mitigation	
Food security	• Increases crop production, especially vegetable cultivation. • Increases income. • Produces off-season vegetables. • Produces foods/vegetables all year round.
GESI	• Reduces the workload of women as it reduces the time taken to fetch water. It enhances efficient irrigation of the crops.

Advantages

Advantages of Plastic House	Advantages of Drip Irrigation
• The plants will be protected from cold waves and heavy winds. • Allows cultivation of crops throughout the year and hence profit can be maximized per unit area. • It is less labour-intensive once it is installed and utilises locally available materials. • Reduces loss of soil water due to evaporation. • Lower crop water requirement.	• Efficiently utilises water hence helps to save water up to 70% as compared with conventional method of irrigation and saves plants from drought. • Fertilizers and chemicals can be provided through the drip system thus minimising the loss and increasing its efficiency. • Prevents weed growth while controlling soil erosion. • Minimises the risk of diseases as the leaves and soil around the plants are less wet. • Reduces the drudgery of both men and women farmers.

Implementation steps/methods

Steps to be followed to establish a plastic house:

Selection of land: A plastic tunnel can be established on land which lies between 500 and 1,700 masl and in open spaces (without shade) which have a low wind velocity. The plastic house is basically suitable for places receiving sunlight for over six hours a day, have good air circulation and irrigation facilities. Land more than five metres wide is required to construct a plastic house.

Selection of plastic: Silpaulin of 45 to 90 gsm (gram per square metre) in weight is commonly used for plastic houses in Nepal. The thickness of the silpaulin can vary by temperature regimes: thicker silpaulin is preferable for areas with low temperatures and vice versa. Plastic of 120 GSM can be used where there are occurrences of hailstone.

Selection of construction materials: The required construction materials include bamboo, plastic rope, wire and mobile.

Agroecological suitability

Different kinds of plastic houses are suitable for different Agroecological regions. Plastic house technology is more suited for mid-hills and in high-hills eco-regions. A plastic house of 6x12 m^2 is prescribed for mid-hills. However, Gummose can be constructed in the high-hills regions like Mustang and Humla districts to cultivate vegetables all the year round. Similarly, drip irrigation serves best in the hilly regions. Drip irrigation is suitable for semi-commercial and commercial vegetable cultivations.

Implementation cost

The utilisation of various materials for the construction of the plastic house directly relates to the cost. The plastic house, once constructed, can be durable for 3-4 years, depending on the materials used for the construction. The estimated cost of the plastic house is given below:

Table 15: Materials required for construction of 6 x 12m^2 plastic house associated with drip irrigation (Bhusal *et al.*, 2020)

S.N.	Particulars	Unit	Quantity	Price/Unit (NPR)	Total amount (NPR)
1	Silpaulin plastic (70 GSM)	No.	1	5,600	5,200
2	Bamboo (6m)	No.	15	200	3,000
3	Labour charge	No.	4	800	3,200
4	Drip irrigation set	No.	1	4,500	4,500
5	Plastic rope	kg	1	120	120
6	Thumbnail	kg	0.5	100	50
7	Mobil or Bitumen	L	1	100	100
8	Wire	kg	1	150	150
9	Transportation cost/others	Lump sum		500	500
				Total	**17,220**

Note: The price of the materials will be different depending on the location purchases.

Case story

Mr Top Bahadur Rai in his farm. Photo: Sagar GC, LI-BIRD

Mr. Top Bahadur Rai, 49, a resident of Dhangadhimai Municipality 14, Siraha, has a family of four. He is a proactive farmer and member of Karamchauri Mahila Krishak Samuha. His main occupation is agriculture and his wife supports him in performing agricultural operations. Although one of the lead farmer of the village, previously he was not aware of modern technologies in agriculture. He received orientation on vegetable cultivation from the Samarthya project and became a member of Karamchauri Mahila Krishak Samuha. Following this he received trainings from the project on vegetable cultivation and was selected as a vegetable nursery farmer. With support from the Samarthya project, he further got an opportunity to take part in a seven-days training on nursery establishment at Kapildev Nursery located at Zeromile of Dhangadhimai Municipality.

After the training, he established a nursery on his own land. LI-BIRD supported him with polybags, nursery trays, watering can, wheel barrow, green net and Silpaulin plastic for the preparation of a plastic house. He raised the saplings of Mulberry trees (*Morus alba*) and seedlings of cauliflower and brinjal in his plastic house. During the first year of using a plastic house, he was able to sell Mulberry and earn NPR 8,000. Similarly, he earned NPR 2,500 from selling cauliflower seedlings. Now he has almost 1,000 saplings of Badhar, Monkey fruit (*Artocarpus lacucha*) worth more than NPR 15,000 in his plastic house. He shares, "Before the Samarthya project, I used to hear only about the benefits of a plastic house in vegetable production. However, after being a part of the Samarthya project, I am now able to differentiate between the production system of a plastic house and the open field. This is a result of being a practitioner of the technology in my own fields." He further shared that there are many advantages to growing vegetables and raising nursery plants inside a plastic house. "I used to have various crop disease problems while raising vegetables seedlings in an open field, but now I can grow healthy seedlings, easily protecting them from diseases. The temperature inside the plastic house is more favorable for production of healthy saplings. Apart from selling the seedlings grown in the nursery, I also transplanted them in my main field and sold 300 kg of cauliflower", Mr. Rai continued. He further added, "A plastic house has become a very important technology for growing healthy seedlings. It also protects the crops from cold and rainfall and even disease and insects are found in less number inside the plastic house. I have just planted tomatoes inside the plastic house and expect to have a good harvest."

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Technology VI

COMMUNITY SEED BANK

Community Seed Bank at Jungu, Dolakha.
Photo: Niranjan Pudasaini, LI-BIRD

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Community Seed Banks (CSB) is a community administered facility to manage plant genetic resources, primarily of local origins. However, improved varieties that are locally adapted and popular varieties are also part of the banking system. CSBs are operated at the local level with stepwise identification, documentation, production, collection, storage, distribution (exchange and share), and marketing. In Nepal, the CSB approach has been successful for on-farm conservation of crop varieties and as a means to provide easy access to quality seed and planting material (Shrestha *et al.,* 2013). For example, IMISAP 2018-2025, NBSAP 2014-2020, Agro-biodiversity Policy 2014, Road Map of MoALMAC 2018, National Seed Vision 2013-2025, ADS 2015, National Agricultural Policy 2004, CSB Guidelines 2008) and numerous national and international agencies including governments have been integrating CSBs into their periodic and regular plans.

CSB offers options to local adaptation

Climate change affects agricultural productivity and food security, mainly in marginal areas with limited access to resources and communities with limited capacity to afford inputs to reduce climate change impacts. Global warming resulting in increased temperatures, erratic rainfall, and severe droughts and floods pose a severe threat to food production (IPCC, 2014). In recent years, better utilisation of local plant genetic resources by strengthening the local seed system has been an effective way to mitigate climate change impacts. It is widely accepted that the use of locally adaptable plant genetic resources could be one of the coping strategies to deal with pressures posed by climate-induced hazards. Jarvis *et al.*, (2015) identified several of these concrete actions in the Food and Agricultural Organization of the United Nations (FAO) publication "Coping with climate change - the roles of genetic resources for food and agriculture".

One common strategy for adapting to climate change is to utilise genetic sources adapted to abiotic and biotic stresses. Species' diversity can be another effective alternative strategy. Farmers can grow diversified crop species by switching to crops or enterprises that are more resilient. To a limited extent, intraspecific crop diversity within the production system reduces disease incidence and risks related to climate change (Jarvis *et al.*, 2011a). Such practices likely reduce the intensity of pest and disease infestations. CSBs are banks of genetic diversity adapted to prevailing climate conditions. They may be useful to contribute to community-based strategies for local adaptation. However, to date, CSBs have received little attention in the literature related to climate change adaptation.

Seed-Smart: CSBs focused on enhancing access and availability of diverse planting materials with associated knowledge locally, and at a cheaper price. Increased diversity at the farm level helps to improve better choices that help reduce climatic stresses. Linn (2011) elaborates on the multiple benefits of crop diversification practices such as using varietal diversity in mono-cultures, mixed cropping with non-crop vegetation species, crop rotations, poly-cultures (including wild varieties), agroforestry, and diverse landscapes. Farmers can access various seeds as per their requirement, which suits specific soil and land types, use-value and stress-tolerant characteristic of particular varieties that are not usually supplied by formal seed sectors (Vernooy *et al.,* 2014).

Institutional-Smart: CSB is managed and governed by the community organisation and promotes participatory actions in an institutional way. CSBs organise farmers for the conservation and utilisation of local crop diversity, and are promoting as an income generation enterprise. CSB instrumentally engages multiple stakeholders for collective actions and social mobilisation. A consistent interaction and alliance among stakeholders proved to be an effective mode of enhancing community adaptive capacity. As robust social capital helps to better act to combat emerging hardship, CSB can be described as an institutional smart method. CSBs can perform as a local level institution for social capital building enabling the environment of knowledge, resource and opportunity sharing in equitable manner.

Contribution to CSA pillars

Pillars	Description
Adaptation	CSB allows farming communities to exchange seeds in a decentralised manner through social networks and by organising events, such as diversity fairs and participatory seed exchanges. Local planting materials which are by default broad genetic base varieties, better adapt with the local climatic conditions and hold capacity to tolerate various biotic and abiotic stress. In summary, CSB can be consider as a seed smart technology which helps to increase access to diverse planting materials at local level which better adapts with local climate and have abilities to tolerate climate induced stress.
Mitigation	Most crop species of local origin are adapted to low input agriculture and are choices for options where climate induced hazards pose threats of crop failure. Growing crops with efficient use of scarce resources with application of soil nutrients of organic origins are better choices over high input agriculture that release more GHG.
Food security	As CSBs directly contributes to improved access locally to good quality seeds and planting materials. With seeds easily available time is not spent on researching seeds in the market. Several researches have shown that only using good quality seeds can increase yield up to 20% more than otherwise. In addition, CSB provides opportunity of knowledge and skill sharing on various farming matters contributing to resolve issues at the local level with local resources. According to Vernooy *et al.* (2014), CSB can play an instrumental role in achieving food security by enhancing seed sovereignty.

Cross-cutting issues smart

CSB promotes participation of marginal, resource-poor and smallholder farmers and ensures women's enhanced participation in decision-making. It has helped many resource-poor farmers by improving access to soft loans, enabling them to increase income opportunities at the local level. Evidence has shown that the running a CSB enhances community leadership. They can now influence local planning and evidence-based advocacy to influence the policy related to agro-bio-diversity conservation and use. Sthapit (2013) considered community seed banks as platforms of community-based management of agricultural biodiversity, ensuring effective implementation of farmers' rights and participation in decision-making concerning conservation, benefit sharing, and advocacy on seed regulatory framework. CSB has played an instrumental role in advocating farmers' rights and developing farmer-friendly agro-diversity policy in the Nepalese context. As described by Sthapit et al. (2012), CSB can perform as a multipurpose tool which can contribute to sustaining livelihood, conserving diversity and organising community and advocate to secure farmers' right. In brief, benefits of CSB are described in terms of ecology, economic, social, and cross-cutting as show below:

Table 16: Multi-sectorial benefits of the community seed bank

Agroecological Benefits	Economic Benefits	Social Benefits	Cross-cutting Benefits
• Identify and document rare and unique crops/ varieties. • Promotes on-farm conservation of local agro-biodiversity through its increased utilisation. • Promotes introduction, exchange and sharing of diverse planting materials. • Enable opportunities to harness agro-ecosystem generated ecosystem services. • Performs as an ecologically responsible institution at local level.	• Provide opportunities of biodiversity based income generation activities. • Helps to increase agro-production by providing good quality planting materials. • Increase access to financial resources among resource poor and marginal farmers as a soft loan. • Creates opportunities of local level employment generation. • Contribute to reduce seed import from foreign countries. • Promote to develop seed entrepreneurship at local level.	• Organise local farmers for better sharing of resources and opportunities. • Promote social harmony and collective actions. • Develop networking among diverse stakeholder for achieving the common goal of agro diversity conservation and promotion. • Performs as a centre of excellence and learning sharing platform at local level. • Perform as a robust community organisation for agricultural development.	• Ensure participation of women, resource poor and marginal communities • Helps to combat against seed crisis during natural disasters and hardships. • Contributes to reducing climate change vulnerability of a community by increasing adaptive capacity. • Flag farmers' issues and make them heard by the concerned authorities. • Advocate for farmers' rights by generating ground level evidences. • Provide platform for research students and scientist on agro-biodiversity related topics.

Process of CSB implementation

CSB is established, managed and governed by community based institutions which might be a farmers' group, a Co-operative or a local level non-governmental organisation. Till date, there is not any legal provisions in order to register the CSB as a stand-alone institution in Nepal. Hence, it has to be operated as a part of any community based institution which is registered in a legal way. In some cases, CSBs are being managed informally without any legal recognition or existence. Shrestha and Rana (2018) have considered ten major steps for establishing a fully functioning CSB as shown in Figure 1. All of the mentioned key steps are not necessarily supposed to be conducted in sequential manner. Some steps come sequentially by default while some can be conducted simultaneously. Since this is a process, not an activity, it needs longer term involvement and continuous support to establish any functional CSB. Generally, a period of three to five years is need to fully accomplish all aspects of the CSB establishment process. As mentioned, a brief description for each step is as follows:

1. Site selection: Appropriate site selection for effective CSB establishment is critical. Diversity affluent areas where local communities largely depend on local planting materials and have good access to road and market would be an ideal place to establish a CSB. Similarly, the presence of vulnerable and marginal communities, well-functioning farmers' institutions, and opportunities for commercial scale seed business should be considered major determining factors for the CSB establishment.

2. Community consultation: Developing a joint agreement among local farmers and relevant stakeholders is crucial to build community ownership and ensure the community's participation. Adequate community consultation, sensitisation, and need is vital before deciding on CSB establishment

3. Institutional set-up: A legally registered farmers' organisation is considered a must for initiating a CSB. Depending on the local context, a new or existing institution could operate CSB as an additional sector. The process helps to legalize the approach without obtaining support from the local government, a national extension programme, and any external agencies, which could become problematic.

4. Capacity building: Through various activities - training, visits, and interactions - the CSB members' capacity is enhanced regarding tools/methods, on-farm diversity management, community seed bank management, quality seed production and storage, and organisational leadership, governance, and sustainability aspects. Usually, during the first training, an action plan, implementation timeline, and division of tasks are prepared to move ahead. Simultaneously, physical infrastructure development for seed storage, diversity display, and offices can be setup in collaboration with the local government and other relevant stakeholders.

5. Documentation of diversity and knowledge: Documentation of available crop diversity and traditional knowledge associated with those varieties is crucial for the CSB establishment process. Preparation of crop inventory, Four Cell Analysis, maintaining a Community Biodiversity Register, and passport data are essential milestones to identify unique, rare, and genetic resources that need immediate attention.

6. Collection of diversity: Diversity collection of available planting materials is essential for seed regeneration, multiplication, and diversity dissemination. It would be a good idea to display seeds with passport data for public awareness. Depending on the crop/varieties' status, crop varieties might go for diversity blocks, some for seed multiplication, and some might go for ex-situ conservation. Along with the passport data, one set of all crop varieties conserved in the national gene bank.

7. Development and implementation of action plan: An action plan needs preparation during the training session. Developing an action plan is a mandatory process to move CSB on track to achieve CSB's overall objectives. Usually, action plans are made covering all aspects of the CSB establishment process, like managing resources, infrastructure, conducting field level activities. Preparation of a detailed seed production and marketing plan is a must. Exploration of financial resources and materialist support has to be planned and defined in the action plan.

8. Capacity building for quality control: After completion of the necessary steps and initiation of seed production activities, capacity building training and orientation focusing on quality seed production, seed certification, and organisational governance has to be organised targeting seed producer farmers and the management team. During this phase, CSB management needs support and facilitation to approach line agencies for coordination and collaboration. One kind of training programme does not suit all stakeholders. Instead, develop separate training according to their need. For example, training on quality seed production, seed certification, labeling packaging and governance is given to members of the governing body. Government line agencies like AKC, NARC-Gene Bank, etc. can also provide technical capacity building training to the management team and facilitate seed production legalization.

9. Partnership and collaboration: Linking CSB and community institutions with governmental and non-governmental line agencies for resource leveraging and joint work is vital during the process. Adequate linkages with diverse organisations help to ensure sustainability by enabling opportunities, resource leveraging, and technical backstopping.

10. Development of self financing model: The final step is the establishment of a self-financing model for CSB management sustainably. Two separate funds, namely, Seed Fund and Community Biodiversity Management (CBM) fund, have been established to achieve self-financing mechanisms (Shrestha and Rana, 2018). The CBM fund mobilised as a revolving fund that provides a collateral-free loan to the farmers in lower interest rates than other sources (Shrestha et al., 2012). Revenue generated by the fund mobilisation is used for the conservation of local crop diversity and covers administrative expenses of the CSB. The seed fund is used to procure the produced seed and marketing and reimbursed again after completing certain functions. Earned profit from both funds are used for the sustainable management of CSB.

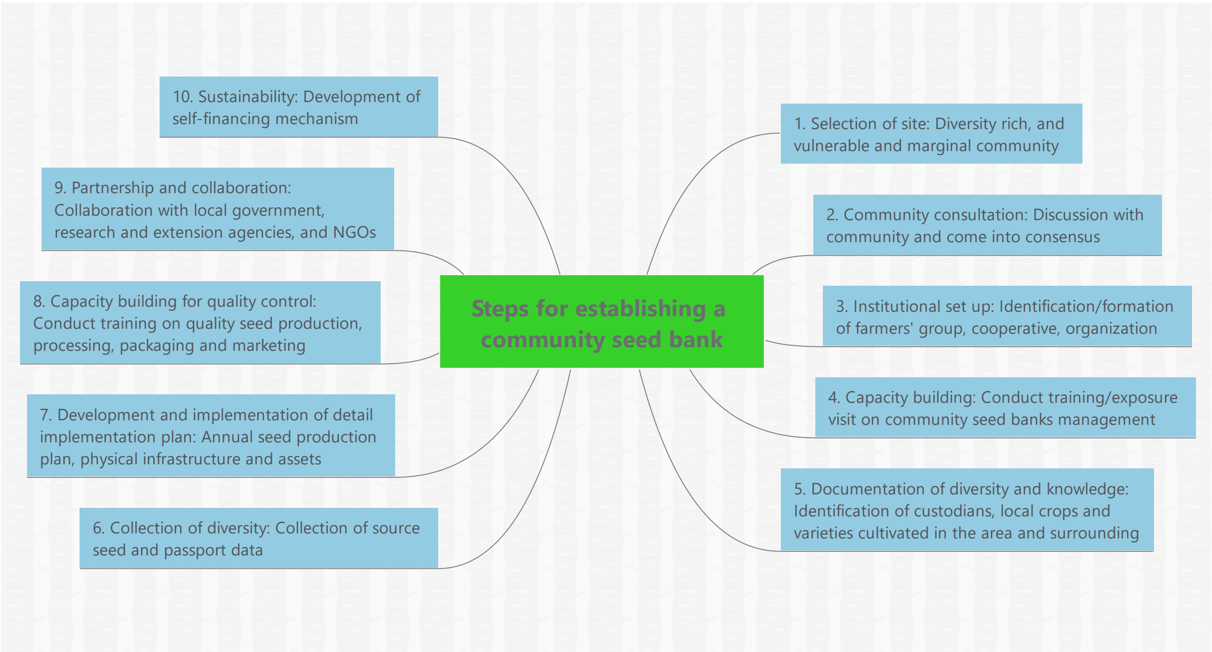

Figure 9: Key steps of CSB establishment and management (Shrestha and Rana, 2018).

Agroecological suitability and investment

In general, CSBs can be established and operated in any Agroecological regions. Depending on the agro-ecology, priority crops for a commercial-scale seed business might be different, for example, the seed business of cereal crops in the Terai region is suitable. At the same time, mid-hills and high-hills are better for vegetable seed production and trade. There is no limitation of CSB operation anywhere, but it might be challenging for a profitable seed business and sustainability of the conservation proposal. As discussed above, without a seed business accompanied by a self-financing system, CSB can hardly survive. Establishment of CSB in a strategic location or region is a must to make seed a profitable business. The required resource and cost of establishment vary upon physical resources and timeframe of the establishment process. It needs a continuous investment of technical and financial resources with longer-term involvement. According to Shrestha (2018), fundamental resources in order to establish a well-functioning CSB are as listed in the table below:

Table 17. Fundamental tools/materials required to run a community seed bank

SN	Resources	Quantity	Remarks	SN	Resources	Quantity	Remarks
1	Land for CSB and seed processing space construction	500 to 1,500 square metres	Public or private land, should be in an accessible area	8	Digital/electric weighting machine	1	Up to 100kg capacity
2	Building	1	Rooms/space for seed storage, diversity display and office/ meeting hall	9	Printed/ labelled seed sacks	As per the requirement	
3	Cemented seed threshing floor	1	Minimum of size 20x20 ft.	10	Telephone/ mobile	1	Dependable communication system
4	Seed grading machine	1	Upon requirement and feasibility	11	Wooden mat	4-5	Depending upon size of the store room
5	Seed winnowing/ cleaning machine	1	Upon requirement and feasibility	12	PICS or grain-pro bags (double layer)	As per the seed quantity	Good for maize, wheat, legume and oil seed storage
6	Moisture meter	1	Easily operate and portable type	13	Jute Sacks	As per the seed quantity	Good for rice seed storage
7	Sack sewing machine	1	Easily operate and portable type	14	Air tight bottles and boxes	As per the seed quantity	Good for low volume seed specially vegetables

Source: Community Seed Bank: Establishment and Management Resource Book (Shrestha, 2018)

Case story

CSB was introduced in Agyauli, Kawasoti 14, Nawalparasi in 2008 under a project called "Community Based Biodiversity Management (CBM)". The project was implemented by LI-BIRD from 2008 to 2016 with financial support from Development Fund, Norway. After the need realisation and joint agreement for CSB establishment was prepared, a participatory working committee was formalised and legally registered in 2010 as a farmers' group. The CSB establishment process was already underway before registering the group. The group was capacitated and mobilised for diversity assessment, collection, seed multiplication, and associated knowledge documentation beforehand. The committee continues to grow and work towards establishing the Agyauli CSB where the project supports them with the required financial resources and technical guidance. As progress continued, the group was formally registered, as the "Agriculture Development and Conservation Committee" in 2013 with the significant objective of managing a CSB sustainably. The project invested a considerable amount of resources and time on the technical capacity building and institutional development of the CSB and was phased out after successfully establishing the CBM fund and seed fund as a self-financing model as discussed above.

After more than ten years of establishment, the Agyauli CSB continues to grow. It is now a well-established and well-functioned community institution capable of 50-60 tons of seed transactions per annum. CSB is mobilizing 41 distinct farmers' groups covering the whole municipality with a total of 953 members (680 female members). The CSB management committee is composed of 11 members led by Ms. Parbati Bhandari. At present, Agyauli CSB conserves 63 varieties of 24 different local crop species producing 1,000 kilograms of seeds and disseminating them at the local level, promoting on-farm conservation through use. CSB has been able to balance commercial-scale seed business and conservation of local landraces. As a self-financing mechanism, CSB has a CBM fund worth NPR 1,071,109 and a seed fund worth NPR200,000 effectively

Community Seed Bank Agyauli, Nawalpur.
Photo: Pitambar Shrestha, LI-BIRD

mobilised by the management committee. Each year 30-50 farmers take a soft loan from the CSBM fund for income generation activities. CSB can then generate some NPR 300,000 of revenue from interest annually. Simultaneously, the principal amount of the CBM fund increases revenue continues to add on.

Similarly, Agyauli CSB has established linkages with multiple stakeholders, including the National Gene Bank, private companies, and local agro-vets and the government seed laboratory. CSB is also linked with government and other development agencies and the local government, enabling resource-leveraging opportunities and the right working environment. Local government supports Agyauli CSB significantly on infrastructure development. CSB started with a single room, has now operates with four separate concrete buildings for meetings/conferences, office work, seed storage, and diversity and knowledge display function. A large concrete seed threshing floor equipped with seed cleaning and grading machines has fulfilled all of the required resources to run a CSB sustainably. Agyauli CSB has been developing as a resource centre for scholars and learners on various aspects of CSB where groups of farmers, students, and research individuals visit each year. Agyauli CSB has set an example on managing a well functioned CSB and has developed itself as the centre of excellence.

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Technology VII

CLIMATE RESILIENT CROP AND CROP VARIETIES

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Heat stress tolerant wheat variety (Gautam) cultivation.
Photo: Aastha Bhusal, LI-BIRD

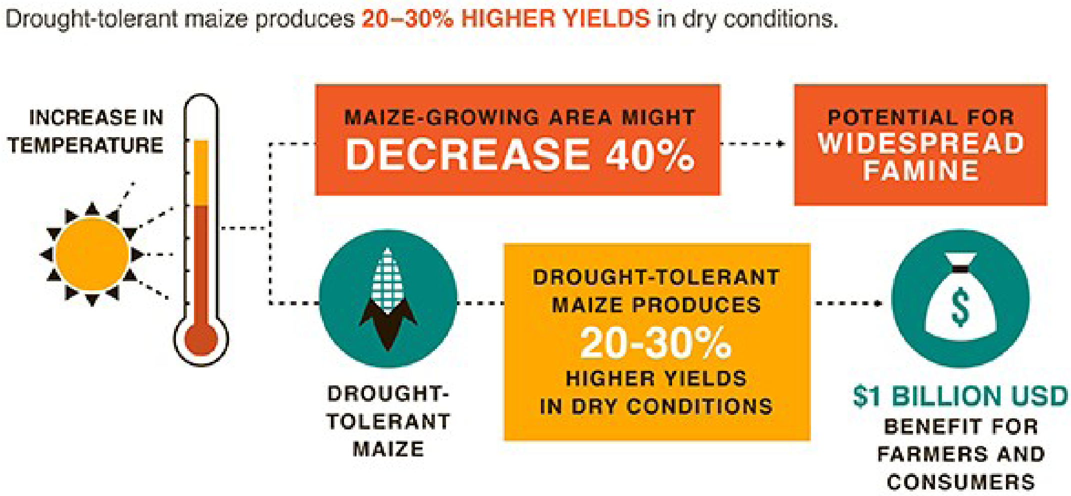
Climate-resilient crop varieties are varieties with superior tolerance to biotic and abiotic stresses induced by climate change. Most of the local origin crop variety can perform well, even under the changing climatic conditions and production environments. Since these crop species are cultivated under optimum, low inputs conditions, they have more resilience to new environments created due to climate change combined with management regimes. At the same time, other sets of crop varieties of local origin may show more susceptibility to a new environment. As a result, farmers may be uninterested in continuing them because of their poor performance. In the present context, the climate-resilient crops and crop varieties that can tolerate the biotic and abiotic stresses are of utmost importance to maintain and increase the yields with changing production environments.

Description of technology

A selection and promotion of climate-resilient crop varieties with consistently higher yields under extreme weather and other abiotic and biotic stresses is urgently needed. A rice variety, Tarahara 1, released as a drought-tolerant variety for Nepal's Terai, yielded 75 % higher over conventional types is recommended for direct seeding that can be economical with reduced puddling operations and water-saving (Tripathi *et al.*, 2012). Likewise, after the 'SUB1' gene was introduced into Swarna and Sambha Mansuli, it successfully grew under submergence conditions, which occur more frequently during monsoon seasons across the lowland Terai region. This variety yields 4-5 t/ha even if submerged underwater four to seven feet; such traits are absent in other rice varieties. Besides, these varieties are preferred for their excellent cooking quality (Tripathi *et al.*, 2012).

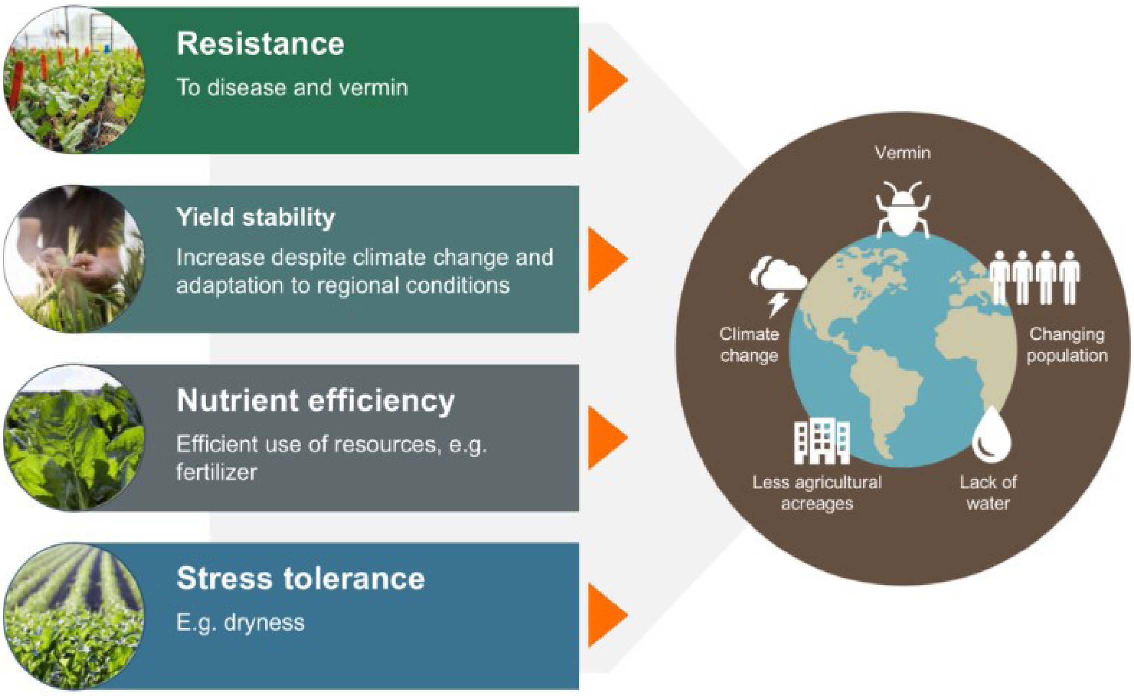
Likewise, cold-tolerant rice varieties like Chandannath 1, Chhomrong, Machhapuchhre 3, etc., have been introduced for the mid to high hill regions where cold stress tolerance genes perform better than other varieties. A study with improved climate-resilient wheat varieties from CGIAR's breeding lines from 1994-2014, with the partnership of ICARDA, showed the global wheat production strengthened with economic benefits generated by the additional grain range from $2.8 billion to $3.8 billion every year (ICARDA, 2019).

Home gardening with year-round vegetables and fruits that are climate-resilient is instrumental in terms of nutrition and food security. Drought tolerant vegetables like pole beans, faba beans, and other legumes develop deep root systems to counter heat and low water levels. Since the leguminous crops fix atmospheric nitrogen they hardly require supplemental fertilizers, resulting in the reduction of GHG emissions otherwise emoted due to added fertilizers. Short duration pulse crop varieties can escape drought, fit into multiple cropping systems, enhance soil fertility, and improve yields, contributing to food diversity and sustainable production. Growing these varieties enhances farming households' resilience through reduced dependence on external inputs, diversification, observation, and knowledge. More interestingly, it does make a positive contribution towards women empowerment through an increased economic contribution to the household, leading to more respect, enhanced social status, and decision-making power.



(Source: ccafs.cgiar.org/bigfacts)

Figure 9: Yield and economic benefit from drought tolerant maize in African countries



(Source: kws.com)

Figure 10: Benefits from climate resilient crop varieties.

Contribution to CSA pillars

Pillars	Description
Adaptation	• Helps in diversification of crops and crops varieties and reduces pressure on cereal monocultures. • Increase the adaptive capacity of vulnerable communities, marginal farming families and women. • Strengthens technical know-how in selecting the crops and cultivars based on land type, maturity classes and expected rainfall behaviour. • Replace lower yielding crops by more productive ones. • Productive use of marginal and less productive land. • Withstand the adverse climate conditions like drought, flooding, heat stress etc.
Mitigation	• Reduces the use of external inputs and reduces GHG emissions. • Increases the nutrient use efficiency while reduces nitrogen and phosphorus leaching that affects the environment. • Increases water use efficiency and reduces irrigation water use (water saving). • Modifies the microclimate to reduce the temperature extremes.
Food security	• More production and stable yield despite changing climatic patterns. • Less susceptibility to field crop losses, reduced damage to food production systems and less chances of total crop failures. • Production of high nutritional content products like QPM varieties of maize (rich in protein and minerals) and tackles malnutrition. • Builds climate-resilient food system.

Advantages

- Farmers can increase agricultural production and productivity against a backdrop of rising temperatures, increasing water scarcity and other climatic extremes.
- Builds climate-resilient food systems and addresses food and nutrition security of the nation while tackles malnutrition.
- Can withstand the severe drought and heating effect, erratic rainfall, flooding and salinity and defenses biotic stress against pests, diseases and weeds.
- Has good performance/production even on marginal and less productive land.
- Possess improved water, nutrient and other resource use efficiency i.e. can perform better even with less input such as fertilizers etc as compared with conventional varieties.
- Support sustainability through adaption and reducing negative impact of climate change and empowers women, poor and marginal farming families/communities.

Implementation steps/methods

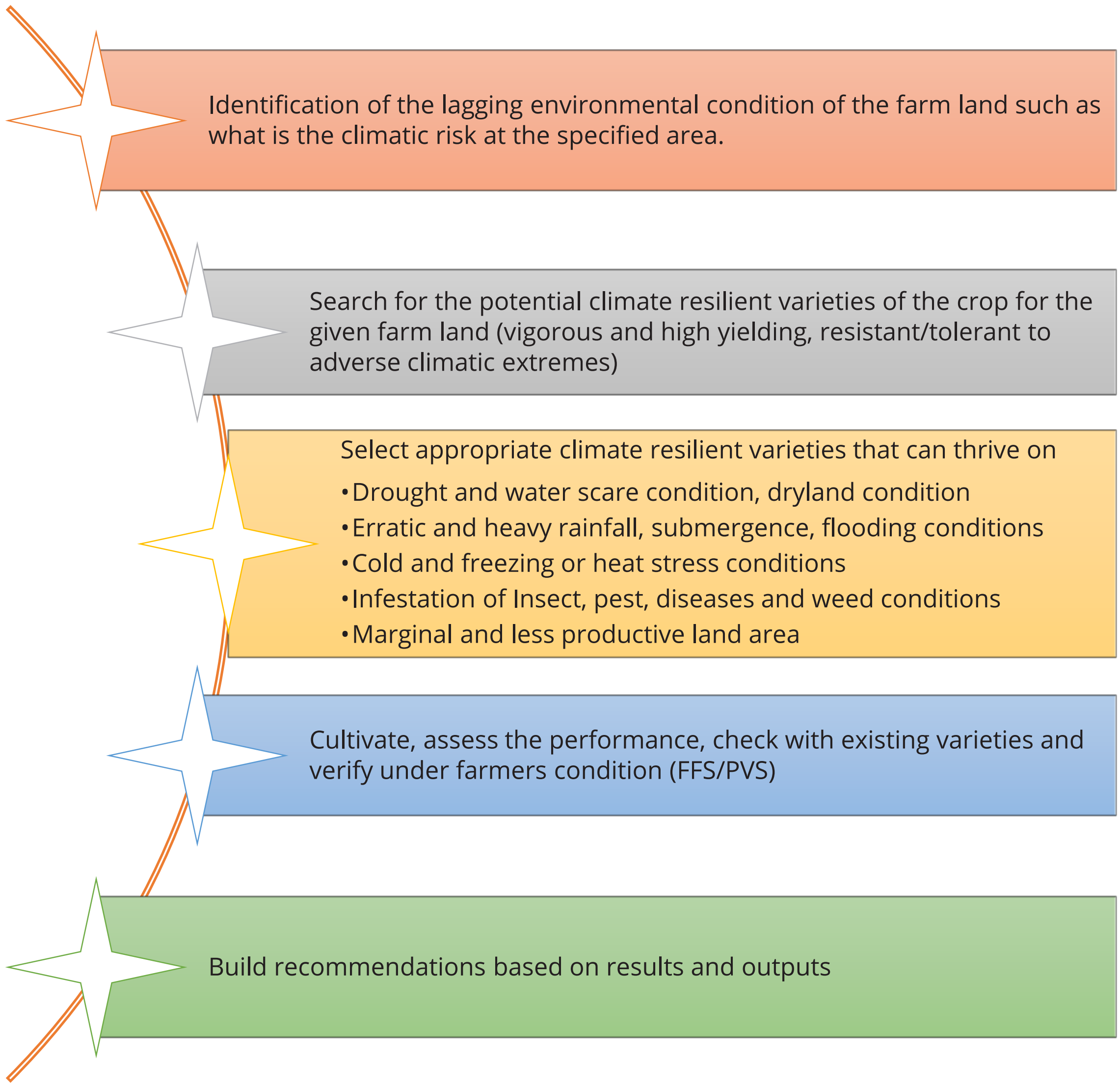


Figure 11: Steps for assessing performance and verifying the climate resilient crop varieties

Agroecological suitability

Different climate-resilient varieties of various crops are recommended on different agro ecological zones based on their suitability. Some of the varieties of major crops recommended for different parts of Nepal are as follows:

Table 18: Recommended domains and special features of major climate resilient crop varieties in Nepal (Source: NARC Diary 2077 & Released and Promising Crop Varieties of Mountain Agriculture in Nepal (1959-2016)

Crop	Variety	Recommended Zone	Special Feature
Rice	Chandanath 1, Chandanath 3, Lekalidhan 1, Lekalidhan 3	High-hills	Cold tolerant
	Swarna sab 1, Saba Mansuli sab 1, Sworng sab 1	Terai and mid-hills	Flood tolerant
	Sukkhadhan 1, Sukkhadhan 2, Sukkhadhan 3, Sukkhadhan 4, Sukkhadhan 5	Terai and mid-hills	Drought tolerant
	Sukkhadhan 6, Bahuguni 1, Bahuguni 2	Terai and mid-hills	Drought and flood tolerant
	Makawanpur 1	Terai	Leaf folder resistant
Maize	Deuti	Mid-hills	Drought tolerant and Grey Leaf Spot (GLS) resistant
	Arun 2, Arun 3, Arun 4, Arun 6	High-hills and winter crop for Terai	Early maturity
	Mankamana 3, Ganesh 1, Shitala	Mid-hills	GLS resistant
	Khumal Hybrid 2	Mid-hills and winter crop for Terai	
	Poshilomakai 1	Mid-hills (below 1,600 m)	Rich in protein
	Poshilomakai 2	Terai (winter season) and mid-hills (rainy season)	
Wheat	Bijaya	Terai, river basin and valley	Tolerant to heat stress, Ug99 and blight resistant
	Gautam		Tolerant to heat stress
	Munal, Chyakhura	Mid-hills and high-hills	Rust resistant
	Danfe	Mid and high-hills	Blight resistant
	Tilottama	Terai	
Potato	Janakdev	Mid to high-hills and winter crop for the Kathmandu Valley and Terai	Late blight resistant
	Khumalbikas	Mid-hills, to high-hills	
	Khumalujjwal		
	Khumal Rato 2	Terai	
	Khumal Seto 1	Mid hills in autumn and high hill in summer season	
	Khumal Upahar	Terai to mid-hills	
Rape seed	Lumle tori 1	Mid and high-hills	Drought tolerant
Amaranth	Ratomarse, Ladimarse, Suntale latte	Mountain region (high and mid-hills)	Drought tolerant and can be cultivated in marginal land
Buckwheat	Mithephaper 1	Mid-hills	Drought tolerant and powdery, downy mildew resistant, resistant of leaf blight and wilt diseases

Proso millet	Dudhe Chino	Mid-hills and high-hills	Drought tolerant and can be cultivated in marginal land
Foxtail millet	Setokaguno, Kalo Kaguno	Mid-hills and high-hills	Drought tolerant, non-lodging and resistant to blast
Finger millet	Dalle 1	Terai and mid-hills	Drought tolerant and non-lodging
	Kabre Kodo 1	Mid-hills	Drought tolerant, non-lodging, resistant to finger blast, neck blast and Cercospora leaf spot and tolerant to heavy rainfall
	Kabre Kodo 2, Okhale 1	Mid-hills and high-hills	Drought tolerant, non-lodging, resistant to finger blast, neck blast and *Cercospora* leaf spot
	Sailung Kodo 1	High-hills	Non-lodging, moderately resistant to finger blast, neck blast and Cercospora leaf spot
Barley	Bonus	Kathmandu Valley and similar Agroecological zones and western hills	Resistant to yellow rust
	Solu Uwa	High-hills and mountain areas (2,000-3,000m) of Mustang, Manang and Dolpa	Drought tolerant

Implementation cost

As farming households have to face financial constraints, to address climatic impacts that are to adjust financial constraints, CSB should devise a strategy to multiply resource-efficient crops that produce relatively higher yields and tolerate biotic and abiotic stresses. Selection of such crop varieties reduces costs for irrigation/water and fertilizers requirements, and costs incurred during plant protection measures. If all the measures are performed during crop growth, then there's an ultimate increase in the production and productivity addressing the climatic risks. The table 20 below present the estimated cost of rice cultivation in one hectare of a high potential production system:

Crop varieties resilient to climate-related problems are even more efficient in their resource use to reduce the agricultural ecosystem's impact and the broader environment. Additional energy costs are involved with achieving better efficiency in irrigation with other crops. However, novel drought-tolerant crops require less water at the field level than conventional lowland rice and reduce the number of irrigation applied, reducing the cost. Similarly, the cultivation of climate-resilient crop varieties of legume crops with the inherent capacity to fix atmospheric nitrogen can reduce the fertilizer requirement.

Implementation cost thus reduces with the cultivation of climate-resilient crops and varieties. The selection of climate-resilient crops and varieties reduces climatic risks, reduces inputs and other processing costs, and eventually increases production and productivity.

Table 19: General cost of transplanted rice cultivation during experiment per hectare area

S.N.	Particulars	Unit	Quantity	Rate (NPR)	Total (NPR)
1	Nursery preparation and seed sowing				
1.1	Land preparation	hr	0.5	1,200	600
1.2	Seed cost	kg	55	50	2,750
1.3	Seedbed preparation, application of fertilizer and seed sowing	man-day	4	500	2,000
1.4	Cost of uprooting	man-day	4	500	2,000
2	Main field preparation				
2.1	Primary plowing with tractor	hr	3	1,200	3,600
2.2	Secondary plowing with tractor	hr	2	1,200	2,400
2.3	Manual bund preparation	man-day	3	500	1,500
2.4	Manual land preparation and puddling	man-day	4	500	2,000
2.5	Transplanting	man-day	4	500	2,000
3	Fertilizers				
3.1	Urea	kg	227	25	5,675
3.2	Diammonium phosphate (DAP)	kg	87	50	4,350
3.3	Muriate of potash (MOP)	kg	67	30	2,010
3.4	Zinc sulphate	kg	20	100	2,000
4	Fertilizer application	man-day	4	500	2,000
5	Irrigation 2 times	hr	3	500	1,500
6	Labour for irrigation	man-day	1	500	500
7	Weeding and plant protection				
7.1	First manual weeding	man-day	7	500	3,500
7.2	Second manual weeding	man-day	7	500	3,500
7.3	Plant protection (pesticides)	Lump sum			1,500
8	Harvesting and post-harvest				
8.1	Harvesting (manual)	man-day	10	500	5,000
8.2	Threshing	man-day	8	500	4000
8.3	Winnowing and storage	man-day	5	500	2,500
	Total				56,885

Source: Katuwal, 2019

Note: The cost of input use and labour rate varies from place to place.

Ciherang Sub 1 rice variety well adapted to the field condition of Ramnagar, Kailali. Photo: Yogendra Katuwal, LI-BIRD

Case story

LI-BIRD has implemented Livelihood and Resilience Enhancement Project (LREP) which aims to improve food and nutrition security, income and resilience of resource poor, marginalised, landless and smallholder farming households especially, Mukta Kamaiyas in the western Terai region of Nepal. Introduction and dissemination of climate-resilient crop varieties through Informal Research and Development (IRD) and diversity kit distribution for enhancing home gardens is one of the major objective of the project. Farmers in Kailali and Bardiya districts cultivate rice in the early season (mostly in May/June) and have been facing problems of pre-monsoon drought that has resulted in low yield of crops. In order to address the climatic risk, the project distributed drought tolerant rice varieties such as Sukkha 2, Sukkha 3, and Sukkha 6 with a subsidy and as IRD support to the farmers in 2018 and 2019. Considerable changes in yield were observed with these varieties even under low rainfall conditions. Upon survey, the mean yield of Sukkha 2 variety was found to be 3.7 t/ha in Bardiya in 2018, whereas mean yield of Sukkha 3 was 3.3 t/ha upto 4.9 t/ha under the best management in Kailali in 2019. In these years, other cultivars like Sarju 52 and Mansuli had relatively lower yield. Farmers preferred the drought tolerant varieties (Sukkha 2, Sukkha 3 and Sukkha 6) better in terms of cooking quality and early harvesting with a less cropping window, thus subsequent wheat and other crop cultivations have more time to grow. In 2020, the project introduced and supported Ciherang Sub 1 variety of rice as IRD in the sites where occurrences of flooding and prolonged submergence have been a major constraint of rice production. The project team has received positive response from the farmers due to higher tillering, effective panicles, and greater yield of this variety.

Similarly, LI-BIRD evaluated 16 farms in Belauri and Laljadi Municipalities with rice varieties: Sukkha 2, Sukkha 3 and Sukkha 6. The yield of the varieties was found higher in Sukkha 2 and Sukkha 3 as compared with improved/local varieties (Radha 4, Anjana and Silk) and farmers preferred these varieties. The demonstrations of the drought tolerant varieties have convinced farmers of the huge potentiality of scaling-up these varieties in a wider area.

Source: LREP Project: OMS survey and UTHAN Project, LI-BIRD

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Technology VIII

ORGANIC AND AGRO-ECOLOGICAL FARMING

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Ecological agriculture is a system-based approach that applies environmental and social principles that seek optimum interactions between plants, animals, humans, and the environment for a sustainable and fair food system and is globally recognised (FAO, 2018). It blends context-specific ecological knowledge and indigenous practices with science adhering to environmental preservation principles, social fairness, and economic stability. Ecological and organic agriculture practices reduce pesticide pollution, supply safe and healthy foods, protect the environment, conserve biodiversity, and utilise locally available production resources on a sustained basis. Building upon indigenous knowledge and local resources helps the farming system to become more robust and resilient to rapidly changing climates, pests, and diseases. Furthermore, ecological and organic agriculture enhances both above ground and soil's habitat to produce strong and healthy plants.

Description of technology/practice

Conventional agriculture systems compromise biodiversity, utilise resources inefficiently, are highly energy-dependent, impose a significant ecological footprint, and are susceptible to pest outbreaks and vulnerable to climatic variability (Thiessen, 2015). Agroecological practices are developed based on various environmental processes such as nutrient cycling, biological nitrogen fixation, natural regulation of pests, soil and water conservation, and biodiversity conservation.

Weather-Smart: Many studies suggest that increasing plant diversity in farming systems reduces vulnerability to extreme climatic events. Diversification is a crucial step towards agroecology. Biodiversity creates various positive interactions among different species making a more rigid agro-ecosystem. For example, intercropping legumes as a cover crop can

Organic vegetable farming at Tallo Kudule village, Syangja.

exhibit multiple effects, including suppressing weeds, adding organic matter to the soil, fixating atmospheric nitrogen, conservation of soil moisture, etc.

Water-Smart: With water becoming scarcer for agriculture, there is a need to use water more efficiently. Ecological farming practices such as mulching, cover crops, minimum tillage, and organic manures can enhance moisture retention hence improving water use efficiency. Organic matter improves soil infiltration that facilitates improved water holding capacity for a more extended period. Furthermore, the cultivation of drought-tolerant varieties can be one of the key examples of smart water practices as they can adapt to water-stressed situations.

Nutrient/Carbon-Smart: Healthy soil is the basis for the proper growth and development of plants. Soil fertility can be enhanced by various ecological farming practices, such as the use of Farm Yard Manures and composts and green manures, enhancing the organic matter content of the soil, and integration of legumes to fix atmospheric nitrogen. Organic matter helps to improve the soil microbial activity, which enhances the physical properties of soil. Mulching with crop residues, legume intercropping as cover crops, and agroforestry helps build soil organic matter, improving soil fertility.

Seed-Smart: Ecological farming encourages the preservation and the use of local varieties. As local varieties adapt better to local farming conditions, they require less external inputs and are more resistant to diseases, pests, and other climatic stresses. Moreover, the seeds of local varieties are preserved and stored by the majority of farmers. Hence, ecological farming encourages farmers to conserve their seeds.

Market-Smart: Ecological products are free from synthetic fertilizers and chemical pesticides, which makes them safe and nutritious. The market for these products is steadily increasing, particularly in urban areas. Ecological or safe products fetch premium prices over conventional products.

Contribution to CSA pillars

Pillars	Description
Adaptation	The smallholder farmers are most vulnerable to increasing weather extremes which brings droughts, floods, destructive rains and winds (*Leu, 2013*). Organic and agro ecological practices are highly adaptive to climate change. These types of farming focus on application of traditional skills and farmers knowledge and have a high degree of diversity. Also, it deals with soil fertility building techniques. Organic/ Agroecological farming uses many management practices like minimum tillage, returning crop residues to the soil, the use of cover crops and rotations, and the integration of nitrogen fixing legumes. This helps in raising productivity and stores carbon in the soil reducing carbon in the atmosphere. Also, it prevents nutrient and water loss, making soil more resilient to floods, droughts, and land degradation processes (IFOAM, 2018).
Mitigation	Synthetic nitrogen fertilizers are one of the main sources of carbon dioxide emissions from agriculture and the most important source of nitrous oxide emissions. Many scientific studies suggest that ecological farming can play a role in reducing greenhouse gas emission. Encouraging usages of quality farm yard manure, composts, crop rotation, and green manures can minimise the use of synthetic fertilizers consequently mitigating a significant portion of agricultural emissions (Rosset and Altieri, 2017).
Food security	The majority of smallholder farmers are traditional farmers who mostly practice Agroecological farming or are organic by default. Training these farmers with good organic/agro ecological practices such as recycling organic matter, improved pest and disease control, water use efficiency, better weed control methods, eco-function intensification etc. leads to increase in yield (Leu, 2013). Therefore, it is important to increase the resilience of small holder farmers to ensure food security.
GESI	Ecological farming is simple and effective, it provides stable yield over time which makes farming less risky and more affordable and accessible to women. Additionally, ecological produce can create high value end products and improved incomes. For example, safe food and organic products fetch premium price in the markets. Agroecological farming encourages cultivation of local seeds using traditional knowledge. This gives a greater role to women, who are traditionally the keepers of seeds and traditional knowledge.

Advantages

Benefits of Ecological Farming

- Ecological farming increases ecological resilience with respect to rapidly changing climate.
- Improves health and nutrition through more diverse, nutritious diets and reduced incidence of pesticide poisonings.
- Conserves biodiversity and natural resources such as soil organic matter, water, crop genetic diversity and natural enemies of pests.
- Improves economic stability with more diverse sources of income, spread of labour needs and production over time, and reduced vulnerability to commodity price swings.
- Mitigates effects of climate change through reduced reliance on fossil fuels and fossil fuel-based agricultural inputs, increased carbon sequestration and water capture in soil.

Source: Pesticide Action Network

Implementation steps/methods

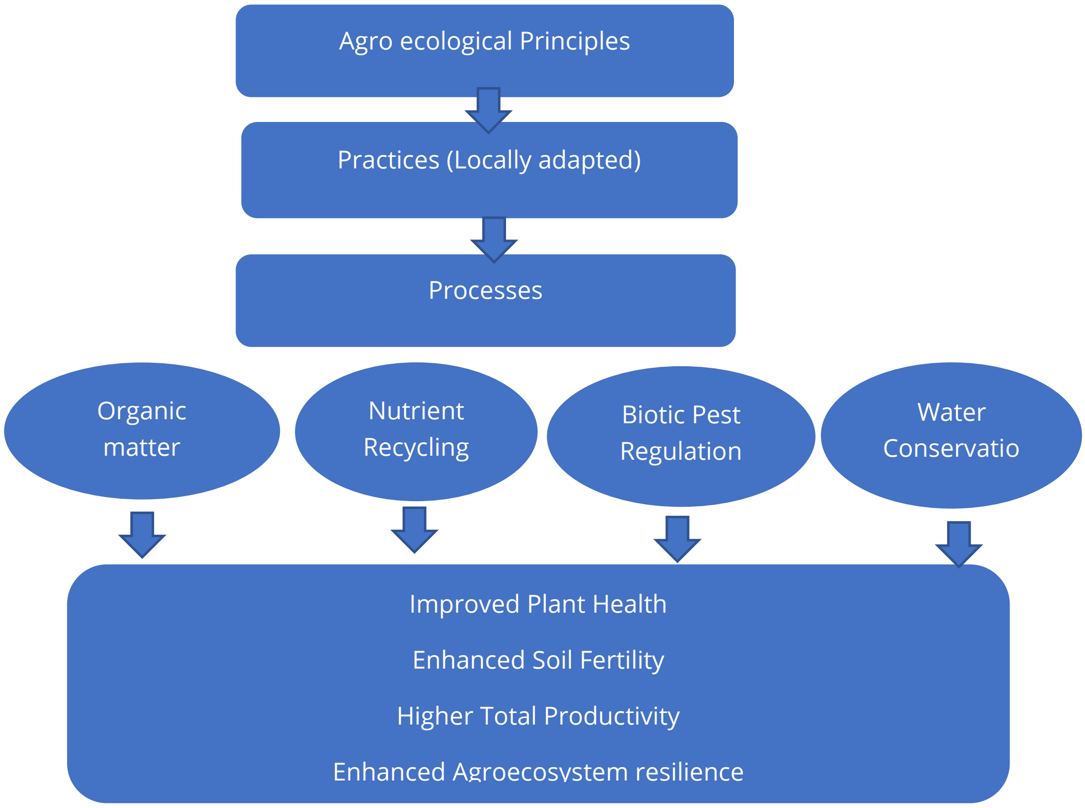

Figure 12: Agro ecological principles for the conversion of farming systems (Source: Nicholls et al., 2016)

The first step in the conversion of farms to agroecology is diversification. As biodiversity increases, there will be more beneficial interactions and high resource-use efficiency. Agroecology relies on complex interactions that emerge from various practices operationalised on each farm (Malezieux, 2012). There is a need to redesign our farming systems based on agroecological principles. These principles can be applied using various locally available practices and strategies to make the farming system more productive and resilient. Agroecological farming aims to imitate natural ecological processes leading to soil and water conservation, optimal nutrient recycling, enhanced soil microbial activity, and natural pest regulations. These processes lead to a strong agroecosystem, allowing farmers to gradually eliminate inputs instead of ecological processes and interactions.

Agroecological suitability

Implementing agroecological farming practices is feasible in all geographical locations. However, depending on the topography, locally available resources, and traditional values and knowledge, the methods may vary from place to place. For example, rice cum duck farming practices may be more reliable and suitable for low land areas. The same process may not work for upland agroecosystems.

Implementation cost

An agro ecological farming system is an approach for enhancing the farming system's resilience, which comprises packages of practices; hence, it is quite challenging to estimate the implementation cost. The cost may vary depending on the specific location, available resources, and many rules implemented.

Case story

Ms. Indira Majhi is a young and proactive farmer from Sunkoshi Rural Municipality, Ward No. 7 of Sindhupalchok district. She has been engaged in ecological farming for the past year after receiving training and support from the "Scaling Up Climate Resilient Agriculture for Sustainable Livelihood of Smallholder Farmers in Nepal" project implemented by LI-BIRD.

Ms. Majhi owns a small piece of land on the bank of the Sunkoshi River, where she used to cultivate only a few vegetables, especially potato, garlic, and green leafy vegetables depending on the season. Before the project's intervention, she used to work as a daily labourer in the nearby town of Khadichaur. "Before we had to buy vegetables from the market. Now we grow our vegetables, which is healthy as we do not apply chemical fertilizer and pesticides. We not only save money but sell the excess products", says Ms. Majhi. "I was able to earn NPR 25,000 in the last six months by selling vegetables!"

Indira Majhi in her Kitchen Garden, Sindhupalchok.
Photo: Prem Raj Bhatt, LI-BIRD

She has constructed a small plastic pond on her farm where she collects grey water to irrigate her vegetables. She has placed two drums of homemade biopesticides (Jholmol 3 and Jibamrit), which she prepared a few months earlier. She uses these homemade pesticides to protect her crops from insects and diseases. Additionally, she has integrated goats and Giriraj chickens in her farming system to meet the fertilizer requirement. "I have recently improved the goat shed and prepared a dung collection pit with shade to maintain manure quality," concludes Ms. Majhi.

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Technology IX

CROP AND LIVESTOCK INSURANCE

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Sharmila Budha insured goat. Photo: Khima Rana Magar, LI-BIRD

Crop and livestock insurance can be critical risk management strategies that enable farmers to continue their farming even in unfavorable conditions (Ghimire, 2014). To support insurance schemes, the Insurance Board (*Beema Samitee*) of Nepal has formulated and endorsed Crop and Livestock Insurance Directives (2069) and Crop and Livestock Subsidy Premium Insurance Directives (2070) (Ghimire *et al.*, 2020). There are currently about 20 non-life insurance companies under directives and are providing crop and livestock insurance. The Government of Nepal (GoN) has subsidised the premium amount (up to 75%) and paid insurance companies (Deepa *et al.*, 2020), which has encouraged both farmers and insurance companies to apply this scheme to the livestock sector successfully.

Crops and livestock insurance supports resilience building

Crop and livestock insurance are strategies introduced to minimize the impacts of climatic hazards. The climate-induced threats, particularly prolonged drought, floods, landslides, and pest incidence and disease, cause significant damage to agricultural production, resulting in vast economic loss (Ghimire *et al.*, 2020). Farmers might also lose their livestock due to adverse climatic conditions such as disease outbreaks, landslides, floods, and drought. Furthermore, these disasters make farmers frustrated and reluctant to invest further in agriculture and livestock-related enterprises. Crop and livestock insurance is a risk-reducing mitigation measure in case farmers have to bear the loss of their crops or livestock due to extreme weather conditions. Besides, insurance schemes also encourage farmers to continue and expand agriculture and livestock-related enterprises.

Weather-Smart: Crop and livestock insurance are a weather-smart strategy. The insurance company compensates up to 90% when farmers lose their crops or livestock due to the impacts of extreme weather conditions or the outbreak of diseases. However, 50% of the total loss is compensated even if farmers' crops, livestock, or poultries become permanently disabled (Deepa *et al.*, 2020). Thus insurance schemes support farmers to continue with crops and livestock development even if there are risks associated with climate change.

Advantages

Following are the advantages of crop and livestock insurance:

- Reduces the risk of crop or livestock loss and increases the risk-bearing capacity of farmers.
- Farmers/entrepreneurs can still get 90% of the total insured amount as compensation from the insurance companies in case of loss of crops and livestock so that farmers have the opportunity to invest.
- Farmers get 50% of the sum insured in case of partial crop loss and permanent disability of their livestock or poultry.
- Farmers/insurer should only pay the minimum amount (25%) of the total premium as insurance companies receive a 75% subsidy from the government.
- Encourages farmers and young entrepreneurs to be engaged in commercial agriculture and livestock production and related enterprises.
- Provision of up to NPR 200,000 accident insurance for farmers at only NPR 100 premium.

Contribution to CSA pillars

CSA pillars	Contribution
Adaptation	• This scheme supports farmers by compensating their crops and livestock if lost due to extreme climatic conditions. • With the provision for compensation, farmers are inspired to continue agriculture and livestock production even knowing environmental factors can pose threats to their enterprise. • Insurance schemes build confidence and farmers' risk-bearing capacity encouraging them to move forward developing agri-enterprises.
Mitigation	• Crops and livestock insurance indirectly contribute to mitigation. For instance, with insurance of high productive livestock and poultry, farmers can establish improved sheds that can emit less greenhouse gas (GHG) compared to raising less productive livestock or crops of local origin. • With provision of insurance schemes, farmers are aspired to grow crops year round resulting in sequestering GHG and also reducing emission of GHG. Additionally the land is not now left fallow.
Food security	• Insurance schemes provide incentives for farmers to grow high yielding crop and livestock breeds, and this contributes to food security. • Insurance schemes enhance food security even in situations where farmers lost their crops or livestock due to climatic hazards. • Farmers get 50% compensation from insurance companies when their crops are partially lost and livestock or poultry turned unproductive or are injured or impaired. • Insurance schemes help farmers take more risks for cultivating crops and rearing livestock, resulting in them making more income that eventually contributes to better food security.
Gender Equality and Social Inclusion (GESI)	• Insurance policies support family farmers especially women who are the custodians of traditional farming systems and seed managers. • In Nepal, women are farmers and their farming responsibility has increased with increasing out migration of their male counterparts for employment abroad. Provisions of the insurance scheme will help women take risks attached with enterprise development.

Implementation steps/methods

Farmers or agro-entrepreneurs who intend to insure their crops and livestock commodities should first consult with an expert at the insurance company or their agents to find out about the provision of insurance and the required documents to submit (Figure 13). Co-operatives can also collectively facilitate the process. In such cases, the insurer can get an additional discount on the premium amount. Then, the insurer should fill in the forms provided by the insurance company. Their commodities are to be insured by commodity-wise technicians based on the cost of production, market price, health, and other risk factors. Based on these items the insurance amount is agreed between the insurance company and the insurer. While submitting the insurance form, the insurer should also submit a copy of their citizenship card and pay the insurance fee (premium as mentioned on commodity wise insurance policy) and stamp and tag cost. Then, insurance companies review all the documents submitted and issue the application.

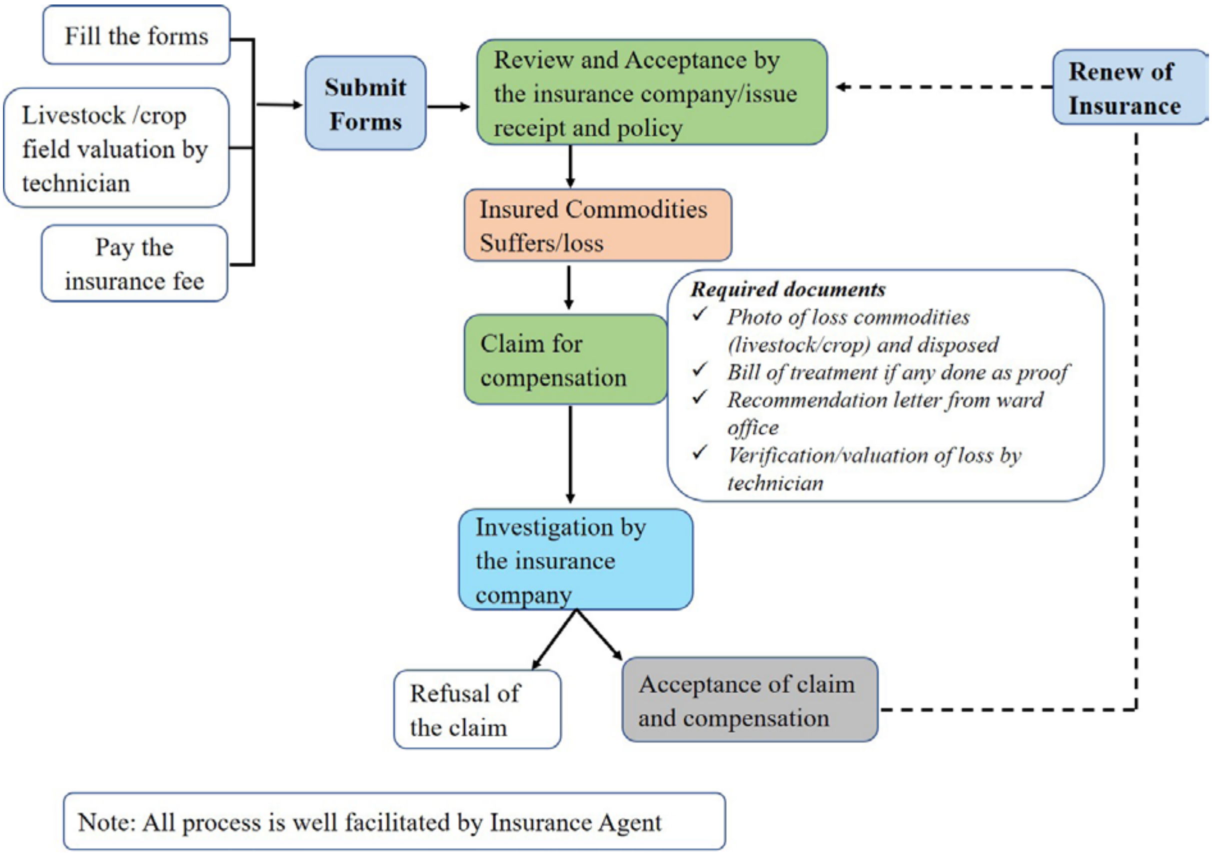

Figure 13: Process of agriculture and livestock insurance

When farmers lose crops and livestock commodities due to disasters, including natural disasters and disease and pests, they should immediately inform the insurance company. They have to apply for the compensation by providing evidence such as photos of loss of agriculture commodities, and digging and burying of livestock. In all images, tags and other information should be visible. The name tag and other documents have to be safely kept and submit at the time of claiming. A recommendation letter from the Ward Office or other government office must be obtained as a validation document in case of loss. Finally, the report of loss of crops or death of livestock and poultry is taken by the locally available technicians and all the required documents should be submitted to insurance companies while applying for a compensation claim.

The insurance company verifies all the insurers' documents, and they might also visit the field for further verification, if needed. Then if proof is sufficient, compensation can be claimed at 90% of the total insured amount. The claim process usually takes around 30 days from the first reporting date to complete (Ghimire, 2014). The insurers have to renew their insurance annually or per crop period as per the nature of commodities (livestock/crop). With insurance of the commodities, farmers are provided with accidental insurance of the livestock up to NPR 200,000 as an incentive for NPR 100 premium, if interested.

Agroecological adaptation

Crop and livestock insurance is suitable for all three ecological regions (high-hills, mid-hills, and Terai). However, commodity wise insurance schemes might vary among ecological areas depending on the potential for different agriculture and livestock commodities. For instance, Terai is suitable for cereal crops, vegetables, tropical fruits, poultry, broiler and layers, fisheries, cows and buffaloes. Likewise, mid-hills are potentials for vegetables, sub-tropical fruits, goats, local poultries, tea and coffee, cow and buffaloes, pigs, and important medicinal plants. In the high-hills, temperate fruits, medicinal plants, yak and chauri, chyangra goat, etc., have potential, so different insurance schemes are required.

Implementation cost

Unlike other climate-smart technologies and practices, the cost of insurance varies depending on the number of livestock commodities and the area of production of agriculture commodities. The insurance cost of agriculture and livestock commodities depends on the insured amount agreed between insurers and insurance companies. Insurance cost for livestock and poultry commodities is more straight forward than the price for agriculture commodities. According to the current insurance policy, the premium amount is five percent for crops and livestock and six percent for poultry of the total insured amount (ASHA, 2018; Deepa *et al.*, 2020).

Table 20: Details on the basis of the insured amount and insurance fee

Insured Object	Basis of insured amount	Insurance fee
Livestock (cattle, buffalo, goat, pig, yak)	Age, local market rate, technician's suggestion and understanding between insurer and insurance company	5% of sum insured amount + stamp and tag cost
Poultry (chicken, duck, etc.)	It is calculated as follows: Per poultry insured amount (Rs) = Feed Cost*Fixed Multiplier + Chicken chicks' cost *Whereas;* *Feed cost = local cost of Per day kg* *Fixed Multiplier:* *Broiler = 4.75* *Layers/Parent and duck = 10.2*	6% of sum insured amount (per year), 1.25% of insured amount per batch + stamp cost
Crops (cereals, vegetables, fruits, potato, tea and coffee, cardamom, etc.)	Area of cultivation, basic investment cost for production cycle (purchase of seedlings, fertilizers, labour charge required until the crops are ready to harvest) provided by Agriculture Ministry	5% of sum insured amount + stamp cost
Fish	Type, rearing technology and duration and product value as given by fish insurance policy.	2% of insurance amount + stamp cost

Of the total premium, the Government of Nepal contributes to compensating up to 75% of the premium amount of NPR 1,000,000. And insurers will pay 25% of the total premium. For example, if a farmer has reared 20 milking cows and s/he intends to insure them at NPR 50,000 per cow, the total amounts insured accounts to be NPR 1,000,000. Five percent of the full premium amount accounts for NPR 50,000. Of which, the government pays NPR 37,500 (75%), and the remaining NPR 12,500 (25%) is required to cover by the insurer. Thus the insurer's total cost to the insurance companies as per current insurance policy is relatively less than their total insured amount, motivating them to be continuously engaged in agriculture and livestock production and related enterprises.

Case Story

Sunita Tharu with her insured pig. Photo: Isha Shrestha, LI-BIRD

Under the Livelihoods and Resilience Enhancement Project (LREP), LI-BIRD introduced a Community Livestock Promotion Fund (CLPF) to support smallholder farmers on livestock rearing in Samman Women Agricultural Co-operative of Sorhawa, Badhaiyatal Rural Municipality Ward 4, Bardiya. The fund provides a loan to smallholder farmers at a six percent interest rate. It promotes to increase the livestock numbers so that livestock can significantly contribute to generating income for the family. Sunita Tharu, aged 50, has taken NPR 20,000 for raising pigs and goats; and has insured them. She was interested in pig farming for five years and started rearing them, but suddenly, her husband fell sick and had to sell all the livestock for his treatment. After 2018 when the project ended, she took a loan of NPR 20,000 from CLPF and again started goat and pig farming. However, she was worried about possible loss as she had no savings. And now, she was in debt. She came to know about the insurance through her group chairman, and with some hesitation, she insured two pigs and two goats supported by the project.

Unfortunately, one of the goats died all of a sudden. Ms. Tharu was worried about it. But she immediately informed the Co-operative members and captured a few photographs for evidence as per the guideline. After processing a claim, the insurance company paid NPR 9,000 (90% of the insured amount). This support gave her relief and helped her continue her farming. From agriculture produce, she has already paid the loan and earned NPR 161,000 since 2018. She is now happy with insurance and has been continuously insuring all her livestock. Building on this success, Samman Women Co-operative has facilitated the insurance for 217 goats and 15 pigs of 102 households.

Commodity wise insurance policy formulated by Government of Nepal

S.N.	Policies
1	Banana Insurance Policy
2	Cattle Insurance Policy
3	Cardamom Insurance Policy
4	Coffee Insurance Policy
5	Fish Insurance Policy
6	Fruit Insurance Policy
7	Ginger Insurance Policy
8	Goat Insurance Policy
9	Grass Insurance Policy
10	Honey Bee Insurance Policy (Revised)
11	Junar Orange Insurance Policy
12	Lemon Insurance Policy
13	Mushroom Insurance Policy
14	Orange Insurance Policy

S.N.	Policies
15	Ostrich Insurance Policy
16	Paddy Insurance Policy
17	Paddy Group Insurance Policy
18	Pheasant (Kalij) Insurance Policy
19	Potato Insurance policy
20	Poultry Insurance Policy
21	Seed Insurance Policy
22	Sugarcane Insurance Policy
23	Tea Insurance Policy
24	Turmeric Insurance Policy
25	Vegetable Insurance Policy
26	Vegetable Insurance Policy (production based)
27	Weather Index Policy

Further reading

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APPENDIX: Definition of terms

Adaptation: Adaptation refers to an adjustment in natural and/or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001).

Agricultural biodiversity: Agricultural biodiversity is also known as agrobiodiversity. It includes the variety and variability of animals, plants and micro-organisms at the genetic, species and ecosystem levels that sustain the ecosystem structures, functions and processes in and around production systems, and that provide food and non-food agricultural products. (FAO, 1999)

Climate change: Climate change is the global phenomenon of climate transformation mainly described by the changes with regards to the climatic parameters such as temperature, rainfall, precipitation, and wind. It can also be defined as any change in climate over time, either due to natural phenomenon or as a result of human interventions.

Climate-Smart Agriculture: Climate-Smart Agriculture (CSA) is an approach which increases the agriculture production and productivity, thereby reducing the emission of greenhouse gases and ensures food security.

IPCC: The Intergovernmental Panel on Climate Change (IPCC) is an intergovernmental body of the United Nations that is dedicated to providing the world with objective, scientific information relevant to understanding the scientific basis of the risk of human-induced climate change, its natural, political, and economic impacts and risks, and possible response options. (Weart and Spencer, 2011)

IPM: Integrated Pest Management (IPM) can be defined as an ecosystem based integrated approach of crop production which encompasses various management strategies and practices such as biological, mechanical, physical, cultural practices to grow healthy crops and thereby minimises the use of pesticides.

Mitigation: Mitigation is an anthropogenic intervention which helps to reduce the emissions of greenhouse gases.

For More Information

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